UNIVERSITY OF ALBERTA

A Study of Optimal Location: Competitiveness of the Alberta Cattle Feeding Industry with U.S. Regions

BY

© **Duncan McKinnon**

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Science**

IN

Agricultural Economics

Department of Rural Economy

Edmonton, Alberta

Fall 1991

ISBN 0-315-70196-X

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: **Duncan McKinnon**

TITLE OF THESIS: **A Study of Optimal Location: Competitiveness of the Alberta Cattle Feeding Industry with U.S. Regions.**

DEGREE: **Master of Science**

YEAR THIS DEGREE GRANTED: **Fall 1991**

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **A Study of Optimal Location: Competitiveness of the Alberta Cattle Feeding Industry with U.S. Regions** submitted by **Duncan McKinnon** in partial fulfillment of the requirements for the degree of **Master of Science** in **Agricultural Economics.**

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ABSTRACT

This study examines optimal location of cattle feeding among Alberta and the northwest U.S.. Optimal location is based on comparative advantage (reflected in lower cost) in the production of resources such as feeds and feeders, and final product of boxed beef. Transportation costs of resources and final product also influence optimal location.

A spatial equilibrium model is developed to determine optimal location among seven regions. It is a linear programming cost minimization model that applies to 1988. A production function for transforming intermediate resources into final product (boxed beef) is used and regional demand for boxed beef is specified.

Alberta beef supply and disposition for 1988 is recreated with various policy simulations then applied to this base model. Results indicate Alberta can be competitive with U.S. regions in feeding and processing cattle. Competitiveness of Alberta's cattle feeding industry is strengthened by the policy simulations.

Comparison of actual 1988 cattle feeding patterns to "optimal" feeding patterns indicated by the model leads to inferences. Significant feeding impacts appear to arise from removal of (or alterations to) the current method of paying the Crow Benefit. The Alberta cattle sector shows considerable sensitivity to this policy through its impact on barley price. Study models indicate the Alberta cattle feeding and processing industry would expand with Crow rate removal.

Secondly, should Pacific Rim demand for high quality beef increase, both Alberta regions would increase exports by shipping through the west coast port of Vancouver. Exports to the Pacific Rim would displace beef shipments from Alberta to eastern Canada.

Depreciation of the value of the Canadian dollar in 1988 would also have led to increased activity in the Alberta cattle sector. Alberta imported more feeders from the U.S. as value added cattle feeding and processing activities increased in Alberta. The additional boxed beef was shipped south to the U.S.

Acknowledgements

Many people deserve recognition for their contribution to the completion of this project. Dr. Bill Phillips initiated my involvement in the study and gave encouragement throughout. My advisor, Dr. M.L. Lerohl, provided direction to my research. He successfully steered me clear of most dead ends and guided me toward productive research. Numerous times he kept me from complicating the issues. His patience while I got on track contributed immensely to completion of the project. Thanks Mel.

Professor A.W. Anderson gave invaluable assistance with the mathematical programming sections of the project. Several times work was stalled until Professor Anderson got a chance to look at it. Perhaps more important than the programming help, thanks Wayne for laughing at my jokes.

Dr. Len Bauer deserves recognition for giving me opportunities throughout my graduate program. Your fine wit was appreciated Dr. Bauer. Dr. Gary Mathison, thanks for providing the animal science knowledge. To both of you, thanks for being on my committee.

Jim Copeland, thanks for timely tips in the computer room. Barb Johnson, thanks for research assistance and advise.

Alberta Agriculture staff provided assistance with data collection. In particular, thanks to Rob Bateman and Barb Gabruch. Darcy Willis at Alberta Agriculture provided the conditions that allowed the project to develop. Challenging conversation with Darcy helped focus this study.

Dedication

To my wife Sheila,

and our children Hannah, Grant and Zane.

Your sacrifice and patience has allowed me to finish.

Table of Contents

Table of Tables

Table of Figures

1 INTRODUCTION

1.1 Background

1.1.1 Competitiveness Issues.

Competitiveness of Alberta beef internationally is important to many sectors of the Alberta economy including the government and the cattle industry. The cattle industry needs to know its competitiveness to make long-run plans. Assume, for example, statutory rates were altered or removed (adjusted) on grain exported from the prairies. Would excess supply of feed grain in Alberta translate into a reduction in Alberta livestock producer feed conversion costs? How would this impact on optimum feedlot location in north-western U.S. and Alberta? The answer would help clarify Alberta's competitive position in the cattle sector. If statutory grain rates are adjusted, feed grain shipment out of the province to eastern Canada could drop off. This should stimulate Alberta's feeding industry at the expense of eastern Canada's cattle feeding industry. Indirect effects of such a policy change may mean eastern U.S. states will draw beef supplies more from western states leaving open for Alberta the possibility of increased exports south to the California area.

Local government is also concerned with competitiveness of the Alberta cattle industry. Policies implemented by itself and others will impact on this competitiveness. Who are the gainers and losers of policy changes? What are the anticipated effects of various policy shocks on the cattle industry? Adjustment to the Crow Benefit Program[1] is one example of impending policy change. Implications of Crow Rate removal on Alberta's cattle feeding industry are examined in this study. Non-harmonized beef grading between Alberta and the U.S. influences trade patterns. Beef inspection problems hinder flow of Alberta beef south. Scrutiny and possibly adjustment faces these regulatory issues. Implications of changes to regulatory issues in the beef sector are of significance to the entire Alberta economy.

Livestock trade between Alberta and the U.S. currently enjoys freer movement than many other agricultural commodities. Alberta's competitiveness in this sector is a sensitive issue as trade surges in livestock products affect the domestic industry more with free trade than with restricted trade. Cattle trade (live and processed) between Alberta and U.S. is of note. In 1988, Alberta exported 226,426 live cattle to the U.S., of which 98 percent were slaughter cattle. In 1989, the pattern was similar with about 95 percent being slaughter cattle. The loss to Alberta of value-added beef processing is disconcerting. This study attempts to identify factors critical to these cattle movements.

Alberta-U.S. trade in beef for 1988 indicates Alberta exported about ten times as much beef to the U.S. as was imported (45 million lbs versus 4 million lbs.). While the direction of these flows is encouraging, the quantity is not large. Alberta produced 800 million lbs of beef in 1988 of which approximately 25 percent (220 million lbs) was consumed in Alberta. Over 400 million pounds

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1 Statutory grain rates on export of prairie grains are those set out in the federal **Western Grain Transportation Act.** They are alternately referred to in this paper as the Crow Benefit Program.

was exported to Ontario and further east. The fact that Alberta can ship beef to eastern Canada competitively (considering the distance and resulting high transportation cost), opens for inquiry the issue of moving beef a lesser distance to the south.

In a study of competitiveness issues in the U.S. beef sector (Johnson et al., 1989), it was predicted there would be increased worldwide demand for beef in the coming years due to rising incomes and improved policy coordination between countries. It is believed that this increased consumption will be met by imports from countries holding a competitive edge in beef production. Recent investment in new slaughter facilities in Alberta indicates a readiness to participate in this anticipated expansion of beef demand. Other measures also suggest Alberta can produce beef competitively.

First, for primary agriculture production such as cattle feeding or fluid milk production, production can be either feed source oriented or market oriented. A study done in the early sixties (King 1961) shows that fluid milk production would be located near consuming centers but that feedlot cattle would be feed source oriented. If Alberta has an abundance of cattle feeds (concentrates and roughages), feedlot cattle production in Alberta may be competitive with the highly developed U.S. cattle feeding areas.

Secondly, the U.S. is a major world importer of high quality beef as opposed to range-fed beef. This distinction between types of beef is important. Several countries (notably Australia, Argentina, Brazil and New Zealand) export range-fed beef. Range-fed beef imported into the U.S. is usually processed further, as are imports of European beef which often come from dairy cattle culls. Range-fed beef and beef from cull cattle is not competitive with the high quality beef that is produced in Alberta and demanded in the U.S.

Finally, Alberta's competitiveness in beef production is enhanced further by the low incidence of cattle disease in our temperate climate. North American imports of beef from Africa, Asia, South America and parts of Europe are restricted because of the prevalence of disease (primarily foot-and-mouth) in these countries.

1.1.2 King and Schrader Paper

The model used in this study follows one developed by King and Schrader (1963). King and Schrader make a distinction between general and partial equilibrium models: Determination of optimal production of an agricultural commodity in a **general** equilibrium framework depends on regional comparative advantage in producing that product in relation to production of all other agriculture products in the region. In the King and Schrader study the model takes regional production of all other livestock products as given and therefore undertakes a **partial** equilibrium analysis of feedlot location assuming as given the location of all other livestock production.

The King and Schrader paper had four objectives in mind:

> 1) "to present a framework for the analysis of interregional competition for the case where a) both intermediate products, such as feed and feeders, and product may be shipped among regions and b) where alternative production activities are specified for conversion of intermediate products into the final product; 2) to apply the model to the analysis of the location of cattle feeding operations in the United States; 3) to determine the effect on location of modify-

ing assumptions of the model as to nonfeed costs and feeding efficiency; 4) and to appraise the possible effect of other factors such as economies of scale in feedlot location."(King and Schrader, 332)

The primary purpose of their study was to "...provide quantification of the effect of factors influencing location of feedlot facilities." (King and Schrader, 332). Determined simultaneously in their model, along with feedlot location, were final product (beef) and factor (concentrates, roughages, and feeder cattle) shipment patterns, as well as beef prices that would result from perfectly competitive behavior.

1.1.3 Objectives and Organization of the Study

The objective of the present study is to estimate the optimal regional location of cattle feeding in Alberta and the north-west states.[2] In carrying out this objective, the model also determines optimal feeder shipments depending on various domestic and trade policies, exchange rates and demand scenarios. The study also indicates sensitivity of feeder shipment patterns to the above major variables.

A cost minimization, spatial equilibrium model is used to generate results. The model minimizes cost of intermediate products, transportation costs, non-feed costs and processing costs. A production function relating quantity of intermediate product required per unit of final product is specified as are regional demand functions for boxed beef. The methodology used has several parallels

2 The eleven north-west states included in the study are: California, Colorado, Idaho, Montana, Nevada, N. Dakota, Oregon, S. Dakota, Utah, Washington, and Wyoming.

with the King and Schrader study although the present study is modified in several ways. The beef production function and the demand function used in this paper are clear examples of modifications.

Is Alberta competitive with the north-west states in feeding and processing cattle? This model is not designed to deliver an unequivocal yes or no but to indicate optimal feeding and processing location given certain assumptions. By definition, the model abstracts from reality. For that reason not all factors impinging on equilibrium location are included. The model does deliver a framework that can be useful in analysis providing the user is fully aware of its assumptions and the resulting simplicity of the solution.

Organization of the study is in 7 chapters. The first provides background to the issue of competitiveness of the beef producing sector in Alberta. It also provides a brief introduction to the relevant trade theory. Chapter 2 introduces Spatial Equilibrium theory and discusses its connection to the study. In chapter 3 the study model is examined as are data requirements and methodology. In chapter 4 results and variations of the base model are presented. Chapters 5, 6, and 7 indicate, respectively, conclusions, bibliography, and appendices.

1.2 Trade Theory

1.2.1 Comparative Advantage/Gains from Trade

The basis for trade between countries or regions is comparative advantage.[3] Gains arising from comparative advantage occur when a country exports goods it can produce at lower cost than other countries and imports goods that others can produce at lower cost. Two distinct lines of reasoning have resulted in the comparative advantage concept.

The Ricardian explanation of comparative advantage implied that all value was rooted in labor. Relative technical efficiencies (ie. economies of scale)[4] were believed to create comparative advantage. When Ricardo conceived this notion, transfer of technical information between regions and countries was limited and the theory was appropriate. Currently, however, it is more reasonable to assume technical information can be transferred very quickly (in many cases instantaneously) and another explanation for comparative advantage is required.[5] The Heckscher-Ohlin concept is that comparative advantage arises from regional availability of fixed factors of production such as land and primary inputs. This concept is applied in the present study.

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3 The law of comparative advantage states that even if one nation has an absolute disadvantage compared to the other nation (or is less efficient than the other nation) in the production of both commodities there may still be grounds for trade. The first nation should specialize in production of the good for which its absolute disadvantage is smaller (the good of its comparative advantage) and import the good in which its absolute disadvantage is greater.(Salvatore 1990)

4 Economies of Scale refers to technical efficiencies (expansion of output in response to expansion of all factors in fixed proportions); Economies of Size refers more to cost advantages that may be realized by following the Least Cost Expansion Path.

5 Differences in size between Alberta and U.S. cattle sectors may be due less to technological advantages than to different demand conditions. The U.S. market is ten times as large as the Alberta market. This allows distinct economies of size advantages for U.S. cattle feeders.

Unless a nation or region has unused resources, production of one good must be foregone to produce another good. This involves rearranging the resource use patterns. Comparative advantage requires examination of the opportunity cost of producing additional units of a particular good in terms of amounts of another good that must be foregone (Houck 1986). Comparative advantage theory then compares these opportunity costs with prices of the goods on the international market. Trading decisions will be based on this comparison. For example, a good will be exported if the international price of the good is greater than the opportunity cost of producing it domestically. Imports require the international price to be lower than domestic opportunity costs of producing the good. Efficiency is improved by the release of resources from the production of goods that can be imported at a lower cost.

Comparative advantage in the production of a commodity leads to specialization and increased utilization of the particular abilities and resources that region/country posesses. Specialization brings change in economic structure and increased investment in sectors that have a comparative advantage in production of a good, and contraction of costly sectors. The expansion in efficient sectors leads to increased input demands which leads to expansion in other sectors of the economy as resources move from less efficient sectors to expanding sectors.

A region may also choose to specialize production for reasons other than comparative or absolute advantage. If it has few feasible alternatives, production of a commodity may occur by default. A second region with absolute advantage in production of that commodity may then find a better use for its "more versatile" resources and utilize them in the production of alternate goods. In such a situation, the first region has the comparative advantage in production of that particular commodity.

For agriculture, the basic resources of land quality, land availability and climate define the feasible alternatives of production. Actual use of these resources depends on the markets for a particular commodity and for alternate commodities, on the location of urban centers of population, on tastes and preferences of individuals and on transfer costs from producing areas to markets (Bressler and King 1970).

Trade resulting from comparative advantage and specialization means buyers have access to goods that are not available or are prohibitively expensive. Trade for lower priced foreign goods effectively raises the real income of domestic consumers--their dollar buys more. Distribution of these "gains from trade" are not even, however. The country as a whole gains from trade but all individuals do not benefit. This leads to protective measures being taken by virtually all participants in the market.[6]

1.2.2 Price Equilibrium

Competitive price equilibrium allocates scarce resources and hence directs economic activity. On the production side, product prices affect factor prices and allocate scarce resources among alternative uses. On the consumption

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6 Protective measures are taken because benefits of additional trade are thinly and widely spread over an entire population, but costs and hardships are paid by relatively few who are often able to organize and effectively voice their opposition.

side, factor prices are income. The interaction of income with commodity prices in the competitive market allocates goods and services among consumers (Bressler and King 1970).

Markets are said to facilitate the creation of place, time and ownership utility. In equilibrium there is one price for each good with a particular place, time and ownership utility. In a single market, price equilibrium occurs when price is reached where quantity supplied exactly equals quantity demanded.

In the present study, although there are several regions used, they are interconnected by trade and therefore constitute a single market. The uniqueness of place utility is the only difference between price in two separate regions. What the transfer activity does is to change the place utility of the commodity in the single market. What results is one *multiple price* market where price differences are due entirely to differences in place utility. Practically speaking, there may be other reasons for the price difference. The following section illustrates price equilibrium in geographically separated regions, and how price adjusts to account for transfer cost between regions.

1.2.2.1 Price Equilibrium In Spatially Separated Markets

Modern spatial equilibrium models originate in the theory of trade between spatially separated regions. The following explanation (based on Bressler and King 1970) illustrates the mechanism for determining price equilibrium between regions.

Examining price equilibrium between two regions requires a single commodity to be traded. Assume supply and demand curves are given in the two regions. With no trade, price equilibrium is determined in isolation in each region. With trade opened between two regions, call them region X and region Y, traders will equalize price through arbitrage[7]. They will lower price in, say, region X and raise price in region Y. Arbitrage will continue until price in region X equals price in region Y and a combined equilibrium price is reached between the two regions.

To this point no transportation costs are included. This allows price to be exactly equalized between regions. More realistically, prices between regions would approach equalization until they differ by the transfer cost. This can be shown graphically by adjusting upwards the supply and demand curves in the exporting region by an amount *t*, indicating the extra cost to region Y of delivering its product to the market in region X. This is done in Fig 1. Now, a horizontal line such as $c' c'' c'$ through the diagram indicates a combined equilibrium price that differs by the transportation cost between region Y and region X, with price in region Y being less than price in region X by the amount *t*.

7 Arbitrage is transactions designed to make a profit from inconsistent prices.

Figure 1.
Price Equilibrium in Spatially Separated Markets

Figure 1 has been removed due to copyright restrictions.

Source: Bressler and King 1970, 90.

The relationship between transfer cost and trade flows can be illustrated by another curve that measures the *vertical* difference between the excess supply curves[8]. Fig 2 represents the situation.[9] Drawing $ES_x - ES_y$, transfer cost can be read off the vertical axis with the height of t representing transfer cost. Extending a line up and down from the intersection of t with the new curve, off the horizontal axis can be read the reduction in trade volume, *(Oh - Oh')*, resulting from transfer costs; and from where the line crosses the excess supply curves, the equilibrium prices in each region, Px and Py, that will differ by transfer cost.

8 Excess supply curves are the horizontal difference between supply and demand in the corresponding regions.

9 Figure 2 is another way of expressing what is said in Figure 1. It is included to give another perspective on price equilibrium. Figure 2 also plays a role in describing transformation of the spatial equilibrium problem from a descriptive to an optimizing framework in section 2.3.

Figure 2.
Price Equilibrium in Spatially Separated Markets
(Alternate Representation)

Figure 2 has been removed due to copyright restrictions.

Source: Bressler and King 1970, 91.

2 SPATIAL EQUILIBRIUM THEORY

2.1 Introduction

Neoclassical economic analysis does not explicitly consider the effects of spatial relationships:

> "Even the theory of international economics, duly incorporated into neoclassical analysis, finds itself in a paradoxical position: it denies the existence of space, yet it attempts to explain comparative advantage, a doctrine which cannot be properly interpreted without taking the cost of transportation into account." (Lefeber 1958, 1)

Since these words were written, considerable progress has been made toward incorporating spatial variables in economic equilibrium models. Development of mathematical programming techniques and improved computational abilities of computers in the last thirty years have led to considerable empirical work in this area.

The purpose of this section is to identify the theory of spatial equilibrium and illustrate how it is made operational in empirical studies. To accomplish this task, the chapter is broken into five parts. The first introduces location theory as discussed by Weinschenck et al. (1969). The second part is centered on Samuelson (1952). His paper makes the connection between theoretical problem and operational solution and explains the descriptive to optimizing transformation required for analysis. In the third part an example of an optimizing problem is given from Judge and Wallace (1958).

The Judge and Wallace solution algorithm is examined because it illustrates the component parts necessary to solve a spatial equilibrium model. With current computer technology, problem solution does not require the time and effort needed in 1958. Modern solution algorithms require less pre-solution computation before using the mathematical programming framework. The fourth part is based on Chiang (1984). It illustrates the mathematical background and techniques used in linear programming. A progression is made from the more general non-linear programming to linear programming to display the setting of linear programming. The final part provides an evaluation of spatial equilibrium models from Bawden (1964).

2.2 Location Theory

Since Ricardo, economists have been aware of the necessity of including space in economic reasoning. Progress in the area has been slow, however, and only recently is space included in a theory of general economic equilibrium. The difference between traditional and modern location theory lies in the ability to make the models operational. Modern theory has made great strides toward achieving this goal by building on the framework set up by traditional location theorists.

2.2.1 Traditional Location Theory

Traditional theory was concerned with problems involving optimal location of a firm; optimal production at a given location; exchange of goods and factors between locations, and; the difference in prices and factor earnings between locations. As noted by Weinschenck et al. (1969), all four of these problems are "...only different aspects of the major problem of the general spatial equilibrium of production." (Weinschenck et al. 1969, 1).

Agriculture location theory began with J.H. von Thunen (Von Thunen, 1966). His descriptive spatial equilibrium problem was as follows:

> "Imagine a very large town, at the center of a fertile plain which is crossed by no navigable river or canal. Throughout the plain the soil is capable of cultivation and of the same fertility. Far from the town, the plain turns into an uncultivated wilderness which cuts off all communication between this State and the outside world.
>
> There are no other towns on the plain. The central town must therefore supply the rural areas with all manufactured products, and in return it will obtain all its provisions from the surrounding countryside.... The problem we want to solve is this: What pattern of cultivation will take shape in these conditions?; and how far will the

> farming system of the different districts be affected by their distance from the Town?" (Weinschenck et al. 1969, 4)

Intent only on determining the influence of different distances from the market on types of land use, keeping all other factors constant, von Thunen demonstrated that two spatial conditions are necessary for a good to be produced: 1) The inner boundary (with respect to the market) of production of a good must be closer to the market than the intersection of the boundary of production of this good with all other goods that generate a lower rent. Similarly, 2) The outer boundary (with respect to the market) of production of a good must be farther from the market than the intersection of the boundary of production of this good with all other goods that generate a higher rent. In other words, as distance from the market increases, rent per unit land decreases.

Von Thunen's descriptive model was a first step toward explicitly including space when determining an economic equilibrium. After von Thunen, location factors were generalized by other traditional location theorists. They considered different production functions, introduced economies and diseconomies of scale and looked at other location factors that affect production. These include geographical conditions, stage of economic development and personality of the farm operator (Weinschenck et al. 1969, 13).

2.2.2 Modern Location Theory

While traditional location theory focused on description and hence delivered primarily explanatory models, modern spatial equilibrium theory has become committed to making the models more operational. This is accomplished by incorporating implicitly into the supply and demand functions and transportation costs for a good, the many explicit location factors of traditional models. These composites are modelled rather than individually modelling many implicit location factors (see Figure 3). A further development of modern spatial equilibrium theory is the use of a discrete number of points rather than allowing space to change continuously. Relations between prices and supply, prices and demand, and the dependence of transportation costs on the direction of product flows are handled easier if a finite number of regions are used. (Weinschenck et al. 1969, 15).

Figure 3: Components of location definitions.

Figure 3 has been removed due to copyright restrictions.

Note: Taken from Weinschenck et. al. 1969, 14.

2.3 From Descriptive to Optimizing Framework

Samuelson (1952) formalizes the descriptive problem in the following way:

> "...we are given at each of two or more localities a domestic demand and supply curve for a given product (e.g., wheat) in terms of its market price at that locality. We are also given constant transport costs (shipping, insurance, duties, etc.) for carrying one unit of the product between any two of the specified localities. What then will be the final competitive equilibrium of prices in all the markets, of amounts supplied and demanded at each place, and of exports and imports?"(Samuelson 1952, 284).

Behind the scenes in this descriptive problem we assume an almost infinite number of atomistic competitors operate to maximize their own personal welfare. They take no **conscious** account of the principle of mathematical maximization. Yet, this perfect competition does lead to efficient allocation and use of resources.

The difficulty has been in describing how this intuitive maximization situation can be transformed to a framework that can be solved by mathematical maximization techniques. Samuelson (1952) illustrates how an area under the net excess supply and demand curves describes a combined social pay-off of two or more regions. In Figure 2 (see chapter 1) the area under the $ES_x - ES_y$ curve and bounded by the vertical and horizontal axis is this social pay-off of (in this case) both markets. Transformation to an optimizing problem involves maximizing this social pay-off area net of transport cost.

2.3.1 Samuelson's Net Social Pay-off Formulation

According to Samuelson, social pay-off for a region will be the area under the region's excess supply or demand curve.[10] Once all regional social pay-offs are determined by integration, they can be summed and total transport costs subtracted to arrive at a net social pay-off for all regions (Samuelson 1952, 291).

$$NSP = \sum_{1}^{n} S_i(E_i) - \sum_{i<j}\sum t_{ij}(E_{ij})$$

Where: NSP is net social pay-off; $S_i(E_i)$ indicates social pay-off in region i is a function of exports in region i; i < j is a notational requirement to preclude double counting the transportation rates[11], and $t_{ij}(E_{ij})$ refers to transport costs between any two regions being a function of exports.

At this point the descriptive problem is now a maximum problem awaiting solution. As Samuelson says, "...this maximum problem can be solved by trial and error or by a systematic procedure of varying shipments in the direction of increasing social pay-off."(Samuelson 1952, 292).

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10 Social pay-off for a region is the sum of individual consumer surplus for the region.

11 Otherwise we could have region 1 shipping to region 2 and region 2 shipping to region 1, which is a double counting of the same rate (in other words, back-hauling). This way we utilize only rates above OR below the diagonal of the transportation matrix.

One such systematic procedure is to use linear programming, which is maximization of a linear expression subject to a set of linear constraints. If total exports of each region were known but not the destination, the destination corresponding to the minimum transportation costs could be found.

2.4 Operational Example of Samuelson Formulation

Samuelson's transformation from descriptive to optimizing framework renders the problem operational. Mathematical programming techniques can be used to derive solution, once the excess supply and excess demand have been identified. These solutions deliver information that is useful to decision makers at government and industry levels. Using comparative statics,[12] the models can be used to determine consequences of changes in: transportation costs; domestic and foreign regulatory issues[13]; the level and distribution of regional demand and macroeconomic policies such as exchange rates.

2.4.1 Assumptions

Solution of the spatial equilibrium problem using mathematical programming techniques requires the following simplifying assumptions be met:

1. each region is represented by a single point in terms of supply and demand.

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12 Comparative statics is analyzing the impact of changing the model parameters. This is done by comparing the original equilibrium with the equilibrium after changing the parameters. In chapter 4, for example, models 2 thru 5 relate to the base model (model 1) through comparative statics.

13 In this study regulatory issues refer to beef inspection and grading concerns arising between Canada and the U.S.

2. regional demand can be represented by known linear demand functions and supplies are taken as predetermined for the given time period.
3. all regions are connected by transportation costs that are independent of direction or volume and flows of product among regions is unhampered by governmental or other interference.
4. the product is homogenous.
5. consumers are indifferent as to the source of the product.
6. factors affecting consumption other than price are considered predetermined.
7. exports and imports outside the model boundaries are negligible.
8. total production equals total consumption for any time period.
9. production and consumption of product can take place in all regions and product consumed locally requires no transportation.
10. there can be no negative shipments.
11. due to the maximum profit assumption there can be no cross-hauling (Judge and Wallace, 1958).

In empirical applications many of these assumptions can be relaxed or modified as the situation dictates. For example, assumption's number 7 and 8 are easily adjusted to fit supply and demand conditions within the model.

2.4.2 Model Solution

In the typical spatial equilibrium model, two components require determination: 1) equilibrium prices, consumption, and surplus or deficits for all regions, and; 2) minimum cost flows among all regions. Judge and Wallace (1958), illustrate that only the second of these can be solved by linear programming, Advancements in computing capabilities have meant that the entire problem can now be solved using linear programming. If demand and supply functions (or assumptions concerning them) are specified for regions, the linear programming framework will solve for both components.

Solution of the first component can be determined without any algebra by using statistical data. If data are not available, demand schedules are derived and used to estimate regional prices, consumption, and surplus or deficits for all regions. Judge and Wallace (1958) give a detailed explanation of the first solution component using demand estimation techniques.

With surplus and deficit regions known and quantities of excess supply and demand known for each region, determining minimum cost flows of a commodity is a straight forward application of the linear programming transportation problem. This is represented as follows (Judge and Wallace 1958, 808):

$$\text{MINIMIZE} \quad \sum_{j=1}^{m} \sum_{i=1}^{n} X_{ij} C_{ij}$$

subject to:

$$\sum_{j=1}^{m} X_{ij} = a_i; \quad i = 1, \ldots, n$$

$$\sum_{i=1}^{n} X_{ij} = b_j; \quad j = 1, \ldots, m$$

$$\sum_{i=1}^{n} a_i = \sum_{j=1}^{m} b_j,$$

and

$$X_{ij} \geq 0 \text{ for all } i, j$$

Where X_{ij} are commodity shipments, C_{ij} are transportation costs of commodity shipments, a_i equals total excess supply of region i and b_j equals total excess demand of region j.

2.5 Mathematical Programming

The linear programming framework developed in the late 40's and early 50's and utilized by Samuelson (1952) in solving spatial equilibrium problems, is part of a broader framework called mathematical programming. Linear programming is actually a subset of non-linear programming, which is a subset of mathematical programming. Dynamic, recursive and geometric programming are also subsets of mathematical programming.

2.5.1 Linear programming

The linear programming procedure will provide normative answers to problems involving choice of optimum location of production of a commodity, or optimum distribution routes of a commodity. A "normative answer" is provided by comparison of actual location or distribution with model location or distribution results.

In the present study linear programming is used to derive an optimal allocation scenario given the study specific assumptions indicated in chapter 3. This normative solution is then compared to actual allocation for policy analysis. Other solution procedures, for example regression analysis, are based on historical time series allocation data and describe actual allocation decisions made, not optimal allocation decisions with assumptions of perfect competition, perfect knowledge etc. Hence, they give no "yardstick for measurement" as does the linear programming technique.

Heady and Candler (1958) classify several uses of the linear programming framework, among which they include it's ability "...to specify spatial equilibrium patterns in the flow of agriculture products, to indicate optimum interregional patterns of resource use and product specialization in agriculture, and to solve related types of problems." (Heady and Candler 1958, 1).

They go on to say that "In solving a farm policy question, the problem may be one of determining which agriculture region should produce a quantity of a particular commodity consistent with a given level of demand." (Heady and Candler 1958, 3). These comments apply directly to the objectives stated at the beginning of this study and show the logic of using linear programming methods for solution of the present problem.

All linear programming problems involve: 1) a linear objective function, 2) two types of constraints: those that express special conditions of the problem; and non-negativity requirements, 3) as well as choice variables. The choice variables make up the linear objective function and each one indicates the level of some operation, called an activity or process.(Dorfman, Samuelson, and Solow 1958).

Whatever the objective when solving a problem, if there is only one method (process) of reaching the objective, there is no need for linear programming. The linear programming problem is choosing the optimal process. That explains the choice variables in the objective function. Also, a linear programming problem does not exist if resources are unlimited. Resource limitations are the constraint component of the linear programming set up. In the current study, constraints are composed of supplies and demands of beef and factor inputs at regional producing and consuming centers.

According to Chiang (1984), the n-variable linear minimization program in general notation is expressed in the following way:

$$\text{Minimize} \quad C = \sum_{j=1}^{n} c_j x_j$$

$$\text{subject to} \quad \sum_{j=1}^{n} a_{ij} x_j \geq r_i \quad (i = 1, 2, \ldots, m)$$

$$\text{and} \quad x_j \geq 0 \quad (j = 1, 2, \ldots, n)$$

Where X_j are the choice variables, c_j are given constant coefficients, as are a_{ij}. The r_i represent requirements.

2.6 Spatial Equilibrium Model Evaluation

An economic spatial equilibrium model is any model with space explicitly considered. These models involve one or more commodities (primary, intermediate and/or final goods), and are able to determine optimal equilibrium location, level of production and consumption and optimal shipping patterns between regions.

According to Bawden (1964), the multitude of spatial equilibrium models can be categorized into standard equilibrium models and activity analysis models. Standard equilibrium models use typical supply and demand functions. Activity analysis models let demand functions determine regional consumption but, rather than using supply functions, require production functions to determine different production levels and therefore costs. In Figure 3, definition 2 defines an activity analysis model and definition 3 refers to a standard equilibrium model.

To reiterate, the main difference between standard equilibrium models and activity analysis models is in the treatment of supply. Activity analysis models generate their own supply relationships while standard equilibrium models use explicit supply functions as derived from production functions.

Both types of spatial models provide: 1) efficient shipping patterns, regional production and resource allocation; 2) forecasts of shipping patterns, regional production and resource allocation, regional consumption, prices, storage requirements; 3) as well as effects of changes in exogenous variables such as government intervention upon the model.

All of this information is useful for policy makers in both government and industry groups, individual entrepreneurs and consumers (Bawden 1964, 1374). Some of the information is handled better by standard equilibrium models and some better by activity analysis models. In general, activity analysis models provide the best results in the long run and standard equilibrium models the best results in the short run. This is primarily because in standard equilibrium models the supply functions are usually estimated by regression analysis which are more useful for short run predictions since "... producer inertia, short run inflexibility, and inadequate knowledge of changing conditions are likely better reflected in supply functions estimated by regression analysis." (Bawden 1964, 1376). Regression equations do not perform as well for long run prediction, hence the production function approach of the activity analysis models can more accurately capture the long run adjustment process.

For short run activity analysis models, regional resources are assumed fixed as are processing facilities. Transportation costs are given for all mobile commodities, be they resources, intermediate goods or final products. Assuming profit maximization or cost minimization, the models yield optimal organization of production, consumption and shipment of commodities (factor, intermediate goods, or final product).

2.6.1 Limitations

Limitations of spatial models pertain to two areas in particular; data requirements, and the aggregation problem.

The aggregation problem arises from the assumption of regions being represented by a single point rather than a continuum of points. To make this conclusion, it must be assumed that regions represented by a single point represent homogeneity of all exogenous factors defining a region (Weinschenck et al. 1969). This may be unrealistic--transportation costs within a region that are assumed to be equal or zero is an example of the implications of this assumption. The practical problem becomes one of finding an adequate breakdown of regions that will minimize the error resulting from this problem. Hence, care should be taken in defining regions.

Data requirements are difficult to fulfill for spatial equilibrium models. For activity analysis models, data must allow determination of existing and potential activities for the region. Determination of variable production costs is required. For example, non-feed feedlot costs or processing costs. Input-output relationships for the final product must be known and, for the present study, feed conversion efficiencies and input-input ratios are also necessary.

Problems arise because countries often do not provide data for the desired regions, or data are not collected at a regional level. Another drawback is that current data collected may not use the same methodology for collection as previously collected data.

Spatial equilibrium models solved by linear programming techniques are static. This can be a drawback. Solution of spatial equilibrium models by dynamic programming would overcome this problem.

2.7 Summary

This chapter attempts an overview of spatial equilibrium theory. It outlines the foundations of spatial equilibrium theory as they have arisen from traditional location theory; and highlights more recent applications as practitioners endeavor to integrate spatial considerations into general equilibrium theory. It's application to the partial equilibrium model used in this study is of equal relevance.

From an initial descriptive problem, spatial equilibrium theory has evolved substantially to the point where, as an optimizing model, significant numbers of empirical studies have been done--in virtually all sectors of the economy. The theory of spatial equilibrium as made operational by mathematical programming techniques currently holds a prominent position in economic analysis. Results generated have the potential to be invaluable as an input to the decision making process; government and industry groups alike are sensitive to empirical results. The potential benefits from this type of model will increase as they continue to evolve and as data limitations are overcome.

3 THE MODEL

3.1 Introduction

Optimal location of feedlots among regions depends on many complex relationships. Demand for various final products has an impact. If demand is for hamburger that can be supplied by imports or cull dairy cows, feedlot location may be different than if the predominant demand is for high quality beef. Production possibilities for feeds may also influence feedlot location. Since cattle production is feed source oriented, regional availability of basic factors such as land and favorable climate may determine feed production functions and therefore the feasibility of cattle production. Transfer costs linking all regions spatially will also have an influence. Cattle producers will seek markets in major consumption centers and prohibitive transfer costs would eliminate profitability.

In the present study, two Alberta regions are separated from five U.S. regions by an international border. This can also affect optimal feedlot location as trade barriers and protection measures utilized by each nation are brought to bear. It also permits assessing impacts on the livestock sector of various trade and policy scenarios such as differing grading regulations and the effect of exchange rates.

This study of regional location of cattle feeding is a partial equilibrium analysis since it does not examine the effects of cattle feedlot location on other sectors. Hogs, poultry, and the dairy industry, for example, consume the same feeds as cattle, but constraining effects on these sectors of feed consumption by feeder cattle is not considered. Further, the model is static with optimal feeding location determined for 1988. Model results can be compared with actual 1988 results for policy analysis.

Each of the seven regions is represented by a single point for purposes of determining transfer costs. Regional demand is at these points and regional supply of fed and non-fed boxed beef is available at an assumed distance from these points for consumption in the home region or for shipment to other regions as required by regional demands.

Available at each of the seven points are given quantities of fixed factors (land, labor and capital) to support the cattle industry. Mobile intermediate products (feeder cattle, roughages and concentrates), that can be used to produce fed beef in the region or can be shipped to another region for use in fed beef production are also available at the regional points.

Regional demand functions for beef in the King and Schrader study are specified as a function of price, population, and per capita income. In the present study regional demand is per capita boxed beef consumption multiplied by regional population. The model is based on annual data and therefore abstracts from seasonal demand conditions (barbecues), or seasonal availability of feed and feeder cattle.

A fixed production function is utilized, although the framework exists to use alternative production processes to convert intermediate products into a final product (see King and Schrader 1963, 350). In models containing a production function (activity analysis models), product supply is endogenous. Supply of beef in the present model, therefore, is determined in the model by considering a joint equilibrium for the intermediate product and the final product. Regional quantities of fed-beef production depends on the cost (interregional transfer cost, intermediate product cost, non-feed cost, and processing cost)[14] of regional production.

Transfer functions are given which specify unit cost of interregional shipping of intermediate products of concentrate, roughage and feeder cattle; and unit cost of inter and intra regional shipments of final product of boxed beef. Cattle are assumed slaughtered 50 miles from consuming centers to derive intraregional meat transfer costs. Feeds and feeders are assumed available at the feedlots. Slaughter weight cattle are not shipped in this model. Slaughter plants are assumed located at feedlot locations.

Regional supply of non-fed beef is taken as given at estimated levels with that supply being independent of feeding operations. Non-fed beef was considered a direct substitute for fed beef in most model runs, however in one model (section 4.2) a distinction is made between fed and non-fed beef to test this assumption.

One advantage of the linear programming framework is that subsequent inclusion of factors affecting equilibrium can be done by adding new constraints or integrating the material into existing constraints. Grading differences between Alberta and U.S. regulators are currently an issue. They are addressed in this study (section 4.1.1) by reducing factor inputs to fed-beef production in Alberta as a proxy for grade differences. These can be allowed to vary between U.S. and

14 Non-feed costs are incurred in the feedlot and processing costs refer to the packing sector. These are dealt with in section 3.3.4.2.

Alberta regions. Border inspection concerns can be added as some form of "risk premium" to transportation rates on product crossing the international border between Alberta and the U.S. The anticipated effect on Alberta livestock production of statutory rate removal for grains destined for export (Crow rate removal) can be simulated by adjusting price on concentrates fed in the two Alberta regions.

Since the next part of this chapter illustrates the mathematical model and notation used, this may be the time to draw parallels between this model and the underlying theory (linear programming and spatial equilibrium) developed in chapter 2. The objective function of this model is designed to minimize intermediate factor costs, transportation costs between spatially separated regions, non-feed costs and processing costs of beef production. The minimization is subject to constraints on the choice variables. These constraints are the regional resource availability and regional demand for boxed beef. The problem becomes one of determining the optimal level of use of the choice variables. In other words determining the process that will satisfy the resource constraints while minimizing cost. Such an outcome will describe optimal shipments of intermediate factors of feeder cattle, concentrates and roughages, as well as optimal regional location of cattle feeding given the assumptions noted above.

3.2 Notation and Mathematical Model

Notation used in the model is indicated in Table 1. Explanation of variables is as follows: Quantities available of the intermediate products of feeder cattle, concentrate feed, roughages and of non-fed beef[15] are taken as predetermined for 1988. Quantities of fed beef produced in each region will be derived from a fixed production function with parameters constant for U.S. regions and constant for Alberta regions. Total quantity of intermediate product used in fed beef production for each region is determined in the model as equilibrium between supply and demand is reached.[16] Total beef demanded in each region is predetermined by the fixed demand assumption.

Units of intermediate and final product quantities shipped from region i to region j are: numbers for feeder cattle, '000Mcal for concentrates and roughages, and '000lbs for boxed beef. Transfer costs for final and intermediate products are in dollars per unit (indicated above) per shipment distance. The "Input use" notation is included to allow costing of feeders and concentrates for sensitivity analysis. FC indicates feeder use and BC refers to barley use (corn use in U.S. regions). Input costs per unit available are: CDN$ per animal for feeders and CDN$ per tonne for the concentrate. Barley price per tonne is used to represent Alberta concentrate costs and corn price per tonne represents U.S. concentrate costs. Exports in the model go to either New York or Toronto, and Vancouver is given a fixed

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15 A description of non-fed beef is taken up in section 3.3.7.

16 Amounts of intermediate product required per unit final product is predetermined by the fixed production function.

demand moderately higher than actual Alberta exports to British Columbia for 1988. Non-feed costs and processing costs are CDN$ per thousand pounds of boxed beef produced.

Table 1.
Model Notation

Item	Fedr.Ctl.	Conc.	Ruff.	Fed.Bf.	Nfed.Bf.	Totl.Bf.
* Q avail in reg i.	W_i	Y_i	Z_i		X_i	
* Q prod in reg i.				V_{il}		
* Q used/demnd in reg i.	W^i	Y^i	Z^i			DM^i
* Q shpd from i to j.	W_{ij}	Y_{ij}	Z_{ij}			X_{ij}
* Trnsfr cost/unit.	t^w_{ij}	t^y_{ij}	t^z_{ij}			t^x_{ij}
* Input use.	FC_i	BC_i				
* Input cost/unit.	C^w_i	C^y_i				
* Exports.						EX
* Non-feed/prcssng csts.				q_i		

Note: Based on notation in King and Schrader 1963, 341.

The objective is to determine the optimal regional location of cattle feeding and final and intermediate product shipment patterns that would result from perfectly competitive behavior under the assumptions of the model indicated above. To accomplish the objective, the linear programming framework will minimize transportation cost of final and intermediate product, non-feed and processing costs, cost of feeders and cost of concentrates:

$$\sum_i \sum_j X_{ij} t_{ij}^x + \sum_i \sum_j W_{ij} t_{ij}^w + \sum_i \sum_j Y_{ij} t_{ij}^y + \sum_i \sum_j Z_{ij} t_{ij}^z$$
$$+ \sum_i V_{i1} q_i + \sum_i W^i C_i^w + \sum_i Y^i C_i^y$$

Subject to:[17]

1) Shipments of beef from any region to itself and to all other regions must equal the nonfed beef available in the region plus beef produced in the region:

$$\sum_j X_{ij} = X_i + V_{i1}$$

2) Amounts of intermediate products used in any region must be less than or equal to amounts available in the region plus in-shipments minus out-shipments:

$$0 \leq W^i \leq W_i + \sum_j W_{ji} - \sum_j W_{ij}$$

$$0 \leq Y^i \leq Y_i + \sum_j Y_{ji} - \sum_j Y_{ij}$$

$$0 \leq Z^i \leq Z_i + \sum_j Z_{ji} - \sum_j Z_{ij}$$

3) Supply of beef to a particular region, including shipments from that region to itself will be equal to regional demand:

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17 Based on notation used in King and Schrader, 341.

$$DM^{i} = \sum_{j} X_{ji}$$

where j includes i

4) Two export points are included in the model to accomodate the excess supply of beef.

$$EX \leq \sum_{i} X_{iox}$$

where i = 1,2,...,6.

A two region example of the model in the linear programming framework is shown in Table 2.

Table 2.
Linear Programming Example of A Two Region Model

	X_{11}	X_{16}	X_{1v}	X_{61}	X_{66}	X_{6n}	FC_1	FC_6	BC_1	CC_6	V_{11}	V_{61}	W_{16}	W_{61}	Y_{16}	Y_{61}	Z_{16}	Z_{61}
GM	$-t^x_{11}$	$-t^x_{16}$	$-t^x_{1ex}$	$-t^x_{61}$	$-t^x_{66}$	$-t^x_{6ex}$	$-C^w_1$	$-C^w_6$	$-C^y_1$	$-C^y_6$	$-q_1$	$-q_6$	$-t^w_{16}$	$-t^w_{61}$	$-t^y_{16}$	$-t^y_{61}$	$-t^z_{16}$	$-t^z_{61}$
$X_1 =$	1	1	1								-1							
$X_6 =$				1	1	1						-1						
$0 \geq$							-1				W^1		1	-1				
$W_1 \geq$							1											
$0 \geq$								-1				W^6	-1	1				
$W_6 \geq$								1										
$0 \geq$									-1.4		Y^1				1	-1		
$Y_1 \geq$									1									
$0 \geq$										-1.6		Y^6			-1	1		
$Y_6 \geq$										1								
$Z_1 \geq$											Z^1						1	-1
$Z_6 \geq$												Z^6					-1	1
$DM^1 =$	1			1														
$DM^6 =$		1			1													
$EX \leq$			1			1												

Note: Based on notation in King and Schrader 1963, 342.

3.3 Data Requirements

Data requirements for the model are extensive. Needed are: the regional availability and price of intermediate products required to produce final product; the production process for conversion of intermediate products into final product; the regional demand for beef; transfer costs for intermediate products and final product; and regional availability of non-fed beef. As noted above (section 3.2) several assumptions separate this study from King and Schrader (1963). The inclusion of intermediate product price in this model allows sensitivity analysis of hypothesized changes to statutory grain rates in Alberta.

A need to minimize data requirements for the beef production process resulted in simplifying the process to a single fixed production function applying to all regions. Additional research at a later date could add realism by providing quantification of alternative production processes that would accomodate input substitution in the production function.

3.3.1 Regional Demarcation

The seven regions used in this model are grouped into two regions in the province of Alberta and five regions encompassing eleven north-western U.S. states. For the Alberta regions, Alberta Agriculture Production Branch (Alberta Agriculture 1990) lists three cattle production areas in the province. Demarcation based on this study or one using alternate regional breakdowns would have been acceptable. It was felt, however, that two regions could provide conclusions as valid as three or four regions and, further, use of two regions allows some pooling of available resources in Alberta in order to compete with massive U.S. resource supplies. Alberta regions are by census divisions (C.D.).

For the US regions, boundaries are designed to include one USDA feeding state[18] in each region and to keep the regions geographically homogenous. States marked with an asterisk are feeding states. The central points are located close to the center of the region and are on primary transportation routes. Regions and central points are shown in Figure's 4 and 5.

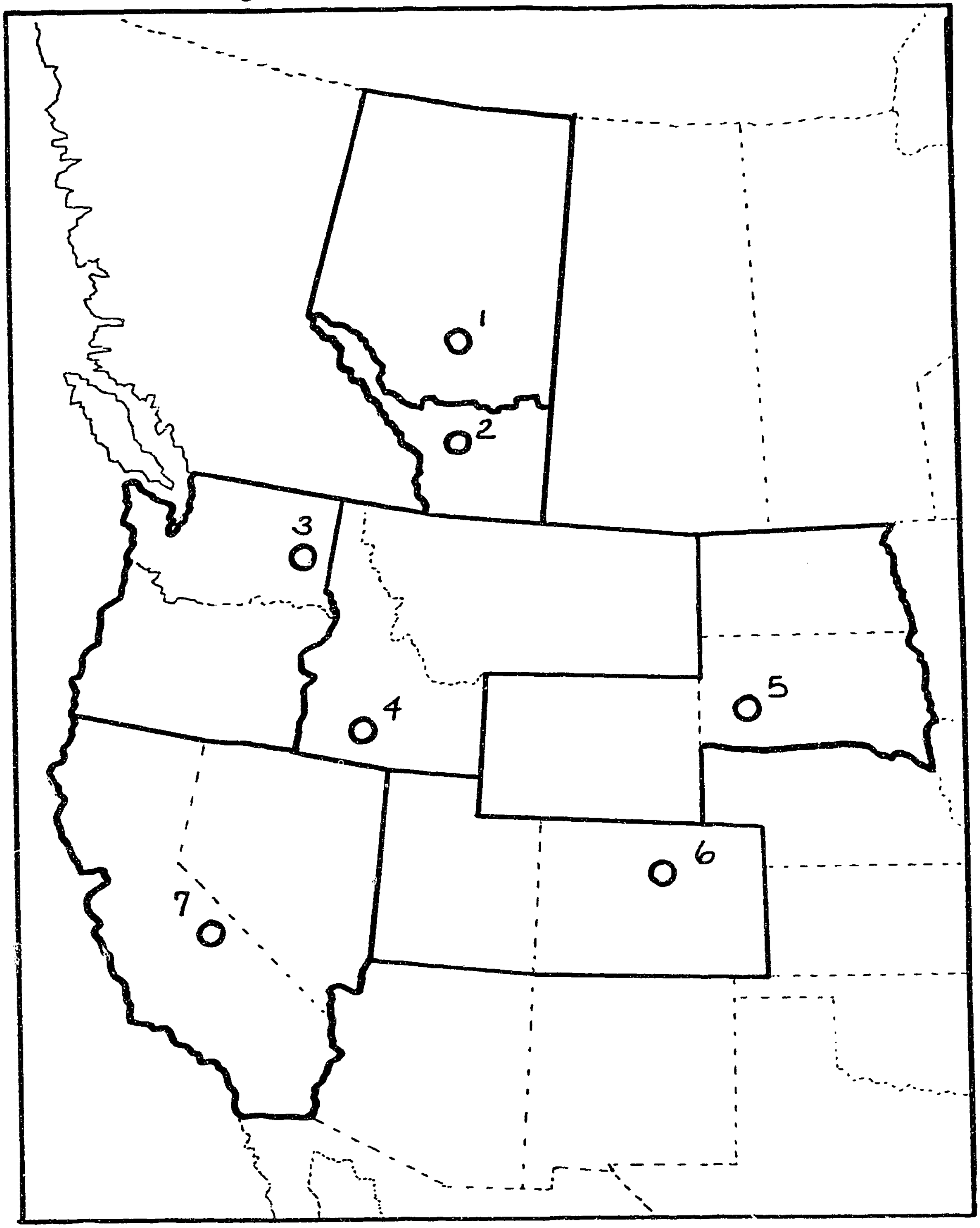
Figure 4.
Regions and Central Points Used in the Model

REGIONS	AREA INCLUDED	CENTRAL POINT
1	Alta C.D. 7-14 & 16-19	Edmonton, Alberta
2	Alta C.D. 1-6 & 15	Calgary, Alberta
3	Washington*, Oregon	Spokane, Washington
4	Idaho*, Montana	Twin Falls, Idaho
5	S. Dakota*, N. Dakota, Wyoming	Rapid City, S. Dakota
6	Colorado*, Utah	Denver, Colorado
7	California*, Nevada	Bishop, California

Note: Adapted from King and Schrader (1963).
Note: * indicates feeding state.

18 USDA NASS ASB Statistical bulletin No. 798 gives feeder cattle data for the "13 major feeding States" in the U.S. In this study it was determined to have one of these major feeding States in each of the five U.S. regions used.

Figure 5.
Regions and Central Points Used in the Model



3.3.2 Intermediate Product Supply

3.3.2.1 Feeder Cattle

Methodology for estimating feeder cattle supplies varies between Alberta regions and the US regions.[19] For the US, a "placements to number on feed"[20] ratio was calculated for feeding states. This ratio was then used to estimate placements for non-feeding states.

In Alberta, calf inventory numbers for July 1, 1987 were converted into placement numbers for 1988. While imports would be included in the US placement numbers, they must be added to the Alberta calf inventory numbers. The placements resulting are indicated in Table 3.

TABLE 3.
Estimated Placements for 1988 by Region

Region	Estimated Placements (#'s)
1	701,616
2	688,384
3	726,778
4	878,600
5	939,208
6	2,437,741
7	946,681
Total	7,319,008

Note: Based on notation in King and Schrader (1963).

19 See Appendix B for preliminary data tables and methodology used for US and Alberta regions.

20 "Placements" refers to the number of cattle placed on feed during the period Oct 1, 1987 to Sept 30, 1988. "Number on feed" indicates number of cattle on feed Jan 1, 1988.

3.3.2.2 Concentrates

Regional use of concentrate feed for livestock other than feeder cattle is assumed predetermined for the year beginning "fall 1987". All concentrates are converted to net energy in Mcal/tonne[21] and are seen as perfectly substitutable on these terms. Regional supply is taken as production plus imports plus beginning stocks, and regional use other than for feeder cattle is amounts fed to other livestock[22] plus exports plus industrial, food and seed uses. The difference between these two amounts is the supply variable used to feed feeder cattle. Regions 3 and 7 indicate a negative amount available to feed cattle. This indicates imports from other regions are necessary to satisfy feed requirements for other than feeder cattle before feeder requirements can be taken care of. As noted by King and Schrader (1963), this implies that other uses have first claim on feed supplies and may bias equilibrium feedlot location toward feed source. Concentrate availability is summarized in table 4.

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21 Mcal refers to million calories of net energy with the values specific for feeder cattle.

22 Feeding rates for livestock for both concentrates and roughages were required to calculate amounts "Fed to livestock other than beef cattle". These rates, along with concentrate and roughage data methodology are included in Appendix A.

TABLE 4.
Regional Availability of Feed Concentrates Expressed in '000 Mcal
(For the year beginning "fall 1987")

Region	Available for all livestock	Fed to livestock other than beef cattle	Available to feed cattle
1	7,274,340	2,203,011	5,071,329
2	4,268,790	1,608,860	2,659,930
3	2,887,737	3,697,943	(810,205)
4	19,551,965	11,031,999	8,519,966
5	24,590,131	7,110,619	17,479,512
6	7,595,824	2,180,205	5,415,619
7	2,821,246	15,082,020	(12,260,774)
TOTAL	68,990,034	42,914,657	26,075,377

Note: Based on notation in King and Schrader 1963, 341.

3.3.2.3 Roughages

Regional amounts of roughages are determined in much the same way as the concentrates. Calculation is simpler since roughages do not have the same number of alternative uses as do concentrates, (for example industrial and food uses do not apply to roughages).[23]

Included in the roughage category are silages. The high moisture content of these feeds translates to expensive per unit (1000Mcal net energy per tonne as fed) shipping costs and precludes interregional shipments. As a result, they are allowed as feed in region of origin only.

23 The roughages included are not an exhaustive list. There are possibly other regional specific feeds that are used in the feedlot (sugar beet tops in southern Alberta) and these could be included for sake of completeness.

TABLE 5.
Regional Availability of Feed Roughages Expressed in '000 Mcal
(For the year beginning "fall 1987")

Region	Available for all livestock	Fed to livestock other than feeder cattle	Available to feed cattle
1	4,902,603	1,259,474	3,643,130
2	2,123,767	761,639	1,362,128
3	4,821,408	2,337,428	2,483,980
4	8,275,305	4,572,020	3,703,285
5	12,248,749	4,323,080	7,925,669
6	5,914,152	1,946,060	3,968,092
7	9,416,392	4,915,581	4,500,811
Total	47,702,376	20,115,282	27,587,094

Note: Based on notation in King and Schrader 1963, 341.

3.3.3 Intermediate Product Cost

Feeder cattle and feed costs amount to approximately 85 percent of feedlot production costs with non-feed costs being a portion of the other 15 percent (Barkema and Drabenstott 1990, 59). As such, cost of the intermediate products of feeder cattle and concentrates are included in the mathematical model in their own column.[24] Separation of feeder and feed costs allows assessment of various policy scenarios that may affect the cattle sector through costs of these inputs. The particular concern here is with impending changes to the Crow rate on statutory grains for export. It is assumed by some (Alberta Agri-

24 Roughage costs are not isolated in this study. The assumption is, consequently, that roughage costs are the same in U.S. and Alberta regions. Actual average hay prices in 1988 were about 50 percent higher in the U.S. than in Alberta (*USDA ERS FDS-318*, May 1991 and *Alberta Agriculture, Agriculture Statistics Yearbook - 1988)*. Had roughage costs been isolated, they would have helped to skew cattle feeding toward Alberta regions.

culture 1990: Freedom To Choose) that removal of (or alterations to) the Crow will lead to reduced feed grain prices in western Canada as export markets for prairie grains shrink. This should stimulate the livestock sector through lower input costs. Analysis of effects of differing concentrate costs on optimum feeding location is undertaken in chapter 4.

Alberta feeder cattle and concentrate cost data for 1988 were taken from (Canfax 1988). Average cost for a 650 lb steer in Alberta was $637.00. Concentrate cost in Alberta uses barley price as a proxy. Price in June 1988 at the feedlot for barley was (approximately) $90.00/tonne in southern Alberta and $85/tonne in northern Alberta. The Crow benefit offset payment in 1988 was $13/tonne. The base model, therefore, (section 4.2.1) uses barley price of $77/tonne and $72/tonne in the two Alberta regions.

U.S. costs for corn in 1988 are from (USDA 1990 Nov., 38). Corn #2 yellow, Central Illinois was $3.16 CDN/bu or $124.40/tonne. Feeder costs are from (USDA 1989 Feb., 22). Average price in 1988 for 600-700 lb feeder steers in Kansas City was $618.00CDN. Table 6 indicates these costs with feeder costs per pound and Alberta concentrate cost being approximate.

Table 6.
Intermediate Product Cost

	Alberta	U.S.
Feeders	$.98/lb	$1.03/lb
Concentrates	$75.00/t	124.00/t

Source: Data from references.

3.3.4 Production Process

3.3.4.1 Feed Conversion

The production process for feeders has been simplified relative to the King and Schrader study. Alternate production processes are not allowed, nor is input substitution. The following assumptions were made: Feeder animals in Alberta reach the feedlot at 295 kg (650 lbs) and are sold at 480 kg (1050 lbs). In the U.S. they go on feed at 275 kg (600 lbs) and are slaughtered at 500 kg (1100 lbs). The distinction is due primarily to U.S. feedlot operators feeding animals for a different grading system than Alberta feedlot operators.

In this study, model assumptions dictate that the feeder animal requires 14.5 Mcal per day of Net energy.[25] With an assumed concentrate to roughage ratio of 80/20, 11.6 Mcal per day must come from concentrates and 2.9 Mcal per day will come from the roughages. Multiplying these feed amounts by appropriate length of stay gives feed consumption per animal per feeding period.

According to USDA (1988), U.S. feeders are on feed for 180 days. With gain per period at 500 lbs this is 2.8 lbs gain per day. In Alberta, (Canfax

25 As mentioned in the conclusion (section 5.1), the assumption that U.S. feeders and Alberta feeders have the same energy requirements is not entirely correct. U.S. feeders are fed to a heavier weight and they require more energy per day for that reason. This is an area where further work could improve specification of the production process.

1988) assumes yearling feeders are on feed for 143 days (average stay for heifers and steers). At 400 lbs gain per period this is also 2.8 lbs gain per day.

The fixed production function in general form is:

$$V_{il} = f(W^i, Y^i, Z^i)$$

With the assumptions stated above this works out to be for Alberta regions;

$$480kgV_{il} = 295kgW^i + 1659McalY^i + 415McalZ^i$$

Assuming a dressing percentage from live to carcass to boxed in Alberta of (.585)(.65)[26] = .380, gives;

$$182.4kgV_{il} = 295kgW^i + 1659McalY^i + 415McalZ^i$$

Standardizing this to 1000 lbs of beef we obtain, for Alberta;

$$1000\,lbsV_{il} = 2.49W^i + 4131\,McalY^i + 1033McalZ^i$$

For U.S. regions 3 thru 7, the production function is;

$$500kgV_{il} = 275kgW^i + 2088McalY^i + 522McalZ^i$$

Assuming a dressing percentage from live to carcass to boxed in U.S. regions of (.63)(.755) = .476, we get;

$$238.0kgV_{il} = 275kgW^i + 2088McalY^i + 522McalZ^i$$

Standardizing this to 1000 lbs of beef we obtain, for the U.S.;

$$1000\,lbsV_{il} = 1.91\,W^i + 3988McalY^i + 997\,McalZ^i$$

The main difference between Alberta and U.S. production functions is in the dressing percentages. Animals in Alberta are trimmed leaner than in

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26 The dressing percentages; (.585)(.65) for Alberta and (.63)(.755) for U.S. regions were obtained from, respectivly, Cargill personnel at High River and *Livestock and Poultry Situation and Outlook Report*. Aug 1990, 30-31.

the U.S. to reflect differences in consumer tastes. This results in considerably more feeder required (2.49) in Alberta than in the U.S. (1.91) to produce 1000 lbs of boxed beef.

3.3.4.2 Non-feed and Processing Costs

In this study, non-feed costs and processing costs are calculated on a per unit basis (1000 lbs boxed beef) and entered in the linear programming framework as the objective row value for the fed beef production activity. Non-feed costs in Alberta and U.S. regions are feedlot costs that include similar entries such as: vet and medicine, livestock hauling, marketing charges, death loss and overhead. Processing costs are packing plant slaughter costs only; fabrication costs were not identified and consequently are assumed identical between Alberta and U.S. regions. Processing costs are from a 1984 study (Dawson Dau, 1984) and reflect 1983 data. They can, however, be taken to reflect 1988 processing costs since the ratio between Alberta and U.S. proccssing costs varied little between 1983 and 1988 (Geitz 1991).

NON-FEED COSTS:

For Alberta, non-feed costs are derived from (Canfax 1988) where the average non-feed costs for 1988 for steers and heifers in at 650lbs, out at 1050lbs and on feed for approximately 143 days is $101.55/feeder/period. In Alberta it takes 2.49 feeders to produce 1000lbs of boxed beef. Non-feed costs for Alberta regions, therefore, are $101.55(2.49) = $252.86/1000lbs boxed beef produced.

US non-feed cost data is from (USDA 1989 LPS-35, 56). For animals in at 600lbs, out at 1100lbs, and on feed for 180 days, non-feed costs are given as $10.21/cwt of liveweight sold. Assuming slaughter weight of 1100 lbs leads to $10.21(11) = $112.31(US)/feeder/period. Converting to Canadian currency, $112.31(1.2309) = $138.24/animal/period. In the U.S., 1.91 feeders are required to produce 1000 lbs of boxed beef. U.S. non-feed costs then are taken to be $138.24(1.91) = $264.04(CDN)/1000lbs boxed beef produced.

The longer feeding period in the U.S. leads to higher non-feed costs than in Alberta. This difference has been reduced somewhat by the smaller amount of feeder needed to produce 1000 lbs of boxed beef in the U.S.

PROCESSING COSTS:

Processing costs in Alberta are biased upwards by labor costs that are higher than in the U.S. Costs of labor for processing are documented by Dawson Dau (1984). They claim that the major share of the difference between Alberta and U.S. processing costs is due to wages and salaries. The Dawson Dau study has processing costs for comparable size U.S. and Alberta plants (90 head per hour), and for a larger U.S. plant (300 head per hour). In this study the Alberta processing costs are compared with the similar size U.S. plant. Costs are indicated in Table 7.

Table 7.
Non-Feed/Processing Costs per 1000lbs Boxed Beef

Costs/1000lbs boxed beef	Alberta	U.S.
Non-feed	252.86	264.04
Processing	75.37	52.43
Total	328.23	316.47

Source: Data from references.

3.3.5 Transfer Costs

All transfer costs were derived with the help of Alberta Agriculture staff, the Trimac Trucking Model (TTM), and industry quotes. While such rates cannot be assured accurate they are thought to be representative and to be proportionally correct. Rates assume one way hauls only, no backhauls are included. Description of individual interregional product rates follows.

BEEF:

Rates for beef shipments contain the following assumptions: Trucks carry 45000 lbs of boxed beef except for shipments within Alberta where an industry quote indicated 48000 lbs. The procedure was to take the rate per mile/truck obtained from TTM, multiplied by shipment mileage to get cost of truck load from region i to region j. This amount was divided by 45 or 48 to get cost per 1000lb unit of boxed beef.

FEEDERS:

Feeder rates are again derived from the TTM combined with several industry quotes (Alberta and U.S.) to give rates per mile/truck. This rate is multiplied by shipment mileage and divided by 70[27] (average number of 600-700lb feeders in a possum bellied livestock carrier) to get a rate per unit (1 feeder) of feeder cattle.

CONCENTRATES:

Rates used for concentrate shipments were boxed beef rates less 2-5 cents per mile depending on length of haul. Short hauls take off less per mile than longer hauls. This rate multiplied by mileage gives a total truck cost. Total truck cost is divided by 30 (on average 30,000 Mcal of concentrates on 45000lb load) to get cost per unit (1000Mcal) of shipping concentrate.

ROUGHAGES:

Roughage shipments are assumed to not cross the international border. Therefore we have Alberta rates and U.S. rates. Silage is assumed not hauled out of the region. Industry sources indicated 17 tonnes of roughage could be hauled on a flatbed truck. No industry quotes were available for rates so the TTM was used to estimate rates. The estimating procedure was to take rate per mile per truck multiplied by trip mileage divided by 14.3 (on average 14,300 Mcal of roughage on a 17 tonne load) to get the rate per 1000 Mcal unit of roughage. The U.S. rates are derived from Alberta rates.

27 The number of feeders per truck were obtained from an industry quote (Agriculture Canada 1991).

Distances used in calculating transfer costs are from regional central points. Mileages between central points are shown in the Table 8 in miles. Table's 8a thru 8d indicate transfer costs for boxed beef, feeders, concentrates and roughages.

TABLE 8.
Distance in Miles Between Regional Central Points

	1	2	3	4	5	6	7
1							
2	180						
3	600	435					
4	960	780	515				
5	1005	860	850	790			
6	1275	1100	1100	690	390		
7	1500	1320	935	540	1170	960	
Van	740	600	385				
Tor	2090	2110					
NY				2355	1690	1780	n/a

Source: Mileages are from Alberta Agriculture, Transportation Section.

Table 8a.
Beef Transfer Costs/1000lbs Boxed Beef

	1	2	3	4	5	6	7
1	1.90		22.25	35.11	34.68	44.41	48.08
2	5.86	1.90	17.26	27.84	30.61	37.85	42.73
3	21.89	16.72	1.90				
4	34.60	27.65	17.17	1.90			
5	35.80	31.36	28.33	26.33	1.90		
6	45.69	39.16	29.33	23.00	15.60	1.90	
7	48.90	43.33	31.17	18.00	31.20	32.00	1.90
Van	24.07	19.75	14.11				
Tor	78.38	79.13					
NY				62.67	45.07	47.47	n/a

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.

Table 8b.
Feeder Transfer Costs/Animal

	1	2	3	4	5	6	7
1	0.00		23.83	39.75	39.44	53.18	59.43
2	5.73	0.00	12.22	27.84	36.52	41.61	55.45
3	24.50	20.45	0.00				
4	40.62	28.97	16.19	0.00			
5	41.68	38.11	34.61	32.16	0.00		
6	55.54	44.17	44.79	28.09	12.26	0.00	
7	61.24	56.76	38.27	16.97	47.64	39.09	0.00

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.

Table 8c.
Feed Concentrate Transfer Costs/1000Mcal

	1	2	3	4	5	6	7
1	0.00		32.66	51.29	50.61	64.79	69.29
2	9.26	0.00	25.51	40.73	44.91	55.45	62.30
3	*	*	0.00				
4	*	*	25.41	0.00			
5	*	*	41.65	38.71	0.00		
6	*	*	42.53	34.04	23.14	0.00	
7	*	*	45.82	26.64	45.63	46.72	0.00

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.

* Barley shipments are not permitted to cross the international border to comply with CWB export regulations.

Table 8d.
Feed Roughage Transfer Costs/1000Mcal

	1	2	3	4	5	6	7
1	0.00						
2	24.80	0.00					
3	*	*	0.00				
4	*	*	54.02	0.00			
5	*	*	89.16	82.87	0.00		
6	*	*	115.39	72.38	40.91	0.00	
7	*	*	98.08	56.64	122.73	100.70	0.00

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.
* Roughages are not permitted to cross the international border.

3.3.6 Regional Beef Demand

July 1, 1988 regional population and 1988 annual per capita beef consumption data are used as a proxy for beef demand. For the US, per capita consumption in 1988 was 102.3lbs carcass weight or 77.2lbs of boxed beef.

Total beef demanded per region is per capita consumption multiplied by regional population. Assuming the above per capita consumption of boxed beef for the U.S. and Canada, regional beef demand is indicated in Table 9.

Table 9.
Regional Beef Demand for 1988

Region	Population July1/88	Per capita Consumption (lbs)	Rgn'l Dmnd for Boxed Beef (lbs)
1	1,376,000	77	105,952,000
2	1,019,000	77	78,463,000
3	7,415,000	77	570,955,000
4	1,808,000	77	139,216,000
5	1,859,000	77	143,143,000
6	4,991,000	77	384,307,000
7	29,368,000	77	2,261,336,000
Total	47,836,000		3,683,372,000

Source: Alberta population data are from *Alberta Statistical Review Q1 1990*, and U.S. population data are from *Statistical Abstract of the U.S. 1989*. Per capita consumption data are from *Agriculture Canada: Handbook of Food Expenditures, Prices and Consumption 1990, 282.*

3.3.7 Beef Other Than Fed

Non-fed beef for 1988 includes beef from cull dairy animals, beef cows and heifers, bulls, calves and other cattle as well as imports of beef. For the US regions, sources used were USDA (1989, Cattle) and USDA (1989, Agriculture Statistics Handbook). The process for determination of the non-fed beef supply variable involved subtracting regional fed cattle marketed from total marketings as indicated in USDA (1989, Agriculture Statistics Handbook, Table 399). This number plus calves marketed per region plus imports of meat equals the supply variable. Meat imports for U.S. regions was per capita imported meat consumption multiplied by regional population.[28] Non-fed

28 Per capita imported meat consumption was 9.78lbs (total U.S. beef imports multiplied by U.S. population).

cattle marketed were converted to lbs of boxed beef by multiplying by average U.S. live weight of 1125lbs and then by the dressing percentage of (.63)(.755). For U.S. calves the conversions used were 251lbs and (.56)(.755).[29]

For Alberta regions, total slaughter numbers of cattle and calves are taken from Alberta Agriculture (1989, Agriculture Statistics Yearbook). Fed cattle slaughter of steers and heifers was subtracted from total slaughter numbers to leave a difference of 170,407 animals which was taken as non-fed beef. For Alberta an average live weight of 1150lbs for cattle and 418.8lbs for calves was used. Dressing percentages used for Alberta cattle was (.585)(.65) and for Alberta calves (.52)(.65).

Alberta imported 1,925 tonnes of beef in 1988 (1.77lbs per capita). These amounts of non-fed beef are apportioned among Alberta regions according to shares of regional slaughter. The regional supply of non-fed beef is indicated in Table 10.

Table 10.
Regional Non-Fed Beef Supplies for 1988

Region	Non-fed cattle marketed (#)	Calves marketed (#)	Meat Imports (lbs)	Non-fed beef (lbs)
1	60,068	2,230	2,435,520	29,018,364
2	110,339	4,096	1,803,630	50,633,110
3	309,200	252,000	72,518,700	264,716,498
4	914,600	935,000	17,682,240	606,315,234
5	1,869,200	1,081,000	18,181,020	1,133,120,369
6	539,200	231,000	48,811,980	361,855,637
7	1,006,100	398,000	287,219,040	867,826,313
Total	4,808,707	2,903,326	448,652,130	3,313,485,525

Source: Study results.

29 These live weights are from (USDA 1989, Agriculture Statistics Handbook). The cattle slaughter weight of 1125 lbs is heavier than fed cattle slaughter weight presumably because bulls, dairy animals, etc. are included.

Table 11 shows beef demanded per region and supplied by fed[30] and non-fed sources. The surplus must be shipped outside the regions to enable demand supply equilibrium. This results in the addition of export points in the model, Vancouver, Toronto, and New York. These points are demand centers only, they contribute no supply.

30 Total fed beef produced in Table 11 assumes all feeders are fed and slaughtered in their respective home regions. This is a type of "status quo" fed beef production. If all feeders were shipped to U.S. regions for feeding, total fed beef produced would be 7319008/1.91 = 3,831,941,000 lbs. If all beef was produced in Alberta there would be 7319008/2.49 = 2,939,360,000 lbs.

Table 11.
Equilibrium Beef Market for 1988

Region	Beef demanded ('000 lbs)	Fed beef produced ('000 lbs)	Nonfed beef available ('000 lbs)	surplus/ (deficit) ('000 lbs)
1	105,952	280,123	29,018	203,189
2	78.463	274,812	50,633	246,982
3	570,955	380,220	264,716	73,981
4	139,216	459,697	606,315	926,796
5	143,143	491,404	1,133,120	1,481,381
6	384,307	1,275,441	361,856	1,252,990
7	2,261,336	495,275	867,826	(898,235)
Total	3,683.372	3,656,972	3,313,484	3,287,084

Source: Study results.

4 MODEL VARIATIONS AND RESULTS

4.1 Introduction

Five variations of the model are used to illustrate cattle feeding allocations.[31] Models differ from each other by barley cost, exchange rate used, export destination allowed, and by proportion of fed-beef consumption required per region. Barley cost is $72-$77/tonne in the base model and models 3, 4 and 5. In model 2 (with removal of the Alberta Crow Benefit Offset Payment), barley price is $85-$90/tonne. In both cases the lower price is in region 1 and the higher price is in region 2. The barley cost difference between the base model and model 2 is intended to simulate effects of Crow Benefit rate removal on optimum location of cattle feeding. Crow rate removal would lower grain prices in Alberta and make cattle feeding more cost effective.

In model 5 a distinction is made between fed and non-fed beef. Forcing consumption to be one-half fed beef was attempted since an optimum allocation without this restriction may leave some regions consuming no fed beef and others with no non-fed beef. That would be unrealistic. The restriction was accomplished by two distinct runs of the model. One run was with regional demand halved and intermediate products and the production function removed from the model. The

31 Actual 1988 regional marketings for Alberta are Alberta slaughter cattle marketings plus B.C. and Saskatchewan exports to Alberta of slaughter cattle. The data is from Ab. Ag. Stats. Yearbook, Ab. and B.C. Brand Inspection data and the Sask Cattle Marketing Report. They are apportioned according to a chart in (Alberta Agriculture 1990). Actual marketings for U.S. regions are from (USDA 1989. Cattle, Final Estimates, 37-40).

result was a simple transportation model that gave the optimum allocation of non-fed beef. The second run again halved regional demand but this time it removed availability of non-fed beef.

Beef shipments from Alberta to the U.S. experience resistance at border crossings. USDA inspectors use several methods to slow down shipments. U.S. inspectors discover bone fragments, grease, hair or bruises on the product that Canadian inspectors cannot detect. Determining per unit cost of this harassment is arbitrary but some indicators are available. One rejection at the border requires inspection of the following 15 shipments, and each inspection costs the packer at least $450 (The Edmonton Journal, Saturday, June 9, 1990. D8). Some Alberta beef processors have stopped beef shipments to the U.S. altogether, and one Alberta processor indicated that "we are basically out of business in the U.S." (Alberta Agriculture Trade Policy Secretariat staff). In this study the cost is accounted for by doubling transportation rates on beef shipments from Alberta to the U.S. regions.

The inclusion of "X" in Table's 13 through 17 refers to the two export regions used, Toronto and New York. Regions 1 and 2 can export to Toronto and regions 4, 5 and 6 can export to New York. Region 3 can export a limited amount to Vancouver ("V" in the Tables) as can the two Alberta regions. Region 7 does not export because it is a beef deficit area (see Table 11). Export regions are included since the model requires demand to equal supply and we have excess supply of boxed beef if all or even most feeder cattle are fed and marketed.

Demand at "X" is set high enough to force the model to feed nearly all feeders. Further, demand at "X" assumes all feeders are fed and marketed in the region of their availability. This is an arbitrary setting since, for example, if all U.S. feeders were shipped to Alberta regions where more animals are required to produce a given amount of beef (1.91 in the U.S. and 2.49 in Alberta), it would not be possible to satisfy the demand at "X". In the present case, however, there are enough surplus feeders in the model that this in not a major concern.

The possibility for interregional roughage shipment was allowed for but under no circumstances did roughage move across regional borders. The cost per unit of energy to ship these bulky products apparently precludes long shipments.

4.1.1 Grading Issues

Alberta beef is given a 20 percent price premium over U.S. beef. This was done to simulate a consumer preference for Alberta lean beef over the heavier U.S. product. In the U.S. there is currently a 12 cent per pound price premium (Canadian Meat Council 1990) for Choice beef over Select beef. Select beef is comparable to Alberta lean beef. In Canada this preference is reversed with the price premium going to the leaner Alberta product.

The price premium in Canada for Grade A1, A2 over the heavier A3 is approximately 10 percent (Agriculture Canada 1988). In this study, the 10 percent price premium is used, plus an extra 10 percent to account for intangible factors such as Canadian consumer allegiance to Canadian grading standards with which they are familiar.

No-roll beef, an ungraded U.S. product comparable to U.S. Select, is competing with Alberta lean beef in the eastern Canadian market where grade labelling is not mandatory. This product is popular with wholesalers since it is comparable with the leaner U.S. Select but less expensive. Canadian meat packers, on the other hand, consider the no-roll product to be inferior and of inconsistent quality. If no-roll is inferior, this is added justification for the price premium on Alberta lean beef.

Worldwide the trend is toward leaner meat although at this time it appears to be a niche market. The Japanese are said to prefer a leaner alternative to U.S.D.A. Choice beef (Canadian Meat Council 1990, 23) and results of this study indicate Alberta is in good position to exploit this market.[32] [33] Current consumer trends in the U.S. also indicate a move towards leaner more convenient beef products (Barkema and Drabenstott 1990).

The price premium is made operational by reducing quantities of intermediate product required to produce one unit (1000 lbs) of boxed beef in Alberta. The 20 percent price premium leads to intermediate products being reduced by a factor of: (1/1.20) = .833. This is essentially indicating that a smaller quantity of Alberta beef is equivalent in value to a larger quantity of U.S. beef.

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32 See Model 3 where Alberta regions 1 and 2 ship 736 million pounds of beef to Vancouver for export.

33 A major benefit of the proposed reciprocal grading is that it would allow Alberta packers to compete head to head with U.S. packers for a larger share of the Japanese markets where U.S.D.A. grades are currently recognized by Japanese cattle buyers.

4.2 Results

This section provides results of the various models and sensitivity analysis of relevant variables. At the end of the section is a table (Table 18) that provides a summary of results for the two Alberta regions.

4.2.1 Model 1

Model 1 is the base model. It is intended to duplicate the actual supply and disposition of Alberta beef in 1988. It has barley cost at $72/tonne in region 1 and $77/tonne in region 2.[34] Table 12 indicates differences between actual and Model 1 supply and disposition.

Table 12.
Actual and Model 1 1988 Beef Supply and Disposition

	Actual S & D Mln lbs	Model 1 S & D Mln lbs
Alta Production	798	750
Alta Consumption	220	184
Exports to BC	116	150
Exports to E. Can	416	402
Exports to US	46	14

Source: Alberta Agriculture, Statistics Branch publications and model results.

Looking at Table 13, the number of cattle marketed in this model (ie. 993 thousand in region 1) is related to production of fed beef by the coefficients in

34 Barley price at the feedlot in Alberta in 1988 varied from $64/tonne early in the year to $120/tonne in the winter months with northern Alberta feedlots paying $5/tonne less (Alberta Agriculture Market Analysis staff). An average of $90/tonne was selected for region 2 and the $13/tonne Crow benefit offset payment was applied, resulting in the $72-$77 price range.

the production function. Region 1 produced 479 million pounds of fed beef. At 2.074 feeders/1000 pounds boxed beef this is 993 thousand feeders. Number of cattle marketed in Alberta in model 1 are greater than actual marketings by about 300,000 head. This is due partly to exports of slaughter weight cattle (216,000 in 1988) and partly to differences between coefficients in the actual and model production functions.

Results of the base model indicate more cattle being fed and processed in northern Alberta (Red Deer and north) than in southern Alberta. This is reverse to actual and would be attributable to quantities of resources available there as well as lower transport costs to key export points. For example, per unit shipping costs to Toronto are less from region 1 than from region 2 (see Table 8a). This would skew Alberta production to the north with exports to Toronto originating there.[35]

Non-fed beef production in Table 13 represents predetermined regional supply of dairy culls, imports of manufacturing beef etc. Total regional production is fed plus non-fed beef. Predetermined regional demand is subtracted from total production to arrive at regional surplus/deficits with deficits indicated by brackets.

Model equilibrium is accomplished by shipments of inputs and boxed beef from surplus to deficit regions. These movements are indicated in the lower portion of Table 13.

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35 In reality, economies of size and infrastructure in southern Alberta preclude the Alberta feeding allocation indicated by the base model. In the near future, northern Alberta will not likely feed and process more cattle than southern Alberta.

Region 1 supplies itself and eastern Canada while region 2 supplies itself, ships limited amounts to region 3, and supplies total demand at Vancouver. Region 3 and 7 ship 1,444 thousand feeders to region 4 for feeding. Table 13 also indicates that region 4 ships concentrate to regions 3 and 7 which are deficit in concentrate (see Table 4).

Sensitivity analysis indicates that if barley cost in region 1 dropped by 3 percent barley use would increase by 15 percent. At that point region 1 would begin shipping boxed beef to region 2. In region 2, if barley price dropped by 1 percent, barley use would increase by 75 percent and region 2 would begin exporting boxed beef.

Non-feed/processing costs in the two Alberta regions show sensitivity similar to barley cost with a 1 percent decline in these costs in region 1 leading to a 15 percent increase in region 1 fed beef production. A 1 percent decline in non-feed/processing costs in region 2 results in a 75 percent increase in fed beef production in the region. This result emphasizes the sensitivity of the southern Alberta cattle sector to economies of size. Size increases in the Alberta cattle industry would lower non-feed/processing costs and dramatically (according to this model) improve competitiveness of Alberta's cattle industry.

Table 13.
Model 1 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 1 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	993	479	29	508	106	402
2	660	398	192	51	243	78	165
3	728			265	265	571	(306)
4	825	2,323	1,216	606	1,822	139	1,683
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,093	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	ALL Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	106				
	X	402				
2	2	78	1	291		
	3	14				
	V	150				
3	3	265	4	727		
4	3	292			3	506
	4	136			7	8,106
	7	1,394				
5	5	143				
	X	1,482				
6	6	384				
	X	1,254				
7	7	867	4	717		

Source: Derived from LP model 1 solution.

4.2.2 Model 2

In model 2, barley cost is raised by $13/tonne (amount of 1988 Alberta Crow Benefit Offset Payment) to $85/tonne in region 1 and $90/tonne in region 2. This is done to simulate the effect of Crow Benefit grain rates on Alberta livestock producers. Existence of the Crow Benefit opens potential export markets for prairie grains and increases domestic market price for Board grains by up to $26 per tonne (Alberta Agriculture 1990: Freedom To Choose). This model imitates the 1988 situation if Crow Benefit monies were disbursed via the pay the railways approach and the ACBOP was not made.

Table 14 indicates results. Fed beef production in Alberta decreases to 338 million pounds from 671 million pounds. Southern Alberta (Region 2) experienced the most decline as beef feeding disappears altogether. All southern Alberta feeders are shipped south to U.S. feedlots. Exports to eastern Canada decline to 84 million pounds from 402 million pounds, and exports to region 3 (Washington-Oregon) cease. Alberta maintains the Vancouver market with most beef originating in region 1 (99 million pounds).

This model is also very sensitive to changes in the cost of barley. In region 1 a decrease of 8 percent in barley price would result in a 95 percent increase in barley use as region 1 increases feeding. At that point region 1 would begin importing feeders from region 2. In region 2, a 4 percent decline in non-feed/processing costs would initiate feeding in southern Alberta as fed beef production increased to 99 million pounds.

Table 14
Model 2 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 2 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	701	338	29	367	106	261
2	660	0	0	51	51	78	(27)
3	728			265	265	571	(306)
4	825	2,351	1,231	606	1,837	139	1,698
5	945	1,547	810	1,133	1,943	143	1,800
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,038	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	ALL Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	106				
	2	78				
	V	99				
	X	84				
2	V	51	4	126		
			5	562		
3	3	265	4	727		
4	3	306			3	506
	4	136			7	8,106
	7	1,394				
5	5	143				
	X	1,800				
6	6	384				
	X	1,254				
7	7	867	4	607		

Source: Derived from LP model 2 solution.

4.2.3 Model 3

In model 3 , the fixed demand at Vancouver was increased from 150 million pounds to 1,000 million pounds. This was done to explore Alberta's position had there been a substantial export market to Japan. The results are not surprising given comparative distances between Alberta and major U.S. feeding regions to Vancouver. Alberta dominates the export market to the Pacific Rim as indicated in Table 15. Regions 1 and 2 export 736 million pounds of boxed beef to Vancouver with southern Alberta benefitting the most.

Exports to the Pacific Rim are at the expense of eastern Canada as specification of the Japanese market alters total Alberta production but does not diminish it. Shipments of beef east from Alberta disappear under this scenario. Presumably, the eastern Canadian market would be supplied by eastern and midwest U.S. regions that are closer.

Region 3 supplies the remaining Vancouver demand of 265 million pounds. If a Pacific coast U.S. export point were included, however, results may be different as relative distances from Alberta and U.S. regions to the export point changed. Region 4 in particular would be able to export through Washington or California to the Pacific Rim.

Sensitivity analysis on this model indicates that a 1 percent decrease in non-feed/processing costs in region 2 would increase production by over 20 percent. At that point region 2 begins importing feeders from the U.S.. A 1 percent decrease in barley cost in region 2 has a similar eff[illegible] arley use would increase by over 20 percent with feeders again imp[illegible] m the U.S.

Table 15
Model 3 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 3 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	701	338	29	367	106	261
2	660	689	332	51	383	78	305
3	728			265	265	571	(306)
4	825	2,324	1,217	606	1,823	139	1,684
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						1,000	(1,000)
X						2,287	(2,287)
Total	7,003	7,093	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	FED Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	15				
	V	353				
2	V	383				
3	V	265	4	727		
4	3	292			3	506
	4	136			7	8,106
	7	1,394				
5	1	91				
	2	78				
	5	143				
	X	1,312				
6	3	279				
	6	384				
	X	975				
7	7	867	4	17		

Source: Derived from LP model 3 solution.

4.2.4 Model 4

In this model, a 10 percent depreciation of the Canadian dollar is hypothesized. The depreciation is introduced to the model by increasing all costs of U.S. origin by 10 percent. Alberta cattle feeders would pay more for U.S. intermediate products brought into Alberta but fed beef production in Alberta would be relatively less expensive. Other than depreciation, model 4 is equivalent to the base model.

As Table 16 indicates, depreciation of the Canadian dollar increased Alberta fed beef production to 962 million pounds from 671 million pounds in the base model. Southern Alberta (region 2) fed 1,004 thousand cattle as opposed to 398 thousand cattle fed in southern Alberta in base model 1. Southern Alberta imports an additional 659 thousand feeders from region 3 as it's own feeders move north to region 1.

Apparently, the advantage southern Alberta producers realized due to relatively lower production costs than U.S. regions outweighs the increased cost of importing the feeders. This enables them to import resources and export value added products as region 2 ships 306 million pounds of boxed beef back to region 3.

In this model if non-feed/processing costs in region 2 declined by 1 percent, fed beef production would increase by 30 percent and region 2 would begin shipping beef to eastern Canada. The same outcome would result if barley cost in region 2 fell by 1 percent.

Table 16
Model 4 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 4 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	991	478	29	507	106	401
2	660	1,004	484	51	535	78	457
3	728			265	265	571	(306)
4	825	1,767	925	606	1,531	139	1,392
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,141	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	ALL Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	106				
	X	402				
2	2	78	1	291		
	3	306				
	V	150				
3	3	265	2	659		
4	4	139			3	506
	7	1,394			7	8,106
5	5	143				
	X	1,482				
6	6	384				
	X	1,254				
7	7	867	4	891		

Source: Derived from LP model 4 solution.

4.2.5 Model 5

Model 5 makes a distinction between fed and non-fed beef. This is done to force regional consumption to be one-half fed beef and one-half non-fed beef. Since intraregional shipping is always lower cost than interregional shipping, regional consumption is always met first by internal supplies of beef. In some cases this may be all non-fed beef. Model 5 makes the distinction to ensure each region consumes some fed beef.

Total Alberta fed beef production of 671 million pounds in this model is the same as in the base model. Region 1 consumes 53 million pounds of fed beef and region 2 consumes 39 million pounds of fed beef. Region 2 ships 24 million pounds of non-fed (manufacturing) beef to region 1 and 267 million pounds of fed beef to the Washington-Oregon area (region 3).

Location of fed beef production in this model can be compared to base model location with the only distinction between model specification being quality of beef consumed. The present specification is more realistic than in the base model where quality of meat consumed is not known. Fed beef production is more evenly distributed between Alberta regions in this model than in the base model although total production is the same.

As Table 17 indicates, this model specification also results in location of beef production in Alberta being equivalent to location of beef production when Japan is the primary export market (model 3). That bodes well for the southern Alberta cattle industry as it authenticates Alberta's comparative advantage in producing beef for export to the Pacific Rim. With the Japanese market closed, as it is in this model, fed beef exports resume to eastern Canada with region 1 shipping 236 million pounds.

Sensitivity analysis indicates this allocation is fairly stable for region 2. A 7 percent decrease in non-feed/processing costs would induce only a 3 percent increase in region 2 fed beef production as feeders began to move south from region 1. Fluctuations in barley cost have a similar effect. A 10 percent decrease in barley cost leads to only a 3 percent increase in barley use in region 2.

Table 17
Model 5 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 5 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	701	338	29	367	106	261
2	660	689	332	51	383	78	305
3	728			265	265	571	(306)
4	825	2,326	1,218	606	1,824	139	1,685
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,437	1,276	362	1,638	384	1,254
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,093	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	FED Beef Q	NONFED Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs	Mlnlbs		Ths hd		Mln Mcal
1	1	53	29				
	2	39					
	V	10					
	X	236					
2	1		24				
	2		27				
	3	267					
	V	65					
3	3		190	4	727		
	V		75				
4	2		12			3	506
	3	18	96			7	8,106
	4	70	70				
	7	1,131	263				
	X		166				
5	5	71	72				
	X	420	1,062				
6	6	192	192				
	X	1,084	170				
7	7		867	4	722		

Source: Derived from LP model 5 solution.

4.2.6 Summary of Results

Table 18 summarizes results of Model's 1, 2, 3, 4 and 5 for the two Alberta regions. A description of the fed beef production for the two Alberta regions is given. Also, beef shipments and quantity shipped; and feeder shipments and quantity shipped are given for the two Alberta regions under each model scenario.

Table 18
Summary of Results for Alberta Regions

Model #	Significant Change From Base	Region 1 Fed Beef Prod'n	Region 2 Fed Beef Prod'n	Beef From Region	Beef To Region	Quantity	Feeders From Region	Feeders To Region	Quantity
		Mlnlbs	Mlnlbs			Mlnlbs			Ths hd
1	Base Model	479	192	1 2	1 X 2 3 V	106 402 78 14 150	2	1	291
2	Increased Brly Price	701	0	1 2	1 2 V X V	106 78 99 84 51	2	4 5	126 562
3	Increased X to Japan	338	332	1 2	1 V V	15 353 383			
4	Depreciation of CDN $	478	484	1 2	1 X 2 3 V	106 402 78 306 150	2 3	1 2	291 659
5	Fed/Non-fed Distinction	338	332	1 2	1 2 V X 1 2 3 V	82 39 10 236 24 27 267 65			

Source: Derived from Table's 13, 14, 15, 16 and 17.

5 SUMMARY AND CONCLUSIONS

The Linear Programming approach used in this study stresses the importance of considering raw resources used in the makeup of final product. It indicates that Alberta has an abundance of these intermediate products necessary for a successful cattle industry, and suggests that Alberta is competitive in producing high quality fed beef.

The location of feedlots is determined by a spatial equilibrium model that minimizes cost of concentrates, cost of feeders, non-feed costs, processing costs, and transportation costs of intermediate and final products. Production functions that relate quantities of intermediate products required per unit of final product are specified, as are regional demand functions for boxed beef.

Several basic assumptions of the model can be summarized:[36]

1. The model is static and the results apply to the 1988 calendar year.
2. Feeder cattle are assumed to be of uniform quality and weigh 600 pounds in U.S. regions and 650 pounds in the Alberta regions.
3. Feeds within the concentrate group and within the roughage group are considered perfect substitutes for each other. Supply of these feeds is predetermined and therefore inelastic for the study period.
4. Non-feed costs for the feedlots relate to an average size feedlot (commercial and farmer owned feedlots), and processing costs do not include fabrication to boxed beef.
5. The production function used to relate intermediate inputs to boxed beef output is fixed for Alberta regions and fixed for U.S. regions.
6. Regional supply of non-fed beef is predetermined and assumed indistinguishable from fed beef except for model 5. It is available to satisfy demand in the home region or for shipment to other regions.
7. The demand function used combines per-capita boxed beef consumption and regional population. No prices or per capita incomes are used.
8. Each region is represented by a single point that represents demand and supply.
9. Processing plants are assumed located at feedlots since slaughter animals are not shipped in this study.

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36 These assumptions are derived from (King and Schrader, 1963) since the model used in this study is analogous to their study.

In all the models used in this study, transportation rates on boxed beef moving south from Alberta are doubled and a 20 percent price premium is placed on Alberta beef. These specifications were necessary to calibrate the base model. Non-feed feedlot costs and processing costs used in the model are representative of actual costs.

Results of the base model indicate beef shipments similar to actual 1988 Alberta beef shipments. Actual Alberta beef shipments to the U.S. were 46 million pounds and the base model indicated shipments of 14 million pounds. Actual Alberta beef shipments to eastern Canada were 416 million pounds and the base model indicated 402 million pounds. The proximity of Alberta to the west coast leads the cost minimization model to ship as much beef there as allowed by model specifications. Shipments to B.C. in the model are limited to 150 million pounds. In reality, shipments to the west coast are limited by demand as actual shipments to B.C. were 116 million pounds. When demand at Vancouver is artificially increased (as in model 3) Alberta regions benefit more than U.S. regions. The precondition for Alberta to benefit from increased demand would be (hypothetically), increased Japanese demand for Alberta lean beef.

In model 2, specifications and assumptions are identical to model 1 except concerning barley cost which is raised in accordance with effects of the Crow Benefit on Alberta livestock feeds. As suggested in section 4.2.2, model results are very sensitive to barley cost. Results indicate that when barley cost increases, cattle feeding in southern Alberta is suspended as feeders are shipped south. The loss of feeding is a direct consequence of higher barley costs. According to model 2 results, viability of the southern Alberta cattle sector is contingent upon removal of or alterations to the

Crow Benefit. The Alberta Crow Benefit Offset Program (ACBOP) maintained a feasible cattle feeding industry in southern Alberta in 1988 by reducing barley cost by the amount of the Crow Benefit distortion.

Model 3 introduced a hypothetical scenario in which Japanese demand is for lean high quality beef. Alberta beef meets these requirements and appears able to expand production and exports, given the particular assumptions and specifications of the model (the critical assumption being continuance of the ACBOP on barley). Alberta would export 620 million pounds to Japan (736 Mln to B.C. less 116 Mln Vancouver demand) under this scenario, and southern Alberta has the most to gain.

Model 4 represents an equilibrium scenario with the Canadian dollar worth 10 percent less in 1988 than was actually the case. Other specifications as to costs and regional demand are unchanged from the base model. Results with this assumption indicate a feedlot allocation significantly different from the base model. Total annual production in Alberta is 291 million pounds higher than the 671 million pounds in the base model. The destination of this additional production (U.S. region 3) indicates that Alberta could export to the U.S. with a lower valued Canadian dollar. The pattern of feeding in Alberta is reversed with a lower Canadian dollar. Southern Alberta does the majority of feeding as opposed to the base model where northern Alberta had the lions share. Southern Alberta fed an extra 659 thousand feeders that were imported from the Idaho-Montana area. Apparently the relatively lower production costs and therefore greater margin for Alberta cattle feeders allows movement of these animals.

In model 5, specification of regional demand as including fed and non-fed beef is the only change from base model specifications. This restriction is realistic. It differentiates between high quality fed beef and manufacturing beef from culled dairy animals and old cows or bulls. This consumption constraint leads to location of Alberta fed beef production in this model being the same as location in model 3 (the "Japan scenario"). This appears to strengthen the case for Alberta's comparative advantage in export to the Pacific Rim. It indicates that location of Alberta fed beef production in model 3 was realistic. Further, the location of production in this model appears more logical than production in the base model since it is evenly distributed throughout Alberta.

Total Alberta production of fed beef in model 5 (670 million pounds) is the same as production in the base model but regional allocation of this production is changed. Region 2 markets considerably more cattle in model 5 than in model 1. Total Alberta exports to eastern Canada are down from base model exports east. Southern Alberta exports to the U.S. are considerably higher than actual exports of 46 million pounds, and base model exports of 14 million pounds. Southern Alberta exports 267 million pounds of high quality lean Alberta beef to the Washington-Oregon area (region 3) whe[illegible] inction is made between fed and non-fed beef.

Region 3 and region 7 did not feed cattle in any model specification. This is due in part to these regions having a concentrate deficit (see Table 4) that must be eliminated prior to feeding cattle. A more thorough analysis of feed availability may change this result. California, for example, has considerable feed in the form of silage from irrigated crops that could affect concentrate availability. Southern Alberta also would have similar products that are not included in this analysis.

As noted in section 4.1, modifications were necessary to achieve the base model (ie. price premium and alteration to shipping rates). Firstly, the doubling of transportation rates for Alberta beef exported to the U.S. may seem unnecessarily harsh. However, any adjustments made to these rates would be speculation. Actual cost of shipping final and intermediate products across the border is difficult to model. Criticisms of the TTM arise because, as a model, it does not accurately represent ad-hoc situations such as the inspection problems encountered here. That some adjustment is required to compensate for aggravation to the Alberta cattle sector is well documented, and reports of border inspection delays are continually before us. When the cost of having one truck inspected is identified (section 4.1), a doubling of transportation rates does not appear unreasonable.

Secondly, absence of a reciprocal grading arrangement between Alberta and U.S. makes cross border hauls of boxed beef more complicated. This lack of harmonized grading led to the price premium discussed in section 4.1.1. U.S. no-roll beef, discounted in the U.S., is competing in Canada ungraded, and overfat cattle that would be discounted in Alberta can receive a price premium in U.S.. Depending on relative prices, it sometimes pays producers in both countries to produce these respective products for export. That confounds analysis of optimal allocation based on comparative advantage of factors of production as opposed to technological or regulatory advantages.

With the current grading scenario, Alberta product is perceived as inferior in the U.S. and U.S. Choice beef is generally acknowledged as inferior to A1 in Alberta. As long as grading regulations in the two countries remain unharmonized, penetration of Alberta boxed beef into the U.S. market may be restricted primarily to supplying feeders to the relatively more efficient U.S. feeding and packing industry.

For their part, industry analysts in the U.S. are aware of the need to market leaner beef. Explaining how the cattle industry must cut costs to remain competitive with other meats in the retail market, analysts note that; "The future of the cattle industry depends on whether it can lower it's costs while satisfying the consumer's demand for leaner, more convenient beef products." (Barkema and Drabenstott 1990, 49). Alberta already has the product consumers demand and may be positioned to establish markets before retooling of the U.S. cattle industry is complete.

At this time, the future of Alberta's cattle feeding and processing industry appears to lie in production of a high quality lean product for domestic and export markets that is differentiated from the heavier U.S. product. Alberta lean beef is a superior product appropriate to current consumer trends. If Alberta is to be successful internationally with beef exports, this quality difference must be emphasized. Some price premium is legitimate, the question is how much.

A third reason for difficulty in getting the model to feed in Alberta without adjustments is the size difference in the cattle sectors between Alberta and U.S. regions. In the U.S., three packers (Conagra, IBP, Excel) control the market that supplies 250 million people. The 4 largest companies have 70 percent of U.S. slaughter. In 1988, the 5 U.S. regions in this study had 245 slaughtering plants compared to a handful in Alberta, and 90 percent of U.S. slaughter took place in plants handling greater than 50,000 animals per year (American Meat Institute, 1989). In Canada there are several packers (XL Foods, Burns, Lakeside-Centennial, Cargill Foods, etc.) for 25 million. Economies of size in the U.S. packing sector lead to efficiencies that cannot presently be achieved in Alberta.

A final factor that predisposes cattle feeding away from Alberta relates to isolation. As the model is set up, the two Alberta regions are geographically separated from U.S. regions. This means transportation of final product out of Alberta and of intermediate product into Alberta is more costly than interregional product movement between adjacent U.S. regions. Demand in the U.S. regions dwarfs Alberta demand and this tends to skew cattle feeding and processing toward these areas where transportation costs are lower.

Conclusions drawn from this study pertain more to trends in production and product movement than to specific cattle feeding allocations indicated in the various models. For purposes of this study, policy implications arising from these location trends focus on the Crow Benefit. Of special interest is the sensitivity of study models to barley cost and the reflection of this result on Canadian grain transportation policy. This study concurs with the notion that the Alberta livestock sector would realize positive welfare gains from removal of or alterations to the Crow Benefit.

Second, future welfare of the Alberta cattle sector may depend on expanding Pacific Rim markets. Alberta appears able to take advantage of increased Japanese demand if it can compete with the dominant U.S. sector. Sensitivity of the models to non-feed and processing costs suggests Alberta would benefit from size increases in the livestock sector. Alterations to the Crow Benefit could leave a void in Alberta's agriculture sector as the export grain industry diminished. This would create an opportunity for the livestock sector to expand and capture economies of size presently possible only in the U.S. industry.

Third, north and north-central Alberta appear able to competitively ship beef to eastern Canada as well as to the Pacific Rim countries. Diversification of beef packing in the province may be warranted given the abundance of resources and raw materials available in this region. Again, alterations to the Crow Benefit could possibly hasten the diversification process.

Finally, results of model 4 illustrate the importance of Canada's monetary policy on the Alberta livestock sector. Alberta experienced a simulated 43 percent increase in fed beef production with a lower Canadian dollar. The increased production was made possible by 659 thousand imported U.S. feeders. Virtually all of the increased fed beef production was shipped back to the U.S. market.

For Alberta to source U.S. feeders, competitiveness in feeding and processing cattle in Alberta must improve. Model 4 indicates substantial in shipments of U.S. feeder cattle are a possibility if Canada had a lower valued dollar. More generally, sensitivity analysis indicates competitiveness in fed beef production in Alberta would improve with relatively lower production costs. Lower production costs can be achieved by lower barley costs, size increases in the Alberta cattle sector, or changes in exchange rates. Reduced barley costs and size increases may be possible with alterations to the Crow Benefit.

5.1 Recommendations for Further Study

Further study of Alberta's cattle industry could focus on the impact of economies of size on Alberta's competitiveness. Economies of size are not directly addressed in this study although they do play a major role. Larger U.S. feedlots and processors are able to reduce per unit costs because of their larger size. Structural change presently occuring in the U.S. industry, including vertical integration of the beef subsectors, allows cost savings in procurement and marketing.

In further studies similar to this one, the production function used should be modified to allow input substitution. When input substitution in the production function is allowed, per unit costs will also fall. Input substitution leads to an efficient Least Cost Expansion Path for processors that cannot be obtained with the production function used in this study. The current production function requires expansion along a factor beam. This does not allow cost savings that result from substituting lower cost inputs.

Another adjustment that could be made in further study would be to allow two types of beef in the demand function; a lean product and a heavier marbled product. If two types of beef were allowed, the fed beef production functions could be specified more explicitly. This would overcome a limitation of the present study where it has been assumed that daily energy needs for U.S. cattle are the same as for Alberta cattle. U.S. consumers have a preference for more marbling than Alberta consumers. In Alberta, the premium beef grade is leaner than the U.S. premium beef grade. Separation of demand may lead to more realistic feeding location as beef for the Alberta consumer would efficiently originate in Alberta. Harmonized grading between the two countries should further rationalize feeding location and improve efficiency.

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7 APPENDICES

7.1 Appendix A (Feed Data Methodology)

Concentrate and roughage availability was determined by first gathering regional quantities available (in tonnes), of various feedstuffs. Availability for all livestock is taken as production + imports + beginning year stocks - [ending stock + exports + seed and industrial use]. Regional feed availability for all livestock, feeding rates used and net energy of feeds are given in the Tables below.

Table A1.
Concentrate Availability (fall 1987)
('000 tonnes)

Region	wheat	oats	barley	rye	corn	sorghum	Total
1	414	1178	3548	33	-	-	5173
2	723	182	1959	78	-	-	2942
3	-	134	1185	-	592	-	1911
4	-	108	1433	-	8042	2501	12084
5	-	1633	4286	-	9064	599	15582
6	-	75	617	-	3520	412	4624
7	-	52	486	-	1142	70	1750
Total	1137	3362	13514	111	22360	3582	44066

Note: Based on Tables used by King and Schrader, 1963.

Table A2.
Roughage Availability (fall 1987)
('000 tonnes)

Region	tame hay	processed alfalfa	greenfeed cereal	silage cereal (barley)
1	6042	33	-	-
2	2122	-	22	171
3	5182	-	-	-
4	9690	-	-	-
5	12795	-	-	-
6	5703	-	-	-
7	9421	-	-	-
Total	50955	33	22	171

Table A2.
Roughage Availability "fall 1987" (continued)
('000 tonnes)

Region	silage hay	silage corn	silage sorghum	fodder corn	Total
1	-	-	-	-	6075
2	17	79	-	165	2576
3	-	1560	-	-	6742
4	-	958	109	-	10757
5	-	4391	331	-	17517
6	-	2991	245	-	8939
7	-	4387	76	-	13884
Total	17	14366	761	165	66490

Note: Based on Tables used by King and Schrader, 1963.

Table A3.
Livestock Feeding Rates (average)

Livestock Type	Concentrates (tonne/year)	Roughages (tonne/year)
Cattle and Calves:		
bulls > 500lbs	0.1	1.5
milk cows > 500lbs	2	4.7
dairy heifers > 500lbs	0.6	2.7
beef cows > 500lbs	0.1	1
beef heifers for breeding > 500lbs	0.2	1
backgrounding steers > 500lbs	0.4	1
Hogs:		
breeding stock 6 mos and over	1	-
all other pigs (pig crop)	0.7	-
Sheep:		
one year and older	0.02	.250
Poultry:		
chicken for meat	0.0204	-
turkey	0.0622	-
laying hens/pullets	0.0336	-

Note: laying hens/pullets and pullets of less than laying age have been combined to give concentrate use for "one bird/year".
Note: Feeding rates were obtained from U of A Animal Science professors and Alberta Agriculture staff.
Note: Based on Tables used by King and Schrader, 1963.

Table A4.
NET Energy of Various Feedstuffs
(with the values specific for feeder cattle)

Feedstuff Type	NET Energy/tonne (DM basis)	NET Energy/tonne (Mcal as fed)
CONCENTRATES		
wheat	1700 Mcal	1530
oats	1400 Mcal	1260
barley	1600 Mcal	1440
rye	1600 Mcal	1440
corn	1900 Mcal	1710
sorghum	1600 Mcal	1440
ROUGHAGES		
tame hay	900 Mcal	810
processed alfalfa	900 Mcal	810
greenfeed cereal	900 Mcal	810
silage cereal (barley)	900 Mcal	360
silage hay	900 Mcal	360
silage corn	1000 Mcal	400
fodder corn	1100 Mcal	550
silage sorghum	900 Mcal	360

Note: Based on Tables used by King and Schrader, 1963.

7.2 Appendix B (Feeder Data Methodology)

For the US regions, feeder cattle numbers were estimated using (USDA 1989, Cattle, Final Estimates 1984-88, NASS ASB #798), and (USDA 1989, Agricultural Statistics Yearbook 1989). For the five feeding states; California, Colorado, Idaho, South Dakota and Washington, feeder cattle placements and number on feed data are available. The other six states have data for the number on feed only. The average ratio of placements to number on feed for the feeding states is (2.64). Applying this ratio to the other six states gives estimated placements for each US region. This methodology assumes that for every animal on feed Jan 1/1988, 2.64 animals will be placed on feed during the year Oct1/87 to Sept 30/88. Results are indicated in Appendix Table B1.[37]

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37 Not indicated by Table B1 (but considered in final totals used) is the fact that included in U.S. placement numbers are a category called "other dissappearance". These animals are not marketed in the region and so must be taken off the regional placements used in this study. The assumption is that they are shipped east to Kansas and Nebraska as slaughter animals. This involved 600,000 animals.

Table B1
US Placement Methodology

Region	State	Placements (Q4/87-Q3/88)	# on feed Jan 1/88	Ratio	Estimated Placements
3	Washington	497000	198000	2.51	497000
	Oregon		95000	Avg 2.64	250800
					747800
4	Idaho	608000	195000	3.12	608000
	Montana		110000	Avg 2.64	290000
					898000
5	S.Dakota	695000	300000	2.32	695000
	N. Dakota		45000	Avg 2.64	118800
	Wyoming		100000	Avg 2.64	264000
					1077800
6	Colorado	2450000	940000	2.61	2450000
	Utah		45000	Avg 2.64	118000
					2568000
7	California	1160000	435000	2.66	1160000
	Nevada		28000	Avg 2.64	73920
					1233920
Total		5410000	2491000		6525520

Note: Derived from data collection.

In Alberta, methodology to determine supply of feeder cattle is based on calf numbers July 1/87. Alberta Agriculture Statistics Branch has these numbers broken out by census division in a publication called: **Cattle Numbers #2, December 6, 1988**. Of the total number of calves on July 1/87, (1,280,000), 90% (1,152,000) are assumed spring calves. Of this, one-half (576,000) are assumed steers and one-half are heifers. Of the heifers, 48% (289,000), are for slaughter. This gives a total of 856,000 animals on July 1/87 targeted for eventual slaughter. Of these 856,000, 30% (257,000), are assumed overwintered and 70% (599,000), go straight to finishing pens to finish in spring of 88 while the 30% are pastured in spring of 88 and finished in fall 88. Of the calf inventory, 60% were located in region 1 and

40% were located in region 2.

Imports of feeders to Alberta would not be included in this methodology so must be calculated separately. In 1988, Alberta imported 533,000 cattle (Alberta Agriculture, 1988 Alberta's Agricultural Exports) that are assumed feeders (Adam 1991). They were apportioned among the four regions according to shares of regional slaughter data found in (Alberta Agriculture, 1990. The Location of Cattle Production in Alberta). For 1988, region 1 had 35.2% of slaughter volume, and region 2 had 64.8%. These amounts were added to domestic feeders to get Alberta placements as in Appendix Table B2.

Table B2.
Alberta Placement Methodology

Region	Imports	Calf #s July 1/87	Placements
1	(.352)533000	(.60)856000	701615
2	(.648)533000	(.40)856000	688384
Total			1389862

Source: Derived from data collection.

7.3 Appendix C (MTS Base Model Results)

The first section of this appendix contains an abbreviated copy of the MTS print-out results for the base model. The base model was an attempt to recreate actual 1988 supply and disposition of Alberta beef. The second section of this appendix contains an abbreviated copy of the MTS printout results for Model 2. The only distinction between model 2 and the base model is the increase in barley price.

Base Model MTS Results

```
$RUN -MPSCC SPRSBT+-IRIPT
      PROGRAM
      INITIAL2
      MOVE(XDATA,'RECDAT')
      MOVE(XPBNAME,'MODELB')
      MOVE(XOBJ,'MAXIMIZE')
      MOVE(XRHS,'RHS1')
      CONVERT('SUMMARY')
      XCBOUT
      SETUP('MAX')
      TRANCOL
      PRIMAL
      SOLUTION
      RANGE
      EXIT
      PEND
$ENDFILE
NAME          RECDAT
ROWS
N   MAXIMIZE
E   NFBFAVA1
E   NFBFAVA2
E   NFBFAVA3
E   NFBFAVA4
E   NFBFAVA5
E   NFBFAVA6
E   NFBFAVA7
L   FOCTAVA1
L   FOCTBAL1
L   FOCTAVA2
L   FOCTBAL2
L   FOCTAVA3
L   FOCTBAL3
L   FOCTAVA4
L   FOCTBAL4
L   FOCTAVA5
L   FOCTBAL5
L   FOCTAVA6
L   FOCTBAL6
L   FOCTAVA7
L   FOCTBAL7
L   CONCAVA1
L   CONCBAL1
L   CONCAVA2
L   CONCBAL2
L   CONCAVA3
L   CONCAVA4
L   CONCBAL4
L   CONCAVA5
L   CONCBAL5
L   CONCAVA6
L   CONCBAL6
L   CONCAVA7
L   RUFFAVA1
L   RUFFAVA2
L   RUFFAVA3
L   RUFFAVA4
L   RUFFAVA5
L   RUFFAVA6
L   RUFFAVA7
```

C1

```
L   RSILAVA3
L   RSILAVA4
L   RSILAVA5
L   RSILAVA6
L   RSILAVA7
E   TLBFROD1
E   TLBFROD2
E   TLBFROD3
E   TLBFROD4
E   TLBFROD5
E   TLBFROD6
E   TLBFROD7
E   TLBFRODV
E   TLBFRODX
COLUMNS
    X11       MAXIMIZE   -1.9         NFBFAVA1   1.0
    X11       TLBFROD1   1.0
    X12       MAXIMIZE   -6.46        NFBFAVA1   1.0
    X12       TLBFROD2   1.0
    X13       MAXIMIZE   -43.76       NFBFAVA1   1.0
    X13       TLBFROD3   1.0
    X14       MAXIMIZE   -62.20       NFBFAVA1   1.0
    X14       TLBFROD4   1.0
    X15       MAXIMIZE   -71.60       NFBFAVA1   1.0
    X15       TLBFROD5   1.0
    X16       MAXIMIZE   -91.36       NFBFAVA1   1.0
    X16       TLBFROD6   1.0
    X17       MAXIMIZE   -97.60       NFBFAVA1   1.0
    X17       TLBFROD7   1.0
    X1V       MAXIMIZE   -24.07       NFBFAVA1   1.0
    X1V       TLBFRODV   1.0
    X1X       MAXIMIZE   -76.38       NFBFAVA1   1.0
    X1X       TLBFRODX   1.0
    X21       MAXIMIZE   -6.86        NFBFAVA2   1.0
    X21       TLBFROD1   1.0
    X22       MAXIMIZE   -1.90        NFBFAVA2   1.0
    X22       TLBFROD2   1.0
    X23       MAXIMIZE   -33.44       NFBFAVA2   1.0
    X23       TLBFROD3   1.0
    X24       MAXIMIZE   -65.30       NFBFAVA2   1.0
    X24       TLBFROD4   1.0
    X25       MAXIMIZE   -62.72       NFBFAVA2   1.0
    X25       TLBFROD5   1.0
    X26       MAXIMIZE   -74.32       NFBFAVA2   1.0
    X26       TLBFROD6   1.0
    X27       MAXIMIZE   -66.66       NFBFAVA2   1.0
    X27       TLBFROD7   1.0
    X2V       MAXIMIZE   -19.75       NFBFAVA2   1.0
    X2V       TLBFRODV   1.0
    X2X       MAXIMIZE   -79.13       NFBFAVA2   1.0
    X2X       TLBFRODX   1.0
    X31       MAXIMIZE   -22.26       NFBFAVA3   1.0
    X31       TLBFROD1   1.0
    X32       MAXIMIZE   -17.26       NFBFAVA3   1.0
    X32       TLBFROD2   1.0
    X33       MAXIMIZE   -1.00        NFBFAVA3   1.0
    X33       TLBFROD3   1.0
    X34       MAXIMIZE   -17.17       NFBFAVA3   1.0
    X34       TLBFROD4   1.0
    X35       MAXIMIZE   -24.33       NFBFAVA3   1.0
```

X35	TLBFROD5	1.0		
X36	MAXIMIZE	-28.33	MFBFAVA3	1.0
X36	TLBFROD6	1.0		
X37	MAXIMIZE	-31.17	MFBFAVA3	1.0
X37	TLBFROD7	1.0		
X38	MAXIMIZE	-18.11	MFBFAVA3	1.0
X38	TLBFROD8	1.0		
X41	MAXIMIZE	-35.11	MFBFAVA4	1.0
X41	TLBFROD1	1.0		
X42	MAXIMIZE	-27.84	MFBFAVA4	1.0
X42	TLBFROD2	1.0		
X43	MAXIMIZE	-17.17	MFBFAVA4	1.0
X43	TLBFROD3	1.0		
X44	MAXIMIZE	-1.80	MFBFAVA4	1.0
X44	TLBFROD4	1.0		
X45	MAXIMIZE	-28.33	MFBFAVA4	1.0
X45	TLBFROD5	1.0		
X46	MAXIMIZE	-23.00	MFBFAVA4	1.0
X46	TLBFROD6	1.0		
X47	MAXIMIZE	-18.00	MFBFAVA4	1.0
X47	TLBFROD7	1.0		
X48	MAXIMIZE	-62.67	MFBFAVA4	1.0
X48	TLBFROD8	1.0		
X51	MAXIMIZE	-34.88	MFBFAVA5	1.0
X51	TLBFROD1	1.0		
X52	MAXIMIZE	-30.61	MFBFAVA5	1.0
X52	TLBFROD2	1.0		
X53	MAXIMIZE	-28.33	MFBFAVA5	1.0
X53	TLBFROD3	1.0		
X54	MAXIMIZE	-26.33	MFBFAVA5	1.0
X54	TLBFROD4	1.0		
X55	MAXIMIZE	-1.80	MFBFAVA5	1.0
X55	TLBFROD5	1.0		
X56	MAXIMIZE	-15.60	MFBFAVA5	1.0
X56	TLBFROD6	1.0		
X57	MAXIMIZE	-31.20	MFBFAVA5	1.0
X57	TLBFROD7	1.0		
X58	MAXIMIZE	-45.07	MFBFAVA5	1.0
X58	TLBFROD8	1.0		
X61	MAXIMIZE	-44.41	MFBFAVA6	1.0
X61	TLBFROD1	1.0		
X62	MAXIMIZE	-37.45	MFBFAVA6	1.0
X62	TLBFROD2	1.0		
X63	MAXIMIZE	-29.33	MFBFAVA6	1.0
X63	TLBFROD3	1.0		
X64	MAXIMIZE	-23.00	MFBFAVA6	1.0
X64	TLBFROD4	1.0		
X65	MAXIMIZE	-15.60	MFBFAVA6	1.0
X65	TLBFROD5	1.0		
X66	MAXIMIZE	-1.80	MFBFAVA6	1.0
X66	TLBFROD6	1.0		
X67	MAXIMIZE	-32.00	MFBFAVA6	1.0
X67	TLBFROD7	1.0		
X68	MAXIMIZE	-47.47	MFBFAVA6	1.0
X68	TLBFROD8	1.0		
X71	MAXIMIZE	-48.06	MFBFAVA7	1.0
X71	TLBFROD1	1.0		
X72	MAXIMIZE	-42.73	MFBFAVA7	1.0
X72	TLBFROD2	1.0		
X73	MAXIMIZE	-31.17	MFBFAVA7	1.0

C2

X73	TLBFROD3	1.0		
X74	MAXIMIZE	-16.00	MFBFAVA7	1.0
X74	TLBFROD4	1.0		
X75	MAXIMIZE	-31.20	MFBFAVA7	1.0
X75	TLBFROD5	1.0		
X76	MAXIMIZE	-32.00	MFBFAVA7	1.0
X76	TLBFROD6	1.0		
X77	MAXIMIZE	-1.80	MFBFAVA7	1.0
X77	TLBFROD7	1.0		
FC1	MAXIMIZE	-627.00	FOCTAVA1	-1.0
FC1	FOCTBAL1	1.0		
FC2	MAXIMIZE	-627.00	FOCTAVA2	-1.0
FC2	FOCTBAL2	1.0		
FC3	MAXIMIZE	-617.94	FOCTAVA3	-1.0
FC3	FOCTBAL3	1.0		
FC4	MAXIMIZE	-617.94	FOCTAVA4	-1.0
FC4	FOCTBAL4	1.0		
FC5	MAXIMIZE	-617.94	FOCTAVA5	-1.0
FC5	FOCTBAL5	1.0		
FC6	MAXIMIZE	-617.94	FOCTAVA6	-1.0
FC6	FOCTBAL6	1.0		
FC7	MAXIMIZE	-617.94	FOCTAVA7	-1.0
FC7	FOCTBAL7	1.0		
CC1	MAXIMIZE	-72.00	CONCAVA1	-1.45
CC1	CONCBAL1	1.0		
CC2	MAXIMIZE	-77.00	CONCAVA2	-1.45
CC2	CONCBAL2	1.0		
CC4	MAXIMIZE	-124.40	CONCAVA4	-1.55
CC4	CONCBAL4	1.0		
CC5	MAXIMIZE	-124.40	CONCAVA5	-1.55
CC5	CONCBAL5	1.0		
CC6	MAXIMIZE	-124.40	CONCAVA6	-1.55
CC6	CONCBAL6	1.0		
V11	MAXIMIZE	-273.53	MFBFAVA1	-1.0
V11	FOCTAVA1	2.074	CONCAVA1	3.438
V11	RUFFAVA1	.661		
V21	MAXIMIZE	-273.53	MFBFAVA2	-1.0
V21	FOCTAVA2	2.074	CONCAVA2	3.438
V21	RUFFAVA2	.661		
V31	MAXIMIZE	-316.47	MFBFAVA3	-1.0
V31	FOCTAVA3	1.81	CONCAVA3	3.946
V31	RUFFAVA3	.897		
V41	MAXIMIZE	-316.47	MFBFAVA4	-1.0
V41	FOCTAVA4	1.81	CONCAVA4	3.946
V41	RUFFAVA4	.897		
V51	MAXIMIZE	-316.47	MFBFAVA5	-1.0
V51	FOCTAVA5	1.810	CONCAVA5	3.946
V51	RUFFAVA5	.897		
V61	MAXIMIZE	-317.47	MFBFAVA6	-1.0
V61	FOCTAVA6	1.810	CONCAVA6	3.946
V61	RUFFAVA6	.897		
V71	MAXIMIZE	-316.47	MFBFAVA7	-1.0
V71	FOCTAVA7	1.810	CONCAVA7	3.946
V71	RUFFAVA7	.897		
W12	MAXIMIZE	-5.73	FOCTAVA1	1.0
W12	FOCTAVA2	-1.0		
W13	MAXIMIZE	-24.50	FOCTAVA1	1.0
W13	FOCTAVA3	-1.08		
W14	MAXIMIZE	-40.62	FOCTAVA1	1.0
W14	FOCTAVA4	-1.08		

```
W15   MAXIMIZE   -41.66    FOCTAVA1   1.0
W15   FOCTAVA5   -1.08
W16   MAXIMIZE   -55.64    FOCTAVA1   1.0
W16   FOCTAVA6   -1.08
W17   MAXIMIZE   -61.24    FOCTAVA1   1.0
W17   FOCTAVA7   -1.08
W21   MAXIMIZE   -5.73     FOCTAVA1   -1.0
W21   FOCTAVA2   1.0
W23   MAXIMIZE   -30.45    FOCTAVA2   1.0
W23   FOCTAVA3   -1.08
W24   MAXIMIZE   -36.97    FOCTAVA2   1.0
W24   FOCTAVA4   -1.08
W25   MAXIMIZE   -38.11    FOCTAVA2   1.0
W25   FOCTAVA5   -1.08
W26   MAXIMIZE   -44.17    FOCTAVA2   1.0
W26   FOCTAVA6   -1.08
W27   MAXIMIZE   -56.70    FOCTAVA2   1.0
W27   FOCTAVA7   -1.08
W31   MAXIMIZE   -23.83    FOCTAVA1   -.92
W31   FOCTAVA3   1.0
W32   MAXIMIZE   -12.22    FOCTAVA2   -.92
W32   FOCTAVA3   1.0
W34   MAXIMIZE   -15.19    FOCTAVA3   1.0
W34   FOCTAVA4   -1.0
W35   MAXIMIZE   -34.61    FOCTAVA3   1.0
W35   FOCTAVA5   -1.0
W36   MAXIMIZE   -44.75    FOCTAVA3   1.0
W36   FOCTAVA6   -1.0
W37   MAXIMIZE   -36.27    FOCTAVA3   1.0
W37   FOCTAVA7   -1.0
W41   MAXIMIZE   -38.75    FOCTAVA1   -.92
W41   FOCTAVA4   1.0
W42   MAXIMIZE   -27.84    FOCTAVA2   -.92
W42   FOCTAVA4   1.0
W43   MAXIMIZE   -16.19    FOCTAVA3   -1.0
W43   FOCTAVA4   1.0
W45   MAXIMIZE   -32.16    FOCTAVA4   1.0
W45   FOCTAVA5   -1.0
W46   MAXIMIZE   -28.09    FOCTAVA4   1.0
W46   FOCTAVA6   -1.0
W47   MAXIMIZE   -16.97    FOCTAVA4   1.0
W47   FOCTAVA7   -1.0
W51   MAXIMIZE   -39.44    FOCTAVA1   -.92
W51   FOCTAVA5   1.0
W52   MAXIMIZE   -36.92    FOCTAVA2   -.92
W52   FOCTAVA5   1.0
W53   MAXIMIZE   -36.61    FOCTAVA3   -1.0
W53   FOCTAVA5   1.0
W54   MAXIMIZE   -32.16    FOCTAVA4   -1.0
W54   FOCTAVA5   1.0
W56   MAXIMIZE   -12.26    FOCTAVA5   1.0
W56   FOCTAVA6   -1.0
W57   MAXIMIZE   -47.64    FOCTAVA5   1.0
W57   FOCTAVA7   -1.0
W61   MAXIMIZE   -53.18    FOCTAVA1   -.92
W61   FOCTAVA6   1.0
W62   MAXIMIZE   -41.61    FOCTAVA2   -.92
W62   FOCTAVA6   1.0
W63   MAXIMIZE   -44.79    FOCTAVA3   -1.0
W63   FOCTAVA6   1.0
```

C3

```
W64   MAXIMIZE   -23.08    FOCTAVA4   -1.0
W64   FOCTAVA6   1.0
W65   MAXIMIZE   -12.28    FOCTAVA5   -1.0
W65   FOCTAVA6   1.0
W67   MAXIMIZE   -38.09    FOCTAVA6   1.0
W67   FOCTAVA7   -1.0
W71   MAXIMIZE   -58.43    FOCTAVA1   -.82
W71   FOCTAVA7   1.0
W72   MAXIMIZE   -55.45    FOCTAVA2   -.82
W72   FOCTAVA7   1.0
W73   MAXIMIZE   -38.27    FOCTAVA3   -1.0
W73   FOCTAVA7   1.0
W74   MAXIMIZE   -16.97    FOCTAVA4   -1.0
W74   FOCTAVA7   1.0
W75   MAXIMIZE   -47.64    FOCTAVA5   -1.0
W75   FOCTAVA7   1.0
W76   MAXIMIZE   -29.05    FOCTAVA6   -1.0
W76   FOCTAVA7   1.0
Y12   MAXIMIZE   -8.26     CONCAVA1   1.0
Y12   CONCAVA2   -1.0
Y21   MAXIMIZE   -8.25     CONCAVA1   -1.0
Y21   CONCAVA2   1.0
Y41   MAXIMIZE   -61.29    CONCAVA1   -1.0
Y41   CONCAVA4   1.0
Y42   MAXIMIZE   -40.73    CONCAVA2   -1.0
Y42   CONCAVA4   1.0
Y43   MAXIMIZE   -25.41    CONCAVA3   -1.0
Y43   CONCAVA4   1.0
Y45   MAXIMIZE   -35.71    CONCAVA4   1.0
Y45   CONCAVA5   -1.0
Y46   MAXIMIZE   -24.04    CONCAVA4   1.0
Y46   CONCAVA6   -1.0
Y47   MAXIMIZE   -26.64    CONCAVA4   1.0
Y47   CONCAVA7   -1.0
Y51   MAXIMIZE   -50.61    CONCAVA1   -1.0
Y51   CONCAVA5   1.0
Y52   MAXIMIZE   -44.91    CONCAVA2   -1.0
Y52   CONCAVA5   1.0
Y53   MAXIMIZE   -41.65    CONCAVA3   -1.0
Y53   CONCAVA5   1.0
Y54   MAXIMIZE   -38.71    CONCAVA4   -1.0
Y54   CONCAVA5   1.0
Y56   MAXIMIZE   -23.14    CONCAVA5   1.0
Y56   CONCAVA6   -1.0
Y57   MAXIMIZE   -45.63    CONCAVA5   1.0
Y57   CONCAVA7   -1.0
Y61   MAXIMIZE   -64.78    CONCAVA1   -1.0
Y61   CONCAVA6   1.0
Y62   MAXIMIZE   -65.45    CONCAVA2   -1.0
Y62   CONCAVA6   1.0
Y63   MAXIMIZE   -42.53    CONCAVA3   -1.0
Y63   CONCAVA6   1.0
Y64   MAXIMIZE   -34.04    CONCAVA4   -1.0
Y64   CONCAVA6   1.0
Y65   MAXIMIZE   -23.14    CONCAVA5   -1.0
Y65   CONCAVA6   1.0
Y67   MAXIMIZE   -46.72    CONCAVA6   1.0
Y67   CONCAVA7   -1.0
Z12   MAXIMIZE   -24.80    RUFFAVA1   1.0
Z12   RUFFAVA2   -1.0
```

```
231     MAXIMIZE   -36.88       RUFFAVA1   -1.0
231     RUFFAVA7   1.0
234     MAXIMIZE   -54.02       RUFFAVA2   1.0
234     RUFFAVA4   -1.0
235     MAXIMIZE   -69.16       RUFFAVA2   1.0
235     RUFFAVA5   -1.0
236     MAXIMIZE   -115.35      RUFFAVA2   1.0
236     RUFFAVA6   -1.0
237     MA...      -96.08       RUFFAVA2   1.0
237     RUFFAVA7   -1.0
243     MAXIMIZE   -54.02       RUFFAVA3   -1.0
243     RUFFAVA4   1.0
245     MAXIMIZE   -63.87       RUFFAVA4   1.0
245     RUFFAVA5   -1.0
246     MAXIMIZE   -72.36       RUFFAVA4   1.0
246     RUFFAVA6   -1.0
247     MAXIMIZE   -66.84       RUFFAVA4   1.0
247     RUFFAVA7   -1.0
253     MAXIMIZE   -69.16       RUFFAVA3   -1.0
253     RUFFAVA5   1.0
254     MAXIMIZE   -63.87       RUFFAVA4   -1.0
254     RUFFAVA5   1.0
256     MAXIMIZE   -40.91       RUFFAVA5   1.0
256     RUFFAVA6   -1.0
257     MAXIMIZE   -122.73      RUFFAVA5   1.0
257     RUFFAVA7   -1.0
263     MAXIMIZE   -115.30      RUFFAVA3   -1.0
263     RUFFAVA6   1.0
264     MAXIMIZE   -72.30       RUFFAVA4   -1.0
264     RUFFAVA6   1.0
265     MAXIMIZE   -40.91       RUFFAVA5   -1.0
265     RUFFAVA6   1.0
267     MAXIMIZE   -100.76      RUFFAVA6   1.0
267     RUFFAVA7   -1.0
273     MAXIMIZE   -96.06       RUFFAVA3   -1.0
273     RUFFAVA7   1.0
274     MAXIMIZE   -66.64       RUFFAVA4   -1.0
274     RUFFAVA7   1.0
275     MAXIMIZE   -122.73      RUFFAVA5   -1.0
275     RUFFAVA7   1.0
276     MAXIMIZE   -100.70      RUFFAVA6   -1.0
276     RUFFAVA7   1.0
533     MAXIMIZE   -33.33       RUFFAVA3   -1.0
533     RSILAVA3   1.0
544     MAXIMIZE   -33.33       RUFFAVA4   -1.0
544     RSILAVA4   1.0
555     MAXIMIZE   -33.33       RUFFAVA5   -1.0
555     RSILAVA5   1.0
566     MAXIMIZE   -33.33       RUFFAVA6   -1.0
566     RSILAVA6   1.0
577     MAXIMIZE   -33.33       RUFFAVA7   -1.0
577     RSILAVA7   1.0
RHS
    RHS1    HFBFAVA1   29916.0      HFBFAVA2   50533.0
    RHS1    HFBFAVA3   264716.0     HFBFAVA4   605315.0
    RHS1    HFBFAVA5   1133120.0    HFBFAVA6   351456.0
    RHS1    HFBFAVA7   867426.0     FOCTAVA1   0.0
    RHS1    FOCTBAL1   701616.0     FOCTAVA2   0.0
    RHS1    FOCTBAL2   668384.0     FOCTAVA3   0.0
    RHS1    FOCTBAL3   726774.0     FOCTAVA4   0.0
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C4

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    RHS1    FOCTBAL4   578600.0     FOCTAVA5   0.0
    RHS1    FOCTBAL5   630208.0     FOCTAVA6   0.0
    RHS1    FOCTBAL6   2437741.0    FOCTAVA7   0.0
    RHS1    FOCTBAL7   846661.0     CONCAVA1   0.0
    RHS1    CONCBAL1   6173000.0    CONCAVA2   0.0
    RHS1    CONCBAL2   2042000.0
    RHS1    CONCAVA3   -605861.0    CONCAVA4   0.0
    RHS1    CONCBAL4   12084000.0   CONCAVA5   0.0
    RHS1    CONCBAL5   15562000.0   CONCAVA6   0.0
    RHS1    CONCBAL6   4628000.0
    RHS1    CONCAVA7   -8105577.0   RUFFAVA1   3843130.0
    RHS1    RUFFAVA2   1362127.0    RUFFAVA3   2058440.0
    RHS1    RUFFAVA4   2232567.0    RUFFAVA5   5715000.0
    RHS1    RUFFAVA6   2018766.0    RUFFAVA7   3734881.0
    RHS1    RSILAVA3   424140.0     RSILAVA4   308710.0
    RHS1    RSILAVA5   1210688.0    RSILAVA6   1048304.0
    RHS1    RSILAVA7   768839.4     TLBFROD1   105952.0
    RHS1    TLBFROD2   78483.5      TLBFROD3   570955.0
    RHS1    TLBFROD4   126716.0     TLBFROD5   142143.0
    RHS1    TLBFROD6   384307.0     TLBFROD7   2261336.0
    RHS1    TLBFROD9   160000.0     TLBFROD8   3137084.0
ENDATA
$ENDFILE
```

EXECUTOR. MPS/360 V2-M10 PAGE

TRANCOL --- TIME ON ENTRY = 0.00

58 ROWS SELECTED

C5

EXECUTOR. MPS/360 V2-M10 PAGE 15 - 81/143

	X11	X12	X13	X14	X15	X16	X17	X1V	1....1
MAXIMIZE	1.90000-	5.86000-	43.76000-	69.20000-	71.60000-	91.36000-	87.60000-	36.07000-	MAXIMIZE
MFSFAVA1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	MFSFAVA1
TLSFR001	1.00000	.	.	.			.	.	TLSFR001
TLSFR002	.	1.00000	.	.	.	.	.		TLSFR002
TLSFR003	.	.	1.00000				.	.	TLSFR003
TLSFR004	.	.	.	1.00000	.	.	.	.	TLSFR004
TLSFR005	.	.	.	.	1.00000		.	.	TLSFR005
TLSFR006	.	.	.	.		1.00000		.	TLSFR006
TLSFR007	.	.	.	.	.	.	1.00000	.	TLSFR007
TLSFR00V	.	.	.	.	.	.	.	1.00000	TLSFR00V

	X20	X21	X22	X23	X24	X25	X26	X27	2 1
MAXIMIZE	78.36000-	5.66000-	1.00000-	33.44000-	55.30000-	62.72000-	78.33000-	86.66000-	MAXIMIZE
NFBFAVA1	1.00000								NFBFAVA1
NFBFAVA2		1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	NFBFAVA2
TLBFROD1		1.00000							TLBFROD1
TLBFROD2			1.00000						TLBFROD2
TLBFROD3				1.00000					TLBFROD3
TLBFROD4					1.00000				TLBFROD4
TLBFROD5						1.00000			TLBFROD5
TLBFROD6							1.00000		TLBFROD6
TLBFROD7								1.00000	TLBFROD7
TLBFROD8	1.00000								TLBFROD8

C6

EXECUTOR. MPS/360 V2-M10 PAGE 13 - 81/143

	X29	X30	X31	X32	X33	X34	X35	X36	3....1
MAXIMIZE	72.75060-	78.12000-	32.25000-	17.26000-	1.80000-	17.17000-	26.33000-	28.33000-	MAXIMIZE
NFBFAVA2	1.00000	1.00000							NFBFAVA2
NFBFAVA3			1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	NFBFAVA3
TLBFROD1			1.00000						TLBFROD1
TLBFROD2				1.00000					TLBFROD2
TLBFROD3					1.00000				TLBFROD3
TLBFROD4						1.00000			TLBFROD4
TLBFROD5							1.00000		TLBFROD5
TLBFROD6								1.00000	TLBFROD6
TLBFROD7	1.00000								TLBFROD7
TLBFROD8		1.00000							TLBFROD8

110

EXECUTOR. MPS/360 V2-M16 PAGE [illegible]

	X37	X39	X41	X42	X43	X44	X45	X46	
MAXIMIZE	31.17000-	14.11000-	26.11000-	27.[illegible]000-	17.17000-	1.[illegible]-	26.33000-	33.[illegible]-	MAXIMIZE
NFSFAVA3	1.00000	1.00000							NFSFAVA3
NFSFAVA4			1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	NFSFAVA4
TLBFROD1			1.00000						TLBFROD1
TLBFROD2				1.00000					TLBFROD2
TLBFROD3					1.00000				TLBFROD3
TLBFROD4						1.00000			TLBFROD4
TLBFROD5							1.00000		TLBFROD5
TLBFROD6								1.00000	TLBFROD6
TLBFROD7	1.00000								TLBFROD7
TLBFROD8		1.00000							TLBFROD8

C7

EXECUTOR. MPS/360 V2-M16 PAGE 18 - 81/143

	X47	X48	X51	X52	X53	X54	X55	X56	[illegible]
MAXIMIZE	15.00000-	62.67000-	34.88000-	30.61000-	28.33000-	20.33000-	1.60000-	15.60000-	MAXIMIZE
NFSFAVA4	1.00000	1.00000							NFSFAVA4
NFSFAVA5	.	.	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	NFSFAVA5
TLBFROD1	.	.	1.00000		.				TLBFROD1
TLBFROD2		.	.	1.00000	.				TLBFROD2
TLBFROD3	.	.	.		1.00000				TLBFROD3
TLBFROD4	.	.	.		.	1.00000			TLBFROD4
TLBFROD5	.	.	.		.		1.00000		TLBFROD5
TLBFROD6	.	.	.	.	.			1.00000	TLBFROD6
TLBFROD7	1.00000	.	.	.	.				TLBFROD7
TLBFROD8	.	1.00000	.		.	.			TLBFROD8

EXECUTOR. MPS/360 V2-M16 PAGE [illegible]

	X57	X58	X61	X62	X63	X64	X65	X66	6....1
MAXIMIZE	31.20000-	45.67000-	44.41000-	37.85000-	29.33000-	23.00000-	15.60000-	1.00000-	MAXIMIZE
HFBFAVA6	1.00000	1.00000							HFBFAVA6
HFBFAVA7			1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	HFBFAVA7
TLBFROD1			1.00000						TLBFROD1
TLBFROD2				1.00000					TLBFROD2
TLBFROD3					1.00000				TLBFROD3
TLBFROD4						1.00000			TLBFROD4
TLBFROD5							1.00000		TLBFROD5
TLBFROD6								1.00000	TLBFROD6
TLBFROD7	1.00000								TLBFROD7
TLBFROD8		1.00000							TLBFROD8

C8

EXECUTOR. MPS/360 V2-M16 PAGE 21 - 81/143

	X67	X68	X71	X72	X73	X74	X75	X76	7....1
MAXIMIZE	32.00000-	47.47000-	48.05000-	42.73000-	31.17000-	18.00000-	31.20000-	32.00000-	MAXIMIZE
HFBFAVA6	1.00000	1.00000							HFBFAVA6
HFBFAVA7			1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	HFBFAVA7
TLBFROD1			1.00000						TLBFROD1
TLBFROD2				1.00000					TLBFROD2
TLBFROD3					1.00000				TLBFROD3
TLBFROD4						1.00000			TLBFROD4
TLBFROD5							1.00000		TLBFROD5
TLBFROD6								1.00000	TLBFROD6
TLBFROD7	1.00000								TLBFROD7
TLBFROD8		1.00000							TLBFROD8

112

EXECUTOR. MPS/360 V2-M10

	677	FC1	FC2	FC3	FC4	FC5	FC6	FC7	B
MAXIMIZE	1.90000-	637.00000-	637.00000-	617.94000-	617.94000-	617.94000-	617.94000-	617.94000-	MAXIMIZE
MFBFAVA7	1.00000								MFBFAVA7
FDCTAVA1		1.00000-							FDCTAVA1
FDCTBAL1		1.00000							FDCTBAL1
FDCTAVA2			1.00000-						FDCTAVA2
FDCTBAL2			1.00000						FDCTBAL2
FDCTAVA3				1.00000-					FDCTAVA3
FDCTBAL3				1.00000					FDCTBAL3
FDCTAVA4					1.00000-				FDCTAVA4
FDCTBAL4					1.00000				FDCTBAL4
FDCTAVA5						1.00000-			FDCTAVA5
FDCTBAL5						1.00000			FDCTBAL5
FDCTAVA6							1.00000-		FDCTAVA6
FDCTBAL6							1.00000		FDCTBAL6
FDCTAVA7								1.00000-	FDCTAVA7
FDCTBAL7								1.00000	FDCTBAL7
TLBPROD7	1.00000								TLBPROD7

C9

EXECUTOR. MPS/360 V2-M10 PAGE 22 - 81/143

	BC1	BC2	CC4	CC5	CC6	V11	V21	V31	R....1
MAXIMIZE	72.00000-	77.00000-	124.40000-	124.40000-	124.40000-	273.53000-	273.53000-	310.47000-	MAXIMIZE
MFBFAVA1						1.00000-			MFBFAVA1
MFBFAVA2							1.00000-		MFBFAVA2
MFBFAVA3								1.00000-	MFBFAVA3
FDCTAVA1						2.07400			FDCTAVA1
FDCTAVA2							2.07400		FDCTAVA2
FDCTAVA3								1.81000	FDCTAVA3
CONCAVA1	1.45000-					3.43600			CONCAVA1
CONCBAL1	1.00000								CONCBAL1
CONCAVA2		1.45000-					3.43600		CONCAVA2
CONCBAL2		1.00000							CONCBAL2
CONCAVA3								3.84600	CONCAVA3
CONCAVA4			1.55000-						CONCAVA4
CONCBAL4			1.00000						CONCBAL4
CONCAVA5				1.55000-					CONCAVA5
CONCBAL5				1.00000					CONCBAL5
CONCAVA6					1.55000-				CONCAVA6
CONCBAL6					1.00000				CONCBAL6
RUFFAVA1						.66100			RUFFAVA1
RUFFAVA2							.66100		RUFFAVA2
RUFFAVA3								.95700	RUFFAVA3

	V41	V51	V61	V71	W12	W13	W14	W15	10....1
MAXIMIZE	318.47000-	316.47000-	317.47000-	316.47000-	5.73000-	24.50000-	40.82000-	41.84000-	MAXIMIZE
MFBFAVA4	1.00000-								MFBFAVA4
MFBFAVA5		1.00000-							MFBFAVA5
MFBFAVA6			1.00000-						MFBFAVA6
MFBFAVA7				1.00000-					MFBFAVA7
FDCTAVA1					1.00000	1.00000	1.00000	1.00000	FDCTAVA1
FDCTAVA2					1.00000-				FDCTAVA2
FDCTAVA3						1.06000-			FDCTAVA3
FDCTAVA4	1.91000						1.06000-		FDCTAVA4
FDCTAVA5		1.91000						1.06000-	FDCTAVA5
FDCTAVA6			1.91000						FDCTAVA6
FDCTAVA7				1.91000					FDCTAVA7
CONCAVA4	2.95800								CONCAVA4
CONCAVA5		2.95800							CONCAVA5
CONCAVA6			2.95800						CONCAVA6
CONCAVA7				2.95800					CONCAVA7
RUFFAVA4	.99700								RUFFAVA4
RUFFAVA5		.99700							RUFFAVA5
RUFFAVA6			.99700						RUFFAVA6
RUFFAVA7				.99700					RUFFAVA7

C10

EXECUTOR. MPS/360 V2-M10 PAGE 25 - 81/143

	W16	W17	W21	W23	W24	W25	W26	W27	11....1
MAXIMIZE	55.54000-	61.24000-	5.73000-	23.46000-	28.87000-	38.11000-	44.17000-	56.76000-	MAXIMIZE
FDCTAVA1	1.00000	1.00000	1.00000-						FDCTAVA1
FDCTAVA2			1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FDCTAVA2
FDCTAVA3				1.06000-					FDCTAVA3
FDCTAVA4					1.06000-				FDCTAVA4
FDCTAVA5						1.06000-			FDCTAVA5
FDCTAVA6	1.06000-						1.06000-		FDCTAVA6
FDCTAVA7		1.06000-						1.06000-	FDCTAVA7

EXECUTOR. MPS/360 V2-M10

	W31	W33	W34	W35	W36	W37	W41	W42
MAXIMIZE	23.63000-	12.22000-	16.18000-	34.62000-	44.75000-	36.27000-	39.75000-	27.44000-
FOCTAVA1	.82000-						.82000-	
FOCTAVA2		.82000-						.82000-
FOCTAVA3	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000		
FOCTAVA4			1.00000-				1.00000	1.00000
FOCTAVA5				1.00000-				
FOCTAVA6					1.00000-			
FOCTAVA7						1.00000-		

C11

EXECUTOR. MPS/360 V2-M1 PAGE 27 - 81/1?3

	W43	W45	W46	W47	W51	W52	W53	W54
MAXIMIZE	16.18000-	32.18000-	24.09000-	16.87000-	30.44000-	26.52000-	34.81000-	32.18000-
FOCTAVA1					.82000-			
FOCTAVA2						.82000-		
FOCTAVA3	1.00000-						1.00000-	
FOCTAVA4	1.00000	1.00000	1.00000	1.00000				1.00000-
FOCTAVA5		1.00000-			1.00000	1.00000	1.00000	1.00000
FOCTAVA6			1.00000-					
FOCTAVA7				1.00000-				

EXECUTOR. MPS/360 V2-M16 PAGE 14 - 81/143

	WS6	WS7	WE1	WE2	WE3	WE4	WE5	WE7	14....1
MAXIMIZE	12.26000-	47.64000-	53.14000-	41.61000-	44.71000-	28.08000-	12.26000-	38.60000-	MAXIMIZE
FDCTAVA1			.52000-	.	.	.	.	.	FDCTAVA1
FDCTAVA2			.	.52000-	.	.	.	.	FDCTAVA2
FDCTAVA3			.	.	1.00000-	.	.	.	FDCTAVA3
FDCTAVA4	.	.	.	.	.	1.00000-	.	.	FDCTAVA4
FDCTAVA5	1.00000	1.00000	.	.	.	.	1.00000-	.	FDCTAVA5
FDCTAVA6	1.00000-	.	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FDCTAVA6
FDCTAVA7		1.00000-	.	.	.	.		1.00000-	FDCTAVA7

C12

EXECUTOR. MPS/360 V2-M16 PAGE 15 - 81/143

	W71	W72	W73	W74	W75	W76	Y12	Y21	15....1
MAXIMIZE	60.43000-	56.46000-	34.27000-	16.87000-	47.54000-	39.01000-	8.26000-	8.25000-	MAXIMIZE
FDCTAVA1	.52000-	.	.	.	.	.	.	.	FDCTAVA1
FDCTAVA2	.	.52000-	.	.	.	.	.	.	FDCTAVA2
FDCTAVA3	.	.	1.00000-	.	.	.	.	.	FDCTAVA3
FDCTAVA4	.	.	.	1.00000-	.	.	.	.	FDCTAVA4
FDCTAVA5	.	.	.	.	1.00000-	.	.	.	FDCTAVA5
FDCTAVA6	.	.	.	.	.	1.00000-	.	.	FDCTAVA6
FDCTAVA7	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.	.	FDCTAVA7
CONCAVA1	.	.	.	.	.	.	1.00000	1.00000-	CONCAVA1
CONCAVA2	.	.	.	.	.	.	1.00000-	1.00000	CONCAVA2

EXECUTOR. MPS/360 V2-M10 PAGE 30 - [illegible]

	Y41	Y42	Y43	Y45	Y46	Y47	Y51	Y52	16
MAXIMIZE	51.20000-	40.72000-	35.61000-	38.71000-	34.01000-	35.64000-	60.61000-	46.81000-	MAXIMIZE
CONCAVA1	1.00000-	.					1.00000-		CONCAVA1
CONCAVA2		1.00000-				.		1.00000-	CONCAVA2
CONCAVA3	.	.	1.00000-						CONCAVA3
CONCAVA4	[illegible]	1.00000	1.00000	1.00000	1.00000	1.00000			CONCAVA4
CONCAVA5		.		1.00000-			1.00000	1.00000	CONCAVA5
CONCAVA6	.	.			1.00000-				CONCAVA6
CONCAVA7		.				1.00000-	.		CONCAVA7

C13

EXECUTOR. MPS/360 V2-M10 PAGE 31 - 81/142

	Y53	Y54	Y56	Y57	Y61	Y62	Y63	Y64	17....1
MAXIMIZE	41.65000-	36.71000-	23.14000-	45.63000-	64.75000-	65.45000-	42.63000-	34.04000-	MAXIMIZE
CONCAVA1	.	.	.		1.00000-		.	.	CONCAVA1
CONCAVA2	.	.	.			1.00000-	.	.	CONCAVA2
CONCAVA3	1.00000-	.		.	.	.	1.00000-	.	CONCAVA3
CONCAVA4	.	1.00000-	.		.	.	.	1.00000-	CONCAVA4
CONCAVA5	1.00000	1.00000	1.00000	1.00000				.	CONCAVA5
CONCAVA6	.	.	1.00000-	.	1.00000	1.00000	1.00000	1.00000	CONCAVA6
CONCAVA7	.	.	.	1.00000-	.	.	.	.	CONCAVA7

EXECUTOR MPS/360 V2-M10 PAGE 44 - [illegible]

	Y65	Y67	Z17	Z21	Z34	Z35	Z36	Z37	18....1
MAXIMIZE	33.14000-	46.72000-	24.60000-	24.60000-	54.03000-	65.15000-	115.39000-	88.86000-	MAXIMIZE
CONCAVA5	1.00000-								CONCAVA5
CONCAVA6	1.00000	1.00000							CONCAVA6
CONCAVA7		1.00000-							CONCAVA7
RUFFAVA1			1.00000	1.00000-					RUFFAVA1
RUFFAVA2			1.00000-	1.00000					RUFFAVA2
RUFFAVA3					1.00000	1.00000	1.00000	1.00000	RUFFAVA3
RUFFAVA4					1.00000-				RUFFAVA4
RUFFAVA5						1.00000-			RUFFAVA5
RUFFAVA6							1.00000-		RUFFAVA6
RUFFAVA7								1.00000	RUFFAVA7

<14

EXECUTOR. MPS/360 V2-M10 PAGE 33 - 81/143

	Z43	Z45	Z46	Z47	Z53	Z54	Z56	Z57	18....1.
MAXIMIZE	64.63000-	62.67000-	72.38000-	58.64000-	69.16000-	82.67000-	40.81000-	122.73000-	MAXIMIZE
RUFFAVA3	1.00000-				1.00000-				RUFFAVA3
RUFFAVA4	1.00000	1.00000	1.00000	1.00000		1.00000-			RUFFAVA4
RUFFAVA5		1.00000-			1.00000	1.00000	1.00000	1.00000	RUFFAVA5
RUFFAVA6			1.00000-				1.00000-		RUFFAVA6
RUFFAVA7				1.00000-				1.00000-	RUFFAVA7

118

EXECUTOR. MPS/360 V2-M10 — PAGE 34 - [illegible]

	Z63	Z64	Z65	Z67	Z73	Z74	Z75	Z76	Z8
MAXIMIZE	115.35000-	72.36000-	40.81000-	150.70000-	88.84000-	56.64000-	122.73000-	100.70000-	MAXIMIZE
RUFFAVA3	1.00000-				1.00000-				RUFFAVA3
RUFFAVA4		1.00000-				1.00000-			RUFFAVA4
RUFFAVA5			1.00000-				1.00000-		RUFFAVA5
RUFFAVA6	1.00000	1.00000	1.00000	1.00000				1.00000-	RUFFAVA6
RUFFAVA7				1.00000-	1.00000	1.00000	1.00000	1.00000	RUFFAVA7

C15

EXECUTOR. MPS/360 V2-M10 — PAGE 35 - 87/142

	S33	S44	S55	S66	S77	RHS1	
MAXIMIZE	33.33000-	33.33000-	33.33000-	33.33000-	33.33000-	.	MAXIMIZE
HFBFAVA1						25014.000	HFBFAVA1
HFBFAVA2						60633.000	HFBFAVA2
HFBFAVA3						264716.00	HFBFAVA3
HFBFAVA4						606315.00	HFBFAVA4
HFBFAVA5						1122120.0	HFBFAVA5
HFBFAVA6						381856.00	HFBFAVA6
HFBFAVA7						867626.00	HFBFAVA7
FOCTBAL1						701616.00	FOCTBAL1
FOCTBAL2						686364.00	FOCTBAL2
FOCTBAL3						726778.00	FOCTBAL3
FOCTBAL4						478600.00	FOCTBAL4
FOCTBAL5						638206.00	FOCTBAL5
FOCTBAL6						3437741.0	FOCTBAL6
FOCTBAL7						846681.00	FOCTBAL7
CONCBAL1						5173000.0	CONCBAL1
CONCBAL2						2642000.0	CONCBAL2
CONCAVA3						605861.00-	CONCAVA3
CONCBAL4						12084000.	CONCBAL4
CONCBAL5						15582000.	CONCBAL5
CONCBAL6						4626000.0	CONCBAL6
CONCAVA7						6105877.0-	CONCAVA7
RUFFAVA1						3643130.0	RUFFAVA1
RUFFAVA2						1362127.0	RUFFAVA2
RUFFAVA3	1.00000-					2058440.0	RUFFAVA3
RUFFAVA4		1.00000-				3383567.0	RUFFAVA4
RUFFAVA5			1.00000-			6715000.0	RUFFAVA5
RUFFAVA6				1.00000-		3916786.0	RUFFAVA6
RUFFAVA7					1.00000-	3734641.0	RUFFAVA7
RSILAVA3	1.00000					424140.00	RSILAVA3
RSILAVA4		1.00000				309714.00	RSILAVA4
RSILAVA5			1.00000			1210848.0	RSILAVA5
RSILAVA6				1.00000		1048304.0	RSILAVA6
RSILAVA7					1.00000	765830.00	RSILAVA7
TLBFROD1						105852.00	TLBFROD1
TLBFROD2						78463.500	TLBFROD2
TLBFROD3						570955.00	TLBFROD3
TLBFROD4						136216.00	TLBFROD4
TLBFROD5						143143.00	TLBFROD5
TLBFROD6						384307.00	TLBFROD6
TLBFROD7						2261336.0	TLBFROD7
TLBFRODV						150000.00	TLBFRODV
TLBFRODX						3137064.0	TLBFRODX

EXECUTOR MPS/360 V2-M10

SECTION 1 - ROWS

NUMBER	..ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	MAXIMIZE	BS	7744277283.02-	7744277283.02	NONE	NONE	1.00000
2	MPBFAVA1	EQ	28016.00000	.	28016.00000	28016.00000	1832.97611-
3	MPBFAVA2	EQ	60633.00000	.	60633.00000	60633.00000	1832.94726-
4	MPBFAVA3	EQ	264716.00000	.	264716.00000	264716.00000	1864.48726-
5	MPBFAVA4	EQ	606316.00000	.	606316.00000	606316.00000	1848.21726-
6	MPBFAVA5	EQ	1133120.00000	.	1133120.00000	1133120.00000	1866.28811-
7	MPBFAVA6	EQ	361856.00000	.	361856.00000	361856.00000	1863.86611-
8	MPBFAVA7	EQ	867826.00000	.	867826.00000	867826.00000	1866.31726-
9	FDCTAVA1	UL		.	NONE		868.59095-
10	FDCTBAL1	UL	701616.00000	.	NONE	701616.00000	32.59095-
11	FDCTAVA2	UL		.	NONE		663.66095-
12	FDCTBAL2	UL	888384.00000	.	NONE	888384.00000	26.88095-
13	FDCTAVA3	UL		.	NONE		616.72000-
14	FDCTBAL3	UL	726776.00000	.	NONE	726776.00000	.78000-
15	FDCTAVA4	UL		.	NONE		634.91000-
16	FDCTBAL4	UL	878600.00000	.	NONE	878600.00000	16.97000-
17	FDCTAVA5	UL		.	NONE		642.64657-
18	FDCTBAL5	UL	939208.00000	.	NONE	939208.00000	25.90657-
19	FDCTAVA6	UL		.	NONE		642.06646-
20	FDCTBAL6	UL	2437741.00000	.	NONE	2437741.00000	24.12646-
21	FDCTAVA7	UL		.	NONE		617.94000-
22	FDCTBAL7	BS	716673.66615	230007.31265	NONE	946681.00000	
23	CONCAVA1	UL			NONE		48.65517-
24	CONCBAL1	BS	1124435.37653	4034564.62347	NONE	5173000.00000	
25	CONCAVA2	UL			NONE		53.10345-
26	CONCBAL2	BS	454837.87856	2487362.12144	NONE	2942000.00000	
27	CONCAVA3	UL	505981.00000-	.	NONE	505981.00000-	105.65606-
28	CONCAVA4	UL			NONE		60.25406-
29	CONCBAL4	BS	8644054.62071	3339946.37928	NONE	12084000.0000	
30	CONCAVA5	UL			NONE		60.25606-
31	CONCBAL5	BS	1265178.68740	14316821.3126	NONE	15582000.0000	
32	CONCAVA6	UL			NONE		60.25606-
33	CONCBAL6	BS	3283807.16370	1342192.83630	NONE	4626000.00000	
34	CONCAVA7	UL	8105977.00000-		NONE	8105977.00000-	105.59606-
35	BUFFAVA1	BS	411850.50780	3231176.48220	NONE	3843130.00000	.
36	BUFFAVA2	BS	165893.85093	1197033.14907	NONE	1362127.00000	.
37	BUFFAVA3	BS		2055840.00000	NONE	2059840.00000	.
38	BUFFAVA4	BS	1212066.66550	2151440.33450	NONE	3393587.00000	.
39	BUFFAVA5	BS	480256.74136	6234743.25864	NONE	6715000.00000	.
40	BUFFAVA6	BS	1273475.27592	1646312.72408	NONE	2916788.00000	.
41	BUFFAVA7	BS	.	3734881.00000	NONE	3734881.00000	
42	BSILAVA3	BS	.	424140.00000	NONE	424140.00000	
43	BSILAVA4	BS	.	309710.00000	NONE	309714.00000	
44	BSILAVA5	BS	.	1210669.00000	NONE	1210669.00000	
45	BSILAVA6	BS	.	1049304.00000	NONE	1049304.00000	
46	BSILAVA7	BS	.	765930.00000	NONE	765930.06000	
47	TLBFROD1	EQ	105853.00000	.	105852.00000	105852.00000	1834.87611
48	TLBFROD2	EQ	78463.50000	.	78463.50000	78463.50000	1834.84726
49	TLBFROD3	EQ	570855.00000	.	570555.00000	570855.00000	1866.36726

C16

EXECUTOR. MPS/360 V2-M10 PAGE 41 - 81/143

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	TLBFROD4	EQ	136216.00000	.	136216.00000	136216.00000	1851.11726
51	TLBFROD5	EQ	143143.00000	.	143143.00000	143143.00000	1868.18611
52	TLBFROD6	EQ	384307.00000	.	384307.00000	384307.00000	1865.78611
53	TLBFROD7	EQ	2261336.00000	.	2261336.00000	2261336.00000	1867.21726
54	TLBFRODY	EQ	150000.00000	.	150000.00000	150000.00000	1852.65726
55	TLBFRODX	LL	3137084.00000	.	3137084.00000	NONE	1811.35611

SECTION 3 - COLUMNS

NUMBER	.COLUMN	AT	ACTIVITY	INPUT COST	.LOWER LIMIT	UPPER LIMIT.	REDUCED COST
56	X11	BS	105852.00000	1.90000-		NONE	
57	X12	LL	.	5.85000-		NONE	3.36885-
58	X13	LL	.	43.78000-		NONE	10.38885-
59	X14	LL	.	69.20000-		NONE	51.05885-
60	X15	LL	.	71.00000-		NONE	36.35000-
61	X16	LL	.	81.38000-		NONE	58.57000-
62	X17	LL	.	87.80000-		NONE	63.85885-
63	X19	LL	.	24.07000-		NONE	4.34885-
64	X18	BS	401521.87424	78.38000-		NONE	
65	X21	LL	.	5.85000-		NONE	3.03115-
66	X22	BS	78863.50000	1.90000-		NONE	
67	X23	BS	12818.13250	33.44000-		NONE	
68	X24	LL	.	55.26000-		NONE	37.13000-
69	X25	LL	.	63.73000-		NONE	37.48115-
70	X26	LL	.	74.32000-		NONE	16.48115-
71	X27	LL	.	86.66000-		NONE	63.38000-
72	X29	BS	150000.00000	19.75000-		NONE	
73	X28	LL	.	75.13000-		NONE	.73115-
74	X31	LL	.	22.25000-		NONE	61.48115-
75	X32	LL	.	17.26000-		NONE	48.58000-
76	X33	BS	264716.00000	1.90000-		NONE	
77	X34	LL	.	17.17000-		NONE	30.64000-
78	X35	LL	.	26.33000-		NONE	24.63115-
79	X36	LL	.	29.33000-		NONE	38.03115-
80	X37	LL	.	31.17000-		NONE	38.04000-
81	X39	LL	.	14.11000-		NONE	25.00000-
82	X41	LL	.	35.11000-		NONE	48.45115-
83	X42	LL	.	27.84000-		NONE	42.31000-
84	X43	BS	252322.86710	17.17000-		NONE	
85	X44	BS	136216.00000	1.90000-		NONE	
86	X45	LL	.	26.33000-		NONE	7.38115-
87	X46	LL	.	23.00000-		NONE	6.43115-
88	X47	BS	1393510.00000	14.00000-		NONE	
89	X48	LL	.	52.67000-		NONE	.53115-
90	X51	LL	.	34.58000-		NONE	56.08000-
91	X52	LL	.	30.61000-		NONE	57.04685-
92	X53	LL	.	38.33000-		NONE	38.22685-
93	X54	LL	.	36.33000-		NONE	41.49885-
94	X55	BS	143143.00000	1.90000-		NONE	
95	X56	LL	.	15.80000-		NONE	16.10000-
96	X57	LL	.	31.30000-	.	NONE	30.28885-
97	X58	BS	1461706.53718	45.07000-	.	NONE	
98	X61	LL	.	44.41000-		NONE	73.42000-
99	X62	LL	.	37.65000-		NONE	66.88885-
100	X63	LL	.	29.33000-		NONE	26.82685-
101	X64	LL	.	23.00000-		NONE	35.76885-
102	X65	LL	.	15.80000-		NONE	11.30000-
103	X66	BS	384307.00000	1.90000-		NONE	
104	X67	LL	.	32.00000-	.	NONE	28.68885-

C17

EXECUTOR. MPS/360 V2-M10 PAGE 63 - 81/143

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
105	X68	BS	1253852.16848	47.47000-	.	NONE	.
106	X71	LL	.	48.08000-	.	NONE	78.62115-
107	X72	LL	.	42.73000-	.	NONE	73.20000-
108	X73	LL	.	31.17000-	.	NONE	30.10000-
109	X74	LL	.	18.00000-	.	NONE	32.20000-
110	X75	LL	.	31.20000-	.	NONE	26.33115-
111	X76	LL	.	32.00000-	.	NONE	31.63115-
112	X77	BS	867826.00000	1.90000-		NONE	.
113	FC1	BS	701616.00000	637.00000-		NONE	.
114	FC2	BS	548384.00000	637.00000-	.	NONE	.
115	FC3	BS	726776.00000	617.94000-	.	NONE	.
116	FC4	BS	676600.00000	617.94000-	.	NONE	.
117	FC5	BS	939308.00000	617.94000-	.	NONE	.
118	FC6	BS	2437741.00000	613.96000-	.	NONE	.
119	FC7	BS	714873.66815	617.34000-	.	NONE	.
120	BC1	BS	1134436.37663	72.00000-	.	NONE	.
121	BC2	BS	454637.67456	77.00000-	.	NONE	.
122	CC4	BS	4664054.62071	124.40000-	.	NONE	.
123	CC5	BS	1265176.68740	124.40000-	.	NONE	.
124	CC6	BS	3283807.16370	124.40000-	.	NONE	.
125	V11	BS	478456.87434	273.53000-	.	NONE	
126	V21	BS	151746.63290	273.53000-		NONE	
127	V31	LL	.	316.47000-		NONE	55.14218-
128	V41	BS	1215733.56710	316.47000-		NONE	
129	V51	BS	491731.93718	316.47000-		NONE	
130	V61	BS	1276304.16848	317.47000-		NONE	
131	V71	LL	.	316.47000-		NONE	57.72762-
132	W12	LL	.	5.73000-		NONE	11.46000-
133	W13	LL	.	24.50000-		NONE	25.87325-
134	W14	LL	.	40.62000-		NONE	24.50615-
135	W15	LL	.	41.64000-		NONE	15.91665-
136	W16	LL	.	55.54000-		NONE	31.69917-
137	W17	LL	.	61.24000-	.	NONE	62.45575-
138	W21	BS	90701.48337	5.73000-		NONE	
139	W23	LL	.	20.45000-	.	NONE	16.80335-
140	W24	LL	.	28.57000-		NONE	7.12815-
141	W25	LL	.	38.11000-		NONE	6.61665-
142	W26	LL	.	44.17000-		NONE	14.59917-
143	W27	LL	.	56.76000-		NONE	53.24575-
144	W31	LL	.	23.63000-		NONE	36.52633-
145	W32	LL	.	12.22000-	.	NONE	30.18793-
146	W34	BS	726776.00000	18.19000-		NONE	
147	W35	LL	.	34.61000-	.	NONE	8.46363-
148	W36	LL	.	64.75000-		NONE	21.44354-
149	W37	LL	.	34.27000-		NONE	39.05000-
150	W41	LL	.	28.75000-		NONE	56.63633-
151	W42	LL	.	27.84000-	.	NONE	61.99783-
152	W43	LL	.	16.19000-		NONE	32.36000-
153	W45	LL	.	22.16000-		NONE	23.22343-
154	W46	LL	.	28.09000-	.	NONE	20.63354-
155	W47	LL	.	16.87000-		NONE	33.84000-

EXECUTOR. MPS/360 V2-M10

NUMBER	COLUMN	AT	ACTIVITY	INPUT COST	LOWER LIMIT	UPPER LIMIT	REDUCED COST
156	W51	LL	.	39.44000-		NONE	67.26280-
157	W52	LL	.	36.52000-		NONE	69.61450-
158	W53	LL	.	24.61000-		NONE	58.73657-
159	W54	LL	.	32.16000-	.	NONE	41.08657-
160	W55	LL		12.26000-	.	NONE	14.04010-
161	W57	LL		67.64000-		NONE	73.54857-
162	W61	LL		63.16000-	.	NONE	79.22279-
163	W62	LL	.	41.61000-	.	NONE	72.52429-
164	W63	LL	.	44.79000-	.	NONE	68.13848-
165	W64	LL	.	28.08000-	.	NONE	35.24848-
166	W65	LL		12.25000-	.	NONE	10.47090-
167	W67	LL	.	38.09000-	.	NONE	63.21646-
168	W71	LL		59.42000-	.	NONE	81.24823-
169	W72	LL	.	66.48000-	.	NONE	62.83783-
170	W73	LL	.	38.27000-	.	NONE	37.49000-
171	W74	BS	718073.56615	16.87000-	.	NONE	
172	W75	LL		47.64000-	.	NONE	21.73243-
173	W76	LL		39.09040-		NONE	14.98354-
174	Y12	LL	.	8.26000-		NONE	5.81172-
175	Y21	LL	.	9.26000-	.	NONE	12.70828-
176	Y41	LL		51.39000-		NONE	61.89289-
177	Y42	LL		40.73000-		NONE	67.68462-
178	Y43	BS	505141.00000	25.41000-	.	NONE	
179	Y45	LL	.	38.71000-		NONE	38.71000-
180	Y46	LL		34.04000-		NONE	34.04000-
181	Y47	BS	6105077.00000	26.04000-	.	NONE	
182	Y51	LL		50.61000-	.	NONE	81.21289-
183	Y52	LL		44.51000-	.	NONE	73.06462-
184	Y53	LL	.	41.65000-	.	NONE	15.24000-
185	Y54	LL		38.71000-		NONE	38.71000-
186	Y56	LL		23.14000-		NONE	23.14000-
187	Y57	LL		46.63000-		NONE	16.99000-
188	Y61	LL		64.79000-		NONE	95.39249-
189	Y62	LL	.	55.45000-		NONE	42.60462-
190	Y63	LL		42.53000-		NONE	17.12000-
191	Y64	LL		34.04000-	.	NONE	34.04000-
192	Y65	LL		23.14000-	.	NONE	23.14000-
193	Y67	LL	.	46.72000-	.	NONE	20.08000-
194	Z12	LL		24.60000-	.	NONE	24.60000-
195	Z21	LL	.	24.60000-	.	NONE	24.60000-
196	Z34	LL	.	54.02000-	.	NONE	54.02000-
197	Z35	LL	.	89.16000-	.	NONE	89.16000-
198	Z36	LL	.	115.39000-	.	NONE	115.39000-
199	Z37	LL	.	86.08000-	.	NONE	86.08000-
200	Z43	LL		54.02000-	.	NONE	54.02000-
201	Z45	LL	.	82.87000-	.	NONE	82.87000-
202	Z46	LL		72.36000-	.	NONE	72.36000-
203	Z47	LL		56.64000-	.	NONE	56.64000-
204	Z53	LL	.	89.16000-	.	NONE	89.16000-
205	Z54	LL	.	82.87000-	.	NONE	82.87000-
206	Z56	LL		40.81000-	.	NONE	40.81000-

C18

EXECUTOR. MPS/360 V2-M10 PAGE 46 - 81/142

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT..	..UPPER LIMIT.	.REDUCED COST.
207	Z57	LL	.	122.73000-	.	NONE	122.73000-
208	Z63	LL	.	115.39000-	.	NONE	115.39000-
209	Z64	LL	.	72.36000-	.	NONE	72.36000-
210	Z65	LL	.	40.81000-	.	NONE	40.81000-
211	Z67	LL	.	100.70000-	.	NONE	100.70000-
212	Z73	LL	.	86.08000-	.	NONE	86.08000-
213	Z74	LL	.	56.64000-	.	NONE	56.64000-
214	Z75	LL	.	122.73000-	.	NONE	122.73000-
215	Z76	LL	.	100.70000-	.	NONE	100.70000-
216	S33	LL	.	33.33000-	.	NONE	33.33000-
217	S44	LL	.	33.33000-	.	NONE	33.33000-
218	S55	LL	.	33.33000-	.	NONE	33.33000-
219	S66	LL	.	33.33000-	.	NONE	33.33000-
220	S77	LL	.	33.33000-	.	NONE	33.33000-

122

Model 2 MTS Results

```
    PROGRAM
    INITIALZ
    MOVE(XDATA,'RECDAT')
    MOVE(XPBNAME,'MODELD')
    MOVE(XOBJ,'MAXIMIZE')
    MOVE(XRHS,'RHS1')
    CONVERT('SUMMARY')
    BCDOUT
    SETUP('MAX')
    TRANCOL
    PRIMAL
    SOLUTION
    RANGE
    EXIT
    PEND
ENDFILE
NAME          RECDAT
ROWS
 N  MAXIMIZE
 E  NFBFAVA1
 E  NFBFAVA2
 E  NFBFAVA3
 E  NFBFAVA4
 E  NFBFAVA5
 E  NFBFAVA6
 E  NFBFAVA7
 L  FOCTAVA1
 L  FOCTBAL1
 L  FOCTAVA2
 L  FOCTBAL2
 L  FOCTAVA3
 L  FOCTBAL3
 L  FOCTAVA4
 L  FOCTBAL4
 L  FOCTAVA5
 L  FOCTBAL5
 L  FOCTAVA6
 L  FOCTBAL6
 L  FOCTAVA7
 L  FOCTBAL7
 L  CONCAVA1
 L  CONCBAL1
 L  CONCAVA2
 L  CONCBAL2
 L  CONCAVA3
 L  CONCAVA4
 L  CONCBAL4
 L  CONCAVA5
 L  CONCBAL5
 L  CONCAVA6
 L  CONCBAL6
 L  CONCAVA7
 L  RUFFAVA1
 L  RUFFAVA2
 L  RUFFAVA3
 L  RUFFAVA4
 L  RUFFAVA5
 L  RUFFAVA6
 L  RUFFAVA7
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C19

```
 L  RSILAVA3
 L  RSILAVA4
 L  RSILAVA5
 L  RSILAVA6
 L  RSILAVA7
 E  TLBFROD1
 E  TLBFROD2
 E  TLBFROD3
 E  TLBFROD4
 E  TLBFROD5
 E  TLBFROD6
 E  TLBFROD7
 E  TLBFRODV
 E  TLBFRODX
COLUMNS
    X11       MAXIMIZE  -1.9          NFBFAVA1  1.0
    X11       TLBFROD1  1.0
    X12       MAXIMIZE  -6.66         NFBFAVA1  1.0
    X12       TLBFROD2  1.0
    X13       MAXIMIZE  -43.78        NFBFAVA1  1.0
    X13       TLBFROD3  1.0
    X14       MAXIMIZE  -65.20        NFBFAVA1  1.0
    X14       TLBFROD4  1.0
    X15       MAXIMIZE  -71.60        NFBFAV£1  1.0
    X15       TLBFROD5  1.0
    X16       MAXIMIZE  -81.36        NFBFAVA1  1.0
    X16       TLBFROD6  1 0
    X17       MAXIMIZE  -87.80        NFBFAVA1  1 0
    X17       TLBFROD7  1.0
    X1V       MAXIMIZE  -24.07        NFBFAVA1  1.0
    X1V       TLBFRODV  1 0
    X1X       MAXIMIZE  -78.36        NFBFAVA1  1.0
    X1X       TLBFRODX  1 0
    X21       MAXIMIZE  -5 66         NFBFAVA2  1.0
    X21       TLBFROD1  1.0
    X22       MAXIMIZE  -1.80         NFBFATA2  1.0
    X22       TLBFROD2  1 0
    X23       MAXIMIZE  -33.46        NFBFAVA2  1.0
    X23       TLBFROD3  1.0
    X24       MAXIMIZE  -65 30        NFBFAVA2  1.0
    X24       TLBFROD4  1.0
    X25       MAXIMIZE  -62 72        NFBFAVA2  1.0
    X25       TLBFROD5  1.0
    X26       MAXIMIZE  -78.32        NFBFAVA2  1.0
    X26       TLBFROD6  1 0
    X27       MAXIMIZE  -86.66        NFBFAVA2  1.0
    X27       TLBFROD7  1.0
    X2V       MAXIMIZE  -19.75        NFBFAVA2  1.0
    X2V       TLBFRODV  1.0
    X2X       MAXIMIZE  -79.13        NFBFAVA2  1.0
    X2X       TLBFRODX  1.0
    X31       MAXIMIZE  -22.26        NFBFAVA3  1.0
    X31       TLBFROD1  1.0
    X32       MAXIMIZE  -17.26        NFBFAVA3  1.0
    X32       TLBFROD2  1.0
    X33       MAXIMIZE  -1.80         NFBFAVA3  1.0
    X33       TIBFROD3  1.0
    X34       MAXIMIZE  -17.17        NFBFAVA3  1.0
    X34       TLBFROD4  1.0
    X35       MAXIMIZE  -28.33        NFBFAVA3  1.0
```

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X35       TLBFROD5   1.0
X36       MAXIMIZE   -29.33        NFBFAVA3   1.0
X36       TLBFROD6   1.0
X37       MAXIMIZE   -31.17        NFBFAVA3   1.0
X37       TLBFROD7   1.0
X38       MAXIMIZE   -14.11        NFBFAVA3   1.0
X38       TLBFROD8   1.0
X41       MAXIMIZE   -35.11        NFBFAVA4   1.0
X41       TLBFROD1   1.0
X42       MAXIMIZE   -27.84        NFBFAVA4   1.0
X42       TLBFROD2   1.0
X43       MAXIMIZE   -17.17        NFBFAVA4   1.0
X43       TLBFROD3   1.0
X44       MAXIMIZE   -1.90         NFBFAVA4   1.0
X44       TLBFROD4   1.0
X45       MAXIMIZE   -26.33        NFBFAVA4   1.0
X45       TLBFROD5   1.0
X46       MAXIMIZE   -23.00        NFBFAVA4   1.0
X46       TLBFROD6   1.0
X47       MAXIMIZE   -18.00        NFBFAVA4   1.0
X47       TLBFROD7   1.0
X48       MAXIMIZE   -62.67        NFBFAVA4   1.0
X48       TLBFROD8   1.0
X51       MAXIMIZE   -34.66        NFBFAVA5   1.0
X51       TLBFROD1   1.0
X52       MAXIMIZE   -30.61        NFBFAVA5   1.0
X52       TLBFROD2   1.0
X53       MAXIMIZE   -28.33        NFBFAVA5   1.0
X53       TLBFROD3   1.0
X54       MAXIMIZE   -26.33        NFBFAVA5   1.0
X54       TLBFROD4   1.0
X55       MAXIMIZE   -1.90         NFBFAVA5   1.0
X55       TLBFROD5   1.0
X56       MAXIMIZE   -1[illegible].60   NFBFAVA5   1.0
X56       TLBFROD6   1.[illegible]
X57       MAXIMIZE   -31.20        NFBFAVA5   1.0
X57       TLBFROD7   1.0
X58       MAXIMIZE   -45.0[illegible]   NFBFAVA5   1.0
X58       TLBFROD8   1.0
X61       MAXIMIZE   -44.61        NFBFAVA6   1.0
X61       TLBFROD1   1.0
X62       MAXIMIZE   -37.85        NFBFAVA6   1.0
X62       TLBFROD2   1.0
X63       MAXIMIZE   -29.33        NFBFAVA6   1.0
X63       TLBFROD3   1.0
X64       MAXIMIZE   -23.00        NFBFAVA6   1.0
X64       TLBFROD4   1.0
X65       MAXIMIZE   -15.60        NFBFAVA6   1.0
X65       TLBFROD5   1.0
X66       MAXIMIZE   -1.90         NFBFAVA6   1.0
X66       TLBFROD6   1.0
X67       MAXIMIZE   -32.00        NFBFAVA6   1.0
X67       TLBFROD7   1.0
X68       MAXIMIZE   -47.47        NFBFAVA6   1.0
X68       TLBFROD8   1.0
X71       MAXIMIZE   -46.08        NFBFAVA7   1.0
X71       TLBFROD1   1.0
X72       MAXIMIZE   -42.73        NFBFAVA7   1.0
X72       TLBFROD2   1.0
X73       MAXIMIZE   -31.17        NFBFAVA7   1.0
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C20

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X73       TLBFROD3   1.0
X74       MAXIMIZE   -18.00        NFBFAVA7   1.0
X74       TLBFROD4   1.0
X75       MAXIMIZE   -31.20        NFBFAVA7   1.0
X75       TLBFROD5   1.0
X76       MAXIMIZE   -32.00        NFBFAVA7   1.0
X76       TLBFROD6   1.0
X77       MAXIMIZE   -1.90         NFBFAVA7   1.0
X77       TLBFROD7   1.0
FC1       MAXIMIZE   -837.00       FOCTAVA1   -1.0
FC1       FOCTBAL1   1.0
FC2       MAXIMIZE   -637.00       FOCTAVA2   -1.0
FC2       FOCTBAL2   1.0
FC3       MAXIMIZE   -617.94       FOCTAVA3   -1.0
FC3       FOCTBAL3   1.0
FC4       MAXIMIZE   -617.96       FOCTAVA4   -1.0
FC4       FOCTBAL4   1.0
FC5       MAXIMIZE   -617.94       FOCTAVA5   -1.0
FC5       FOCTBAL5   1.0
FC6       MAXIMIZE   -617.94       FOCTAVA6   -1.0
FC6       FOCTBAL6   1.0
FC7       MAXIMIZE   -617.94       FOCTAVA7   -1.0
FC7       FOCTBAL7   1.0
BC1       MAXIMIZE   -65.00        CONCAVA1   -1.45
BC1       CONCBAL1   1.0
BC2       MAXIMIZE   -90.00        CONCAVA2   -1.45
BC2       CONCBAL2   1.0
CC4       MAXIMIZE   -124.40       CONCAVA4   -1.55
CC4       CONCBAL4   1.0
CC5       MAXIMIZE   -124.40       CONCAVA5   -1.55
CC5       CONCBAL5   1.0
CC6       MAXIMIZE   -124.40       CONCAVA6   -1.55
CC6       CONCBAL6   1.0
V11       MAXIMIZE   -273.53       NFBFAVA1   -1.0
V11       FOCTAVA1   2.074         CONCAVA1   3.436
V11       RUFFAVA1   .861
V21       MAXIMIZE   -273.53       NFBFAVA2   -1.0
V21       FOCTAVA2   2.074         CONCAVA2   3.436
V21       RUFFAVA2   .861
V31       MAXIMIZE   -316.47       NFBFAVA3   -1.0
V31       FOCTAVA3   1.91          CONCAVA3   3.988
V31       RUFFAVA3   .897
V41       MAXIMIZE   -316.47       NFBFAVA4   -1.0
V41       FOCTAVA4   1.91          CONCAVA4   3.988
V41       RUFFAVA4   .897
V51       MAXIMIZE   -316.47       NFBFAVA5   -1.0
V51       FOCTAVA5   1.910         CONCAVA5   3.988
V51       RUFFAVA5   .897
V61       MAXIMIZE   -317.47       NFBFAVA6   -1.0
V61       FOCTAVA6   1.910         CONCAVA6   3.986
V61       RUFFAVA6   .897
V71       MAXIMIZE   -316.47       NFBFAVA7   -1.0
V71       FOCTAVA7   1.910         CONCAVA7   3.986
V71       RUFFAVA7   .897
W12       MAXIMIZE   -5.73         FOCTAVA1   1.0
W12       FOCTAVA2   -1.0
W13       MAXIMIZE   -24.60        FOCTAVA1   1.0
W13       FOCTAVA3   -1.06
W14       MAXIMIZE   -40.62        FOCTAVA1   1.0
W14       FOCTAVA4   -1.06
```

W15	FOCTAVA5	-1.08		
W16	MAXIMIZE	-65.64	FOCTAVA1	1.0
W16	FOCTAVA6	-1.08		
W17	MAXIMIZE	-61.34	FOCTAVA1	1.0
W17	FOCTAVA7	-1.08		
W21	MAXIMIZE	-8.72	FOCTAVA1	-1.0
W21	FOCTAVA2	1.0		
W23	MAXIMIZE	-20.46	FOCTAVA2	1.0
W23	FOCTAVA3	-1.08		
W24	MAXIMIZE	-98.57	FOCTAVA2	1.0
W24	FOCTAVA4	-1.08		
W25	MAXIMIZE	-34.11	FOCTAVA2	1.0
W25	FOCTAVA5	-1.08		
W26	MAXIMIZE	-44.17	FOCTAVA2	1.0
W26	FOCTAVA6	-1.08		
W27	MAXIMIZE	-66.76	FOCTAVA2	1.0
W27	FOCTAVA7	-1.08		
W31	MAXIMIZE	-23.63	FOCTAVA1	-.92
W31	FOCTAVA3	1.0		
W32	MAXIMIZE	-12.23	FOCTAVA2	-.97
W32	FOCTAVA3	1.0		
W34	MAXIMIZE	-16.18	FOCTAVA3	1.0
W34	FOCTAVA4	-1.0		
W35	MAXIMIZE	-34.61	FOCTAVA3	1.0
W35	FOCTAVA5	-1.0		
W36	MAXIMIZE	-44.70	FOCTAVA3	1.0
W36	FOCTAVA6	-1.0		
W37	MAXIMIZE	-28.23	FOCTAVA3	1.0
W37	FOCTAVA7	-1.0		
W41	MAXIMIZE	-35.75	FOCTAVA1	-.92
W41	FOCTAVA4	1.0		
W42	MAXIMIZE	-27.64	FOCTAVA2	-.92
W42	FOCTAVA4	1.0		
W43	MAXIMIZE	-16.18	FOCTAVA3	-1.0
W43	FOCTAVA4	1.0		
W45	MAXIMIZE	-33.16	FOCTAVA4	1.0
W45	FOCTAVA5	-1.0		
W46	MAXIMIZE	-24.03	FOCTAVA4	1.0
W46	FOCTAVA6	-1.0		
W47	MAXIMIZE	-16.87	FOCTAVA4	1.0
W47	FOCTAVA7	-1.0		
W51	MAXIMIZE	-35.44	FOCTAVA1	-.92
W51	FOCTAVA5	1.0		
W52	MAXIMIZE	-36.62	FOCTAVA2	-.92
W52	FOCTAVA5	1.0		
W53	MAXIMIZE	-34.61	FOCTAVA3	-1.0
W53	FOCTAVA5	1.0		
W54	MAXIMIZE	-33.16	FOCTAVA4	-1.0
W54	FOCTAVA5	1.0		
W56	MAXIMIZE	-12.26	FOCTAVA5	1.0
W56	FOCTAVA6	-1.0		
W57	MAXIMIZE	-41.64	FOCTAVA5	1.0
W57	FOCTAVA7	-1.0		
W61	MAXIMIZE	-63.16	FOCTAVA1	-.92
W61	FOCTAVA6	1.0		
W62	MAXIMIZE	-41.61	FOCTAVA2	-.92
W62	FOCTAVA6	1.0		
W63	MAXIMIZE	-44.70	FOCTAVA3	-1.0
W63	FOCTAVA6	1.0		

C21

W64	MAXIMIZE	-28.08	FOCTAVA4	-1.0
W64	FOCTAVA6	1.0		
W65	MAXIMIZE	-12.26	FOCTAVA5	-1.0
W65	FOCTAVA6	1.0		
W67	MAXIMIZE	-28.09	FOCTAVA6	1.0
W67	FOCTAVA7	-1.0		
W71	MAXIMIZE	-66.43	FOCTAVA1	-.92
W71	FOCTAVA7	1.0		
W72	MAXIMIZE	-65.45	FOCTAVA2	-.92
W72	FOCTAVA7	1.0		
W73	MAXIMIZE	-36.27	FOCTAVA3	-1.0
W73	FOCTAVA7	1.0		
W74	MAXIMIZE	-16.87	FOCTAVA4	-1.0
W74	FOCTAVA7	1.0		
W75	MAXIMIZE	-47.64	FOCTAVA5	-1.0
W75	FOCTAVA7	1.0		
W76	MAXIMIZE	-38.08	FOCTAVA6	-1.0
W76	FOCTAVA7	1.0		
Y12	MAXIMIZE	-8.26	CONCAVA1	1.0
Y12	CONCAVA2	-1.0		
Y21	MAXIMIZE	-8.26	CONCAVA1	-1.0
Y21	CONCAVA2	1.0		
Y41	MAXIMIZE	-51.28	CONCAVA1	-1.0
Y41	CONCAVA4	1.0		
Y42	MAXIMIZE	-40.73	CONCAVA2	-1.0
Y42	CONCAVA4	1.0		
Y43	MAXIMIZE	-25.41	CONCAVA3	-1.0
Y43	CONCAVA4	1.0		
Y45	MAXIMIZE	-36.71	CONCAVA4	1.0
Y45	CONCAVA5	-1.0		
Y46	MAXIMIZE	-34.04	CONCAVA4	1.0
Y46	CONCAVA6	-1.0		
Y47	MAXIMIZE	-26.64	CONCAVA4	1.0
Y47	CONCAVA7	-1.0		
Y51	MAXIMIZE	-50.61	CONCAVA1	-1.0
Y51	CONCAVA5	1.0		
Y52	MAXIMIZE	-44.91	CONCAVA2	-1.0
Y52	CONCAVA5	1.0		
Y53	MAXIMIZE	-41.65	CONCAVA3	-1.0
Y53	CONCAVA5	1.0		
Y54	MAXIMIZE	-38.71	CONCAVA4	-1.0
Y54	CONCAVA5	1.0		
Y56	MAXIMIZE	-23.14	CONCAVA5	1.0
Y56	CONCAVA6	-1.0		
Y57	MAXIMIZE	-45.63	CONCAVA5	1.0
Y57	CONCAVA7	-1.0		
Y61	MAXIMIZE	-64.79	CONCAVA1	-1.0
Y61	CONCAVA6	1.0		
Y62	MAXIMIZE	-55.45	CONCAVA2	-1.0
Y62	CONCAVA6	1.0		
Y63	MAXIMIZE	-42.53	CONCAVA3	-1.0
Y63	CONCAVA6	1.0		
Y64	MAXIMIZE	-34.04	CONCAVA4	-1.0
Y64	CONCAVA6	1.0		
Y65	MAXIMIZE	-23.14	CONCAVA5	-1.0
Y65	CONCAVA6	1.0		
Y67	MAXIMIZE	-46.72	CONCAVA6	1.0
Y67	CONCAVA7	-1.0		
Z12	MAXIMIZE	-24.60	RUFFAVA1	1.0
Z12	RUFFAVA2	-1.0		

```
    Z32       RUFFAVA2  1.0
    Z34       MAXIMIZE  -84.02        RUFFAVA3  1.0
    Z34       RUFFAVA4  -1.0
    Z35       MAXIMIZE  -88.18        RUFFAVA3  1.0
    Z35       RUFFAVA5  -1.0
    Z36       MAXIMIZE  -115.39       RUFFAVA3  1.0
    Z36       RUFFAVA6  -1.0
    Z37       MAXIMIZE  -96.00        RUFFAVA3  1.0
    Z37       RUFFAVA7  -1.0
    Z43       MAXIMIZE  -84.02        RUFFAVA3  -1.0
    Z43       RUFFAVA4  1.0
    Z45       MAXIMIZE  -82.87        RUFFAVA4  1.0
    Z45       RUFFAVA5  -1.0
    Z46       MAXIMIZE  -72.38        RUFFAVA4  1.0
    Z46       RUFFAVA6  -1.0
    Z47       MAXIMIZE  -85.64        RUFFAVA4  1.0
    Z47       RUFFAVA7  -1.0
    Z52       MAXIMIZE  -48.18        RUFFAVA2  -1.0
    Z53       RUFFAVA5  1.0
    Z54       MAXIMIZE  -82.87        RUFFAVA4  -1.0
    Z54       RUFFAVA5  1.0
    Z56       MAXIMIZE  -40.91        RUFFAVA5  1.0
    Z56       RUFFAVA6  -1.0
    Z57       MAXIMIZE  -122.73       RUFFAVA5  1.0
    Z57       RUFFAVA7  -1.0
    Z63       MAXIMIZE  -115.39       RUFFAVA3  -1.0
    Z63       RUFFAVA6  1.0
    Z64       MAXIMIZE  -72.38        RUFFAVA4  -1.0
    Z64       RUFFAVA6  1.0
    Z65       MAXIMIZE  -40.91        RUFFAVA5  -1.0
    Z65       RUFFAVA6  1.0
    Z67       MAXIMIZE  -100.70       RUFFAVA6  1.0
    Z67       RUFFAVA7  -1.0
    Z73       MAXIMIZE  -96.08        RUFFAVA3  -1.0
    Z73       RUFFAVA7  1.0
    Z74       MAXIMIZE  -86.64        RUFFAVA4  -1.0
    Z74       RUFFAVA7  1.0
    Z75       MAXIMIZE  -122.73       RUFFAVA5  -1.0
    Z75       RUFFAVA7  1.0
    Z76       MAXIMIZE  -100.70       RUFFAVA6  -1.0
    Z76       RUFFAVA7  1.0
    S33       MAXIMIZE  -33.33        RUFFAVA3  -1.0
    S33       RSILAVA3  1.0
    S44       MAXIMIZE  -33.33        RUFFAVA4  -1.0
    S44       RSILAVA4  1.0
    S55       MAXIMIZE  -33.33        RUFFAVA5  -1.0
    S55       RSILAVA5  1.0
    S66       MAXIMIZE  -33.33        RUFFAVA6  -1.0
    S66       RSILAVA6  1.0
    S77       MAXIMIZE  -33.33        RUFFAVA7  -1.0
    S77       RSILAVA7  1.0
RHS
    RHS1      NFBFAVA1  29016.0       NFBFAVA2  50633.0
    RHS1      NFBFAVA3  264716.0      NFBFAVA4  606315.0
    RHS1      NFBFAVA5  1133120.0     NFBFAVA6  361856.0
    RHS1      NFBFAVA7  467428.0      FOCTAVA1  0.0
    RHS1      FOCTBAL1  701616.0      FOCTAVA2  0.0
    RHS1      FOCTBAL2  888384.0      FOCTAVA3  0.0
    RHS1      FOCTBAL3  728774.0      FOCTAVA4  0.0
```

C22

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    RHS1      FOCTBAL4  874600.0      FOCTAVA5  0.0
    RHS1      FOCTBAL5  838208.0      FOCTAVA6  0.0
    RHS1      FOCTBAL6  2437741.0     FOCTAVA7  0.0
    RHS1      FOCTBAL7  848881.0      CONCAVA1  0.0
    RHS1      CONCBAL1  5173000.0     CONCAVA2  0.0
    RHS1      CONCBAL2  7847000.0
    RHS1      CONCAVA3  -505861.0     CONCAVA4  0.0
    RHS1      CONCBAL4  12084000.0    CONCAVA5  0.0
    RHS1      CONCBAL5  15562000.0    CONCAVA6  0.0
    RHS1      CONCBAL6  4625000.0
    RHS1      CONCAVA7  -4105877.0    RUFFAVA1  3843130.0
    RHS1      RUFFAVA2  1382127.0     RUFFAVA3  2058840.0
    RHS1      RUFFAVA4  2393567.0     RUFFAVA5  6715000.0
    RHS1      RUFFAVA6  2814784.0     RUFFAVA7  3734481.0
    RHS1      RSILAVA3  424140.0      RSILAVA4  309718.0
    RHS1      RSILAVA5  1210668.0     RSILAVA6  1048304.0
    RHS1      RSILAVA7  768930.0      TLBFROD1  105962.0
    RHS1      TLBFROD2  74443.5       TLBFROD3  570855.0
    RHS1      TLBFROD4  134216.0      TLBFROD5  143143.0
    RHS1      TLBFROD6  384307.0      TLBFROD7  2261326.0
    RHS1      TLBFRODV  160000.0      TLBFRODK  3137044.0
ENDATA
$ENDFILE
```

EXECUTOR. MPS/360 V2-M10 PAGE 34 - 81/143

SOLUTION (OPTIMAL)

TIME = 0.01 MINS ITERATION NUMBER = 60

..NAME..	..ACTIVITY	DEFINED AS
FUNCTIONAL	7764068854.30-	MAXIMIZE
RESTRAINTS		RHS1

C23

EXECUTOR. MPS/360 V2-M10 PAGE 35 - 81/143

SECTION 1 - ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	MAXIMIZE	BS	7764068854.30-	7764068854.30	NONE	NONE	1.00000
2	MFBFAVA1	EQ	28016.00000	.	28016.00000	28016.00000	1632.07152-
3	MFBFAVA2	EQ	56633.00000	.	56633.00000	56633.00000	1636.28152-
4	MFBFAVA3	EQ	264716.00000	.	264716.00000	264716.00000	1664.46726-
5	MFBFAVA4	EQ	606315.00000	.	606315.00000	606315.00000	1640.21726-
6	MFBFAVA5	EQ	1133120.00000	.	1133120.00000	1133120.00000	1665.38152-
7	MFBFAVA6	EQ	361856.00000	.	361856.00000	361856.00000	1662.84152-
8	MFBFAVA7	EQ	867626.00000	.	867626.00000	867626.00000	1665.31728-
9	FOCTAVA1	UL	.	.	NONE	.	654.28296-
10	FOCTBAL1	UL	701616.00000	.	NONE	701616.00000	17.29286-
11	FOCTAVA2	UL	.	.	NONE	.	656.73260-
12	FOCTBAL2	UL	688364.00000	.	NONE	688364.00000	16.73280-
13	FOCTAVA3	UL	.	.	NONE	.	618.72000-
14	FOCTBAL3	UL	726776.00000	.	NONE	726776.00000	.78000-
15	FOCTAVA4	UL	.	.	NONE	.	634.81000-
16	FOCTBAL4	UL	878600.00000	.	NONE	878600.00000	16.87000-
17	FOCTAVA5	UL	.	.	NONE	.	643.37296-
18	FOCTBAL5	UL	939204.00000	.	NONE	939204.00000	25.43216-
19	FOCTAVA6	UL	.	.	NONE	.	641.59286-
20	FOCTBAL6	UL	2437741.00000	.	NONE	2437741.00000	23.65286-
21	FOCTAVA7	UL	.	.	NONE	.	617.94000-
22	FOCTBAL7	BS	607169.61582	335511.46416	NONE	945581.00000	.
23	CONCAVA1	UL	.	.	NONE	.	56.62069-
24	CONCBAL1	BS	602100.15685	6370689.84105	NONE	6173000.00000	.
25	CONCAVA2	UL	.	.	NONE	.	56.40534-
26	CONCBAL2	BS	.	2942000.00000	NONE	2842000.00000	.
27	CONCAVA3	UL	505961.00000-	.	NONE	505961.00000-	105.56806-
28	CONCAVA4	UL	.	.	NONE	.	80.25806-
29	CONCBAL4	BS	8718459.48392	3364140.51607	NONE	12084000.0000	.
30	CONCAVA5	UL	.	.	NONE	.	80.25406-
31	CONCBAL5	BS	2063348.42372	13498650.5663	NONE	15582000.0000	.
32	CONCAVA6	UL	.	.	NONE	.	80.25406-
33	CONCBAL6	BS	3263467.15370	1342122.83630	NONE	4626000.00000	.
34	CONCAVA7	UL	8105977.00000-	.	NONE	8105977.00000-	106.49806-
35	RUFFAVA1	BS	291268.74446	2351661.25554	NONE	3643130.00000	.
36	RUFFAVA2	BS	.	1362127.00000	NONE	1362127.00000	.
37	RUFFAVA3	BS	.	2058840.00000	NONE	2058840.00000	.
38	RUFFAVA4	BS	1225861.05000	2167605.95000	NONE	3393567.00000	.
39	RUFFAVA5	BS	607297.90556	5907702.09444	NONE	6715000.00000	.
40	RUFFAVA6	BS	1272476.27552	1648312.72448	NONE	3918748.00000	.
41	RUFFAVA7	BS	.	3734881.00000	NONE	3734881.00000	.
42	RSILAVA3	BS	.	424140.00000	NONE	424140.00000	.
43	RSILAVA4	BS	.	309716.00000	NONE	309716.00000	.
44	RSILAVA5	BS	.	1210669.00000	NONE	1210669.00000	.
45	RSILAVA6	BS	.	1043304.00000	NONE	1043304.00000	.
46	RSILAVA7	BS	.	765830.00000	NONE	765830.00000	.
47	TLBFROD1	EQ	105852.00000	.	105852.00000	105852.00000	1633.97152
48	TLBFROD2	EQ	78463.50000	.	78463.50000	78463.50000	1631.93152
49	TLBFROD3	EQ	570855.00000	.	570855.00000	570855.00000	1666.34726

EXECUTOR. MPS/360 V2-M10 PAGE 40 -

NUMBER	.ROW	AT	..ACTIVITY..	SLACK ACTIVITY	..LOWER LIMIT	UPPER LIMIT	DUAL ACTIVITY
50	TLBFROD4	EQ	136216.00000	.	136216.00000	136216.00000	1851.11726
51	TLBFROD5	EQ	143143.00000	.	143143.00000	143143.00000	1857.28152
52	TLBFROD6	EQ	384307.00000	.	384307.00000	384307.00000	1864.88152
53	TLBFROD7	EQ	2261336.00000	.	2261336.00000	2261336.00000	1887.21726
54	TLBFROD9	EQ	150000.00000	.	150000.00000	150000.00000	1856.14152
55	TLBFROD8	LL	3127084.00000	-	3127084.00000	NONE	1910.48152

C24

EXECUTOR. MPS/360 V2-M10 PAGE 41 - 81/143

SECTION 2 - COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT	REDUCED COST.
56	X11	BS	105852.00000	1.90000-	.	NONE	.
57	X12	BS	78463.50000	5.66000-	.	NONE	
58	X13	LL	.	43.78000-	.	NONE	8.48426-
59	X14	LL	.	59.20000-	.	NONE	50.15426-
60	X15	LL	.	71.60000-	.	NONE	36.39000-
61	X16	LL	.	81.36000-	.	NONE	58.57000-
62	X17	LL	.	67.80000-		NONE	62.65426-
63	X19	BS	88367.00000	24.47000-	.	NONE	.
64	X18	BS	63526.72469	78.28000-		NONE	.
65	X21	LL	.	5.46000-		NONE	4.28000-
66	X22	LL	.	1.80000-		NONE	.36000-
67	X23	LL	.	33.44000-		NONE	3.44426-
68	X24	LL	.	55.30000-	.	NONE	40.57426-
69	X25	LL	.	52.72030-	.	NONE	31.52000-
70	X26	LL	.	78.32000-	.	NONE	48.63000-
71	X27	LL	.	46.66000-		NONE	55.63426-
72	X29	BS	60633.00000	19.76000-		NONE	
73	X28	LL	.	78.13000-	.	NONE	5.07000-
74	X31	LL	.	22.25000-	.	NONE	53.76574-
75	X32	LL	.	17.26000-	.	NONE	43.81574-
76	X33	BS	264716.00000	1.80000-		NONE	
77	X34	LL	.	17.17000-	.	NONE	30.54000-
78	X35	LL	.	26.33000-	.	NONE	25.53574-
79	X36	LL	.	28.32000-		NONE	24.93574-
80	X37	LL	.	31.17000-		NONE	28.44000-
81	X39	LL	.	14.11000-		NONE	27.46574-
82	X41	LL	.	35.11000-	.	NONE	50.35574-
83	X42	LL		27.84000-	.	NONE	38.12574-
84	X43	BS	305238.00000	17.17000-		NONE	.
85	X44	BS	136216.00000	1.90000-		NONE	
86	X45	LL	.	26.33000-		NONE	8.26574-
87	X46	LL	.	23.00000-		NONE	7.33574-
88	X47	BS	1363510.00000	18.00000-		NONE	
89	X48	LL	.	52.67000-		NONE	1.43574-
90	X51	LL	.	34.64000-	.	NONE	66.09000-
91	X52	LL	.	30.51000-		NONE	54.06000-
92	X53	LL	.	28.33000-	.	NONE	27.32426-
93	X54	LL	.	28.33000-		NONE	40.59426-
94	X55	BS	143143.00000	1.90000-	.	NONE	
95	X56	LL	.	15.60000-		NONE	15.10000-
96	X57	LL	.	31.20000-	.	NONE	21.38426-
97	X58	BS	1799764.08682	45.07000-	.	NONE	
98	X61	LL	.	44.41000-		NONE	73.42000-
99	X62	LL	.	37.85000-	.	NONE	63.00000-
100	X63	LL	.	29.33000-	.	NONE	25.87426-
101	X64	LL	.	23.00000-		NONE	34.86426-
102	X65	LL	.	15.60000-	.	NONE	11.30000-
103	X66	BS	384307.00000	1.90000-		NONE	
104	X67	LL	.	32.00000-	.	NONE	27.76426-

129

EXECUTOR. MPS/360 V2-M16 PAGE 43 - 81/143

NUMBER	COLUMN	AT	ACTIVITY	INPUT COST	LOWER LIMIT	UPPER LIMIT	REDUCED COST
105	Z61	BS	1252652.16848	47.47000-		NONE	
106	Z71	LL	.	46.88000-		NONE	79.42574-
107	Z72	LL	.	43.73000-		NONE	70.11574-
108	Z73	LL	.	31.17000-		NONE	30.10000-
109	Z74	LL	.	18.80000-		NONE	32.20000-
110	Z75	LL	.	21.20000-		NONE	28.23574-
111	Z76	LL	.	32.80000-		NONE	33.43574-
112	Z77	BS	457826.00000	1.50000-		NONE	
113	FC1	BS	701615.00000	637.07000-		NONE	
114	FC2	BS	858384.00000	627.00000-		NONE	
115	FC3	BS	726776.00000	617.94000-		NONE	
116	FC4	BS	478800.00000	617.94000-		NONE	
117	FC5	BS	538306.00000	617.94000-		NONE	
118	FC6	BS	2427741.00000	617.94000-		NONE	
119	FC7	BS	607163.51542	617.94000-		NONE	
120	BC1	BS	407100.15485	85.00000-		NONE	
121	BC2	LL	.	90.00000-		NONE	5.31220-
122	CC4	BS	4718858.48283	174.40000-		NONE	
123	CC5	BS	2063348.43372	174.40000-		NONE	
124	CC6	BS	3383607.16370	174.40000-		NONE	
125	V11	BS	338281.22469	273.53000-		NONE	
126	V21	BS	.	273.53000-		NONE	
127	V31	LL		316.47000-		NONE	55.14218-
128	V41	BS	1229650.00000	316.47000-		NONE	
129	V51	BS	609727.04682	316.47000-		NONE	
130	V61	BS	1274304.18849	317.47000-		NONE	
131	V71	LL	.	316.47000-		NONE	57.72762-
132	W12	LL	.	5.73000-		NONE	3.28016-
133	W13	LL		26.50000-		NONE	10.57536-
134	W14	LL	.	40.63000-		NONE	9.21016-
135	W15	LL		41.68000-		NONE	1.13016-
136	W16	LL		55.54000-		NONE	16.91267-
137	W17	LL		61.24000-		NONE	48.15776-
138	W21	LL		5.73000-		NONE	8.16984-
139	W22	LL		20.45000-		NONE	4.96520-
140	W24	BS	126003.64905	24.97000-		NONE	
141	W25	BS	562360.31095	34.11000-		NONE	
142	W26	LL	.	44.17000-		NONE	7.94251-
143	W27	LL	.	56.76000-		NONE	46.11760-
144	W31	LL	.	23.63000-		NONE	40.60048-
145	W32	LL	.	12.22000-		NONE	25.74582-
146	W34	BS	726776.00000	16.18000-		NONE	
147	W35	LL	.	34.61000-		NONE	9.95704-
148	W36	LL		44.79000-		NONE	21.91716-
149	W37	LL		36.27000-		NONE	39.05000-
150	W41	LL	.	39.75000-		NONE	72.71048-
151	W42	LL	.	27.64000-		NONE	58.55542-
152	W43	LL	.	14.19000-		NONE	32.38000-
153	W45	LL	.	32.16000-		NONE	23.68704-
154	W46	LL	.	28.09000-		NONE	21.40714-
155	W47	LL	.	16.87000-		NONE	33.04000-

C25

EXECUTOR. MPS/360 V2-M16 PAGE 43 - 81/143

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
156	W51	LL	.	25.44000-		NONE	80.86344-
157	W52	LL	.	36.62000-		NONE	75.69679-
158	W53	LL	.	34.81000-		NONE	59.28295-
159	W54	LL	.	22.16000-		NONE	40.62295-
160	W56	LL	.	12.26000-		NONE	14.04010-
161	W57	LL	.	47.64000-	.	NONE	72.07295-
162	W61	LL	.	53.18000-	.	NONE	82.82324-
163	W62	LL	.	41.61000-	.	NONE	79.00460-
164	W63	LL	.	44.79000-	.	NONE	67.86246-
165	W64	LL	.	28.09000-	.	NONE	34.77266-
166	W65	LL	.	12.26000-	.	NONE	10.47990-
167	W67	LL	.	23.05000-	.	NONE	63.74280-
168	W71	LL	.	50.43000-	.	NONE	75.42048-
169	W72	LL	.	55.45000-	.	NONE	69.18582-
170	W73	LL	.	38.27000-	.	NONE	37.45000-
171	W74	BS	607169.51542	16.87000-	.	NONE	
172	W75	LL	.	47.64000-	.	NONE	22.20704-
173	W76	LL	.	29.09000-	.	NONE	15.43714-
174	Y12	LL	.	9.26000-		NONE	9.47531-
175	Y21	LL	.	9.26000-		NONE	8.04463-
176	Y41	LL	.	51.29000-		NONE	72.92737-
177	Y42	LL	.	40.73000-		NONE	62.58269-
178	Y43	BS	505561.00000	25.41000-		NONE	
179	Y45	LL	.	36.71000-		NONE	36.71000-
180	Y46	LL	.	34.04000-		NONE	34.04000-
181	Y47	BS	6105577.00000	36.64000-		NONE	
182	Y51	LL	.	50.61000-		NONE	72.24737-
183	Y52	LL	.	44.91000-		NONE	46.76269-
184	Y53	LL	.	41.65000-	.	NONE	16.24000-
185	Y54	LL	.	38.71000-	.	NONE	38.71000-
186	Y56	LL	.	23.14000-		NONE	23.14000-
187	Y57	LL	.	45.63000-		NONE	16.89000-
188	Y61	LL	.	64.73000-		NONE	86.42737-
189	Y62	LL	.	55.45000-		NONE	77.30268-
190	Y63	LL	.	42.53000-		NONE	17.12000-
191	Y64	LL	.	34.04000-		NONE	34.04000-
192	Y65	LL	.	23.14000-		NONE	23.14000-
193	Y67	LL	.	46.72000-		NONE	20.04000-
194	Z12	LL	.	24.60000-		NONE	24.60000-
195	Z21	LL	.	24.60000-		NONE	24.60000-
196	Z34	LL	.	54.02000-		NONE	54.02000-
197	Z35	LL	.	89.16000-		NONE	89.16000-
198	Z36	LL	.	115.39000-		NONE	115.39000-
199	Z37	LL	.	96.08000-		NONE	96.08000-
200	Z43	LL	.	54.02000-		NONE	54.02000-
201	Z45	LL	.	82.87000-		NONE	82.87000-
202	Z46	LL	.	72.38000-		NONE	72.38000-
203	Z47	LL	.	56.64000-	.	NONE	56.64000-
204	Z53	LL	.	65.16000-		NONE	65.16000-
205	Z54	LL	.	82.87000-		NONE	82.87000-
206	Z56	LL	.	40.91000-		NONE	40.91000-

NUMBER	COLUMN	AT	ACTIVITY	INPUT COST	LOWER LIMIT	UPPER LIMIT	REDUCED COST
207	257	LL		122.72000-		NONE	122.72000-
208	263	LL		116.35000-		NONE	116.35000-
209	264	LL		72.36000-		NONE	72.36000-
210	265	LL		40.81000-		NONE	40.81000-
211	267	LL		100.70000-		NONE	100.70000-
212	273	LL		56.06000-		NONE	56.06000-
213	274	LL		56.64000-		NONE	56.64000-
214	275	LL		122.73000-		NONE	122.73000-
215	276	LL		100.70000-		NONE	100.70000-
216	533	LL		33.33000-		NONE	33.33000-
217	544	LL		33.33000-		NONE	33.33000-
218	565	LL		33.33000-		NONE	33.33000-
219	566	LL		33.33000-		NONE	33.33000-
220	577	LL		33.33000-		NONE	33.33000-

C26

EXECUTOR. MPS/360 V2-M10 PAGE 45 - 81/143

RANGE

TIME = 0.02 MINS. ITERATION NUMBER = 80

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INVERT CALLED     TIME   0.02   CURRENT INVERSE ---- ETA-VECTORS ....71   ELEMENTS ...484   RECORDS .....1   ITERATION ....80
 BASIS ---- NO.OF ROWS .... 55   LOGICALS ........19   STRUCTURALS ....36   ELEMENTS ...137
  INVERSE -- NUCLEUS  ....  .0   TRANSFORMED .....0   ETA-VECTORS ....36   ELEMENTS ...118   RECORDS .....1   TIME TAKEN   0.00
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