NON-GM WHEAT SEGREGATION STRATEGIES: COMPARING THE COSTS

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PERMISSION TO USE

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ABSTRACT

Genetically modified (GM) wheat is expected to receive regulatory approval in Canada between 2003 and 2005. There may be a definitive portion of the supply chain for wheat set to realize the potential benefits of GM wheat. However, by September 2000, 18 countries and the EU, 21 food retailers, 29 food manufacturers and six restaurant chains around the world had announced intentions to introduce either mandatory or voluntary labelling requirements for genetically modified foods. Thus, to allow genetically modified varieties of crops to be grown in Canada, while maintaining access to export markets requesting labelling, crop segregation or identity preservation systems must be introduced.

The primary objective of the study was to compare the private and regional costs of three potential segregation alternatives, all of which utilize the bulk commodity infrastructure already established in western Canada to handle the segregation of non-GM wheat. The systems that were examined included the designation of a high throughput terminal, the designation of multiple small wooden elevators and lastly, the segregation of GM and non-GM wheat within terminals. The three options were analyzed under various GM adoption rates and volumes of non-GM wheat being demanded under the assumption that the low-cost option would be dependant on the availability of non-GM wheat in the region, as well as the amount of product requiring segregation.

A model was used that attempted to simulate the decision-making processes of producers in the region as well as methods used by the companies handling the segregation in their attempts to source the required amount of non-GM grain. The results of the model indicated that segregation within terminals was almost always the low-cost option. However, an analysis of the potential risk of contamination indicated that this option was most likely the least feasible option. An analysis of the remaining two options indicated that the low-cost option for the entire region would be to designate a high throughput terminal under any circumstances. The results of the study illustrate the importance of contamination risk when determining the low-cost segregation strategy. The results also illustrate that failing to include regional costs, including lost rail incentives and the inefficiencies of small elevators may lead to sub-optimal strategies.

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CHAPTER 1 - INTRODUCTION

1.1 Background

Genetically modified (GM) wheat is expected to receive regulatory approval in Canada between 2003 and 2005 (Rempel 2001). The agri-food industry is in the midst of a debate over what actions need to be taken to avoid the potential loss of valuable export markets. The current registration system will approve a variety provided it meets the scientific guidelines for registration. As a result, crop segregation and identity preservation (IP) systems will be required in order to maintain those markets that are requesting non-GM grain.

Genetic engineering involves the transfer of genetic material from one living organism to another through the use of sophisticated biotechnological techniques. The resulting organisms are considered to be genetically altered from their original state and thus are classified as genetically modified organisms (GMOs).

The first genetically engineered crop variety registered for commercial production in Western Canada were released in 1995. The product was an input-based, herbicide tolerant (HT) canola variety engineered to be resistant to the non-selective herbicide, Roundup™.

Many Canadian producers have recognized the potential benefits of GM crops and as a result have adopted them to a large extent in their farming practices. In its short life span, HT canola has quickly captured a large portion of the canola acres in Western Canada. In 1997, HT canola was grown on 25% of the total canola acres in the Prairie Provinces. This number steadily increased over the next three years to its current level of 77% of all canola acres grown (Phillips 2001).

The introduction of GM technology to those industries that supply food for human consumption has been met with mixed reaction. Although Canada has approved the introduction of GM varieties, many of its export markets, including the EU and Japan, have shown considerable resistance to the technology (Phillips and Foster 2000). From this comes the need to implement crop segregation strategies.

To facilitate large volumes of exports destined for countries all around the world, the Canadian grain industry relies on a commodity-based supply chain. This system is not geared towards low volume, highly specific grain shipments and thus, the requirement for segregation and IP systems may exert considerable pressure on the efficiencies of this system. However, with large levels of capital already tied up in the grain-handling facilities and the bulk system, grain-handling companies will have a significant interest in restructuring the system to meet the need for segregation and IP systems.

1.2 Problem Statement

By September 2000, 18 countries and the EU, 21 food retailers, 29 food manufacturers and six restaurant chains around the world had announced intentions to introduce either mandatory or voluntary labelling requirements for genetically modified foods (Phillips and Foster 2000). To allow genetically engineered varieties to be grown in Canada, while maintaining access to export markets requesting labelling, crop segregation or identity preservation systems must be introduced. Segregation and IP systems will add costs to all levels of the supply chain including primary production, grain-handling and transportation. These costs will be borne by consumers, producers or marketers of these crops. The extent and distribution of these segregation costs will influence the overall gains or losses from the introduction of GM varieties.

1.3 Objectives of the Study

The primary objective of this study is to examine and compare the costs of potential options for segregation while focusing on utilizing the bulk commodity infrastructure already in place in the prairie region. A simulation model is used to estimate the costs of segregation for three potential non-GM segregation strategies. The three systems examined include:

1) the designation of a high throughput inland terminal.
2) the designation of multiple small wooden elevators.
3) segregation within the inland terminals.

Variable adoption rates (20%, 50% and 80%) of GM wheat and variable demand (60,000, 120,000 and 180,000 tonnes) for non-GM wheat are imposed on the model in attempts to determine the optimal outcome given different potential scenarios. Specifically, the three main objectives of the thesis are to:

1) Compare the costs associated with three potential segregation systems for non-GM wheat, all of which utilize the grain handling infrastructure already in place in the region
2) Impose variable adoption rates and variable demands for non-GM wheat on the model to illustrate the impacts these factors have on the relative costs of each segregation option.
3) Identify the optimal strategy given each adoption rate/volume demanded scenario.

1.4 Scope of the Study

The thesis concentrates on only a portion of the supply chain for Canadian Western Red Spring (C.W.R.S.) wheat destined for export. The costs for segregation are estimated for producers and grain handlers in the region up to the point where the wheat is loaded on rail cars to be shipped to the port terminal. Although the requested tolerance for GM wheat in non-GM shipments is vital to the costs and feasibility of segregation, the thesis assumes tolerance levels are such that segregation is feasible. Similarly, the model also assumes that the segregation systems are effective and thus contamination risk is not factored into the simulation model. The model focuses on a specific region in southern Manitoba, which may or may not be reflective of the costs for other regions in western Canada.

1.5 Hypotheses

The move towards high throughput terminals in the grain-handling industry can largely be explained by the fact that there are gains to efficiency and lower average costs of operations compared to smaller elevators when large volumes of grain are being handled. In a segregation system, designating a terminal to handle non-GM grain may be effective if the quantity being segregated is large. Presumably, however, it would not be desirable to reduce the volume being handled at the terminal to a great extent. To designate small elevators would require them to be re-opened and may not be desirable for low volumes as the average cost of operating elevators is higher than the average cost of operating high throughput terminals. As a result, the hypotheses for the study are:

1) Segregation within terminals will be the optimal strategy for low volumes of non-GM wheat demanded. 2) Multiple designated points will become optimal as volumes demanded increase until a point where a designated terminal becomes the optimal strategy for high volumes demanded from the region. 3) The adoption rates will not affect the relative costs of segregation and the optimal strategy, but will impact the absolute costs.

1.6 Organization of the Study

The remaining chapters of the thesis are organized as follows. Chapter two introduces and discusses GMOs, focusing on their presence in the prairie agricultural region. Chapter three outlines the current supply chain for wheat in western Canada followed by a discussion surrounding the impacts segregation and IP systems will have on the future of the wheat supply chain. Included in this chapter is a review of the literature pertaining to the segregation of crops. Chapter four discusses the economic theory underlying the simulation model. Chapter five discusses the construction of the simulation model and how results were calculated. Chapter six presents and discusses the model results. Included in this chapter is a discussion on potential policy implications revealed by the study. Finally, Chapter seven summarizes the study and outlines its limitations. Also included in this chapter are recommendations for further research.

CHAPTER 2 –GENETICALLY MODIFIED ORGANISMS: AN OVERVIEW

2.1 Introduction

The advent of biotechnology has enabled scientists to genetically modify many of our food crops through genetic engineering. While genetic engineering has the potential to provide significant benefits to some Canadian producers, the use of these technologies in agriculture is being met with many concerns. While many of these transformations are awaited by many in the farm sector, some producers, many consumers and some citizens are worried about their effect on health, the environment, the industry, and society in general. It is possible that if Canadian producers are going to be able to grow these crops in the future, something will have to be done to structure the marketing system to segregate genetically modified crops from conventionally bred crops, in order to secure the markets that are concerned about the technology. This chapter lays out the situation facing the wheat industry as it considers the pending introduction of genetically modified, herbicide tolerant varieties in 2003 or 2004.

2.2 Biotechnology and GMOs

Biotechnology involves using biological processes to produce products for agriculture, the environment, industry and medicine (CFIA 2001a). One of the more recent developments in biotechnology is genetic engineering. This technique involves the transfer of a select piece of genetic material from one organism to another. This process is otherwise known as transgenic or genetic engineering. Through genetic engineering it is easier to introduce new traits without changing other desirable traits in the plant or animal (CFIA 2001a). It is also possible through genetic engineering to introduce desirable traits from outside the species, something that is not possible with traditional breeding methods (CFIA 2001a).

Genetic modification (GM) is achieved by changing the organization of genetic material of an organism. Over time, virtually all agricultural crops have been genetically modified through traditional breeding methods (Stevens 2000). More recently, genetic modification is being conducted by moving a gene or genes from one organism to another, also known as genetic engineering. Although genetic engineering, otherwise referred to as transgenics, is only a single arm of genetic modification, the two terms are often used interchangeably. For the purpose of this study, the term GM will be used to refer to the biotechnological process of genetic engineering while the transgenic products of this process will be referred to as genetically modified organisms (GMOs).

Genetic engineering got its start in the early 1970s when scientists discovered how certain enzymes could be used to remove specific genes from a DNA chain carrying genetic information. This allowed for the addition, deletion or modification of genes that control specific functions of an organisms. This also allowed genes that control desirable traits to be grown on tiny bacteria or viruses to then be transferred to plants of economic interest. Other research that has been conducted to aid in this procedure includes genome mapping of living organisms and marker assisted genetic modifications, which assist in the identification of desirable genes (Klein et al. 1998). These studies have provided a scientific basis for genetic modification and provided the tools scientists need to improve the characteristics of certain organisms by introducing selected beneficial traits. The first plant transformation was undertaken in 1984.

In North America, there are currently GM varieties registered for canola, soybean, corn, cotton, sugar beet, tomato, squash, potato and tobacco production. Research has also been conducted in the wheat and flax industries in Canada, and although one variety of flax was granted regulatory approval in 1995, GM varieties have not yet been grown commercially in either industry. GM wheat is expected to be registered for commercial production between 2003 and 2005.

2.3 The Issues Surrounding GMOs

The specific intent of those who conduct genetic engineering is to introduce varieties of crops with attributes or traits that will provide benefits to producers and/or consumers, as well as to remaining members of the supply chain. The traits being transferred into host organisms can be categorized as either input-traits or output-traits. Input-traits include herbicide tolerance, insect resistance and viral resistance which are aimed at providing a faster, more effective, and lower cost improvement to traditional methods of crop management.

Output-traits are those that are intended to provide a product with specific end-use characteristics that may garner a premium in the market. The specific end-use characteristics are in some cases used for industrial purposes, but in other cases may offer consumers improved nutritional or aesthetical characteristics (i.e. Golden Rice, Flavr-Savr tomatoes). Specific examples include specialty oils, pharmaceutical traits and nutraceutical traits to name a few.

There are a number of scientific aspects of genetic modification that are fundamental to the use of the technology that cause some concern among consumers and regulators. Similarly, public perception of the technology and its costs and/or benefits varies. The following section presents some of the scientific issues and public perception surrounding the technology.

2.3.1 Technical Aspects of GM Crops

As mentioned previously, input-traits are aimed at providing a faster, more effective, and lower cost improvement to traditional pest control methods. These traits include herbicide tolerance to chemicals that would normally kill the unmodified crop, internal insect resistance to common pests, and viral resistance to diseases that are often not possible to control.

Although herbicide resistance still requires the use of chemicals, very often the amount of chemical required decreases. An independent Monsanto study, for instance, indicated that Roundup Ready™ crops, the most common herbicide tolerant varieties used on the Prairies, require 10% to 40% less herbicide in total (Monsanto 1999). From an environmental perspective, the reduction of chemical use can be viewed as beneficial. In some cases, the chemicals being used are also less harmful than the alternative chemical options. Glyphosate, for use on Roundup Ready™ canola, is three times less toxic than synthetic herbicide alternatives and persists in the environment half as long (Heimlich 2000).

Insect resistance, most commonly in the form of *bacillus thuringensis* (Bt), is inserted into plants using genetic engineering techniques, thereby allowing those plants to express various forms of toxins that kill target insects (Stevens 2000). Bt toxins are very specific in the species they affect, and exhibit low toxicity to humans and other animals (McHughen 2000). In cotton, it has been estimated that there has been a reduction of two million pounds of insecticides that were traditionally used to control pests to which the plants are now resistant (Carpenter and Gianessi 1999). Once again, from an environmental standpoint, any reduction in the use of insecticides can be viewed as beneficial and in some cases the insecticides being reduced are among the more toxic.

Both the reduction in herbicides and insecticides can also be viewed as beneficial to human health, especially for those crops that see little processing between field and plate (i.e. fruits and vegetables). Also, the potential benefits of future output-trait varieties that are aimed at improving the nutritional composition of plants used in foods is viewed as beneficial from a human health standpoint.

2.3.2 Scientific Concerns

There are a number of scientifically-based concerns over the potential adverse effects of genetic modification, specifically related to food safety, the environment and the impacts on agricultural production. Scientifically-based food safety concerns surround the potential transfer of allergens and toxicants from one species to another through genetic modification. Environmental concerns include such issues as the out-crossing of herbicide tolerant traits into weed species, and the impact insect resistant plants might have on the non-targeted insect population. Agricultural production concerns relate to the ability to control herbicide tolerant volunteer plants and the potential for out-crossing of traits into noxious weed species.

Food safety is perhaps the most prevalent concern regarding GM crops. While there is no evidence of existing modifications causing any health impacts, some scientists express concerns about the potential transfer of allergens among foods. This problem could occur in the event that a gene from a known allergen like peanuts is introduced into another food product. For this reason, before any genetically modified micro-organism or plant is approved by Health Canada as a safe food, it must undergo a thorough assessment, which includes explicit consideration of potential allergenicity of the novel food (CFIA 2001b).

There was a case where research was being conducted in order to improve the quality of soybean meal as an animal feed. This involved the transfer of genetic material coding for a storage protein from a Brazil nut to soybean. Since the Brazil nut is known to cause allergic reaction, laboratory tests were conducted in order to determine whether an allergenic protein had been transferred to the soybean. The results of the laboratory tests showed that the gene obtained from the Brazil nut likely encoded the major Brazil nut allergen and research on this product was discontinued. The company did not officially apply for approval of this product, the product was never commercially developed and soybeans containing a Brazil nut protein were never available on the market (CFIA 2001b).

Also of great concern in relation to food safety is the increased use of antibiotic resistant marker genes in the GM process. This creates the fear that with the presence of antibiotic markers in food, humans will become more resistant to antibiotics, thus reducing their effectiveness to fight illnesses (Hobbs and Plunkett 1999).

From an environmental standpoint, the concern over the out-crossing of herbicide tolerant traits to weed species is legitimate, but often over-emphasized (Stevens 2000). It is not surprising, however, that this concern exists when there are cases, such as the one in Alberta in the spring of 2000, where multiple herbicide resistance has appeared in a field. In this case, a volunteer canola plant showed resistance to three novel trait herbicides, namely Roundup™, Liberty™, and Odyssey™ (MacArthur 2000). These traits are bred into plants independently thereby indicating that out-crossing must have caused the multiple-resistant volunteer plant to appear. Scientifically, this concern is never disputed, however, in order for out-crossing to weed species to occur, the weed must be a wild relative of the modified crop (Stevens 2000). In the wild, the passing of herbicide tolerance to weeds may not be a concern, as herbicides are not sprayed in unmanaged environments (Stevens 2000). In a producer's field, however, this may cause problems if different management practices are required to control the weed in question. Problems like this also cause concern among producers who fear that production costs may increase if weeds and volunteer plants become harder to kill in the future should the resistance traits move freely among plants.

Concern surrounding insect resistance and the Bt technology has to do with the impact these plants will have on non-targeted insects. A laboratory study conducted by John Losey reported the death of 44% of Monarch larvae that were fed genetically modified Bt maize pollen, while those that were fed ordinary pollen survived (Losey et al. 1999). The scientific relevance of this study has frequently been questioned. The fact of the matter is, however, Bt will kill insects and in the event that a non-target insect eats a plant or pollen containing the Bt trait, there is a chance it will die. The question then becomes whether or not non-target insects will be consuming plants or pollen with the Bt gene. In the Bt corn example, subsequent field trials have shown that Monarch larvae are seldom in, or near pollinating corn fields, and so the risk is likely less than for other pest control options. Other species in other crops may face different situations.

2.3.3 Public Perception

Similar to the scientific issues surrounding GMOs, public perception is split between support and concern. There is evidence that objections to the technology focus on specific applications of the technology, rather than genetic engineering per se (Frewer et al. 1997).

A Canadian survey by Decima Research in 1993 showed that consumer attitudes toward gene transfers differ between plant-to-plant transfers (more acceptable) and animal-to-human transfers (least acceptable) (Decima Research 1993). There is also a greater acceptance of medical applications (particularly those leading to development of medicines and vaccines) than there is for food biotechnology products. (Einsiedel 1997). The majority of Canadians are prepared to accept "unintended" risks and surrender ethical concerns about biotechnology as long as they lead to benefits in health, medical care and the environment (Pollara and Earnscliffe 1999).

More recently, in an Angus Reid World Poll (Angus Reid 2000), consumers were asked about the perceived benefits or advantages of the technology. The results revealed that respondents associate benefits with genetically modified foods to be production related. In total, 31 per cent of consumers believe that the main benefits involve improved efficiency or higher yields in production, followed by better food quality mentioned by 15 percent and fewer pesticides mentioned by another 15 per cent. As well, one in ten consumers cited improved nutritional value as an advantage or benefit (Angus Reid 2000).

Consumer opposition to genetically modified foods is driven in part by the uncertainty about possible negative health and environmental effects and a widespread perception that the biotech industry and farmers are the primary beneficiaries of agricultural biotechnology (Angus Reid 2000).

According to the Angus Reid World Poll (Angus Reid 2000), when consumers were asked about perceived risks associated with genetically-modified foods, 31 per cent of consumers cited food safety and health concerns. An equal proportion (30 %) also said that they were concerned about the unknown impact and experimental nature of GM foods (Angus Reid 2000).

Fear of unknown human health consequences also plays a very large role in the debate over GMOs (Hobbs and Plunkett 1999). Because this is a new technology, many consumers are concerned over the long-term effects of consuming GM food. Many ask: how can anyone be sure that consuming GM food today won't cause health problems years down the road?

Ethical concerns arise due to the fact that scientists have the ability to conduct procedures that have only occurred naturally for all of history (Hobbs and Plunkett 1999). Some non-GMO advocates feel that scientists shouldn't be tinkering with what "God" intended.

Lastly, increased corporate control of the food supply has been raised as a concern in the debate over GMOs (Runge and Jackson 1999). With large multi-national corporations, including Monsanto and Aventis, owning the rights to these technologies, some producers fear that in the future they may be faced with a situation where they have less control over what they are able to produce. Consumers are also concerned with this issue, as they fear that with increased control of the food supply, the price they pay for food could increase or their choices could be reduced.

2.3.4 Externalities

The scientific and public debates about the use of biotechnology to create GM crops indicates that the introduction of GM wheat could pose serious challenges to the participants of the supply chain for wheat. These differences in the perceived costs and benefits of GM crops have the potential to cause consumers to value GM and non-GM wheat differently, creating externalities in the marketplace. Externalities are costs or benefits that flow between economic agents with incomplete compensation or remuneration (Gray et al. 2000). Positive externalities exist where a good generates benefits that are not being fully paid for in the market place (Gray et al. 2000). For example, a producer pays for all of the inputs required to produce GM crops, but is not required to pay for the potential benefits they provide to the environment. Negative externalities exist when some cost is imposed on other members of society without compensation (Gray et al. 2000). For example, a farmer growing Bt crops will not pay if the non-targeted insect population is affected.

Gray et al. (2000) identify that the externalities associated with GM crops consist of human health externalities, ecosystem externalities, reduced demand for undifferentiated non-GM products, marketing/segregation externalities, production cost externalities and information cost externalities.

Human health externalities could arise in the event that GM crops, or foods containing GM crops result in either positive or negative health impacts to consumers. Positive health externalities could potentially arise considering the fact that GM crops may require less chemicals as well as use less harmful chemicals. Negative health externalities could result if GM foods are detrimental to human health (i.e. contain allergens or otherwise). In each case, the consumer realizes a cost or benefit from the consumption of GM food. Depending on the market (i.e. the presence of premiums and discounts), the producer may or may not pay for or receive compensation for these costs and/or benefits.

Ecosystem externalities associated with GM crops could potentially be positive or negative as well. These externalities could include changes in the social use value of the environment for recreation or hunting purposes, and non-use values such as aesthetics or existence values (Gray et al. 2000). A reduction in chemical use may result in a positive externality to the environment if it increases its value for those who use it (Gray et al. 2000). A negative externality may result if GM crops result in a change to the environment which makes it less desirable (i.e. if the non-target insect population is damaged by Bt crops). In each case, the producer would not pay for, or receive compensation for the impacts GM crops they produce have on the environment.

Reduced demand for undifferentiated non-GM products (reduced demand externality) in the presence of GM products is perhaps the issue that concerns the entire wheat market the most. This externality can be explained using Akerlof's market for "lemons" theory (Akerlof 1970). Adverse selection is the basis for Akerlof's theory and can be defined as the potential for hidden information prior to a transaction (i.e. the seller may have more information than the buyer) (Gray et al. 2000). In Akerlof's analogy of the used car market, if the buyer is unable to distinguish between a good car and a "lemon", they will not be willing to pay the "good car" price, thereby resulting in a market in which only "lemons" are sold (Akerlof 1970). In the wheat market, if a buyer with a demand for non-GM wheat is unable to distinguish between GM and non-GM, they will not be willing to pay the non-GM price. The buyer may also choose not to buy any wheat with the potential that it may contain GM varieties. In such cases, the market for both GM and non-GM wheat is impacted as consumers will buy products other than wheat, or wheat from nations where GM products are not being grown.

Marketing/segregation externalities are associated with the costs involved with distinguishing between GM and non-GM product. If GM producers do not have an incentive to segregate and distinguish their product (i.e. premiums in the market), their existence may force non-GM producers to segregate their product to distinguish it from lesser-valued GM products (Gray et al. 2000). This would be considered an externality as the costs associated with segregating are paid by the non-GM producers and are thus outside the GM market (Gray et al. 2000).

Production cost externalities are associated with the potential that non-GM producers may have increased production costs due to the existence of GM varieties (Gray et al. 2000). This relates to the potential for out-crossing of traits that was discussed earlier. If a non-GM producer has a field in the close vicinity to GM crops, out-crossing of herbicide tolerant traits has the potential to increase the costs of production for the non-GM producer. In the event that out-crossing occurs, the non-GM producer may be required to change his management practices to control the GM plants, which may result in higher costs.

Lastly, information cost externalities arise if consumers must incur costs to obtain and process new information (Gray et al. 2000). If consumers are uncertain as to the potential positive and adverse effects of GM crops, and are unable to distinguish between GM and non-GM products visually, there may also be costs associated with the need for public and private resources to produce and communicate the information (i.e. labelling) (Gray et al. 2000).

The existence and magnitude of externalities in a market that contains GM products may result in the need for government and industry intervention to address these issues. The decision whether or not to intervene depends on the nature and magnitude of the externalities and the costs associated with intervention (Gray et al. 2000). Potential strategies to address the presence of externalities will be discussed later in the chapter.

2.4 Producer Response

Many Canadian producers have recognized that there are potential benefits to growing GM crops and as a result have adopted them to a large extent in their farming practices. In Canada in 1999, GM corn made up 44% of the total corn acres (Roederer et al. 2000). Similarly, novel trait canola varieties (approximately 70% of which are transgenic) accounted for approximately 77% of the Western Canadian Canola acreage in 2000 (Phillips 2001). The share of GM soybean acres is much lower at 10% of total acres planted (Roederer et al. 2000). The rapid and relatively large adoption of canola compared to corn and soybeans can possibly be explained by two key factors. First, broad-spectrum weed control is a desirable option in canola production as the alternatives are either considerably higher cost or don't have the same level of control. Second, the market for canola does not take into account GM versus non-GM production. In other words, the two are not segregated and the price is the same for both. In corn and soybeans, there has been some segregation taking place to take advantage of premiums for non-GM production in the market (Bender et al. 1999). Therefore, the potential benefit may be reduced with premiums for conventional varieties.

The only other agricultural crop to be genetically modified in Canada was flax. In 1996, CDC Triffid, a GM linseed flax variety received regulatory approval in Canada and the United States. The variety had the potential to benefit producers in that it was designed to allow flax to be grown on herbicide contaminated soil that would normally not support the growth of flax (McHughen 1996). This variety, however, was never approved for use in the United Kingdom. Due to concerns over the loss of the European market (equal to approximately 60% of Canada's total export market over the 1989-1998 time period (Canada Grains Council 1999)), the release of CDC Triffid into commercial production was postponed. In 2001, due to increasing producer concerns, the registration of CDC Triffid was cancelled (CFIA 2001c).

As can be seen by the flax case, market concerns may prompt producers to become more concerned over the issue of whether or not to grow GM crops. This may be a cause for the levelling off of GM varietal use after rapid increases through the late 1990s. In the future, if producers become even more wary of GM varieties and marketing problems, there may be a decline in the number of acres allocated to transgenic crops.

2.5 Consumer Response

As illustrated by the section on public perception, consumer opinion in Canada is split between approval and resistance. Many consumers are concerned with the technology and would like the option to choose whether they will consume food containing GMOs. Canadian consumers in general have been more accepting than consumers in other countries. Angus Reid (1999) reports that although still positive, it appears that acceptance in Canada may be on the decline. Einsiedel (2000) notes that although Canadians remain "cautiously supportive" of biotechnology, optimism has declined since 1997. However, researchers have found that in assessing attitudes towards different food safety issues in Canada, pesticide and chemical residues along with bacterial contamination of food are regarded as bigger food safety threats than GM food (Hoban 1999, Einsiedel 2000).

Away from the domestic market, eighteen countries plus the EU, 29 food manufacturers, 21 food retailers and six restaurant chains around the world have signalled intentions to adopt voluntary or mandatory labels for GM foods or to eradicate GM ingredients (Phillips and Foster 2000).

2.6 Strategies for the Wheat Market

There is scientific evidence to support the assertion that there are potential benefits of GM crops. As a result, if GM varieties are offered to producers, adoption is likely to take place (to some degree). Nevertheless, public perception and scientifically-based concerns, have the potential to result in non-market externalities associated with the GM market. This section outlines three potential strategies available to the Canadian grain industry to coincide with the potential registration of GM wheat. These strategies include; 1) allowing the market mechanism to work, 2) government and industry intervention to regulate the existence of GM crops, and 3) segregation of either non-GM production or GM production.

The first, and perhaps least desirable strategy, would be to allow the market mechanism to determine the fate of GM wheat in the market. The problem with using the market to determine the desirability of these products is that it may ignore the presence of externalities (Gray et al. 2000). If the benefits are such that producers adopt

GM wheat, the result may be non-market externalities which negatively impact non-GM producers, consumers and the environment. The concern is more centred around the potential for negative externalities as compared to positive externalities as they deal with costs (as opposed to benefits) that will be incurred by other members of the supply chain and society.

The second strategy involves government or industry intervention to regulate the existence of GM crops. To address all potential negative externalities may require that the production of GM crops be restricted to a certain level, or banned completely. Restricting production to a certain level, or completely banning GM wheat would require changes to the current registration policies already in place in Canada. While assessing this option, one must consider the potential positive externalities, which would be forgone if new GM varieties are restricted.

In Canada, the organizations responsible for assessing and registering crop varieties are the Canadian Food Inspection Agency (CFIA) and Health Canada. Over time, these organizations have established science-based guidelines for the registration of plants with novel traits and subsequently registered varieties that met those guidelines (CFIA 2001d). Health Canada assumes responsibilities for the safety assessment of novel foods, including foods derived through genetic engineering. CFIA is responsible for assessing the potential risk of adverse environmental affects as well as the safety of crops for feed use (Health Canada 2001). Upon completion of these assessments, the two organizations grant regulatory approval based on acceptable results and varieties are then submitted to a varietal registration committee. Registration is then determined using the guidelines for novel trait varieties.

Currently, the regulatory system takes no consideration of non-scientific of commercial harm when varieties are being considered for registration. The only consideration for "harm" exists where the delivery of a variety in which the biochemical or biophysical characteristics distinguish it from the majority of registered varieties of the same kind or species, may have an adverse effect on the identity of traditional registered varieties (CFIA 2000). For these circumstances, a contract registration has been developed that requires the applicant to submit a quality control system that describes how any and all potentially adverse effects of the variety will be managed. The problem with relying on this provision to address the marketing and reduced demand externalities of GM wheat, is that GM varieties may or may not have different biophysical or biochemical characteristics compared to other varieties in their class. Also this provision will not prevent GM varieties from being registered, but will simply require them to be segregated. Therefore, to ban the registration of GM wheat will require even further changes to the varietal registration policy.

Lastly, in the event that contract registration is not required (thereby enforcing segregation for quality control), segregation and labelling of either non-GM or GM wheat would be an effective means to address a number of the non-market externalities discussed earlier. Segregation could be either voluntary (with the existence of premiums) or compulsory.

Compulsory segregation may result if the contract registration provision discussed earlier is expanded or changed to take into consideration the potential for commercial harm based on consumer preference (i.e. the reduced demand externality). If compulsory segregation is imposed on GM production, a number of negative externalities may be eliminated. The reduced demand for undifferentiated non-GM products may no longer be a concern if consumers are confident in the system and are confident that the non-GM product they are buying is free from GMOs. Also, the marketing/segregation externalities are no longer a concern as non-GM producers are no longer required to incur the costs of segregating their production. Also, a portion of the information cost externalities may be eliminated as consumers would now have a label that would indicate the presence or absence of GMOs in their food.

A voluntary segregation system for GM varieties will only exist if there is a premium for the GM product and thus an incentive to keep it separate from non-GM product. As soon as the premium disappears, at any level of the supply chain, there will be no longer be an incentive to segregate and most likely the voluntary segregation system will break down. The voluntary segregation of GM products would eliminate the same externalities as compulsory segregation of GM products, however, there is presumably a much higher risk of contamination in this system, in which case the reduced-demand externality may once again arise (i.e the market for "lemons").

Lastly, voluntary segregation of non-GM wheat would address the reduced demand externality, but would directly result in the marketing/segregation externality discussed previously. This segregation strategy is analyzed in this study. The costs that are estimated in the study reflect marketing/segregation externality costs as non-GM producers and the non-GM supply chain are bearing the costs of segregation.

2.7 Summary

Genetic engineering has the potential to provide significant benefits to some Canadian producers. However, the use of these technologies in agriculture is being met with many concerns. This chapter discussed some of the benefits and outlined a number of concerns. One can be left with the feeling that if Canadian producers are going to be able to grow these crops in the future, something will have to be done to secure the markets that are resisting the technology. The next chapter discusses the options for the Canadian grain industry to remedy this problem.

CHAPTER 3 -THE SUPPLY CHAIN FOR WHEAT: NOW AND IN THE FUTURE

3.1 Introduction

To facilitate large volumes of exports destined for countries all around the world, the Canadian grain industry has traditionally relied on a bulk commodity-based supply chain. For many years, the CWB purchased grain from farmers based on a single 13.5% protein requirement for #1 CWRS wheat (Giannakas et al. 1999). During this time, the bulk system was for the most part effective as elevators were dealing with large volumes of each specific grade. For a brief period after 1988, protein premiums were paid in .5% increments with higher protein content receiving higher premiums. This resulted in a need for a greater number of storage bins to handle smaller volumes of more specific grades. In 1999 the CWB began paying protein premiums based on a .1% scale, which once again increased the need to have a greater number of lower-volume storage bins (Hanson 2001).

In 1985, there was a total of 12 possible segregations for wheat. By 1995, this total increased to 68 possible segregations (CGC 1998). Genetic modification, and the segregation requirements that come with it, has the potential to double this number. As a result, the system has begun to adapt in order to handle increased segregation requirements.

The increasing reliance on segregation in an industry that previously relied on bulk handling of commodities will require a number of changes to the supply chain. Strict requirements involved in guaranteeing quality exports demanded by importing nations will introduce a number of issues, including closer monitoring of producer activities, contractual relationships and in some cases investments in new handling equipment. An overview of the wheat supply chain currently in place in Canada is presented in the following section, followed by a discussion of options for the future of the supply chain for wheat.

3.2 Wheat Industry Statistics

The wheat industry in Western Canada is a substantial and important industry. Between 1989 and 1999, Western Canadian farmers designated on average 24 million acres of cropland per year for the production of spring wheat (not including durum) (Canada Grains Council 1999). This equates to almost half of the 55 million acres of cropland on the Prairies (not including summerfallow). As a result, annual production over the same time period has averaged approximately 21.5 million tonnes. While this is small in the context of world production, which has averaged 580 million tonnes over the past ten years (Canada Grains Council 1999), due to minimal domestic requirements, Canada's presence in the export market is much more substantial.

World wheat trade between 1989 and 1999 has averaged approximately 112 million tonnes (Canada Grains Council 1999). Canadian exports make up close to 15% of world trade with approximately 16 million tonnes exported annually, equal to 74% of domestic production (Canada Grains Council 1999). Canada exports wheat to approximately 75 countries around the world. Eight of these countries alone import over half of Canada's exports, with the remaining countries importing anywhere from 1,000 to 500,000 tonnes each year (Canada Grains Council 1999). Canadian Western Red Spring wheat makes up the majority of wheat exports with approximately 13.5 million tonnes exported annually. Once again, eight countries alone make up over half of Canada's total CWRS exports (Canada Grains Council 1999).

3.3 The Current Supply Chain for Canadian Bread Wheat

The supply chain for CWRS wheat in Canada involves a number of distinct stages. The chain begins with research and development, advances through seed multiplication, production and handling stages at which point the wheat reaches the processor or export position. The following section outlines the key players involved in the chain and discusses their roles and responsibilities.

3.3.1 Development and Registration

The majority of wheat varieties currently grown in western Canada have been introduced by public institutions. These include universities and government organizations that use a combination of public and private investment to conduct their research. As the first link in the supply chain, these institutions are responsible for conducting research and submitting varieties to the registration committee.

The wheat registration system in Canada is based on the kernel visual distinguishability (KVD) system. This system was introduced to facilitate wheat classification at the point of delivery and forms part of the basis for registration policies in Canada.

There are two main features of the KVD system. First, each of the seven wheat classes is assigned a combination of seed-coat colour, and physical kernel configuration that is distinctive. The differences have to be great enough to permit grain inspectors to readily distinguish one type of wheat from another as they move through the supply chain. A second part of the KVD system that is important is the stipulation that a variety of wheat with the kernel shape of one of the wheat classes will have specific quality characteristics (CWB and CGC 2000).

The KVD system, in its ability to allow classification at the point of delivery through visual inspection, effectively aides in the role of blending. Through KVD, elevators in the bulk system are able to blend two lots of grain in confidence that the end product of blending will have identical end-use characteristics and specific quality characteristics as each lot had prior to blending. The ability to blend provides the elevator agent the potential to generate additional profits. Profits from blending can be achieved by adding grain of lower grades to grain of higher grades until the combined grain meets the maximum allowed under the grade standard (Giannakas et al. 1999). Profits can also be generated by blending a lot that lies between the grade standards with another lot (of lower quality) such that the blended output lies at, or just above, each grade increment (Giannakas et al. 1999). The presence of GM wheat in a market where GM and non-GM are valued differently will remove the confidence instilled by the KVD system. Due to the fact that GM wheat in a specific class looks identical to non-GM wheat in that class, elevator agents will no longer be able to simply visually inspect the two lots being blended, but will be required to conduct tests to determine if one of the lots contains GM varieties.

The final registration requirement for CWRS varieties specifies that any variety submitted for registration must equal the end-use quality characteristics of the standard variety for its class. This limits the number of varieties that are registered and maintains high quality standards by requiring that varieties with superior performance in one area must also meet the minimum requirements of all the other characteristics of the standard and must maintain the KVD for the class (CWB and CGC 2000).

3.3.2 Seed Multiplication

Production and multiplication of seed for wheat varieties currently grown in Western Canada is conducted by members of the Canadian Seed Growers Association (CSGA). Members of the CSGA are responsible for the production of pedigreed seed including breeder seed, select seed, foundation seed, registered seed, and lastly certified seed. Certified seed is the terminal pedigreed class, which is grown commercially by farmers. Pedigreed seed production ensures a clean and genetically pure seed source that is important for such factors as yield, quality, disease resistance and morphological characteristics. By setting strict land and isolation requirements, the CSGA is able to ensure these objectives are met and producers are receiving a clean and genetically pure seed for commercial production (CSGA 2001).

3.3.3 Production

Producers are the next link in the supply chain. They are responsible for growing certified seed varieties in attempts to produce and ensure a quality product for export. Through sound agronomic practices and with the help of the KVD system, Canadian producers have built a solid reputation among foreign buyers for producing a consistently high quality product. Producers in Canada are responsible for on-farm storage of wheat until the Canadian Wheat Board (CWB) introduces a quota call for it. The on-farm storage capacity in Western Canada is approximately 62 million tonnes (Westac 1998).

3.3.4 Transportation

Transportation from farm to primary elevators is either handled by producers or trucking companies. The rationalization of the grain elevator system has resulted in longer hauling distances required to get grain from the farm to primary elevators. As a result, there has been a move towards more custom grain hauling and less producer movement. Trucking companies involved in custom hauling most commonly move grain in 40 tonne shipments from the farm to the elevator. It is becoming very common to see grain-handling companies organize custom hauling for the producer.

CP Rail and CN Rail handle transportation from primary elevators to export position, depending on which line the elevator is located. Both companies offer rail incentives based on the number of car spots present at any given delivery point. The rail incentives are $6/tonne for 112 car spots (100 for CN), $4/tonne for 56 car spots (50 for CN) and $1/tonne for 25 car spots. This incentive is geared towards compensating the delivery point for a portion of the cost savings from not having to assemble unit trains.

3.3.5 The Canadian Wheat Board

The Canadian Wheat Board is the agency that handles the marketing of all wheat and barley intended for domestic human consumption as well as exports. The CWB acts as a single desk seller and represents farmers selling their wheat into export markets.

The CWB advocates that, acting as one body, farmers have a much stronger position in the market. The CWB pays farmers a pooled return for their grain. This ensures that all farmers receive their share of CWB sales proceeds and they do not face the risk of selling at the bottom of the market (Arason 2000).

3.3.6 Grain-Handling

The CWB handles grain through a network of twenty-three different grain-handling companies. The Canadian grain-handling system is comprised of four components (CFIA 1999). Each component has duties and responsibilities for moving grain through the system efficiently and cost-effectively.

The first component, referred to as primary elevators, is responsible for receiving grain directly from producers for storage or immediate forwarding. This portion of the grain handling infrastructure has undergone vast changes over the past three decades. The number of primary elevators on the prairies has decreased from over 5000 in 1971 to less than 1000 today, while the average capacity of those elevators has increased from approximately 2000 tonnes to over 8000 tonnes (CGC 2001). As of January 17, 2001, there were 804 licensed primary elevators with a total capacity of 6,806,090 metric tonnes (CGC 2001). The majority of the elevators being closed are older wooden elevators, which are being replaced by high throughput terminals. This trend is expected to continue until very few, if any, small wooden elevators remain.

At primary elevators, agents conduct the necessary testing procedures required to classify and grade the grain they receive. This is done through visual inspection (KVD) as well as with sophisticated machinery, i.e. near infrared spectroscopy, which indicates protein content. Primary elevators are located throughout the prairie agriculture region.

Grain is transported from primary elevators on the prairies to either processing facilities or port terminals. Grain may move to a process elevator if its intended use is domestic consumption or to be exported as a processed product. If grain is intended to be exported as raw product, port terminals become the next link in the chain. Port terminals are located at Thunder Bay, Churchill, Prince Rupert and Vancouver.

Thunder Bay terminals clean, dry, store and ship grain and serve as the junction centre between the prairies and the eastern seaway. The Churchill terminal is used for summer shipment of grain and therefore has limited grain flow annually. Vancouver and Prince Rupert terminals receive grain by train and have similar duties to terminals at Thunder Bay. During peak export months, however, the responsibilities of these terminals may differ in relation to terminals at Thunder Bay. During this time, utilizing inland terminals for cleaning and drying rectifies congestion problems caused by transportation bottlenecks like the Rocky Mountains (CFIA 1999).

The next link in the grain-handling system for raw product depends on the location of the port terminal. Most of the grain moving through the Thunder Bay port terminals is shipped by train or boats to transfer elevators located along the Great Lakes or the St. Lawrence River (CFIA 1999). The remainder is exported directly to overseas customers by ocean vessels (CFIA 1999). Transfer elevators are used to store, weigh, inspect and grade grain before it is finally loaded onto ocean going vessels. During winter months, grain may be shipped by train from transfer elevators along the Great Lakes and St. Lawrence to other transfer elevators in Montreal, Quebec City, Trois Rivieres, St. John and Halifax in order to be loaded onto ocean going vessels (CFIA 1999).

3.4 The Future of Supply Chain Management in the Wheat Industry

Although the traditional commodity market remains dominant in the grains industry, technological developments like genetic engineering, along with increasing demand for highly-specific shipments of grain, are adding pressure for increased reliance on other forms of co-ordination. In the past, specialty grains such as lentils and chickpeas have been passed from the producer to processor using something other than the traditional commodity market. Trends in the wheat, canola and barley industries appear to be moving in this direction as well, with the introduction of IP systems for high erucic acid rapeseed (HEAR), malting barley, AC Karma wheat and Warburtons wheat (CGC 1998). The occurrence of specialty or IP grains is expected to continue to grow (Duval and Biere 1998).

The introduction of genetically engineered wheat varieties appears to be consistent with this trend. As mentioned in chapter 2, a number of importing nations have begun to implement labelling strategies. The result is a need to preserve the identity of varieties that they are demanding (i.e. non-GMO). In the future, however, even if consumer resistance to genetically engineered varieties diminishes, the need for segregation and identity preservation will not disappear. The trend towards smaller, more specific shipments of wheat to importing nations is growing as demand for specific quality increases.

3.4.1 Labelling

Labelling of food allows the transformation of product characteristics consumers are unable to evaluate, referred to as credence attributes, into search attributes that consumers can learn about by inspecting a product prior to purchase (Caswell 1998).

With labelling of attributes that are important to a consumer's purchase decision, the consumer can make an informed decision about what foods they will purchase. Credible labelling of GM foods requires that the product be segregated throughout the supply chain. As a result, agriculture industries in a number of countries, including Canada, have recognized the need to implement crop segregation and IP systems.

3.4.2 Segregation and Identity Preservation Systems

There are a growing number of crop segregation and identity preservation systems emerging in the agriculture industry. In Western Canada, there have been identity preservation systems established for special crops like lentils and chickpeas, as well as for more traditional crops like canola, barley and wheat to name a few. The aforementioned IP systems in the wheat, barley and canola industries can be used as examples to illustrate reasons for the increasing occurrence of these systems.

AC Karma wheat is a Canada Prairie Spring White (CPSW) wheat variety that has improved quality for certain Asian noodle products compared to other varieties in its class. With the potential for premiums from the Asian market, the need to segregate to ensure a specific quality was required (CGC 1998).

With perceived variability in end-use characteristics within and between shipments of CWRS wheat from Canada, Warburtons, a baker in the U.K., conducted its own research into which varieties, or blends of varieties, worked best under its breadmaking system (Kennet 1997). Their results concluded that a blend of three CWRS varieties, namely Teal, Pasqua and Columbus, was the best formula for their baking needs (Kennet 1997). As a result, they have developed an IP system alongside the CWB and two Canadian grain companies (Paterson and Agricore) which ensures the shipments of wheat they receive from Canada contain only the three desirable varieties outlined (Kennet 1997).

For many years, malting barley customers insisted on receiving malting barley on a variety-specific basis (CGC 1998). Therefore, to meet these customers needs, and to ensure the grain they receive meets their specifications, the CWB operates an IP system for malting barley (CGC 1998).

High erucic acid rapeseed (HEAR), which contains 50% erucic acid (compared to 2% in canola) is used in the production of oleochemicals, such as erucamide (a component of Olestra) and polyethylene films (CGC 1998). Shipments of HEAR varieties can be contaminated if mixed with traditional canola varieties (edible oil varieties). Likewise, canola shipments can be contaminated if mixed with HEAR varieties. The second contamination potential, that which sees commercial harm to the traditional marketing channel if HEAR varieties are present in the shipment, resulted in the registration of HEAR under the contract registration provision. As discussed previously, this required the establishment of an IP system prior to the registration of the varieties.

More recently, with the need to separate non-GM and GM varieties, these systems are becoming more prevalent. Along with their emergence, a number of studies have been conducted examining the added costs involved with implementing the systems. Attempts have also been made to determine the most efficient system available given varying circumstances. Finally, a number of studies have looked at the feasibility of proposed systems to determine whether the current supply chains can be altered to effectively support such plans. A variety of research studies have estimated the range of system costs between Cdn. $10 and Cdn. $55 per tonne (Roederer et al. 2000).

3.4.3 Contamination Concerns

Crop segregation and IP systems require close management of all links in the supply chain where potential contamination could occur. A report prepared by the Canadian Grain Commission (CGC) (1998), which doesn't focus directly on the GM/non-GM issue, outlines the critical points where monitoring and enforcement are required to ensure contamination is prevented. Their proposed system begins by outlining that breeders/owners, the registration system and seed growers are all responsible for ensuring that the initial seed grown is of a guaranteed quality. The system also includes a contract facilitator who would be responsible for having a variety-specific delivery and/or a production contract for the commodity in question. Finally, the system advances through producers, primary elevators, transportation companies and port/transfer terminals outlining which member of the supply chain would bear the responsibility of preventing contamination and who would be liable should contamination occur.

Although the system proposed by the CGC includes the primary elevator infrastructure and other components of the Canadian bulk grains system, the control points should not change considerably if a containerized system is implemented. Reichert and Vachal (2000) allude to this in their report that compares containerization and the traditional bulk system. Their study reveals that containerization modifies the chain by allowing the product to bypass certain critical points where contamination could occur. The number of points being bypassed in a system of this nature depends on where the grain is loaded into containers and the mode of transportation used.

3.4.4 Potential Segregation Scenarios

Roederer et al. (2000) identify three potential IP situations within the context of GMOs: voluntary IP of GM products, voluntary IP of GMO-free products and compulsory IP for GM products. Each segregation alternative outlined in their report has been analyzed in various studies by other authors to determine feasibility and system costs (Bender et al. 1999, Buckwell et al. 1999, Phillips and Smyth 1999, Lin et al. 2000, Maltsbarger and Kalaitzandonakes 2000, Reichert and Vachal 2000). While some of these studies utilize historical data, others rely on estimation and comparison to existing IP channels in the grain industry for their cost analysis. As a result there are discrepancies among the studies as to what would be the costs of implementing the system.

3.4.4.1 Voluntary IP of specific GM traits

In this scenario, all members of the supply chain for GM varieties voluntarily implement an IP system and therefore are also responsible for the costs. In order for this scenario to arise, a specific incentive would be required for GM producers, grain-handlers, processors and retailers to adopt the strategy. For input-trait GM wheat, this scenario will only arise if there is a distinct group of buyers willing to pay a premium for the GM production. Otherwise, there will be no incentive to segregate and this scenario will not develop. Unless segregation is implemented by other members of the supply chain for wheat, GM and non-GM wheat will remain un-segregated.

An incentive to voluntarily segregate GM wheat could arise in the case of genetic modification involving output traits for which consumers are willing to pay a premium relative to a conventional product. Specific examples in this category of GMOs are specialty oil products, GM pharmaceutical traits and nutraceutical traits.

In this type of system, because these costs are borne wholly within the GM marketing chain, the market can be used to determine whether the production and segregation of these varieties is economically viable. Due to low volumes of these types of varieties in the market, this scenario has yet to play a significant role. There have been a few positively labelled GM products, Flavr-Savr tomatoes for example, that have been voluntarily segregated to extract market premiums. However, there have been no studies conducted to determine the costs and effectiveness of these systems.

3.4.4.2 Voluntary Segregation of GMO-free products

In this scenario, the non-GM supply chain voluntarily segregates non-GM products and therefore bears the costs of segregation. The occurrence of these systems can be explained by the market for "lemons" theory discussed earlier (Akerlof 1970). In the wheat market, non-GM buyers will not pay a premium without a guarantee that the product is free from GM varieties ("lemons"). Instead, they will only be willing to pay the GM price or even worse, they will avoid buying wheat from Canada completely. Therefore, the supply chain for non-GM wheat may voluntarily implement a segregation system to distinguish their product and receive the premiums in the market.

This is currently the most common system being utilized in the market due to the fact that the majority of varieties currently registered are those that contain input traits. Input traits are aimed at providing cost of production benefits to producers, most commonly through built-in insect and herbicide resistance. Consumers generally do not benefit from this technology and therefore are not willing to pay a premium for the product (Buckwell et al. 1999). Instead, consumers in regions requesting labelled products may be willing to pay a premium for product that is free from GMOs.

The majority of literature to date revolves around this scenario. A study produced by Bender et al. (1999) at the University of Illinois examines segregation costs incurred by the grain-handling link in a supply chain for specialty corn and soybeans. The specialty corn varieties were high-oil varieties that were bred using traditional methods. They were segregated to attract a premium in livestock feed markets as a high energy feed alternative. The specialty soybean varieties, STS soybeans, were traditionally bred varieties resistant to a specific herbicide. They were segregated to attract a premium as a non-genetically modified, herbicide resistant variety (Bender et al. 1999).

Although only part of the study focuses specifically on non-GM crops, it is useful in that the system being examined could be used to IP all non-GM crops. Their estimates were obtained by surveying a sample of elevators in the U.S. that were identified as possible handlers of specialty oilseeds crops. The estimates of added costs were U.S. $0.17 per bushel for corn and U.S. $0.48 per bushel for soybeans.

Lin et al. (2000) modified the Illinois study to provide estimates for non-GM segregation. Their results indicated that costs for segregating non-biotech crops could be higher than the estimates for specialty crops. They make adjustments to account for increased testing costs and two-tier segregation. They also mention potential cost increases due to risk management.

The adjustment for increased testing costs reflects the higher cost of testing for GM content compared to testing for physical characteristics such as oil content. The adjustment for two-tier segregation reflects the costs required to segregate GM from non-GM varieties, and then to further separate the GM varieties approved for shipment to the EU from the EU-unapproved varieties. Risk management costs reflect the costs of monitoring the system, as well as the implications of contamination when attempting to guarantee non-GM shipments. As long as there is a premium for non-GM varieties in the market, there will be an incentive to represent GM varieties as non-GM. This incentive to cheat will be present at every point in the system unless monitoring and enforcement are present. Risk management costs reflect the added costs of monitoring and enforcement in the system. Also included in risk management costs are the costs associated with contamination of product targeting non-GM markets. Contamination could result in a load being rejected thereby having serious consequences for grain exporters. The costs of contamination, whether accidental or intentional, have the potential to make a segregation system unaffordable which would then result in the loss of all non-GM markets.

Maltsbarger and Kalaitzandonakes (2000) expand the two previous studies in their report on the hidden costs in IP supply chains. Specifically, they factor in lost opportunity costs at the primary elevator level. These include margins from value-added activities (i.e. grinding), storage, or from carrying grain over an extended time period in expectation that there will be a positive spread. The spread is the net difference between current price and expected future price less storage and lost interest costs. The results of their study show that including these opportunity costs can result in increased costs to the system in the range of U.S. $0.07/bu. to U.S. $0.22/bu.

Fulton and Giannakas (1999) examine the issue of contamination and resulting product mislabelling in their study of the consumption effects of genetic modification. When they introduce this concept to their analysis, they conclude that the higher the probability of mislabelling occurring, the greater the loss in consumer welfare. With lack of faith in the labelling system, consumers will be less likely to buy GM or non-GM product, instead choosing to purchase substitute goods. As a result, the implementation of a segregation system must also instil consumer faith in order to be effective.

Vandeburg et al. (1999) use IP cost estimates from industry experts when comparing two alternative segregation strategies, namely designating specific IP elevators versus segregating within the elevators. Using a cost-minimizing model, they estimate that as the cost of maintaining IP increases, using designated IP locations becomes the cost-effective strategy.

3.4.4.3 Compulsory Segregation for GM products

A compulsory IP system for GM products could potentially take a number of forms. The strictest form would fall under the Canadian Food Inspection Agency contract registration provision. This category of registration is used for those varieties whose biochemical or biophysical characteristics distinguish it from the majority of registered varieties of the same kind or species and whose delivery into traditional commodity channels would cause harm to those channels (CFIA 2000). Under these circumstances, the applicant must make available a quality control system that describes fully how potentially adverse effects of a variety will be managed (CWB and CGC 2000).

Alternatively, there have been cases where compulsory systems have emerged from voluntary initiatives on the part of certain members of a supply chain. To deem these systems compulsory requires the assumption that as soon as rules are imposed on upstream levels of a supply chain the system becomes compulsory in nature.

In 1995, the canola industry in Western Canada saw commercial production of GM varieties for the first time. At the time, Japan and the EU had yet to approve the varieties being grown. In this circumstance, and because the Government of Canada does not have the legal mandate to govern the exporting of GM canola, the industry was forced to implement an IP structure of its own (Phillips and Smyth 1999).

The research/seed companies, namely Monsanto and Aventis (Agrevo at the time) were approached by industry representatives and were urged to introduce an IP system until Japan approved the technologies in question. Both companies co-operated and vertically aligned themselves with grain companies to manage the systems that segregated GM canola to ensure that it remained within the domestic market.

The IP system implemented included contracts with growers of the technology, and kept the export market free from the specific varieties. The entire production (approximately 100,000 tonnes) was crushed at Canadian facilities and remained in the domestic market. Costs of the systems were estimated between Cdn. $34/tonne and Cdn. $37/tonne by Manitoba Pool Elevators and between Cdn. $33/tonne and Cdn. $41/tonne by Saskatchewan Wheat Pool. Only one dollar per tonne of these added costs were incurred by producers as increased on-farm costs. As a result, many producers were still able to realize a net benefit from adopting the new technology.

The remainder of the cost was incurred during transportation, by the processor, in administration, and through opportunity costs. Opportunity costs were included in the cost estimates due to the strict requirement that segregated grain remains in the domestic market. This prevented grain companies from marketing product to countries willing to pay a higher price than the domestic market (Phillips and Smyth 1999).

Table 3.1 summarizes a number of the studies mentioned in the previous sections. The table outlines the crop being studied, their GM/non-GM status, the identity preservation or segregation strategy implemented and the estimated costs.

Table 3.1 - Examples of IP and segregation systems for GM and non-GM crops.

Country	Crop	GM/non-GM	Identity Preservation and Segregation System Attributes	Total IP Costs	
USA	Soybeans	Non-GM (Voluntary)	Farm loaded containers moved to export position.	U.S. $20/ton	(1)
USA	Soybean	GM quality traits (Voluntary)	Farm level through elevator and processor to refinery level.	U.S. $17-$25.2/tonne	(2)
Canada	Canola	GM input traits (Compulsory)	Direct trucking from farm to domestic processor.	Cdn. $34 - $37/tonne	(3)
Canada	Canola	GM input traits (Compulsory)	Direct trucking from farm to domestic processor.	Cdn. $33 - $41/tonne	(3)
USA	High Oil Corn	Non-GM (Voluntary)	Farm level through to processor/export position.	U.S. $0.17/ bushel	(4)
			-including consideration for higher testing costs, two-tier segregation costs and risk management costs.	U.S. $0.22/ bushel	(5)
			-including consideration for lost opportunity costs from value-added activity, storage, and marketing at the primary elevator level.	U.S. $0.29-$0.44/ bushel	(6)
USA	STS Soybeans	Non-GM (Voluntary)	Farm level through to processor/export position.	U.S. $0.48/ bushel	(4)
			-including consideration for higher testing cost, two-tier segregation costs and risk management costs.	U.S. $0.54/ bushel	(5)

Sources: (1) Reichert and Vachal 2000; (2) Buckwell et al. 1999; (3) Phillips and Smyth 1999; (4) Bender et al. 1999; (5) Lin et al. 2000; (6) Maltsbarger and Kalaitzandonakes, 2000.

3.5 Estimating the Costs Involved with Segregation

An examination of the research that has been conducted indicates a wide variety of segregation alternatives that are directly related to or could be altered for use in segregating GMOs/non-GMOs. The majority of the studies agree that the costs and feasibility of the proposed systems depend on a few key issues. Relative adoption rates, requested tolerance levels, testing costs and procedures, market volumes, agronomic traits and differences in approval status of GMOs in importing countries have immense impacts on system costs.

The range of tolerance levels for approved GM varieties being requested by various countries appears to be between one and five percent; there is zero tolerance for un-approved varieties. Industry experts and economics studies suggest that to guarantee contamination levels at or below one percent requires much higher costs and a much more closely managed system than the five percent level. As a result, the tolerance level requested by importing nations may be the most decisive factor in determining system costs. Roederer et al. effectively outline all points in a given supply chain where increased costs could appear.

3.5.1 Seed Production

Seed production costs increase as the requested tolerance level falls due to testing requirements and increased isolation distances between GM and on-GM crops. These costs depend on the crop in question as cross-pollination problems vary with the seed being produced. Industry representatives indicate they could provide seeds at any tolerance level requested, however the costs of doing so rise considerably as the tolerance level approaches zero (Roederer et al. 2000).

3.5.2 Production

Prevention of contamination at the farm level involves minimizing volunteer plants, avoiding cross-pollination concerns and preventing mechanical commingling. Once again, the costs incurred by farmers will be relative to the tolerance level requested and the crop being grown. For example, canola cross-pollinates relatively easily and pollen can travel further distances than is the case for wheat. As a result, controlling this problem will be more costly when growing crops such as canola.

3.5.3 Testing

Current testing procedures for GMOs are both time-consuming and costly to conduct. However, testing will be required in a segregation system to discourage cheating and also detect contamination should it occur. The fewer the tests required, the less costly the IP system will be. However, taking the costs of a load of grain being rejected into consideration, the system must ensure that enough testing is conducted to guarantee the shipments are below the tolerance level requested. The testing procedure required is dependent on the number of modified genes within a given variety and the number of varieties within the grain class that have been altered.

Enzyme-Linked Immunosorbant Assay (ELISA) testing and strip-testing can be used if the modification being tested for is known. ELISA is a lab test allowing quantification of the GMO content of a sample for a given transformation event. Strip-tests are qualitative tests, giving a yes/no answer to detection of a targeted GMO in a sample (Bullock et al. 2000). Both procedures are relatively cheap and results are known quickly.

Polymerase chain reaction (PCR) tests are required if testing becomes more complicated. In the case of canola for example, if a non-GM status were required, ELISA and strip-testing would only indicate whether a specific protein for a given trait is present. As a result, separate tests would be required for all potential modified traits.

PCR testing examines the genetic makeup of a seed to determine if any modifications have been conducted. PCR is also required if testing is being conducted on processed food. It is important to note that testing will become much more costly once plant breeders begin to stack traits in a single crop, thereby requiring multiple testing for given samples. Even if the crop contains only one GM trait, if there are other potential GM traits for that crop, testing would be required for all of them. If this becomes prohibitively expensive, it may not be economically efficient to test them all. Instead, closer vertical co-ordination may be required to guarantee a labelling claim through closer supply chain monitoring and control of downstream activities. However, the fewer tests being conducted, the greater the chance of contamination through both accidental and intentional (cheating) means.

3.5.4 Transportation and Storage

Transportation and storage cost increases will depend on the number of varieties requiring segregation, the amount of product being segregated and the tolerance level for contamination. Increased trading involving IP crops will reduce the value of a commodity-based system and with lower volume, highly specific trading taking place, economies of scale may not be reached. Bullock et al. (2000) stress the importance of this issue in their study of the economics of non-GMO segregation and identity preservation. They conclude that the major costs of the systems will not come from cleaning machinery or testing, but rather from the reshuffling of the grain handling system.

3.5.5 Processing

The processing industry costs are dependent on similar variables as the transportation and storage links in the chain. Costs will increase if processing facilities have to be shut down and cleaned numerous times throughout the year to avoid mixing GM and non-GM product. These added costs could be lowered or prevented if volumes are significant enough to designate processing facilities to handle only one product.

3.5.6 Processed Foods

After examining the impacts of segregation on a supply chain, one can see the problems facing manufacturers of processed foods. Supply chains of processed products often involve up to 30 separate ingredients. If all ingredients sourced must be GM-free, identity preservation may become prohibitively costly.

Golder et al. (2000) examine this issue in their report on the potential costs of mandatory labelling for food products. They report that 70-85% of all processed food products could be subject to labelling if derived additives, processing aids and flavourings are subject to labelling. Subsequently, labelling costs could be equivalent to at least 9-10% of the retail price of processed food and 35-41% of producer prices. Knowing this, some EU processors have reformulated their recipes to use ingredients from non-GM sources in order to obtain GM-free status. In such cases, the problem no longer involves the costs of segregation, but moreso the costs of substitution and lost markets.

3.6 Who Pays?

With segregation strategies becoming essential, the next question is who is responsible for implementing and paying for the system? This question relates to the discussion earlier surrounding marketing/segregation externalities. The three alternatives previously outlined show that there is uncertainty about this. Should non-

GM producers be required to segregate their production when GM producers gain cost of production benefits? They may not be responsible, but they may have an incentive to do so for two reasons. First, importing regions such as the EU and Japan may be willing to pay a premium for imports free from GMOs. Secondly, producers will see a reduction in demand for their products unless they incur a cost to segregate their non-GM product.

Depending on the volumes being produced, it may be more efficient for GM producers to segregate their production. The problem with this, however, is they generally do not have incentives to do so. Until GM varieties emerge that attract a premium above the cost of production for the entire supply of a given variety, this will remain a problem. The question then becomes: does market failure exists and if so, do regulatory policies need to be put in place in order to force GM producers into a compulsory IP system?

3.7 Segregation Options and Uncertainties

A variety of potential systems have been analyzed to differing degrees and with many different results. The most popular alternatives appear to be segregating within elevators, designating specific grain handling, storage and processing facilities to handle the product being segregated, and lastly containerized shipping.

The studies provide a good understanding of the steps and procedures necessary to implement each strategy. However, they do not provide a satisfactory answer to which system would be most suited to the Canadian grains industry. As a result, the industry needs to determine which system will operate most efficiently for given situations and for each specific crop being grown.

The problem, however, is that there are many uncertainties over the situation being faced. There are uncertainties over how producers will react to the introduction of GM wheat, and what the adoption rate will be. There are uncertainties over the tolerance level being requested by importing nations. There are uncertainties over what volumes of GM and non-GM crops will need to be segregated. There are uncertainties over how effectively a system will work given problems like opportunism and human error and lastly, there are uncertainties regarding the markets that will request labelling. Opportunism may occur in the event that individual producers realize a potential economic gain from cheating the system. For example, in the case where non-GM crops are being segregated for premium markets, GM producers may attempt to market their grain as non-GM to gain the premium available. These problems create difficulty in attempting to pinpoint effective systems and as a result need to be solved before an answer can be found. They also underline the importance of understanding the regulatory and consumer requirements of target export markets before a segregation system is designed and implemented.

3.8 Summary

As outlined in this chapter, it appears the supply chain for Canadian bread wheat is about to undergo a number of changes, not only due to the existence of GMOs in the market, but also due to an increase in the number of segregations appearing in other areas of the market. Importing nations as well as domestic users are becoming very specific in their demand for grain from Canada. Inevitably, this will result in larger numbers of lower volume shipments compared to the large bulk shipments we export today. As a result, there is a need to determine what system will be most efficient and effective in satisfying this demand. This chapter outlined a variety of studies that have been conducted in the area of segregation. The vast discrepancies in system costs and feasibilities indicate that the task of determining the optimal outcome is a difficult one. As discussed, this is largely due to a number of uncertainties surrounding the area, but also becomes difficult due to the fact that the system in the market today hasn't been designed to handle low volume shipments and highly specific demand. Segregation will very likely increase handling costs at all levels of the supply chain, but attempting to prevent contamination of small volumes of grain in a bulk system may prove to be the largest factor involved.

CHAPTER 4 - THEORETICAL FRAMEWORK

4.1 Introduction

The challenge with determining the optimal segregation strategy for an industry lies in the ability to effectively model the actions of all levels of the supply chain requiring segregation. This study employs a simulation model which is comprised of both producer and grain-handlers decision-making processes. The simulation model and the simulation process require the use of a number of fundamental economic theories that are introduced and explained in this chapter. The first section discusses the theories used in the construction of a producer decision-making model. Utilizing the historical case of canola, this section includes a discussion on how the introduction of HT canola impacted producer's decisions. Also included in this section is theory behind premiums and how they will impact producer's decisions. This section is followed by a discussion of the economic theory behind catchment areas and how they can be effectively altered through the use of premiums. The final sections of the chapter examine each segregation option utilized in the model to illustrate the economic theories underlying each option.

4.2 Producer Decision Making Model

In any given year, producers have the option to allocate acreage to a number of alternatives. Most commonly in the prairie region, producers will have portions of their land dedicated to primary crop production (i.e. wheat, barley, canola), pasture land, summerfallow, or a variety of special crops (i.e. chickpeas, sunflowers, dry beans, etc.). The decision over which crops to grow depends on a few key factors including profitability, diversification, pest management, and land resource management.

Perhaps the most important determinant factor in land allocation is the profitability of growing one crop versus another. If a producer feels that growing one crop will generate more income than another, the decision would presumably be to grow the most profitable crop. Profitability depends on the price received for the commodity, the expenses incurred in production and the amount of crop produced. Considering the fact that all three factors affecting profitability aren't known for certain at the time of seeding, basing the decision on profitability is somewhat difficult and thus must be based on the expected profitability of growing one crop versus another. Producers are also limited in their ability to take advantage of the most profitable crops. The importance of crop rotations in managing weed pressure, disease pressures and land resources, as well as the desire to diversify risk ultimately result in the allocation of acreage to a variety of alternatives instead of entirely one crop.

4.2.1 Introducing GMOs

The commercial registration of GM varieties of crops will change the decision making process for many farmers. Now instead of just having to decide which crops to grow, producers must also decide if they will dedicate all, or a portion of the acres designated for a specific crop to GM varieties. Once again, this decision is largely based on profitability.

Since their inception in 1995, HT canola varieties have quickly captured a large portion of the canola acreage on the prairies. The explanation for this is largely twofold. First, due to varying levels of weed pressure on most farms, many producers have portions of acreage on which it is more costly to grow traditional varieties versus HT varieties. Very often this is due to higher populations of perennial weeds which are more costly and more difficult to control. Growing HT canola has been estimated to provide a cost reduction benefit to prairie producers of on average between $5 and $8 per acre (Mayer 1997). The second reason is due to the fact that growing HT varieties is considered by many producers to be less management intensive as well as less risky. Timely weed control is a very important factor in the resulting yield of a crop. HT canola varieties remove some of the risk and difficulty involved in determining when to apply herbicides to the crop. As a result, this factor has largely influenced the adoption of HT varieties in Western Canada.

To demonstrate the production decisions of farmers in the presence of HT varieties, the canola case can be used. As mentioned previously, producer benefits for HT canola have been estimated to be between $5 and $8 per acre. To facilitate the illustration, the assumption will be made that the average benefit to producers is $6 per acre. If the assumption is made that marginal cost increases across all acres on a given farm, and that at the margin, marginal benefit equals marginal cost, a $6 per acre average benefit would suggest that half of the acres dedicated to HT varieties are receiving between $6 and $12 per acre benefit while the other half are receiving between zero and $6 per acre benefit. With this level of benefit, the adoption rate for HT varieties in 2000 was approximately 77% (Phillips 2001). Once again, to facilitate illustration, assume an adoption rate of 80%.

The total allocation of acreage to HT and conventional varieties can be explained by illustrating graphically, the marginal costs of both alternatives (Figure 4.1) for all acres designated to a certain crop. This analysis assumes that all farms are homogeneous in their proportion of high cost and low cost acres. Thus the only difference between farms would be the level of costs along the vertical axis, which will not affect the relative cost analysis farm by farm.

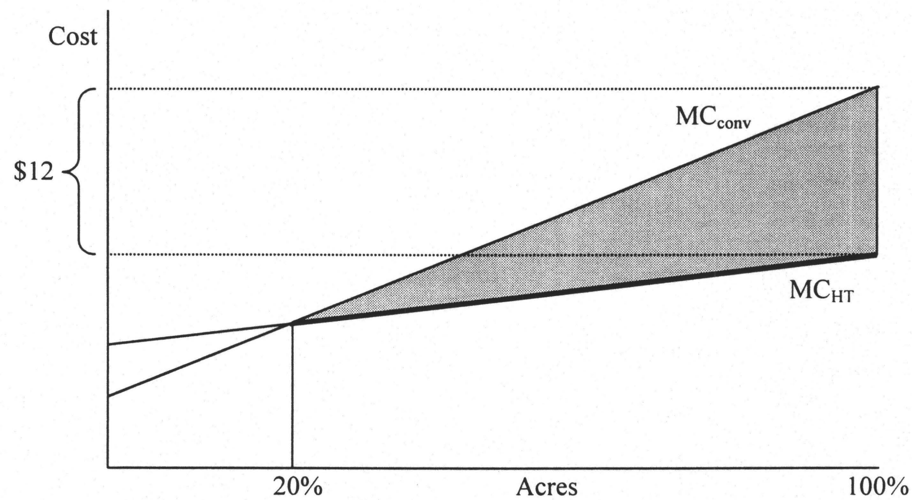

Figure 4.1 – Acreage Allocation Based on Least Marginal Cost.

Figure 4.1 illustrates that on each farm, the marginal cost of producing one unit of conventional canola (MC_{conv}) is higher than the marginal cost of producing one unit of HT canola (MC_{HT}) on 80% of the acres. The acres closest to the vertical axis are those that are relatively less costly to produce canola under any circumstances. This might be due to low weed pressures and the absence of hard to kill weeds which both would limit the need for HT canola varieties. As you move away from the vertical axis, the difference in marginal cost between conventional varieties and HT varieties diminishes to a point where it becomes more profitable to grow HT varieties. The acres to the right of this point are those acres where weed pressures are most likely higher and the presence of hard to kill weeds increases. The cost of producing conventional canola on these acres increases rapidly and at a higher rate than the cost of producing HT varieties. As a result, it becomes more profitable to allocate these acres to the production of HT varieties.

This theoretical model can be aggregated to illustrate the adoption of HT canola in the entire prairie region. The graphical depiction would be identical, with the horizontal axis representing the total canola acreage in the prairie region and the vertical axis representing the average level of costs for each farm.

4.2.2 The Segregation Requirement

The previous section examined the historical response of canola producers in Western Canada to the introduction of HT canola. Currently the Canadian canola industry does not distinguish between HT and conventional canola, thereby eliminating the need to segregate on-farm and within the remainder of the supply chain. The upcoming section is intended to illustrate theoretically the impact premiums would have on the decision making process of producers if the industry distinguished between HT and conventional varieties. Prior to this discussion, it is important to distinguish between cost recovery premiums and incentive based premiums.

The segregation process will come at a cost to the entire chain. The portion of those costs borne by producers in their production practices include the costs involved with cleaning equipment, ensuring adequate buffer zones are in place to reduce cross-pollination potential and lastly the increase in labour and management costs required to implement segregation on the farm. Under the assumption that all farms are homogeneous in costs, as is the case for this study, the recovery of these costs through compensatory premiums would not impact the production decision of farmers, as it is simply a break-even transfer of funds. In reality, production decisions may be impacted if a contract specifies an equal provision to all farmers for on-farm segregation. This is due to the fact that some producers would receive a compensatory premium above their costs, while others would not be fully compensated for their costs. In the analysis of the entire system, these costs will be included as they must be incurred somewhere in the chain in order for segregation to take place. The following discussion of incentive-based premiums will thus be defined as premiums offered above and beyond cost recovery premiums.

4.2.3 Producer Decision Making in the Presence of Incentive Based Premiums

The impact of price premiums on a producer's decision making model can be depicted in a spatial context with price on the vertical axis and acreage on the horizontal axis (Figure 4.2). Instead of illustrating the marginal cost of both alternatives as was shown previously, the spatial model examines the relative marginal cost of growing HT canola versus conventional canola. The marginal cost curve depicted on the graph is thus the net difference in marginal cost between growing HT varieties and conventional varieties. Under the assumption that the horizontal axis represents the entire acreage allocated to canola, the curve on the graph becomes indicative of the supply for HT canola as a percentage of total supply by the farm in question. Note that the shaded area in figure 4.2 is identical in size to the shaded area in figure 4.1 and can be defined as the increase in producer welfare resulting from the introduction of HT canola.

Price P_1 on the price axis is representative of the price received for HT canola. With the absence of premiums or discounts in the market, P_1 would also be the price received for conventional canola. As mentioned previously, with zero premiums or discounts for either variety, the adoption rate has been approximately 80%.

Despite the fact a producer receives the same price for both (P_1), the cost of producing HT is less, in effect generating higher returns for HT varieties. The intersection of the HT supply curve and price P_1 is the point where relative profitability shifts from growing HT to conventional varieties. All acres to the right of this point are those acres where it is less costly to grow conventional varieties than it is to grow HT varieties.

The presence of premiums for either HT or conventional canola will impact the decision making process for producers and can be illustrated by shifting the price along the vertical axis. In order for premiums to have an impact on the planting decisions of farmers, they must be offered and in place before planting begins. Through contracts, market signals or otherwise, producers must be informed of the premiums that will be offered in order to alter their production decisions.

An upward shift in price (P_2) is representative of a premium for HT varieties. The result of the premium is an outward shift in the proportion of acres allocated to HT varieties (point x).

A premium for conventional varieties can be illustrated with a downward shift along the price axis (P_3). The downward shift indicates that because there is now a premium for conventional varieties, HT varieties are being sold at a discount (i.e. a lower price relative to conventional varieties). The result is an inward shift in the proportion of acres allocated to HT varieties (point x').

Figure 4.2 – The Supply of HT Canola and the Impacts of Premiums.

Once again, if homogeneity among farms is assumed, the model will appear exactly as depicted for each individual farm. The only difference will be the initial price each farmer receives for their grain (P_1), which has no impact on the workings of the model. The differences in P_1 can be explained by the fact that each producer will have different transportation costs, grain handling costs and freight costs depending on their distance to the delivery point, the handling charges at that delivery point and the freight costs from delivery point to the market.

This analysis shows that the presence of premiums in the market can effectively be used to alter the production decisions of farmers. The importance of this concept will be discussed and illustrated later in the chapter.

4.3 The Economics of Grain Elevator Catchment Areas

Grain elevators provide a service to producers. These facilities collect grain at a common point and subsequently store the grain until it is loaded onto rail cars and shipped to port. Most elevators are now also equipped with grain drying and cleaning equipment. Without the service of elevators, producers would be required to find an alternative method of delivery for their grains destined for export. As a result, producers growing crops destined for export have a demand for grain handling services.

Producer demand for the services of any given delivery point is a function of the handling charges and rail freight rates at that point, the trucking costs to the point, the handling charges and rail freight rates at alternative points, and the trucking costs to alternative points. There are also a number of quality factors that may affect a producer's demand for elevator services. These include the number of elevator firms at the point, available elevator space, patronage in the case of co-operatives, management quality, etc. (Wilson and Tyrchniewicz 1981). Producer demand for the services at a delivery point can be summarized by the following function (Karadininis 1985).

$$Q_{kj} = f\left(H_1,..,H_j,..,H_n,R_1,..,R_j,..,R_n,T_{k1},..,T_{kj},..,T_{kn},S_{11},..,S_{1j},..,S_{1n},..,S_{m1},..,S_{mj},..,S_{mn}\right) \tag{4.1}$$

With trucking costs expressed as:

$$T_{kj} = f\left(V_k, D_{kj}, P_{kj}\right) \tag{4.2}$$

Where:

Q_{kj} = quantity of services of point j demanded by producer k,

$H_1,..,H_j,..,H_n$ = handling charges at point j and alternative points (1,..,i,k,..,n),

$R_1,..,R_j,..,R_n$ = rail freight rates at point j and alternative points (1,..,i,k,..,n),

$T_{k1},..,T_{kj},..,T_{kn}$ = trucking costs incurred in moving grain from farm k to point j and alternative points (1,..,i,k,..,n),

$S_{11},..,S_{1j},..,S_{1n},..,S_{m1},..,S_{mj},..,S_{mn}$ = service quality attributes (1,..,m) associated with point j and alternative points (1,..,i,k,..,n),

V_k = volume of grain to be delivered by farm k,

D_{kj} = distance from farm k to delivery point j

P_{kj} = trucking premium being offered by delivery point j to farm k

Linearly, the demand for grain handling services is depicted in figure 4.3. If the assumption is made that all delivery points within a region have identical freight and handling charges, trucking premiums are absent, and quality factors aren't taken into consideration, those producers positioned directly beside an elevator would have the greatest demand for that elevator's service. Their costs to deliver to that point would be the lowest. Even those producers directly beside an elevator would not have zero cost of delivery due to the costs involved with loading a truck for delivery, etc. As a result, their demand for grain handling services is Q_0 at C_0. Note that due to the assumptions listed above, the demand for an elevator's service in the model illustrated is only a function of transportation costs to the elevator in question as well as alternative elevators. As distance increases, the cost to deliver also increases and the demand for the service by producers diminishes to a point where there is zero demand for the service (C_1).

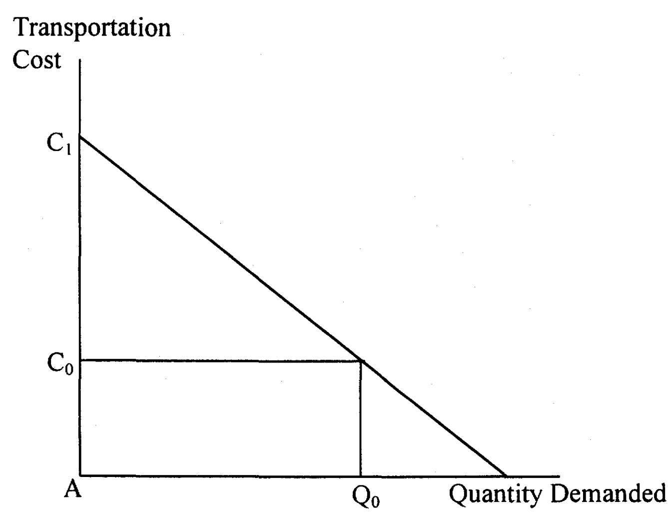

Figure 4.3 – Demand for Grain Handling as a Function of Transportation Cost.

By tilting the portion of the graph between C_0 and C_1 90 degrees so that transportation costs are now on the horizontal axis, a catchment area can be illustrated

(Figure 4.4). Using C_0, the point of greatest demand for services, as the delivery point and the difference between point C_0 and point C_1 on the price axis converted to distance as the radius, a circular catchment area can be shown (Appendix A). The area under the cone can also be calculated to determine the total demand for grain handling services (Losch 1938).

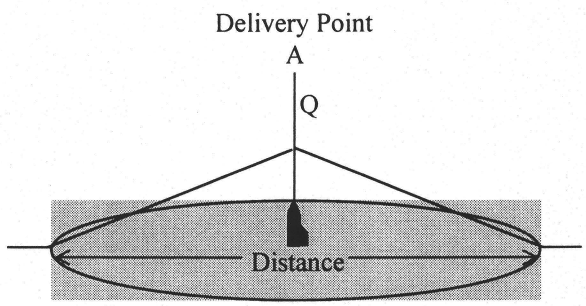

Figure 4.4 – The Circular Catchment Area.

Circular market areas spread evenly across the plane of a region with no overlap would result in gaps between circles, in other words areas where some producers have zero demand for grain-handling services from any elevator. By moving the circles closer together, the gaps are removed, but each delivery point also gives up a portion of its catchment area. The result is hexagonal catchment areas with no gaps in services (Figure 4.5).

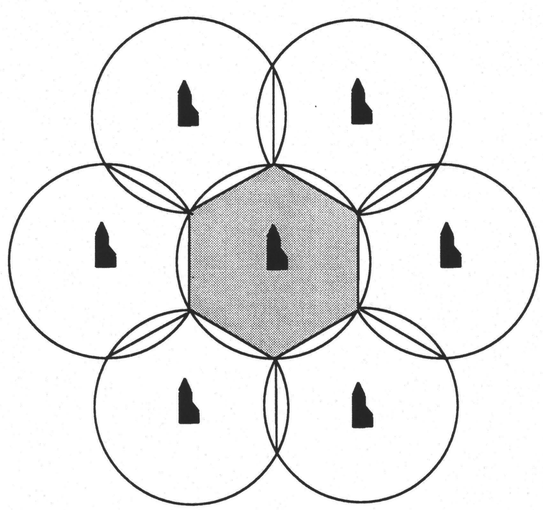

Figure 4.5 – The Hexagonal Catchment Area.

The model in this study assumes that there is a road network that would allow a producer to haul directly, in a straight line, from his farm to the elevator. A more representative approach to the situation in the Canadian prairies is to assume a grid road system. In this case, the least costly area to haul from is not a hexagon, but square tilted 45 degrees to the road maps (French 1960). This scenario is illustrated in figure 4.6. Note that Producers II and III are in the definitive catchment area of an elevator while Producer I will be indifferent between delivering to the two elevators that are closest to his farm. This model has limitations as well due to the fact that producers are somewhat constrained by the road infrastructure available to them. A grid road system is closer to reality in comparison to "as the crow flies", but is also a somewhat limiting assumption.

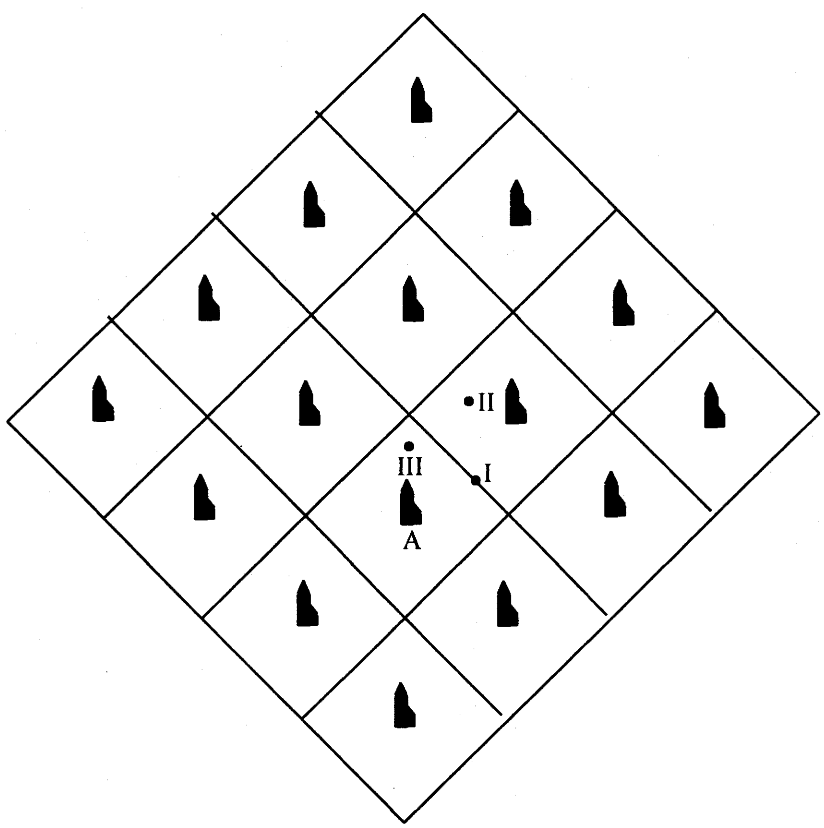

Figure 4.6 – Catchment Areas in a Grid Road System.

These concepts can be further illustrated in a spatial model (Figure 4.7). In this graph, producers are evenly distributed across the horizontal plane with elevators at points A, B and C. Producers have the option to deliver to all points but as long as their objective functions are to maximize profit or minimize costs then they will only deliver to the elevator at the lowest cost. If the previous assumption remains that all three elevators have the same handling and rail freight costs and that producers don't base any of their delivery decisions on quality attributes, then the upward slope of the marginal cost (MC) curves are based solely on transportation costs. For illustrative purposes, a linear cost curve is utilized to depict increasing costs (λ) with distance.

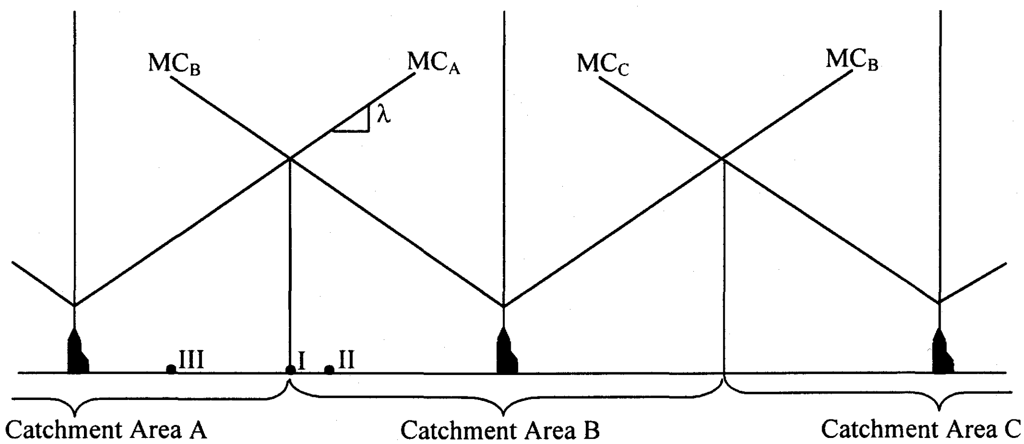

Figure 4.7 – Catchment Areas Illustrated Spatially.

4.3.1 Trucking Premiums vs. Handling Cost Premiums

The rationalization of the Western Canadian grain handling system has resulted in a significant decrease in the number of elevators and subsequently a significant increase in trucking distances from farm to primary elevators. Most of the remaining delivery points are large high throughput inland terminals, designed to handle much larger volumes of grain compared to the traditional wooden elevators. Trucking premiums have been used extensively in the rationalization process in attempts to speed the transition from traditional elevators to high throughput terminals (Fulton 1996).

Trucking costs are one area where grain companies have the ability to adjust the rates they charge. Trucking premiums are thus commonly used to attract producers as opposed to lower handling charges, etc. A trucking premium offered by an elevator lowers the cost of delivery to that point. Unlike premiums intended to alter production decisions, which must be offered before planting, premiums introduced to increase market share can be offered on the spot, and after production has taken place. These premiums can be offered to specific farmers without having to worry about competing elevators and neighbouring farmers knowing the level of premium being offered. Grain companies are thus able to charge different rates to different customers, in effect discriminating against those close to the delivery point while attracting producers further away. As long as the premium being offered doesn't exceed the revenue generated, it is worthwhile for the grain company to offer the premium. The use of trucking premiums is thus employed and effective in influencing the movement of grain in a region.

4.3.1.1 The Economics of Trucking Premiums

Figure 4.8 illustrates the effect trucking premiums will have on producers' decisions to deliver to one elevator versus another. Due to the fact that producers located within the initial catchment area are captive to that point, the elevator will not have to offer those producers an incentive to deliver. This situation changes somewhat if there happens to be two competing elevators at one point but for ease of explanation, assume each point has just one elevator.

If the farmer is delivering the grain themselves, or has hired an independent trucking firm to haul their grain, the premium would in effect be offered as a monetary incentive to alleviate the portion of the trucking costs that exceeds the cost of delivering to an alternative elevator. The amount of the premium must increase with distance for the obvious reason that trucking costs will increase with distance. However, the increase actually exceeds the added trucking costs due to the fact that the further away a producer is, the closer they will be to the competing elevators. The vertical distance between line MC_A and line MC_B is the minimum amount of premium that would be required to attract the producers in the initial catchment area B. Theoretically, one cent above the difference in the two trucking costs should result in the producer delivering to A instead of B. Note that elevator A is able to increase its share of the market by offering a trucking premium. By offering a premium they have not only attracted the business of producer I who was initially on the border of the two catchment areas but also producer II who was initially within the catchment area of elevator B. The total cost of the premiums can be calculated as the shaded area between the curves MC_A and MC_B to the right of the original equilibrium. As long as this cost doesn't exceed the net revenue associated with handling the increased volume of grain the elevator is better off.

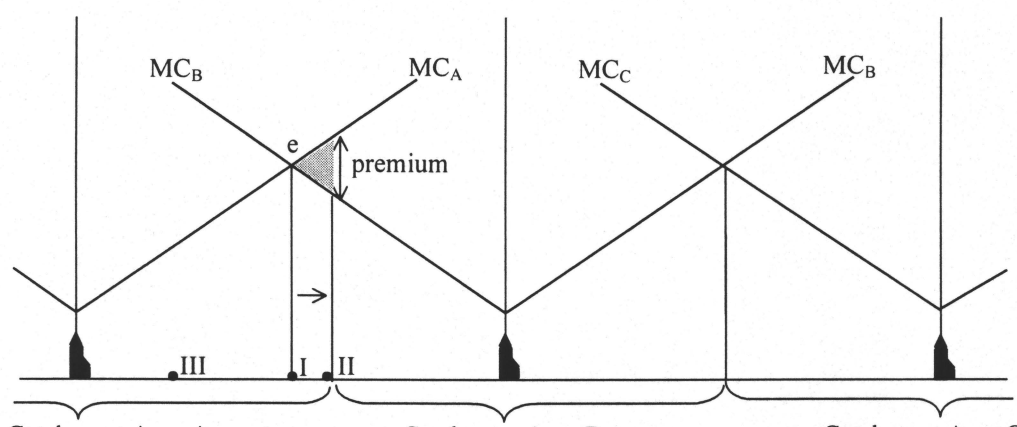

Figure 4.8 – The Impact of Trucking Premiums on Catchment Areas.

If the situation differs in that producers don't haul their own grain or hire independent trucking firms to haul their grain, the elevator is in a position where they can discriminate even further against those producers captive to that point. This concept will be discussed further in the section on designated points where trucking costs are included in a specified contract for segregated grain.

4.3.1.2 The Economics of Handling Tariff Premiums

Another option available to elevators is to offer premiums and incentives on handling tariffs. This method would provide the same results if it could be offered at the same level and to the same producers as the transportation premiums. However, lowering handling charges for one farmer will most likely result in having to lower handling charges to all farmers in a region. Further, lowering handling charges to attract farmers in a competitor's catchment area may result in the competitor matching the reduced rates (Fulton 1996). Figure 4.9 illustrates graphically the impact of elevator A lowering their handling charges to all producers in a region in attempts to increase their catchment area. In order to match the market area increase realized in the transportation premium model, the premium offered would have to equal the vertical distance between MC_A and MC_A'. Note that this is far more costly to the elevator as the total cost of the premium now the entire shaded area.

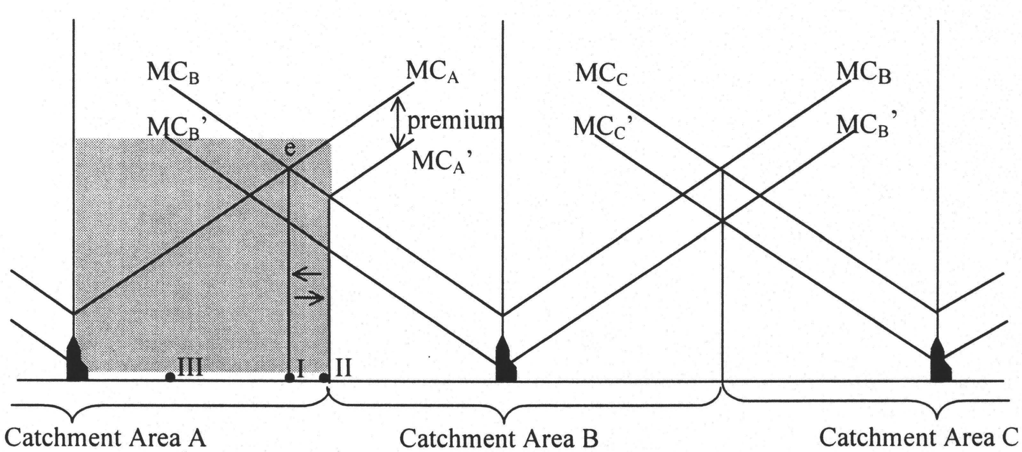

Figure 4.9 – The Impact of Handling Premiums on Catchment Areas.

By lowering handling charges at delivery point A, the elevator must now offer services at a lower rate than previously was the case. If elevator B is not willing to give up its market share, they may be inclined to match the premium being offered by elevator A. The result would be a shift in the total cost curve for delivery to elevator B from MC_B to MC_B'. The border between catchment areas for elevators A and B would subsequently move back to its original equilibrium point and both elevators will be worse off. If elevator C is not willing to sacrifice market share, they will also match the premiums being offered by B and so on. The outcome for all elevators offering premiums will be similar volumes handled as before, with a decrease in handling revenue.

This analysis shows why there is a strong reliance on trucking premiums versus premiums on handling tariffs.

4.4 Segregation Using Designated Points

The preceding analysis of producer decision making, catchment areas and the impacts of premiums on both are an integral part of the following section which examines the designation of an elevator in a region for the purpose of segregating a specific type of commodity. The designation of an elevator or terminal to handle a specific type of commodity (i.e. non-GM wheat) may result in an increased dependence on trucking premiums to provide incentive for farmers to not only deliver to the designated point, but to allocate acreage to the commodity being segregated. Depending on the volume of the specific commodity being demanded from the region and the location of the terminal, the need to expand the designated elevators' catchment area may result in premiums being offered. The economic theory underlying this scenario differs somewhat than was outlined in the previous sections. This is because the designated elevator is now in a situation where they are not competing directly against other elevators, but in order to attract a desired capacity, they may have to provide incentive for producers to grow the product being handled at their point.

4.4.1 Discriminatory Premiums

Assuming the designated point knows the volume of grain they are seeking from a region, an assessment can be made to determine what level of premiums will be required to attract that volume. If the collection of the segregated commodity includes a contract that specifies trucking costs, the designated point can effectively use this contract to selectively source grain. As was discussed previously, a contract of this nature would allow the designated point to discriminate against those producers closest to the point (captive producers) by charging a higher trucking cost than they would normally be charged. This concept is illustrated in figure 4.10 with the underlying assumption that producers either grow the unsegregated product, or grow the segregated product and deliver to the designated point. The concept of varying levels of production will be discussed later.

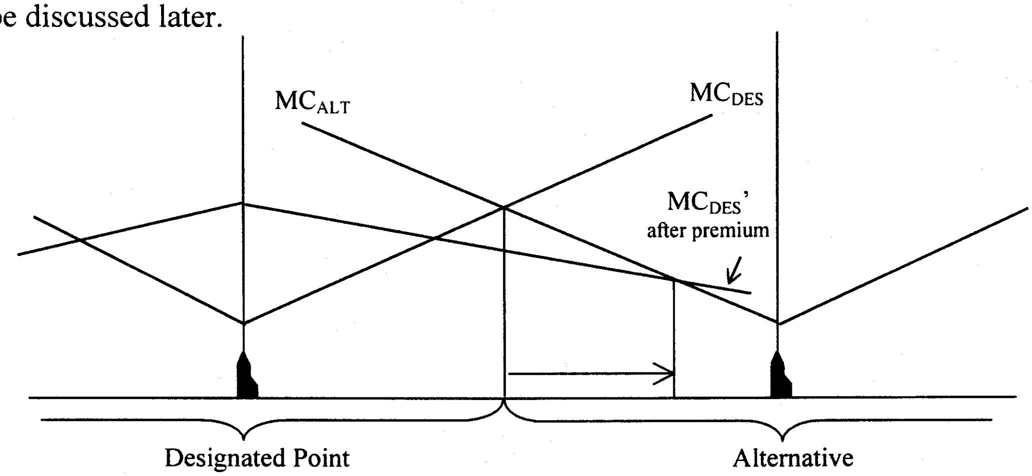

Figure 4.10 – Discriminatory Trucking Premiums.

With existing transportation costs in the market, the designated point and the alternative point share the market evenly. The impact of a premium introduced by the designated point can be shown by the MC_{DES}' curve. This curve is shown as downward sloping indicating that the premium being offered increases as distance from the point increases. Producers in the region where MC_{DES}' exceeds MC_{DES} are being charged more than the cost of transportation to the designated point. This is still less than delivering to the alternative point, thereby satisfying a cost minimization objective function. Producers in the region where MC_{DES}' is below MC_{DES} and MC_{ALT} are being charged less than the cost of transportation to the point and thus benefit from the premium. The designated point, through offering a premium, has increased its share of the market to the point where MC_{DES}' now intersects with MC_{ALT}.

In theory, the discriminatory premium could be more drastic than shown. The designated point could potentially charge producers one cent less than the next best alternative and still attract the grain. This would result in much greater costs to those producers captive to the point and much less benefit to those producers in the original catchment area of the alternative delivery point.

4.4.2 Introducing Variable Production

The problem becomes more complicated for the designated point with the introduction of variable production, in other words when the level of the premium can impact the production decision of farmers. By discriminating fully against captive producers, the designated point will only attract the amount of grain captive producers would grow under normal circumstances. Subsequently, to reach capacity they may have to attract the remainder of the desired volume from producers greater distances from the original catchment area. They would have to pay those producers outside the existing catchment area a premium for each tonne of grain delivered to offset trucking cost increases. As a result, the designated point must determine if it is less costly to reduce the trucking costs faced by captive producers to shift more of their acreage to the segregated crop, or pay the premium to attract the grain from outside the region. This concept can be summarized by the following objective function:

$$\underset{TP_{ik}}{Min}\, TC_i = \sum_{k=1}^{n}(CRP_k \times \delta_k) + \sum_{k=1}^{n}\left(TP_{ik} \times Q_{ki}^{non-GM}\right) \tag{4.3}$$

subject to:

1. $\sum_{k=1}^{n} Q_{ki}^{non-GM} = Q$ (4.3.1)
2. $\delta_k = 0,1$ (4.3.2)
3. $(1-\delta_k)\times Q_{ki}^{non-GM} = 0$ (4.3.3)
4. $Q_{ki}^{non-GM} = f\left(TP_{ik}, T_i, T_j, HC_i, HC_j, F_i, F_j\right)$ (4.3.4)

Where:

TC_i = total cost of segregation to the designated point, i.

CRP_k = constant cost recovery premium paid to producer k.

δ_k = if farm k contracts with designated point, i, equal to 1, otherwise equal to 0.

TP_{ik} = trucking premium offered by designated point, i, to farm k=(1,…,n), where n equals the number of farms contracting with the elevator.

Q_{ki}^{non-GM} = quantity of grain delivered from farm k to the designated point, i.

Q = total quantity of non-GM wheat requiring segregation.

T_i = trucking costs from farm k to the designated point.

T_j = trucking costs from farm k to initial low-cost delivery point.

HC_i = handling tariff charged by the designated point.

HC_j = handling tariff charge by initial low-cost delivery point.

F_i = freight costs at the designated point.

F_j = freight costs at the initial low-cost delivery point.

The first constraint (4.3.1) simply states that the designated point must minimize it's costs of sourcing a specified quantity of grain (i.e. the sum of quantities being sourced from each farm must equal a predetermined volume, Q). The second constraint (4.3.2) states that δ_k is binary, meaning that it will be either 0 or 1, depending on whether or not farm k chooses to contract with the designated point. The third constraint (4.3.3) illustrates mathematically the determination of the δ_k variable. In the event that farm k delivers to the designated terminal, in order for this equation to hold, δ_k must be equal to 1, thereby resulting in costs associated with the CRP_k variable. In the event that farm k does not deliver to the designated point, δ_k becomes zero, and the designated point is not responsible for the cost-recovery premium and the administration costs for that specific farm. The final constraint (4.3.4) simply states that the quantity of non-GM wheat being contracted with the designated point is a function of the trucking premium being paid by the designated point, the costs of delivering to the designated point, and lastly the costs of delivering to the alternative point (where non-GM wheat would be sold as GM). The explanation of the constraints holds for equations 4.3 to 4.6 with the only difference being the inclusion of the administration cost variables (A_k and A_{kj}).

4.4.3 Designating Multiple Points

The designation of multiple points to handle a segregated product will result in competition among the designated points unless the system is managed by a single entity. Managing each elevator separately will result in competition between designated points similar to that in figure 4.8 above where, in order to attract a given volume of grain, trucking premiums must be offered to producers in order to offset the cost above delivering to the next closest alternative. By managing the designated points as one system or one unit, premiums can be offered to minimize the costs of sourcing grain for the entire system. This means that premiums can be offered to the level that is required to reach optimal capacity for the system of elevators instead of each elevator individually. As a result, competition between designated points for the product being segregated is removed and the grain can be sourced at the lowest cost to the region. The following objective function summarizes the segregation of grain using multiple designated point:

$$\underset{TP_{jk}}{Min}\, TC_s = \sum_{k=1}^{n}\sum_{j=1}^{m}\left(CRP_{kj} \times \delta_{kj}\right) + \sum_{k=1}^{n}\sum_{j=1}^{m}\left(TP_{jk} \times Q_{kj}^{non-GM}\right) \quad (4.4)$$

subject to:

1. $\sum_{k=1}^{n} Q_{kj}^{non-GM} = Q$ (4.4.1)
2. $\delta_{kj} = 0,1$ (4.4.2)
3. $\left(1-\delta_{kj}\right) \times Q_{kj}^{non-GM} = 0$ (4.4.3)
4. $Q_{kj}^{non-GM} = f\left(TP_{jk}, T_j, T_i, HC_j, HC_i, F_j, F_i\right)$ (4.4.4)

Where:

TC_s = total cost to the multiple designated points in the segregation system.

CRP_{kj} = constant cost recovery premium paid to producer k by point j.

δ_{kj} = if farm k delivers to designated point, j, equal to 1, otherwise equal to 0.

TP_{jk} = trucking premium to farm k=(1,…,n) from designated point j=(1,…,m), where n equals the number of farms taking part in the program and m equals the number of designated points in the system.

Q_{kj}^{non-GM} = quantity of grain delivered from farm k to designated point j.

Q = total quantity of non-GM wheat requiring segregation.

T_j = trucking costs from farm k to designated point, j.

T_i = trucking costs from farm k to initial low-cost terminal.

HC_j = handling tariff charged by designated point, j.

HC_i = handling tariff charged by initial low-cost terminal.

F_j = freight costs at designated point, j.

F_i = freight costs at original low-cost terminal.

Note that those producers who have an economic incentive to produce the segregated grain will deliver to only one of the elevators in the multi-point system. As a result, if farm 1 is delivering to designated point 2 ($Q_{12}>0$), then $Q_{1j\neq2}$ will be zero. The same holds true for all farms in the region.

4.4.4 Transaction Costs

Transaction costs include the search/information costs, negotiation costs and monitoring and enforcement costs that arise in the event of a transaction between a buyer and seller. Information or search costs include the costs involved with price discovery, obtaining product information and gathering information on buyers and sellers. Negotiation costs include the physical costs involved with negotiation and the drafting of a contract between the buyer and seller. Monitoring and enforcement costs are the costs involved with ensuring the guidelines defined in the contracts are followed and if not, the cost of taking actions against those who break the contractual agreement (Hobbs 1996).

These concepts evolved from the work of Coase (1937) who outlined that the neo-classical assumptions of a cost-less exchange between buyer and seller are limiting and that there are indeed costs involved with using the market mechanism. Further to the work of Coase, Williamson (1979) outlined that the magnitude of transaction costs are dependent on the level of investment in specific assets required for the transaction to take place, the notion that the potential for opportunism exists and that humans are bounded by the information available to them.

Opportunism is defined by Williamson as self-interest seeking with guile and explains the fact that if an individual has the opportunity to benefit from their actions, even a binding contract may not prevent them from doing so. Bounded rationality is the term used to explain that individuals are bounded by the information available to them and although they would like to make the most rational decision, a lack of available information may limit their decision-making ability.

4.4.4.1 Transaction Costs and Segregation

Segregation, whether carried out through a designated delivery system or conducted within elevators, will include transaction costs as defined above. The search costs inherent in a system of this nature will include those costs involved with identifying suitable growers (e.g. those who can be trusted to conduct the necessary actions to guarantee the product being delivered is pure as well as limit the potential for opportunistic behaviour).

The inclusion of contracts in this process will result in negotiation costs, which include the legal and managerial costs involved with drafting a contract as well as the costs involved with negotiating with those producers chosen to grow the crop.

The need for segregation arises due to the demand for varieties of crops that are of guaranteed quality and are grown to meet specific guidelines to guarantee that quality. In the case of segregation of non-GM crops these guidelines would include all actions necessary to guarantee that the allowable tolerance of GM material is not exceeded. In order to learn and understand these requirements, training and educating the producer will be required. Along with stringent requirements comes the need to monitor the producers in the system to ensure they are following the guidelines set out in the contract. Should contamination due to accidental error or opportunistic behaviour occur, actions will be required to penalize the grower in question. Due to the potential for human error and opportunistic behaviour, testing procedures are required to ensure the pooled grain at the delivery point and even further down the supply chain doesn't become contaminated. All of these costs are referred to as monitoring and enforcement costs and depending on their magnitude will impact the efficiency of a segregation system.

Transaction costs (which will later be referred to as administration costs) will impact the cost minimization objective function of designated points and thus must be included in the objective function. The majority of the transaction costs involved in the system will be present for only those producers involved in the system. As a result, the objective function of a designated point will become:

$$\underset{TP_{ik}}{Min}\, TC_i = \sum_{k=1}^{n}\left(\left(CRP_k + A_k\right)\times\delta_k\right) + \sum_{k=1}^{n}\left(TP_{ik}\times Q_{ki}^{non-GM}\right) \quad (4.5)$$

subject to:

1. $\sum_{k=1}^{n} Q_{ki}^{non-GM} = Q$ (4.5.1)

2. $\delta_k = 0,1$ (4.5.2)

3. $(1-\delta_k)\times Q_{ki}^{non-GM}=0$ (4.5.3)

4. $Q_{ki}^{non-GM}=f(TP_{ik},T_i,T_j,HC_i,HC_j,F_i,F_j)$ (4.5.4)

Where:

TC_i = total cost to the designated terminal, i.

CRP_k = constant cost recovery premium paid to producer k.

A_k = constant representing the transaction costs (administration costs) involved with including farm k in the contract.

δ_k = if farm k delivers to designated point, i, equal to 1, otherwise equal to 0.

TP_{ik} = trucking premium offered by designated point to farm k=(1,...,n), where n equals the number of farms in the region.

Q_{ki}^{non-GM} = quantity of grain delivered from farm k to the designated point.

Q = total quantity of non-GM wheat requiring segregation.

T_i = trucking costs from farm k to designated terminal, i.

T_j = trucking costs from farm k to initial low-cost delivery point.

HC_i = handling tariff charged by designated terminal, i.

HC_j = handling tariff charged by initial low-cost delivery point.

F_i = freight costs at designated terminal, i.

F_j = freight costs at initial low-cost delivery point.

Note that the costs are only included for the farms that are included in the system. Now instead of simply determining the lowest costs based on transportation premiums, the designated point must consider whether it is more cost efficient to reduce the number of producers in the system so as to minimize the search, negotiation, monitoring and enforcement costs.

Similarly, the objective function for the system which designates multiple points, managed as one entity becomes:

$$\underset{TP_{jk}}{Min}\, TC_s = \sum_{k=1}^{n}\sum_{j=1}^{m}\left(\left(CRP_{kj} + A_{kj}\right)\times \delta_{kj}\right) + \sum_{k=1}^{n}\sum_{j=1}^{m}\left(TP_{jk} \times Q_{kj}^{non\text{-}GM}\right) \qquad (4.6)$$

subject to:

1. $\sum_{k=1}^{n} Q_{kj}^{non-GM} = Q$ (4.6.1)
2. $\delta_{kj} = 0,1$ (4.6.2)
3. $\left(1-\delta_{kj}\right)\times Q_{kj}^{non-GM} = 0$ (4.6.3)
4. $Q_{kj}^{non-GM} = f\left(TP_{jk}, T_j, T_i, HC_j, HC_i, F_j, F_i\right)$ (4.6.4)

Where:

TC_s = total cost to the multiple designate point system.

CRP_{kj} = constant cost recovery premium paid to producer k by point j.

A_{kj} = a constant representing the transaction costs (administration costs) involved with including farm k in a contract with point j.

δ_{kj} = if farm k delivers to designated point, j, equal to 1, otherwise equal to 0.

TP_{kj} = trucking premium to farm k=(1,…,n) from designated point j=(1,…,m), where n equals the number of farms taking part in the program and m equals the number of designated points in the system.

Q_{kj}^{non-GM} = quantity of grain delivered from farm k to designated point j.

Q = total quantity of non-GM wheat requiring segregation.

T_j = trucking costs from farm k to designated point, j.

T_i = trucking costs from farm k to initial low-cost delivery point, i.

HC_j = handling tariff charged by designated point, j.

HC_i = handling tariff charged by initial low-cost delivery point, i.

F_j = freight costs at designated point, j.

F_i = freight costs at initial low-cost delivery point, j.

4.5 Summary

This chapter outlined the fundamental economic theories underlying the simulation model used in this study. This included the economic theories behind how the introduction of premiums will impact producer decision-making and grain handling catchment areas. The final sections of this chapter outlined where each of the aforementioned economic theories fit in regards to each of the alternative segregation systems analyzed in the study.

CHAPTER 5 - METHODOLOGY

5.1 Introduction

The comparison of the three alternative segregation scenarios in this study relies on a model that attempts to simulate the movement of grain in a region based on a producer's goal to minimize costs and thus maximize profits. The following chapter details the selection and initialization of the region analyzed in the model and then goes on to explain the composition and underlying assumptions present in the simulation process. Each segregation alternative is explained thoroughly, including the process required to simulate grain movement under each scenario. The final section of this chapter details the calculations utilized for the estimation of costs in each alternative scenario. Note that for the remainder of the study, the use of the terminology GM will replace HT, as the purpose of the study was to examine the introduction of GM varieties.

5.2 Region Selection and Characteristics

The region chosen for the simulation model is located in southern Manitoba and covers an area of 5040 square miles (Appendix B). This region was chosen for a number of reasons. The agricultural land base is dedicated to primary crop production including wheat, canola, flax and barley. Considering the model concentrates on wheat production, a region with significant interest in wheat production was desired. The region is located in the eastern portion of the prairie region allowing for the movement of all export grains in the model through Thunder Bay ports. This allowed for the removal of the spatial competition factor between east and west coast ports. The region has an adequate number of high throughput terminals for model simulation. There are nine inland terminals in the region at seven different locations. This allowed for the removal of small wooden elevators from the model, following the trend in the prairie region away from the use of wooden elevators and towards the use of high throughput terminals. The absence of small elevators also removed a large portion of the concern over capacity constraints, etc. in the simulation process. Lastly, the author's familiarity with the region played an important role in the decision to choose this region for the model.

5.2.1 Crop Production in the Region

The 1996 Census data for selected rural municipalities in census regions 3, 4, 5, 7, 8 and 9 was used to establish averages for cultivated acreage in the region and more specifically the portion of those acres dedicated to wheat production (Appendix B). Total acres in all crops was divided by the total potential acreage for the region to determine the percentage of acreage dedicated to crop production.

2,668,008 cult. ac./(5040 sq. miles x 640 ac./sq.mile) = 82.7% ac. in crop. (5.1)

Total wheat acres was then divided by total acres in crops to determine the portion of cultivated acres dedicated to the production of wheat.

986,361 ac. wheat/2,668,008 ac. in crop = 37% of ac. dedicated to wheat. (5.2)

The region was split into 140 township size farms which, for the purpose of the model, were assumed to be homogeneous in nature. Each farm has 23,040 acres in total land area. Taking the average land base utilized for crop production, it was determined that each farm has approximately 19,050 cultivated acres. Furthermore, of the 19,050 cultivated acres, it was determined that each farm would grow wheat on approximately 7050 acres. For easier calculation, the assumption was made that each farm would dedicate 40% of cultivated acres to wheat production resulting in production of wheat on 7600 acres.

5.3 Catchment Areas and Model Initialization

Prior to the simulation process, the model region required initialization to determine the movement of grain under current circumstances. Given that the delivery points are not located uniformly across the region, the movement of grain is presumably not a decision based solely on distance. The combination of distance and trucking rates charged by each delivery point were thus estimated to determine the current allocation of producer's grain to each terminal. The following section outlines the procedure used to initialize the model region so that each terminal handled approximately the same volume of grain relative to their capacity.

5.3.1 Estimating Distance to Each Delivery Point

Small wooden elevators are not represented in the model, leaving nine large inland terminals in seven locations to handle the grain produced in the region. Terminals are located in Boissevain, Killarney (3), Morden (Aggasiz), Elm Creek, Rathwell, Nesbitt and Souris. The three terminals located in Killarney are treated as one entity with a total capacity consisting of the sum of each of the three terminal's capacities.

Each delivery point was given an approximate co-ordinate in an excel spreadsheet to represent their location in relation to the furthest southwest corner of the region. The co-ordinates represented the number of miles east and the number of miles north of the southwest corner.

Each of the 140 farms was also given a co-ordinate in relation to their distance from the southwest corner of the region. It was assumed that each township-size farm would have all of their storage located in the middle of the township (i.e. 3 miles from each side of the farm). It was also assumed that each producer would haul to only one delivery point in the region (Khakbazan 1999).

A formula was designed to determine the distance from all 140 farms in the region to each of the delivery points in the model. This allowed for the minimum distance delivery point for each farm to be estimated and analyzed. As mentioned previously, due to the non-uniformity of delivery points across the region, the minimum distance calculation resulted in a high variance in the amount of grain handled by each point relative to their capacities. Uniformity was desired in the number of turns each elevator would handle for the region. To achieve this uniformity, variable trucking rates were implemented to alter the flow of grain in the region. The following section outlines the procedure used to estimate trucking rates.

5.3.2 The Impacts of Trucking and Handling Charges on the Movement of Grain

A phone survey of four representative trucking firms (Biggar Transport, Matchett Trucking Company Ltd., Ray's Transport Ltd., and Tri-Star Transport Ltd.) was conducted in January 2001 to determine industry trucking rates for the movement of a

40 tonne truckload of wheat over 10, 50 and 100-mile distances. These rates were then used to determine the average trucking rates over these distances.

5.3.2.1 The Trucking Formula

Assuming trucking costs increase at an increasing rate, an exponential function can be used to determine trucking rates over distance. The assumption that trucking rates increase over distance at an increasing rate is justified by the fact that the lengths of hauls in the model region are relatively short. Transport by truck becomes much cheaper per mile as distances exceeding the ones evident in this model are travelled. This assumption can also be justified by the fact that the probability of back-hauls over shorter distances is relatively low. With a low probability of back-hauls over such short distances, trucking companies will set their rates assuming they will be travelling empty on their return. If back-hauls are present with a higher probability, or if hauling distances increase, the trucking costs would presumably still increase over distance, but at a decreasing rate.

The following equation was used in the model to estimate trucking costs in the region:

$$T_d = T_0 e^{gd} \tag{5.3}$$

Where:

$T_d =$ trucking cost charged per tonne to haul 40 tonnes over distance d.

$T_0 =$ constant representing the fixed cost of loading, dispatching, etc.

$g =$ transportation coefficient.

$d =$ distance.

Using the rates gathered from the four representative trucking companies (Biggar Transport, Matchett Trucking Co. Ltd., Ray's Transport Ltd., Tri-Star Transport Ltd. 2001), the constant (T_0) was estimated to be $4.70/tonne while the transportation coefficient (g) was estimated to be .00075. The value of the coefficient is the rate at which trucking costs increase per mile in the exponential trucking formula presented above (Equation 5.3). The positive value indicates that trucking rates increase at and increasing rate.

Prior to using the estimated trucking costs for the initialization process, handling charges needed to be determined to be used in conjunction with the trucking costs and reported freight rates.

5.3.2.2 Estimating Handling Charges

For the purpose of region initialization, supply curve estimation and for the analysis to be conducted later in the study, handling charges were estimated based on the average costs for each terminal. Current handling tariffs could have been used, but are assumed to be based on the current average costs of each elevator turning 4.6 times (CGC 1999). Due to the elimination of small elevators from the model, the terminals in the region were calculated to turn on average 12.86 times. Thus, to determine the new average cost, the operating costs of a terminal required estimation.

The 26,000 tonne Aggasiz terminal can be used to demonstrate this process. Based on the average number of turns for the region (4.6), Aggasiz would handle 119,600 tonnes of grain in a year. The current handling charges at this elevator is $14.57/tonne resulting in total revenue of $1,742,572. Assuming this is breakeven for the terminal, the total cost is then the same (TR=TC). The proportion of total costs that are fixed was assumed to be 78.5% with the remaining 21.5% being variable costs (Ferguson 2001). The total fixed cost and average variable cost (marginal cost) was thus determined using the following equations:

$$\text{Total Cost x } 78.5\% = \text{Fixed Cost} = \$1{,}367{,}919 \quad (5.4)$$

$$\text{Total Cost x } 21.5\% = \text{Variable Cost} = \$374{,}653 \quad (5.5)$$

$$\text{Variable Cost / Quantity} = AVC \text{ or } MC = \$3.13\text{/tonne} \quad (5.6)$$

Total cost for Aggasiz in the model was then calculated to determine the average cost (equal to the handling charge) at 12.86 turns:

$$\$3.13 \text{ x } 12.86 \text{ turns x } 26{,}000 \text{ tonnes capacity} = TVC = \$1{,}046{,}547 \quad (5.7)$$

$$(TVC + FC) \text{ / Quantity} = \$2{,}414{,}466/334{,}360 \text{ tonnes} = AC = \$7.22\text{/tonne} \quad (5.8)$$

The handling charges used in the model are based on these calculations and as can be seen by the Aggasiz example, differ quite considerably from the current rates charged.

5.3.2.3 Combining Distance with Trucking Rates

Equation 5.3 was used in conjunction with the distance to delivery point estimates to determine trucking costs faced by each farm for each alternative delivery point. Using these numbers, a table was constructed in Excel that would identify where each farm would deliver based on minimum total costs. This table was also designed to count the number of farms delivering to each point. Handling charge estimates and rail freight charges were included in the table to ensure that each farm is delivering to the low cost elevator, not just to the elevator with the lowest trucking costs. The table would later be used to make adjustments to the trucking rates in order to achieve a desirable and uniform farm to elevator ratio. Before making the adjustments, the desired number of farms delivering to each elevator needed to be determined.

5.3.2.4 Determining Desirable Handling Volumes

The first step required in determining the desired farm to elevator ratio was to calculate an equal number of turns (of wheat) for all delivery points. This was estimated by dividing the volume of wheat produced in the region by the total elevator capacity for the region. The number of farms delivering to Boissevain (15) and Souris (4) were arbitrarily predetermined and removed from the calculation based on the assumption that they are both close to the western border of the region and would attract grain from outside the region to achieve their capacity expectations. With Boissevain and Souris removed from the calculation, the number of turns was estimated as follows:

$$7600 \text{ tonnes/farm} \times 121 \text{ farms} / 142{,}880 \text{ tonnes total capacity} = 6.43 \text{ turns} \qquad (5.9)$$

Note that each elevator is turning 6.43 times with wheat alone. The 12.86 turns used to determine the handling charges comes from the fact that most elevators handle approximately 50 percent wheat. The number of farms delivering to each of the elevators (excluding Boissevain and Souris) was then estimated using the following calculation:

$$EC_j \times 6.43 \text{ turns} / 7600 \text{ tonnes per farm} = NF_j \qquad (5.10)$$

Where:

EC_j = capacity of elevator(s) at delivery point j

NF_j = number of farms delivering to point j

The resulting equal share of the market has 22 farms making deliveries to Aggasiz, 16 farms to Elm Creek, 45 farms to Killarney, 15 farms to Nesbitt and 23 farms to Rathwell.

5.3.2.5 Altering the Movement of Grain by Adjusting Trucking Rates

An iterative goal seek procedure was used in conjunction with the aforementioned Excel table to adjust the transportation costs charged by each elevator so that the desired number of farms delivering to each point was met. The goal seek procedure provided the ability to set the total farms cell for each elevator to a desirable level by changing the value of another cell in the formula. The constant in the trucking formula was chosen as the variable parameter. This procedure required multiple trials before the desired number of farms delivering to each delivery point was simultaneously met. The result was transportation formula constants ranging between $3.55 and $7.46. Each elevator now handled the same quantity of wheat relative to their total capacity by taking deliveries from the desired number of farms calculated earlier.

The next stage of simulation required a model to determine how producers allocate their acres to alternative varieties initially, and how premiums would impact their acreage allocation decisions later in the model.

5.4 Producer Decision Making Model

Figure 4.2 in chapter four can be used to demonstrate the allocation of wheat acreage to GM and non-GM varieties based on the marginal cost of growing GM wheat relative to non-GM wheat. To introduce this concept to the model, each farm's supply curve for GM wheat based on the relative price difference between GM and non-GM required estimation. Each farm in the simulation model is considered to be homogeneous in nature meaning that, initially, all farms will allocate their acreage to GM and non-GM varieties identically given the same relative price. To satisfy this homogeneity, the supply curve for each farm differs in its intercept but has an identical slope.

5.4.1 Farm Level Supply of GM-Wheat

The supply curve for GM wheat is assumed to be linear, with price for GM wheat relative to non-GM wheat on the vertical axis and acreage on the horizontal axis. To implement an upward sloping supply curve, the assumption was made that each farm will have low cost acres and high cost acres. Those acres furthest left on the supply curve are the highest cost acres, and as you move right along the horizontal axis, the cost of producing one tonne of wheat per acre gradually diminishes. Assuming GM varieties provide the greatest cost reduction on high cost acres, the intercept of the GM supply curve on the vertical axis represents the highest cost reduction benefit available to each farm.

5.4.1.1 Intercept Calculation

To calculate the intercept for each farm, the 20-year average price (1978-1998) for #1 C.W.R.S was used. This average price was determined to be approximately $175.00 per tonne (SAF 1998). Based on this price, it was assumed that each farm would produce 7600 tonnes of wheat by allocating 7600 acres to wheat production and averaging one tonne per acre. Trucking costs, handling costs and freight costs (including the freight adjustment factor) were deducted from the average price for wheat to determine the farm gate price received by each farm. The intercept was then determined by deducting the assumed maximum marginal benefit for growing GM wheat.

Estimates for the potential average benefit of GM wheat adoption range from $6 to $7 per acre (Holzman et al. 2001). For the purpose of the model, the average benefit was assumed to be $6 per acre. This allowed for an assumption to be made that the highest cost acres on a farm realize a $12 benefit while the lowest cost acres which are being planted to GM varieties realize no benefit. Therefore, a maximum benefit of $12 per acre was used to determine the intercept of the curve.

This process resulted in each farm having a different intercept for their supply curve. This can be explained by the fact that each farm has different trucking costs, handling costs and freight costs depending on their distance to delivery point and the handling/freight charges present at the location they are delivering to.

5.4.1.2 Slope Calculation

The calculation for the slope parameter is fully dependent on the adoption rate for GM varieties. As will be discussed later, three different adoption rates are imposed on the model, which results in three different supply curve estimations, each with the same intercept but differing slopes. For example, assuming the adoption rate for GM varieties is 50%, each farm would grow 3800 acres of GM wheat and 3800 acres of conventional wheat. To determine the slope of the supply curve that will produce these results, one can divide the $12 marginal benefit by the number of acres allocated to GM wheat to come up with a farm-level supply curve slope equal to .0031579. This procedure was used to determine the slope of the farm-level supply curves for each adoption rate scenario.

The supply curves were then entered into an Excel spreadsheet to be used as the basis for supply determination after the introduction of trucking premiums in the simulation model. After initializing the region, scenario development was conducted to prepare for the simulation model.

5.5 Scenario Development

Due to uncertainty surrounding the expected adoption rate for GM wheat as well as the demand that will be present in the market for non-GM wheat, variations in each are imposed on the model. Both adoption rate and demand were given three potential outcomes that resulted in 27 different scenarios when compared using three different segregation alternatives.

5.5.1 Adoption Rates

Adoption rates for HT canola by the 2000 crop year were 77% (Phillips 2001). This level of adoption is present with zero premiums or discounts for HT canola. The highest adoption rate utilized in the model is based on the historical outcome for canola and is set at 80% for ease of calculation. The lowest adoption rate in the model is 20% with the third being 50%. These three potential outcomes vary significantly and were chosen for precisely that reason.

5.5.2 Demand

Three separate demands for non-GM wheat are imposed on the model as well. These demands represent the total demand for non-GM wheat from the region and are set at 60,000, 120,000 and 180,000 tonnes. These demands were chosen as they were felt to represent a wide enough range to satisfy the objective of comparing low, medium and high volumes requiring segregation. The 180,000 tonne demand was chosen as it would allow an inland terminal to operate at approximately the same volume as before segregation is introduced. Similarly, 60,000 tonnes demand would allow one small elevator to efficiently handle the entire segregation.

5.5.3 Segregation Options

Three segregation alternatives are analyzed in the model, all of which utilize the bulk handling system already in place in the region. The first option involves the designation of a high throughput terminal to handle only non-GM wheat. The designated terminal is permitted to continue handling initial volumes of other commodities whether they are GM or non-GM. Aggasiz was chosen as the terminal to designate, as it is the closest terminal in the region to the Thunder Bay port.

The second alternative in the model is a multiple-designated point system where small wooden elevators are re-opened to handle non-GM wheat. Depending on the volume in the given scenarios, one, two or three wooden elevators were used. The choice for which elevators to designate attempted to evenly disperse the delivery points across the region to limit the competition factor amongst them. These elevators were assumed to operate as a system, operated by one individual firm. For the 180,000 tonne scenarios, three elevators were chosen in the region. They are located at Winkler, Glenboro and Cartwright. For the 120,000 tonne scenario, only Winkler and Glenboro elevators are re-opened. For the 60,000 tonne scenario, only Winkler is used as, once again, it is the closest point to Thunder Bay ports.

The final segregation option in the model involves segregation within each high throughput terminal in the region. The volumes demanded from the region were allocated to each terminal based on their respective capacities. Each terminal sourced its allocated volume from the required number of farms within its original catchment area.

5.6 The Simulation Model

As mentioned previously, each farm was represented in an Excel spreadsheet with an estimated supply curve for GM wheat. Also present in the spreadsheet for each farm was the distance to their initial delivery point, the trucking costs incurred when delivering to that point, the handling charges at the delivery point and the freight costs for hauling by rail to the Thunder Bay port. These costs are used in calculations later in the model.

5.6.1 Designated High Throughput Terminal (Aggasiz)

The designation of one terminal in a region to segregate non-GM wheat has an impact on both the producers outside the original catchment area as well as the producers within the original catchment area.

Farms outside the region have two alternatives for marketing the non-GM wheat they produce. They must decide whether it is more beneficial to enter into a contract with the designated point and incur the added segregation and trucking costs involved with doing so, or deliver their non-GM wheat to their original delivery point and sell it into the GM market. They must also take into account the differences in handling and freight charges at the two alternative delivery points. If the handling and rail freight charges happen to be lower at the designated point, this would in effect reduce the added trucking costs incurred in delivery to that point. Alternatively, if the handling and freight charges are higher, the added costs of delivering to the designated point increase above the added trucking costs.

Farms within the region are also impacted due to the fact that the GM wheat they produce cannot be delivered to their low-cost delivery point. Their initial delivery point has been removed from the market for GM wheat and as a result, they must haul any GM wheat they produce to an alternative delivery point. Once again, these producers must take the difference in handling and freight charges into account. If these charges are greater at the alternative delivery points, the farmer would presumably grow and contract even more non-GM wheat than they would taking only trucking costs into account.

Taking these factors into account, the designated terminal must determine how it is going to source the required amount of grain from the region. In the absence of trucking premiums, the designated point will receive zero non-GM wheat from outside their original catchment area. However, from the producers within their original catchment area, they will receive more non-GM than would have normally been the case due to the added costs incurred in delivering to points that will handle GM wheat. If the volume of non-GM wheat handled within their original catchment area doesn't meet the required volume being demanded from the region, premiums must be introduced.

5.6.1.1 Trucking Premiums

As discussed in chapter four, trucking premiums are the most efficient method for increasing market share for a designated point. For this reason, a distance based linear trucking premium was introduced to the simulation model. The trucking premium appears in the Excel model in a column that reports the premium offered to each farm based on constant intercept and slope parameters. The intercept and slope parameters are linked to each farm's distance to the designated point to calculate the premium that will be offered. In their decision making process, each farm calculates the difference in handling and rail freight costs between their two delivery alternatives and then deducts the trucking premium from the initial trucking cost to the designated point to determine the quantity of non-GM wheat they will deliver under contract.

5.6.1.2 Administration Costs

Prior to estimating the intercept and slope parameters that would generate the optimal trucking premium to offer, the administrative costs and the compensatory premium costs must be calculated. These costs are assumed to be present only if a given farm enters a contract with the designated point.

The administrative cost is a direct result of the transaction costs discussed in chapter 4 which include contract development, producer training and the monitoring and enforcement of the contract in place.

The estimation of these costs required an assumption that, in reality, there are approximately ten farms within the township size farm. This assumption is included to prevent the under-estimation of the administration costs for a contract. For each of the ten farms within the township, it was arbitrarily assumed that eight hours are spent developing a contract, training the producer and monitoring the producer throughout the year. If the time spent with each farm differs from the assumed eight hours, the analysis will not change considerably, as the administration cost per farm is assumed to be the same for each segregation alternative. Assuming a $25.00 per hour wage cost for the time spent with each farmer, the resulting administration cost equates to $200 per farm. Aggregating back to the township level, the administration costs included in the model are $2000 per farm. The importance of this cost factors into the decision over the optimal trucking premium to offer. The designated point must consider the fact that for every farm with which they contract there will be a $2000 fixed cost.

The cost recovery premiums are intended to compensate producers for the costs of on-farm segregation. Similar to the administration cost calculation, each township was assumed to be comprised of ten individual farms. The calculations were made based on this assumption and were then aggregated back to the township level.

To estimate equipment-cleaning costs, it was assumed that each farm would be required to make two thorough cleanings of their seeding and harvesting equipment per year of production. It was assumed that each cleaning would require two hours of labour and downtime resulting in eight hours total for equipment cleaning. A cost of $25 per hour was associated with this labour and downtime resulting in $200 total cost for equipment cleaning per farm.

It was assumed that each farm would also require an extra bin for on-farm storage. The price for a bin was assumed to be $8000 based on a price quote obtained from Saskatoon Co-op (2001) for 4000 bushels of storage. Assuming a 20-year life for the bin with zero salvage value generated a $400 cost per farm per year.

Each farm was assumed to require the use of one more custom truckload than would be the case if wheat were handled as one commodity. This was included based on a full 40 tonne truckload with the cost being dependent on each farm's initial trucking cost estimates.

Lastly, it was assumed that, similar to the transaction costs incurred by the elevator (administration costs), each producer would spend four hours of management time negotiating the contract, being trained on contract specifications, and ensuring contract specifications were met. Based on an assumed $25 per hour management cost, the total added cost to the producer for management equated to $100. Aggregating all of these costs back to the township level resulted in a total of $7000 plus the costs of 10 more trucks.

Keeping these costs in mind, the designated point(s) must decide whether to attract grain from more farms and incur the administration costs in doing so, or increase the premiums being offered to farms already under contract to increase their acreage allocated to non-GM wheat.

5.6.1.3 Estimating Intercept and Slope Parameters

Assuming the designated point has a cost minimizing objective function, they will want to achieve the desired volume of grain at the lowest possible cost. Presumably there are a number of trucking premiums (composed of different intercept and slope parameters) that would result in the desired volume of grain for the designated point. However, there is only one intercept/slope combination that will generate the lowest cost outcome. Taking this into consideration, the model was constructed such that for differing levels of premiums being offered, the total cost of attracting the desired volume of non-GM wheat could be analyzed and compared. The total cost cell used for comparison consists of the sum of trucking premium, cost recovery premium and administration costs for each farm under contract. A capacity cell was also introduced at this point to calculate the total volume delivered by each contracted farm to the designated point. The calculations conducted in these cells are vital to the following process.

The ability to compare a range of trucking premiums required the construction of a model that would test a matrix of intercepts with a matrix of slopes. This is known as a grid search procedure. To conduct the grid search procedure, a macro was programmed in Excel that would calculate the total cost of sourcing a predetermined volume of non-GM wheat by analyzing the set range of intercepts over a set range of slopes. The macro inserts a value into the intercept cell in Excel and then calculates the total cost under each possible slope parameter by inserting a set range of values into the slope cell. After all slopes in the range are checked, the macro inserts the next intercept value into the intercept cell and again calculates the total cost with all slopes in the range. While doing this, the macro is programmed to report the value in the total cost cell on a separate spreadsheet each time the capacity cell equals or exceeds the predetermined volume. With the reported matrix of costs, the minimum can be determined and is assumed to be the optimal intercept/slope combination.

5.6.1.4 Determining the Range of Intercepts and Slopes

In determining the range of intercepts and slopes to check, one must consider the fact that the designated point has ability to discriminate against those producers captive to the designated point. Discrimination against those producers closest to the delivery point would appear in the linear trucking premium as a negative intercept. The sign of the slope would then dictate whether or not the premium would increase or decrease as distance increased. As a result, the intercepts used in the grid search procedure ranged between negative one dollar and positive one dollar and were checked in one-cent intervals. This range of intercepts allowed for a comparative analysis that considered the potential for discriminatory premiums as well as non-discriminatory premiums.

The slope parameter ranged between negative ten cents per mile to ten cents per mile and varied by one tenth of a cent intervals. This range of slopes allowed for a further comparative analysis that considered the potential for premiums increasing with distance as well as premiums decreasing with distance. Provided the optimal outcome was well within the upper and lower bounds for both parameters, one could be confident the range provided the most efficient optimal outcome. In the event that the optimal outcome approached the bounds for either parameter, the macro was reprogrammed to analyze a wider range of possibilities.

The information gathered in the simulation model was then used to generate the resulting costs of segregation in the designated high throughput scenario. The calculations required to determine the results will be discussed later in the chapter.

5.6.2 Multiple Designated Points

The second segregation alternative involved the designation of multiple designated points located within the region. In essence, the multiple designated point scenario is only truly multiple for the 180,000 tonne and 120,000 tonne scenarios. At 60,000 tonnes, the scenario becomes a designated wooden elevator scenario. This doesn't, however, affect the simulation process.

Unlike the designated high throughput terminal, the multiple designated point alternative examines the option of using existing small wooden elevators in the region to handle the non-GM wheat. As previously mentioned, these points were arbitrarily chosen attempting to disperse them well enough to limit competition for the non-GM wheat. If the selected elevators were located close together, the costs of sourcing the grain would be unnecessarily high, as they would have to compete amongst themselves for the grain. Due to the fact the elevators in the system are assumed to be operated by one firm, limiting the competition factor for the non-GM grain was desired.

A similar analysis was conducted for this model with a number of required alterations and assumptions. Due to the fact the small elevators weren't present in the model during the determination of optimal trucking rates in the initialization process, trucking rates are assumed to be based on the formula estimated using industry quotes. This resulted in two of the elevators charging higher trucking rates than the nearby competing terminals while the third charged a lower trucking rate than nearby terminals.

Although the average variable costs of operating a wooden elevator are reportedly much higher than operating a high throughput terminal (Agricore 2001), the tariff rate calculated earlier, based on the operating costs of a terminal, was used. Freight rates from the wooden elevators to the Thunder Bay port were once again based on industry reports (Warkentine and Associates 2001).

5.6.2.1 Producer Decisions

Producers in the region now have more decisions to make over what they will produce and where they will deliver. There are no longer producers in the region that aren't able to deliver to their initial low-cost point as all the terminals now handle GM wheat. Producers do, however, have to decide if they are going to contract any non-GM wheat and if so which wooden elevator they will deliver to.

Using a formula which accounts for the costs of all four alternatives (three in the 120,00 tonne scenario and two in the 60,000 tonne sceanrio), this decision making process is programmed into Excel allowing each producer to decide if they will contract, how much they will contract and which non-GM delivery point they will use. The costs they must consider include any differences in handling and freight costs as well as the differences in trucking costs when delivering to the designated points. Provided producers choose to contract non-GM wheat, they are only permitted to deliver to one of the three (two in the 120,000 tonne scenario and one in the 60,000 tonne scenario) designated points and must base this decision on which is the lowest cost for delivery.

To alter the production decisions of farmers so that each elevator can source the required amount grain from producers in the region, linear trucking premiums were introduced. The methodology used for the calculation of the intercept and slope parameters for the elevators was the same as in the designated terminal scenario. However, the process was somewhat more complicated as up to three premiums required simultaneous estimation. When dealing with only one terminal or elevator, one range of intercepts can be checked against one range of slopes. When dealing with simultaneous estimation, the range of intercepts and slopes for one elevator must be checked against the range of intercepts and slopes for each alternative elevator in the system. A grid search procedure was used to conduct the estimation similar to the one in the designated terminal scenario. For the two and three elevator scenarios, each potential intercept and slope in the predetermined range for all designated points was compared. For the one elevator scenario, the process was identical to the one for the designated terminal scenario.

The administrative costs and cost recovery premium costs involved with this system were assumed to be identical to those in the designated terminal scenario and were taken into consideration when estimating the optimal trucking premium to offer.

This process generated an optimal outcome with an intercept and slope parameter for each elevator that would source the required amount of non-GM wheat at the lowest possible cost.

The estimated trucking premium, administrative and cost recovery premium costs required to implement the multiple designated point system were used to generate results for the costs of the system. The calculation of the results will be explained later in the chapter.

5.6.3 Segregation within Terminals

The final segregation scenario examines the option of segregating non-GM wheat within terminals in the region. The terminals are permitted to continue handling GM wheat as well, but are required to keep the two commodities separate within the facility. It was assumed that the terminal would continue to operate at their initial handling volumes and that the non-GM wheat would be treated as just another commodity.

Adding non-GM wheat as another commodity compared to adding an entirely different crop creates the need for testing due to the inability to visually distinguish between two commodities (GM and non-GM wheat). Costs to the terminal were thus composed of testing, administration, compensating producers for on-farm segregation and in some cases incentive based premiums.

Each terminal has two options for sourcing the required amount of non-GM from their initial catchment area. Each terminal can source their allocated volume without a premium by contracting with the required number of farms. The second option involves the implementation of an incentive based premium, offered to selected producers to attract a larger volume from their farms while reducing the number of farms contracted with. The second option is aimed at minimizing the administrative and compensatory costs associated with the system.

To determine the lowest cost option available to each terminal for each scenario, the costs associated with offering zero premiums and the costs associated with offering premiums to selected producers were calculated.

5.6.3.1 Sourcing Grain in the Absence of Premiums

Without a premium, each elevator must determine how many contracts are required to attract the tonnage they have been allocated to segregate. This was estimated by dividing each terminal's allocation by the tonnes of non-GM wheat each farm would produce in the absence of incentive-based premiums. In many cases, this resulted in the terminal having to source more grain than was required as it was assumed the contracts would be for all or none of each producer's crop. This led to higher testing costs per tonne and in some cases higher administrative and compensatory costs but eliminated the costs associated with offering premiums.

5.6.3.2 Sourcing Grain Using Premiums

To estimate the optimal number of farms to contract with given a specific volume of non-GM wheat, a formula in Excel was created that would calculate the cost savings after reducing the number of farms under contract. To achieve the desired volume after reducing the number of farms, premiums were offered to the remainder of producers under contract to increase their respective acreage allocations to non-GM varieties. Unlike the other options, the premium in this scenario is a constant per tonne premium not associated with distance from farm to terminal. The optimal number of farms to offer contracts to was determined by reducing the number of farms under contract with each terminal until the highest cost savings was achieved. The optimal number of contracts to reduce differed amongst elevators for each scenario.

With the completion of the simulation model, the costs of each system in all the scenarios was calculated and compared with the initial system costs to determine the total potential costs after introducing and implementing segregation of non-GM varieties.

5.7 Initial Region Costs

Using the estimates for trucking costs and handling costs, along with factual freight costs, the initial system costs were estimated. Based on earlier assumptions, each farm will produce 7600 tonnes of wheat. The total cost for each farm was calculated as follows:

$$TC_{kj} = 7600 \text{ tonnes x } (T_{kj} + HC_j + F_j) \tag{5.11}$$

Where:

TC_{kj} = total cost incurred by farm k to deliver to their low-cost delivery point j.

Tk_j = trucking cost per tonne to deliver from farm k to point j.

HC_j = handling charges at delivery point j.

F_j = freight rate and freight adjustment factor at delivery point j.

The total cost for the entire system was then determined by summing all individual farm costs. By dividing the total amount of wheat handled (140 farms x 7600 tonnes per farm) from the total system cost, the average cost of moving grain to port was determined. This provided a basis for comparison after the total cost of each segregation system in the model is estimated.

5.8 Segregation Costs for a Designated Terminal

The costs that were considered in the designated terminal scenario consist of costs borne by producers in the region, costs borne by the designated terminal as well as costs borne by the remainder of terminals in the region. Table 5.1 depicts and briefly explains the costs that were considered in the designated terminal scenario.

Table 5.1 – Cost variables in the three scenario.

Cost Variable	Explanation
Producer Costs	
Trucking (equations 5.12 and 5.13)	-changes in trucking costs for producers within the designated terminal's initial catchment area, as well as producers outside the initial catchment area who choose to deliver non-GM wheat to the designated point.
Handling & Freight (equations 5.12 and 5.13)	-changes in handling and freight costs for producers within the designated terminal's initial catchment area, as well as producers outside the initial catchment area who choose to deliver non-GM wheat to the designated point.
Designated Terminal Costs	
Administration (within equation 5.14)	-transaction costs incurred in the contracting process (constant per farm cost).
Cost-Recovery Premium (equation 5.15)	-costs paid to producers to compensate them for on-farm segregation (constant per farm cost).
Trucking Premium (within equation 5.14)	-trucking premiums paid to producers (potentially positive or negative depending on the level of discrimination).
Testing (within equation 5.14)	-testing costs for each 40 tonne truckload of non-GM wheat delivered.
Change in Handling Cost (equation 5.16)	-cost/benefit associated with handling a different volume than initially at the designated point (based on average operating costs).
Other Terminal and Region Costs	
Loss of Rail Incentives (equation 5.18)	-cost associated with handling greater amounts of grain at terminals with fewer car spots (thus lower rail incentives).
Change in Handling Costs (equation 5.17)	-cost/benefit associated with handling a different volume than initially at terminals other than the designated point.
Totals	
Designated Point	-total producer and designated terminal costs.
Entire Region	-total producer, designated terminal and other terminal/region costs.

As discussed previously, the added costs to producers in the region are split between producers outside the designated terminal's initial catchment area and those within the initial catchment area.

For those producers located outside the initial catchment area who choose to contract with the designated point, costs consist of increased trucking costs (less premiums) as well as the difference in the handling and rail freight costs at the designated point compared to their initial low-cost point (which may be costs or benefits depending on the difference).

For those producers within the original catchment area, costs consist of the difference in trucking costs for non-GM wheat being delivered to the designated point (which may be higher in the presence of discriminatory trucking premiums) as well as increased trucking costs for delivering to a terminal that will handle GM wheat. Once again, the difference in handling and rail freight costs must also be considered, which may increase or reduce the costs of delivering GM wheat to the next best alternative.

The added costs faced by the designated terminal include trucking premiums, cost recovery premiums paid to producers to compensate them for on-farm segregation, costs incurred from handling less volume, testing costs, and administrative costs associated with the contracts.

The remainder of terminals in the region will realize either costs or benefits depending on the change in the volume of wheat handled at the terminal. Those terminals handling more wheat than initially will realize a benefit while those handling less wheat than initially will face costs.

5.8.1 Producer Costs

The estimates for producer costs can be defined by two formulas, one for producers outside the initial catchment area, and one for producers within the initial catchment area. For those producers located outside the initial catchment area, the costs were calculated as follows:

$$TC_k = (((T_i - T_j) - TP_i) + (HC_i - HC_j) + (F_i - F_j)) \times Q_k^{non-GM} \quad (5.12)$$

Where:

TC_k = total costs incurred by farm k to contract non-GM wheat.

T_i = trucking costs per tonne to the designated terminal, i.

T_j = trucking costs per tonne to original low-cost point, j.

TP_i = trucking premium per tonne offered by the designated terminal.

HC_i = handling charges per tonne at the designated terminal.

HC_j = handling charges per tonne at the original low-cost point.

Fi = freight costs per tonne from the designated terminal

Fj = freight costs per tonne to original low-cost point.

Q_k^{non-GM} = quantity of non-GM wheat contracted by farm k.

For those producers located within the designated terminals original catchment area, the costs were calculated as follows:

$$TC_k = (((T_j - T_i) + (HC_j - HC_i) + (F_j - F_i)) \times Q_k^{GM}) + ((T_i - TP_i) \times Q_k^{non-GM}) \quad (5.13)$$

Where:

TC_k = total costs for farm k to deliver GM wheat to the next best alternative and contract non-GM wheat with the designated point.

T_j = trucking costs per tonne to alternative point.

$T_i =$ trucking costs pre tonne to original low-cost point (designated terminal).

$TP_i =$ trucking premium offered by designated point.

$HC_j =$ handling charges per tonne at alternative point.

$HC_i =$ handling charges per tonne at original low-cost point.

$F_j =$ freight cost per tonne from alternative point.

$F_i =$ freight cost per tonne from original low-cost point.

Q_k^{GM} = quantity of GM wheat delivered by farm k to alternative point.

Q_k^{non-GM} = quantity of non-GM wheat delivered by farm k to designated point.

The total costs incurred per tonne of non-GM wheat segregated were determined by summing all individual total costs for producers and dividing by the total quantity of non-GM wheat being segregated.

5.8.2 Designated Terminal Costs

The costs for the designated terminal consist of trucking premium costs, administrative costs, testing costs, increased handling costs and the compensatory premiums that are required to cover the costs of on-farm segregation. The calculation of administration costs and cost recovery premium costs were discussed earlier but the testing costs require a brief explanation and description of the assumptions required for estimation.

5.8.2.1 Testing Costs

Testing cost estimates were based on strip tests designed to ensure the presence of no more than .5% GM wheat in a non-GM shipment. The strip tests were assumed to be designed to test for traits and not specific events. To achieve 99% confidence, it was assumed that three pooled samples of 400 seeds were required. These samples were also assumed to be representative, meaning that proper sampling techniques were followed. Based on a one dollar cost per strip test, and fifteen minutes of labour to conduct the three tests at $20 per hour, a cost of eight dollars per truckload was estimated. Per tonne, this cost was then calculated to be twenty cents per tonne on a 40 tonne truckload (Rempel 2001).

5.8.2.3 Determining Designated Terminal Costs

The calculation for terminal costs was based on the following formula, which accounts for trucking premiums, cost recovery premiums, administration costs, testing costs and changes in handling costs:

$$TC_i = \sum_{k=1}^{n}\left(\left(A_k + CRP_k\right) + \left(\left(TP_k + ST_k\right) \times Q_{ki}^{non-GM}\right)\right) + \left(\left(\sum_{k=1}^{n} Q_{ki}^{non-GM}\right) + Q_{ki}^{other}\right) \times \Delta EC_i \tag{5.14}$$

With:

$$CRP_k = \left(T_j \times 40\right) + E_k + M_k + B_k \tag{5.15}$$

$$\Delta EC_i = HC_i - \left(\left(\left(\left(\sum_{k=1}^{n} Q_{ki}^{non-GM}\right) + Q_{ki}^{other}\right) \times MC_i\right) + FC_i\right) / \left(\left(\sum_{k=1}^{n} Q_{ki}^{non-GM}\right) + Q_{ki}^{other}\right) \tag{5.16}$$

Where:

TC_i = total cost for designated terminal i.

A_k = administration costs incurred when contracting with farm k.

CRP_k = cost recovery premium costs incurred when contracting with farm k.

TP_k = trucking premium per tonne paid to farm k.

ST_k = strip test costs per tonne incurred when testing grain from farm k.

Q_k^{non-GM} = quantity of non-GM wheat contracted by farm k

Q_k^{other} = quantity of other commodities hauled by farm k to the designated point.

EC_i = elevation costs for the designated terminal.

T_j = trucking costs from farm k to initial low-cost delivery point.

E_k = equipment cleaning costs incurred by farm k.

M_k = management costs incurred by farm k.

B_k = costs incurred by farm k in the purchase of another storage bin.

HC_i = handling tariff charged by the designated point i.

MC_i = marginal cost of operations at the designated point i.

FC_i = fixed costs of operations at the designated point i.

Costs per tonne for the designated terminal were then calculated by dividing the total cost for the terminal (TC_i) by the total volume of segregated non-GM wheat.

5.8.3 Regional Cost/Benefit Calculations

Depending on the volume of non-GM wheat being segregated in the region, the remainder of the terminals in the region will witness either a cost or a benefit from the change in their volume being handled. When terminals lose the non-GM wheat being produced by farmers within their catchment area, the reduction of volume comes at a cost. Alternatively, there are two terminals in the region that can potentially benefit from segregation by handling the GM wheat produced by farmers in the designated terminal's initial catchment area. The calculation of these costs/benefits was determined based on the following formula:

$$TC_j = \left(HC_j - \left(\left(\left(\left(\left(\sum_{k=1}^{n} Q_{kj}^{GM} \right) + Q_{kj}^{other} \right) \times MC_j \right) + FC_j \right) / \left(\left(\sum_{k=1}^{n} Q_{kj}^{GM} \right) + Q_{kj}^{other} \right) \right) \right) \times \left(\left(\sum_{k=1}^{n} Q_{kj}^{GM} \right) + Q_{kj}^{other} \right) \tag{5.17}$$

Where:

$TC_j =$ total costs/benefits for terminal j attributable to changes in volume.

$HC_j =$ handling tariff charged by terminal j.

Q_{kj}^{GM} = quantity of GM wheat delivered by farm k to terminal j.

Q_{kj}^{other} = quantity of other commodities delivered by farm k to terminal j.

$MC_j =$ marginal cost of operations at terminal j.

$FC_j =$ fixed costs of operations at terminal j.

The cost/benefit per tonne for terminals other than the designated terminal resulting from the introduction of segregation was then calculated by dividing the total cost for each by the amount of non-GM wheat segregated.

One other regional consideration is the costs arising from moving grain between terminals with different rail incentives. Aggasiz, Nesbitt, Boissevain and Souris have 112 car spots and thus can potentially receive a $6 per tonne premium on all grain moved through the facility. Killarney and Rathwell, with only 56 car spots, can only receive a $4 per tonne premium. Elm Creek only has a 25 car spot and thus can only receive a $1 per tonne premium. To calculate the total loss in rail incentives, the following equation was used:

$$LRI = ((QE_{GM} - QE_{non-GM}) \times \$5) + ((QR_{GM} - QR_{non-GM}) \times \$2) - (QK_{non-GM} \times \$2) \tag{5.18}$$

Where:

$LRI =$ lost rail incentives.

$QE_{GM} =$ quantity of GM wheat from Aggasiz region moving to Elm Creek.

$QE_{non\text{-}GM} =$ quantity of non-GM wheat from Elm Creek region moving to Aggasiz.

QR_{GM} = quantity of GM wheat from Aggasiz region moving to Rathwell.

$QR_{non\text{-}GM}$ = quantity of non-GM wheat from Rathwell region moving to Aggasiz.

$QK_{non\text{-}GM}$ = quantity of non-GM wheat from Killarney region moving to Aggasiz.

The total lost rail incentive was then divided by the quantity of non-GM wheat being segregated in the region to determine the cost per tonne for lost rail incentives.

5.8.4 Private vs. Regional Costs

The system costs based on the designated terminals point of view were calculated as the costs borne by producers plus the costs borne by the designated terminal. The costs at the regional level considered the same costs as those in the designated terminal's point of view, but also considered the costs and benefits of the terminals not involved with the segregation system. These alternative outcomes are vital to the analysis of the results that will be discussed in chapter 6.

5.9 Segregation Using Multiple Designated Points

As discussed previously, the multiple designated point scenario involved the re-opening of smaller wooden elevators in the region to handle the segregation process. The elevators were assumed to handle only non-GM wheat, leaving the terminals to handle GM wheat and all other commodities in the region. The costs involved with using multiple designated points consist of the costs borne by producers in the region to haul to the designated points, the costs borne by the individual elevators responsible for segregation and lastly the costs borne by the terminals in the region resulting from a decrease in the volume of wheat handled. Table 5.1 can once again be used as an outline for the costs that are calculated. The only difference is that the multiple designated point option has a cost associated with average cost above the tariff rate charged. This replaces the change in handling cost variable in the designated terminal scenario.

5.9.1 Producer Costs

Producer costs were calculated based on the same formula as used for producers outside the designated terminals original catchment area in the designated terminal scenario (Equation 5.12). The absence of producers unable to deliver to their original low-cost terminal eliminated the need to consider the costs of moving GM wheat elsewhere (Equation 5.13).

5.9.2 Elevator Costs

Elevator costs are similar to those in the designated terminal scenario and thus were calculated using equations 5.14 to 5.16 with only a slight alteration being made to equations 5.14 and 5.16. Equation 5.14 takes into account the quantity of other commodities handled at the terminal. The elevators in the model only handle non-GM wheat, so the quantity of other commodities was removed from the equation:

$$TC_i = \sum_{k=1}^{n} \left((A_k + CRP_k) + \left((TP_k + ST_k) \times Q_{ki}^{non-GM} \right) \right) + \left(\sum_{k=1}^{n} Q_{ki}^{non-GM} \right) \times EC_i \quad (5.19)$$

The description of the parameters for elevator i is identical to those for terminal i in equation 5.14.

Equation 5.16 estimated the costs associated with handling a different volume at the designated terminal than initially was the case. For this scenario, equation 5.16 was used to calculate the average cost of operations above the handling tariff they were able to charge.

As discussed earlier, the wooden elevators in this scenario were assumed to charge the same handling tariffs as the terminals in the region, one that was below the calculated average cost of operating a small elevator. The average cost of operating a wooden elevator was calculated based on the proportion of fixed costs and variable costs being 22.9% and 77.1% respectively (Ferguson 2001). After calculating the average costs of handling the volume being segregated at each terminal, equation 5.16 was modified to calculate the costs of charging a handling tariff lower than the average cost of operating the facility:

$$EC_i = \left(\left(\left(\left(\sum_{k=1}^{n} Q_{ki}^{non-GM} \right) \times MC_i \right) + FC_i \right) / \sum_{k=1}^{n} Q_{ki}^{non-GM} \right) - HC_i \qquad (5.20)$$

Where:

EC_i = cost per tonne difference between handling tariff and average costs for elevator i.

Q_{ki}^{non-GM} = quantity of non-GM wheat delivered to elevator i by farm k.

MC_i = marginal cost of operations for elevator i.

FC_i = fixed costs of operations for elevator i.

HC_i = handling tariff charged by elevator i.

The costs per tonne borne by the elevators were calculated by taking the sum of the total costs for each elevator in the system and dividing by the total quantity of non-GM wheat being segregated.

5.9.3 Private vs. Regional Costs

Once again the costs of the system differ when examined at a private level and at a regional level. The costs of the system at the private level were calculated as the sum of producer costs and elevator costs. At a regional level, the costs borne by the terminals in the region and the costs associated with lost rail incentives were considered.

The costs borne by the terminals in the region were calculated based on the same formula as was used to calculate the costs/benefits for the terminals other than the designated terminal in the previous scenario (Equation 5.17).

The costs associated with lost rail incentives were calculated based on the assumption that initially, the terminals would receive the rail incentive on all grain moved to port. The rail incentives in the region range from one dollar to six dollars, depending on the number of car spots at the respective terminal. To calculate the total cost associated with the loss of this rail incentive, the following calculation was used:

$$TC_j = RI_j \times Q_{ki}^{non-GM} \qquad (5.21)$$

Where:

TC_j = total cost of lost rail incentives from terminal j.

RI_j = rail incentive per tonne available at terminal j.

Q_{ki}^{non-GM} = quantity of non-GM wheat being delivered to a designated point by farm k, initially handled by terminal j.

The sum of the lost rail incentive costs were then divided by the total volume of non-GM wheat segregated to determine the per tonne cost. The private and regional costs were once again vital to the analysis that would be conducted later in the study.

5.10 Segregation within Terminals

The costs associated with segregation within terminals consist solely of the costs borne by the terminal. As in the rest of the scenarios, it was assumed that producers were compensated for on-farm segregation costs and in this scenario, they bore no added costs for delivering to different terminals or elevators.

5.10.1 Terminal Costs

Terminal costs were calculated based on a formula that would account for testing costs, administrative costs, and cost recovery premiums paid to producers. In some cases, a premium was introduced to reduce the number of farms under contract and thus minimize the administrative and compensatory costs associated with the system. The following formula was used to calculate the costs for each terminal in the region:

$$TC_i = \sum_{k=1}^{n}(A_k + CRP_k) + \sum_{k=1}^{n}(P_k + ST_k) \times Q_{ki}^{non-GM} \tag{5.22}$$

Where:

$TC_i =$ total cost of segregation for terminal i.

$A_k =$ administrative costs incurred when contracting with farm k.

$CRP_k =$ cost recovery premium costs incurred when contracting with farm k.

$P_k =$ premium per tonne paid to farm k, in some cases zero.

$ST_k =$ strip test costs incurred when testing non-GM wheat from farm k.

Q_{ki}^{non-GM} = quantity of non-GM wheat delivered by farm k to terminal i.

The total cost for the system was then calculated by summing the total costs for each terminal, i, and dividing by the total volume of non-GM wheat that was segregated.

5.11 Summary

The intent of this chapter was to introduce and thoroughly explain the workings of the simulation model used in the study. The basis for region selection, the initialization process, and the construction of the simulation model were explained to illustrate the procedure used for generating numbers on which to base system costs. The calculation of the results, explained in the final sections of the chapter, will be displayed and discussed in the next chapter.

CHAPTER 6 - RESULTS, DISCUSSION AND POLICY IMPLICATIONS

6.1 Introduction

This chapter presents the results of the initialization process followed by the results for each of the scenarios examined in the simulation model. The scenario results are presented in three tables, one for each adoption rate imposed on the model. The reported results are the costs per tonne of non-GM wheat segregated, above the initial costs determined during the initialization process. Following the results, a discussion section examines and compares the results for each scenario. Lastly, a policy implications section discusses some of the potential policies that could result from the results of the study.

6.2 Initial Costs

The initial costs to handle wheat in the region was found to be on average $43.15 per tonne based on the calculations conducted in the intialization process. The average cost is comprised of trucking costs, handling costs and freight costs for each farm to deliver 7600 tonnes of wheat to their low-cost terminal. The estimated trucking cost parameters, handling tariffs and freight rates resulting from and used in the initialization process are presented in table 6.1. The small elevator parameters are presented in this table as well.

Table 6.1 – Estimated Parameters for the Initial Cost Calculations.

	Trucking Formula Constant (k) $Ti = ke^{.00775 \times dist.}$ (\$/tonne)	Handling Tariff (\$/tonne)	Freight Rate Including Freight Adjustment Factor (\$/tonne)	Number of Farms Delivering Initially
Aggasiz	\$7.46	\$7.22	\$27.55	22
Boissevain	\$3.56	\$7.08	\$31.46	15
Elm Creek	\$5.59	\$7.51	\$29.40	16
Killarney	\$4.11	\$7.22	\$30.77	45
Nesbitt	\$3.55	\$6.87	\$32.11	15
Rathwell	\$5.88	\$6.69	\$30.06	23
Souris	\$3.74	\$7.84	\$32.07	4
Cartwright	\$4.70	\$7.22	\$30.07	0
Glenboro	\$4.70	\$7.22	\$31.39	0
Winkler	\$4.70	\$7.22	\$27.95	0

Source: Author's calculations, Warkentine and Associates (2001).

Figure 6.1 illustrates the delivery patterns and catchment areas for the terminals in the region after initialization. The first letter in the terminal name above represents each terminal. Note the absence of the small elevators that are not a factor in the model region until after segregation is introduced.

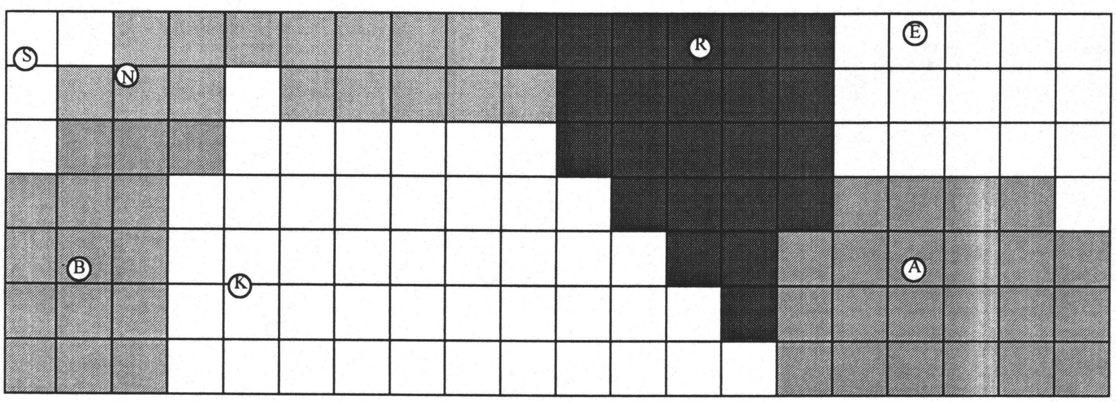

Figure 6.1 – Elevator Catchment Areas after Initialization.

6.3 Results

Tables 6.2, 6.3 and 6.4 presented below illustrate the change in costs associated with gathering a predetermined volume of non-GM wheat for each segregation alternative. The tables present the results based on the assumption that producers in the region would allocate 80%, 50% and 20% of their total wheat acres in the absence of premiums or discounts for non-GM wheat. The full set of results for each alternative, with a complete breakdown of costs is presented in Appendix C along with a brief discussion of those results that require further explanation. Appendix D provides illustrations of the region similar to figure 6.1 above. These illustrations depict the farms choosing to contract non-GM wheat with the designated point(s) for each volume under each alternative adoption rate. These figures are included to illustrate how and where the designated point(s) source the non-GM wheat.

Table 6.2 – Results for the 80% Adoption Rate Scenario.

	Segregation Options		
	Designated Terminal ($/tonne)	**Multiple Points ($/tonne)**	**Segregation Within ($/tonne)**
60,000 Tonnes Demanded			
Producer Costs (a)*[1]	$3.46	($0.40)	n/a
Delivery Point Costs (b)[2]	$11.90	$8.82	$5.65
Other Terminal and Region Costs (c)[3]	($0.68)	$8.70	n/a
Total			
Designated Point(s) (a+b)	**$15.36**	**$8.42**	**$5.65**
Entire Region (a+b-c)	**$14.68**	**$17.12**	**n/a**
120,000 Tonnes Demanded			
Producer Costs (a)	$0.94	($0.42)	n/a
Delivery Point Costs (b)	$7.22	$10.62	$5.64
Other Terminal and Region Costs (c)	$0.12	$8.75	n/a
Total			
Designated Point(s) (a+b)	**$8.16**	**$10.20**	**$5.64**
Entire Region (a+b-c)	**$8.28**	**$18.95**	**n/a**
180,000 Tonnes Demanded			
Producer Costs (a)	$0.06	($0.80)	n/a
Delivery Point(s) Costs (b)	$6.20	$10.63	$5.63
Other Terminal and Region Costs (c)	$0.59	$8.60	n/a
Total			
Designated Point(s) (a+b)	**$6.26**	**$9.83**	**$5.63**
Entire Region (a+b-c)	**$6.85**	**$18.43**	**n/a**

Source: Author's calculations.
* negative numbers in parentheses.

[1] Consists of the change in trucking, handling and freight costs for producers.
[2] Consists of the administration, cost-recovery premium, trucking premium, acreage re-allocation premium, testing , change in handling, and average costs above handling tariff charged costs for the designated point(s).
[3] Consists of the costs of lost rail incentives and the change in handling costs for other terminals in the region.

Table 6.2 indicates that the producer's costs of segregation, which is comprised of added trucking and handling costs, are always lower in the multiple designated point scenario compared to the designated terminal scenario. The producer costs also gradually decline as volumes being segregated increase. Both of these results can be attributed to the handling and freight portion of producer costs. Aggasiz, the designated terminal, has the lowest handling and freight costs in the region. When less volume is handled in the Aggasiz terminal, producers in Aggasiz's initial catchment area are ultimately paying higher costs, as they must deliver their grain to other terminals in the region.

The delivery point costs in the designated terminal scenario gradually decline as the volume being segregated increases. This is due to the fact that at low volumes, the terminal is operating less efficiently than initially was the case As volumes increase, they gain efficiency and thus face lower costs. For the multiple designated points scenario, these costs follow an opposite trend. At the 60,000 tonne volume, only one small elevator is required to handle segregation and can do so with relatively little competition. As volumes increase and more small elevators are required, there is a greater reliance on trucking premiums to attract producer's grain. This ultimately increases the costs to the multiple point system. The costs for the delivery points in the segregation within terminals scenario are relatively static.

Other terminal and region costs, comprised of lost rail incentives and changes in handling costs gradually increase in the designated terminal option (see Table C.1 in Appendix C). Analyzing these two costs separately would produce more definitive trends, each in opposite directions. When they are analyzed at an aggregate level, however, they ulitimately cancel out. Lost rail incentives decrease as volumes being segregated increase. This is due to the fact that Aggasiz can receive a $6 rail incentive while some of the other terminals only receive $4 and $1 rail incentives. Thus, when low volumes are being segregated the terminals in the region with lower rail incentives are handling more grain, resulting in higher costs associated with lost rail incentives. The opposite effect is present in the cost associated with changes in handling volumes. The increased volumes being handled at terminals other than Aggasiz result in lower average handling costs to those terminals. Therefore, as volumes being segregated increase, the costs associated with changes in handling costs trend downwards. The other terminal/region costs are relatively static in the multiple designated point scenario as the costs associated with lost rail incentives and changes in handling costs are similar, regardless of the amount of grain being segregated. Table 6.3 depicts the results for the 50% adoption rate scenario with a more detailed description in Appendix C.

Table 6.3 – Results for the 50% Adoption Rate Scenario.

	Segregation Options		
	Designated Terminal ($/tonne)	**Multiple Points ($/tonne)**	**Segregation Within ($/tonne)**
60,000 Tonnes Demanded			
Producer Costs (a)*	$3.86	($0.29)	n/a
Delivery Point Costs (b)	$7.88	$5.59	$2.95
Other Terminal and Region Costs (c)	($3.38)	$9.66	n/a
Total			
Designated Point(s) (a+b)	**$11.74**	**$5.30**	**$2.95**
Entire Region (a+b-c)	**$8.36**	**$14.96**	**n/a**
120,000 Tonnes Demanded			
Producer Costs (a)	$1.50	($0.35)	n/a
Delivery Point Costs (b)	$3.67	$7.07	$2.78
Other Terminal and Region Costs (c)	($0.17)	$8.89	n/a
Total			
Designated Point(s) (a+b)	**$5.17**	**$6.72**	**$2.78**
Entire Region (a+b-c)	**$5.00**	**$15.61**	**n/a**
180,000 Tonnes Demanded			
Producer Costs (a)	$0.52	($0.22)	n/a
Delivery Point(s) Costs (b)	$2.60	$7.22	$2.75
Other Terminal and Region Costs (c)	$0.42	$8.57	n/a
Total			
Designated Point(s) (a+b)	**$3.12**	**$7.00**	**$2.75**
Entire Region (a+b-c)	**$3.54**	**$15.57**	**n/a**

Source: Author's calculations
* negative numbers in parentheses.

The trends in costs for the 50% adoption rate scenario are similar to those in the 80% adoption rate scenario. The biggest difference is that the trends are less distinctive with the majority of the costs for all members of the supply chain being lower. The lower costs can be attributed to the fact that as adoption rates for GM wheat decrease, non-GM wheat becomes more available in the region. With more non-GM wheat available, the designated points rely less on trucking premiums, etc. as they can source grain from a considerably smaller catchment area than in the 80% adoption rate scenario. This has the greatest impact on trucking premiums and costs associated with lost rail incentives as less grain is required to move to terminals outside the initial catchment areas. The remainder of the costs are relatively static across adoption rates for all three segregation options. Table 6.4 presents the results for the 20% adoption rate scenario with a more detailed description in Appendix C.

Table 6.4 – Results for the 20% Adoption Rate Scenario.

	Segregation Options		
	Designated Terminal ($/tonne)	**Multiple Points ($/tonne)**	**Segregation Within ($/tonne)**
60,000 Tonnes Demanded			
Producer Costs (a)*	$3.96	($0.11)	n/a
Delivery Point Costs (b)	$7.15	$4.44	$2.45
Other Terminal and Region Costs (c)	($6.23)	$9.39	n/a
Total			
Designated Point(s) (a+b)	**$11.11**	**$4.33**	**$2.45**
Entire Region (a+b-c)	**$4.88**	**$13.72**	**n/a**
120,000 Tonnes Demanded			
Producer Costs (a)	$1.52	($0.18)	n/a
Delivery Point Costs (b)	$2.13	$5.84	$2.13
Other Terminal and Region Costs (c)	($0.74)	$8.95	n/a
Total			
Designated Point(s) (a+b)	**$3.65**	**$5.66**	**$2.13**
Entire Region (a+b-c)	**$2.91**	**$14.61**	**n/a**
180,000 Tonnes Demanded			
Producer Costs (a)	$0.49	($0.11)	n/a
Delivery Point(s) Costs (b)	$1.18	$6.13	$1.87
Other Terminal and Region Costs (c)	$0.27	$8.63	n/a
Total			
Designated Point(s) (a+b)	**$1.67**	**$6.02**	**$1.87**
Entire Region (a+b-c)	**$1.94**	**$14.65**	**n/a**

Source: Author's calculations
* negative numbers in parentheses.

Once again, the results for the 20% adoption rate scenario follow similar trends to the previous two scenarios. One key difference, however, is that the private costs for the designated terminal becomes the lowest cost alternative when 180,000 tonnes is being segregated. All other scenarios to this point resulted in segregation within terminals being the low cost option regardless of the volume being segregated.

The total costs for each segregation alternative are lower in the 20% adoption rate scenario due to the increased availability of non-GM wheat in the region, which impacts the lost rail incentives cost and the trucking premium costs to the greatest degree. The next section discusses the results presented in tables 6.2 to 6.4.

6.4 Discussion

All but one of the scenarios examined in the simulation model result in segregation within terminals being the low cost option. The following section explains why the results are so heavily weighted towards one alternative and identifies problems with that option.

6.4.1 Interpreting the Results

The simulation model being so heavily weighted towards segregation within terminals can be explained by one underlying assumption of the model. The model assumed that the tolerance level for GM wheat would be such that the added costs for segregating within terminals would be comprised of only administration costs, testing costs, compensatory on-farm segregation costs and in some cases an incentive based premium introduced to minimize the other three costs.

This assumption was introduced for the reason that at a zero tolerance for GM wheat, segregation within terminals would be infeasible, while higher tolerance levels (even half of one percent) could be effectively managed through blending, etc. provided non-GM deliveries from producers were very close to pure (Skinner 2001). This meant that equipment and storage cleaning within the facility would not be required, thereby eliminating the costs associated with cleaning.

The problem with concluding that segregation within terminals is the best option, even at higher tolerance levels, is the risk of contamination that is not accounted for in the model. Handling GM wheat (the contaminant) in the same facility as non-GM wheat potentially increases this risk and therefore must be considered. In all three systems, human error and cheating could potentially result in contamination of the terminal or elevator. In the segregation within terminals scenario there is also considerable risk of mechanical commingling that cannot be avoided without a thorough, potentially cost prohibitive cleaning of the entire facility (Skinner 2001). This risk of mechanical commingling is not present in the other two segregation options as the contaminant (GM wheat) is not handled at the terminal. The following section focuses on the assumption that without a thorough cleaning, contamination will occur and illustrates that segregating within terminals may not be a feasible option.

6.4.1.1 Accounting for Risk

Presumably, the risk for contamination in the designated point alternative would be very similar to the multiple designated point alternative. Further to this, the absence of GM wheat at the facility should minimize the risk of contamination. Therefore, for the analysis including risk, the designated point(s) options are assumed to be risk free.

The cost of segregation within terminals was estimated by equation 5.22 in chapter 5 which accounts for the administration costs, testing costs, cost-recovery premiums and incentive based premiums in the segregation within terminals model. To introduce risk, one can extend this model to factor in the probabilities and costs of contamination. The cost function for this option then becomes:

$$TC = \left(\sum_{j=1}^{m} SC_j + \sum_{j=1}^{m} \left(P_{B|A} \times C_B\right) + \sum_{q=1}^{r} \left(P_{C|A} \times C_C\right) \right) / Q^{non-GM} \tag{6.1}$$

With:

P_A = probability of contamination at delivery point j.

$(P_B/_A + P_C/_A) = 1$ (indicating that if contamination occurs, it will be detected)

Where:

TC = total cost per tonne for the system with the inclusion of contamination risk.

SC_j = segregation costs per tonne for terminal j, estimated earlier.

$P_B/_A$ = probability of contamination being detected at terminal j.

C_B = cost associated with contamination of terminal j.

$P_C/_A$ = probability of contamination being detected on ship q.

C_C = cost associated with contamination of ship q.

$Q^{non\text{-}GM}$ = quantity of non-GM wheat being segregated in the system.

Constraining the probabilities of detection at the two different levels to sum to one suggests that the probability of contamination going undetected is zero. In reality, there may be a probability of contamination going undetected, but for the purposes of the discussion, it is assumed to be zero. Similarly, the probability of no contamination is not included in the cost function for the reason that when it is multiplied with the cost of no contamination (zero) it disappears from the equation.

The difficulty in modelling the risk factor lies in the inability to estimate probabilities for contamination as well as the probabilities for where contamination will be detected. The costs associated with contamination are also difficult to estimate as they depend on what the alternative market for the contaminated product would be.

The best case scenario would be to find a market willing to accept GM contaminated wheat, should it exist. The price difference between GM wheat sold on the spot market and the contracted price for non-GM wheat would thus be the most significant loss. The total loss depends on both the premium for non-GM wheat in the market as well as the price at which GM wheat can be sold on the spot market (which may depend on the level of bargaining power present, considering the fact that potential buyers might know the exporter is in a "must sell" position).

The worst case scenario would be having to sell the contaminated wheat as feed wheat in which case the cost would be the difference in specific grade non-GM wheat and feed wheat. To eliminate some of the doubt surrounding probabilities and costs, one can calculate the costs for a range of probabilities. Tables 6.5 and 6.6 illustrate a range of possibilities for the 80% adoption/60,000 tonne volume scenario. This scenario was chosen as it has the greatest differential between the segregation within alternative and the next best alternative.

For table 6.5, the costs associated with contamination were estimated assuming a $10 premium for non-GM wheat exists in the marketplace. Thus, in contaminating the grain, $10 per tonne is lost. The assumption was also made that sourcing non-GM wheat is a one-shot deal resulting in an unrecoverable loss of the $10 per tonne premium. Note that legal implications for reneging on the importer's contract for non-GM wheat are not included in the cost.

To calculate the costs associated with contamination, terminals were once again assumed to be of equal size and thus handle an equal quantity of non-GM wheat (6700 tonnes). The costs for contamination when detected at rail car loading would thus be $67,000 per terminal. Assuming the ship holds 35,000 tonnes, the costs associated with contamination left undetected until ship loading would be $350,000 per ship.

Table 6.5 – Costs Associated with Contamination Risk: Best Case Scenario.

Probability of Contamination (P_A)	Probability of Detecting Contamination during Rail Car Loading ($P_{B\|A}$)	Probability of Contamination being Undetected until on-Ship ($P_{C\|A}$)	Cost per tonne Associated with Risk ($TC-\sum SC_j$)
1	1	0	$10.05
1	0.75	0.25	$10.45
1	0.5	0.5	$10.86
1	0.25	0.75	$11.26
1	0	1	$11.67
0.75	1	0	$7.54
0.75	0.75	0.25	$7.84
0.75	0.5	0.5	$8.14
0.75	0.25	0.75	$8.45
0.75	0	1	$8.75
0.5	1	0	$5.03
0.5	0.75	0.25	$5.23
0.5	0.5	0.5	$5.43
0.5	0.25	0.75	$5.63
0.5	0	1	$5.83
0.25	1	0	$2.51
0.25	0.75	0.25	$2.61
0.25	0.5	0.5	$2.71
0.25	0.25	0.75	$2.82
0.25	0	1	$2.92

Source: Author's calculations

Table 6.6 assumes that a buyer cannot be found for the contaminated wheat thereby requiring it to be sold in the feed market. The May 2001 pool return outlook for wheat shows a $75 price differential between feed wheat and #1 CWRS 12.5% protein (CWB 2001). Adding the $10 premium for non-GM results in a $85 per tonne loss from contamination.

To calculate the total costs associated with contamination, terminals were once again assumed to be of equal size and thus handle an equal quantity of non-GM wheat (6700 tonnes). The costs for contamination when detected at rail car loading were thus \$569,500 per terminal. The costs associated with contamination when not detected until the ships are loaded would be \$2,975,000 per ship. To put this in perspective, the net income for Northwest Terminal Ltd. at Unity, Saskatchewan for the 1999-2000 crop year was \$708,400 (Aginfonet 2001). The financial burden of terminal contamination in the worst case scenario would thus have a considerable impact on the financial viability of a large inland terminal. If the terminal is held liable for the contamination of the ship, the cost of contamination could potentially bankrupt a terminal.

Table 6.6 – Costs Associated with Contamination Risk: Worst Case Scenario.

Probability of Contamination (P_A)	Probability of Detecting Contamination during Rail Car Loading ($P_{B\|A}$)	Probability of Contamination being Undetected until on-Ship ($P_{C\|A}$)	Cost per tonne Associated with Risk ($TC-\Sigma SC_j$)
1	1	0	\$85.43
1	0.75	0.25	\$88.86
1	0.5	0.5	\$92.30
1	0.25	0.75	\$95.73
1	0	1	\$99.17
0.75	1	0	\$64.07
0.75	0.75	0.25	\$66.65
0.75	0.5	0.5	\$69.22
0.75	0.25	0.75	\$71.80
0.75	0	1	\$74.38
0.5	1	0	\$42.71
0.5	0.75	0.25	\$44.43
0.5	0.5	0.5	\$46.15
0.5	0.25	0.75	\$47.87
0.5	0	1	\$49.58
0.25	1	0	\$21.36
0.25	0.75	0.25	\$22.22
0.25	0.5	0.5	\$23.07
0.25	0.25	0.75	\$23.93
0.25	0	1	\$24.79

Source: Author's calculations

Table 6.5 and 6.6 illustrate that even in the best case scenarios, where the probability of contamination is low, the added costs from contamination risk are considerable. Further to this, the point of detection does not appear to make much difference to the costs associated with risk. In situations where the probability of contamination is high, added costs become prohibitively high in both the best and worst case scenarios. The purpose of this illustration was to show that although the segregation within terminals option appears to be the low-cost option the majority of the time, the inherent risk behind this alternative rules it out as a feasible alternative.

The designated terminal option and the multiple designated point option can now be compared to determine the best option given different circumstances.

6.4.2 Designated Terminals vs. Multiple Designated Points

The results of the model for the two remaining alternatives provide costs for the designated point(s) as well as costs for the entire region. The difference between the two is key when comparing the two alternative options. One cannot simply conclude that the lowest of the four reported costs is the optimal outcome as the analysis differs for private versus regional costs. In each alternative, the private costs do not account for change in handling costs witnessed at other terminals in the region as well as the costs associated with lost rail incentives. In some cases, the costs considered for the entire region act as a buffer on the private costs while in other cases they add further expenses to the segregation system. To distinguish between the two, the options will be compared at a private level, followed by the regional level. The policy implications section then discusses how government or industry intervention could impact the outcome in the region.

6.4.2.1 Private Costs

The costs for the private firm conducting the segregation follow the same trend regardless of the adoption rate in the region. With 60,000 tonnes demanded from the region, the private costs for the multiple designated point's option are always lower than the private costs for the designated terminal option. This is largely due to the increased handling charges incurred by the terminal in the loss of volume handled.

Somewhere between 60,000 tonnes and 120,000 tonnes demanded lies the breakpoint where the designated terminal option becomes the low-cost option. This can be attributed to the costs incurred at small elevators where average costs of operations exceeds the handling tariff they are able to charge. The designated terminal is handling a greater volume of grain as well, thereby reducing the increased handling cost factor.

At the 180,000 tonne demand, the designated terminal remains the best option. At this demand level, the terminal is handling even more volume than initially and thus witnesses a decrease instead of an increase in the handling costs per tonne. These trends are illustrated graphically in Figures 6.2 to 6.4. The segregation within terminals option is depicted on these graphs without the risk premium cost, despite the fact it was ruled out as a feasible option.

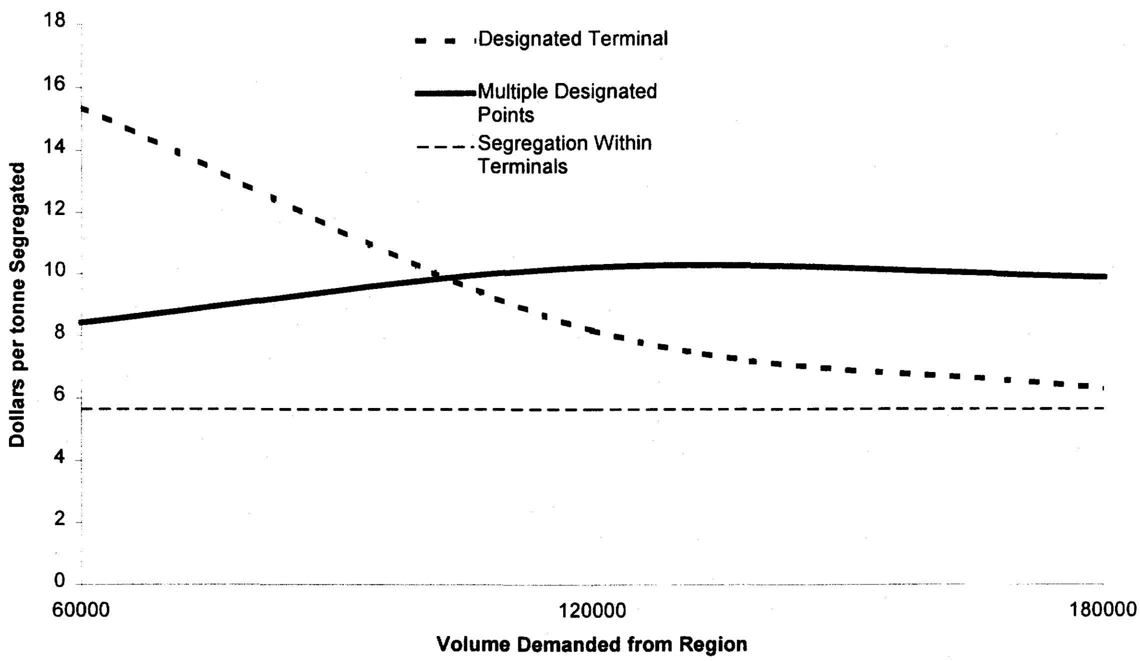

Figure 6.2 – Private Costs of Segregation: 80% Adoption Rate.

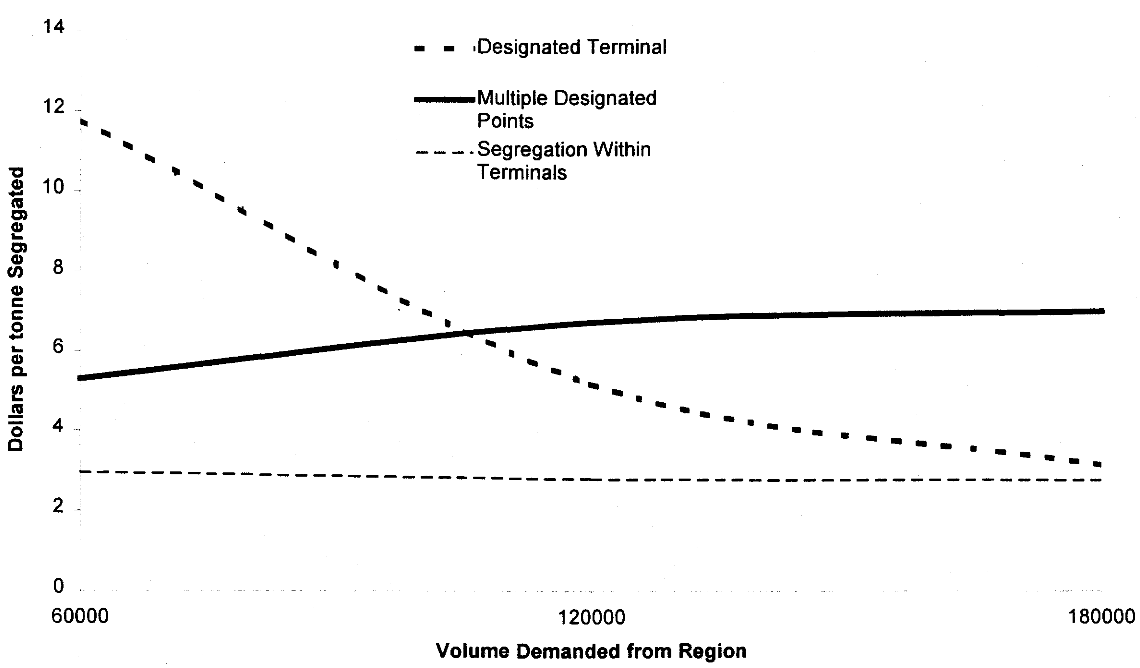

Figure 6.3 – Private Costs of Segregation: 50% Adoption Rate.

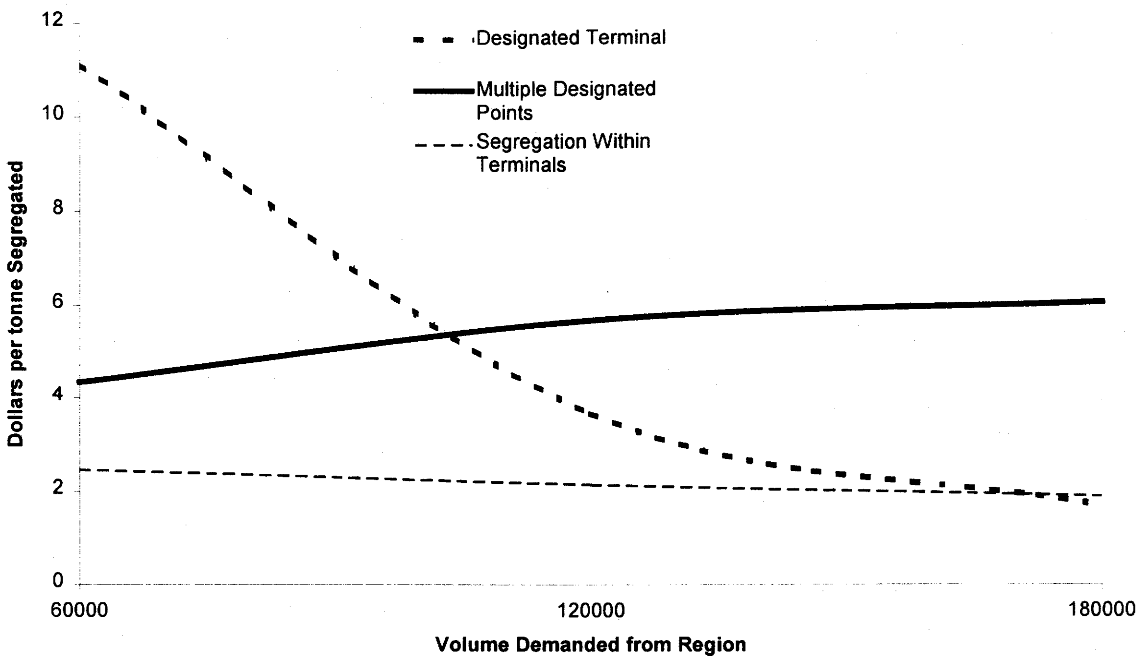

Figure 6.4 – Private Costs of Segregation: 20% Adoption Rate.

Comparing the private costs for alternative options across adoption rates instead of volume segregated shows that the adoption rates have no impact on the optimal segregation strategy. The multiple designated point option is the optimal strategy for segregating 60,000 tonnes regardless of the adoption rate in the region. Similarly, the designated terminal option is the optimal strategy for segregating 120,000 and 180,000 tonnes regardless of the adoption rate. This analysis does show, however, that adoption rates do have a significant impact on the costs of segregation. As expected, the costs increase as the adoption rate of GM wheat increases. Of interest, however, is that the costs increase only slightly between 20% adoption and 50% adoption, but increase at a much higher rate between 50% adoption and 80% adoption. This holds true for both segregation alternatives and can be explained by the fact that at lower levels of adoption, there is a surplus of non-GM wheat within a relatively close vicinity to the designated point(s). As GM adoption levels increase, the designated point(s) must source grain from increasingly larger areas and subsequently more and more farms, thereby increasing administration costs, compensatory premium costs and trucking premium costs.

From this analysis one can conclude that, regardless of the adoption rate in the region, the multiple designated point strategy is optimal for volumes up to somewhere between 60,000 and 120,000 tonnes demanded. As volumes increase beyond this breakpoint to 120,000 and 180,000 tonnes, the designated terminal option becomes and remains the optimal segregation strategy.

6.4.2.2 Regional Costs

When analyzing the entire costs for the region, the results become much more weighted towards the designated terminal option. This can be explained by the two costs factored into the region costs, which are not included in the private costs. These include the costs associated with the change in handling volumes for all terminals in the region as well as the cost associated with lost rail incentives.

The change in handling costs for all terminals in the region are not factored into the private costs for either system. In the multiple point system, when these costs are included, approximately four dollars per tonne is added to the region costs. Factoring in the handling costs in the designated terminal option has the opposite effect. Due to increased handling volumes, Elm Creek and Rathwell terminals have lower handling costs than initially. Therefore, there is a reduction in the costs for the entire region when compared to just the private costs for the designated terminal.

Similarly, the lost rail incentives associated with the multiple point system are higher than those for the designated terminal option. The costs associated with lost rail incentives in the designated terminal option are the net differences in incentives between terminals (between zero and five dollars). The small elevators are not equipped to handle large enough trains to receive any rail incentives and thus the losses are for the full amount of the incentives that would be received if handled at one of the terminals in the region (between one and six dollars). The graphical illustrations of these results are presented in figures 6.5 to 6.7.

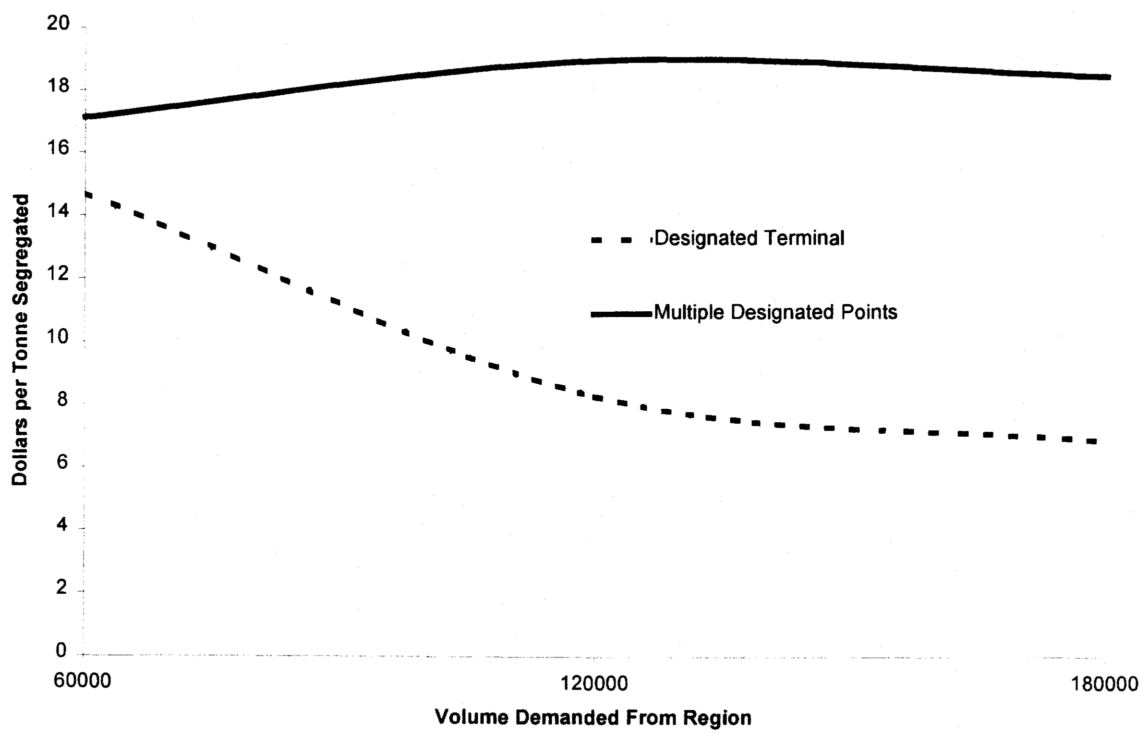

Figure 6.5 – Entire Region Costs of Segregation: 80% Adoption Rate.

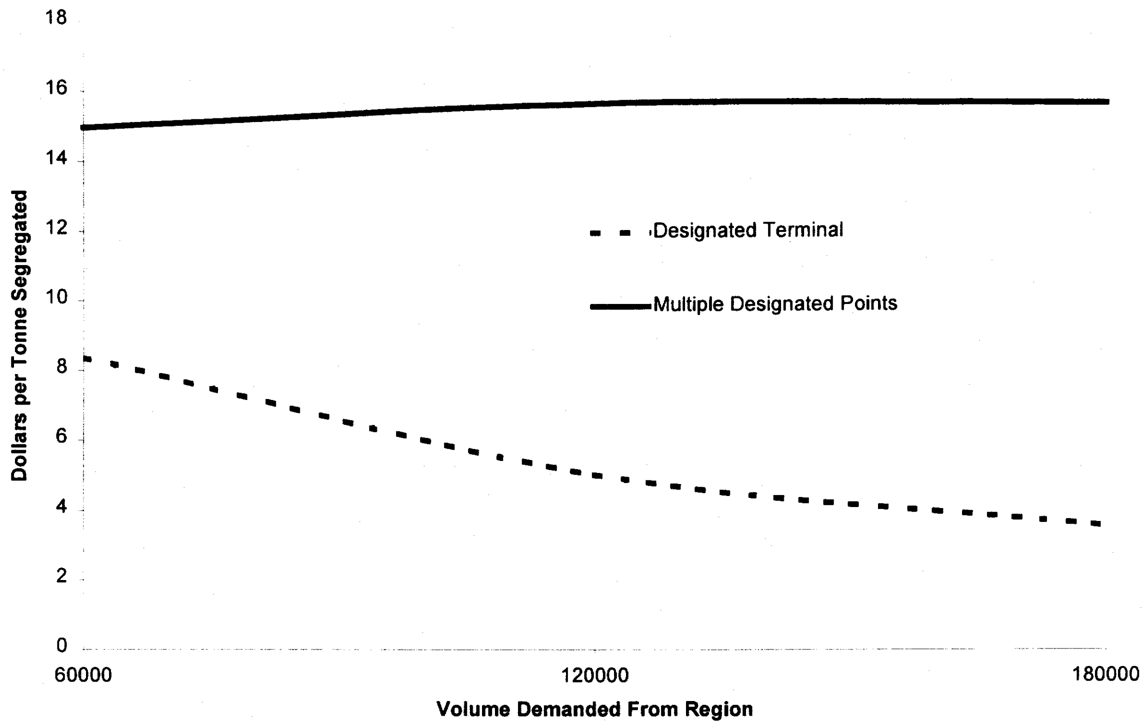

Figure 6.6 – Entire Region Costs of Segregation: 50% Adoption Rate.

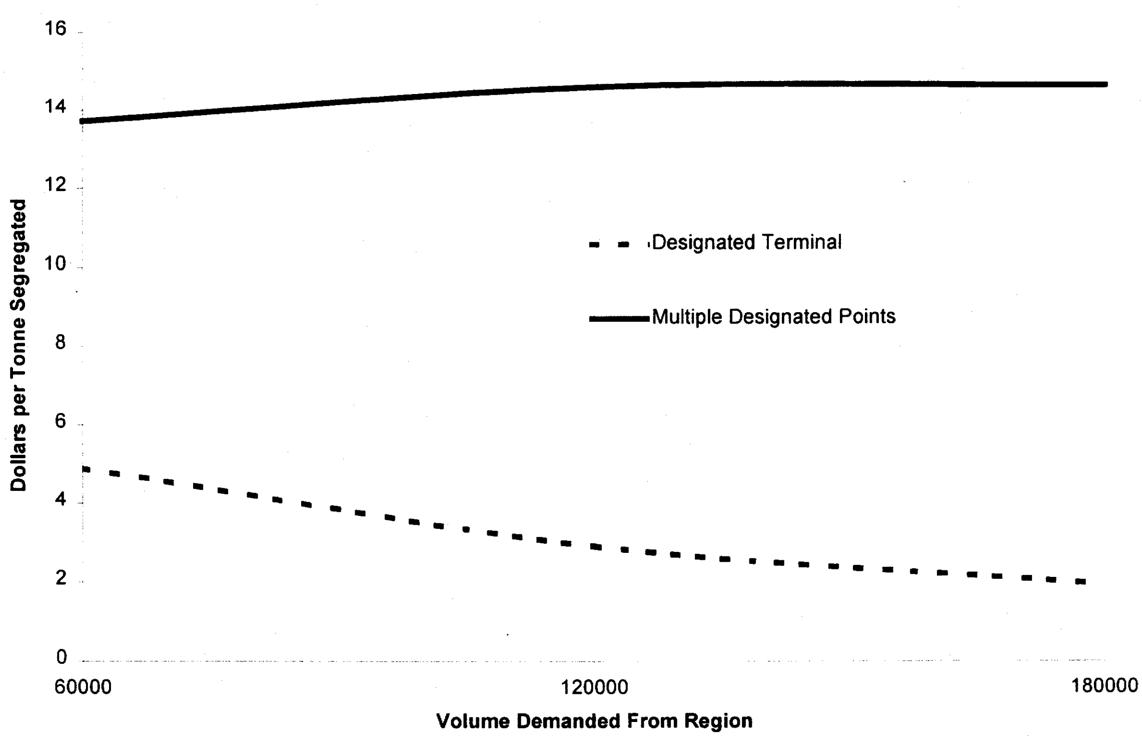

Figure 6.7 – Entire Region Costs of Segregation: 20% Adoption Rate.

The analysis of the regional costs reveals the importance of taking the external costs into consideration and not just focusing on the private firm costs.

Comparing the entire region costs across adoption rates instead of across volumes demanded reveals similar trends as in the private cost analysis. Of interest, however is that the multiple designated point costs appear to increase at relatively the same rate between 20% adoption and 50% adoption as they do between 50% and 80%. The designated terminal option follows a similar trend to the private cost analysis where the costs increase at a much higher rate between 50% and 80% adoption than they do between 20% and 50%.

The inability to handle grain efficiently at small elevators in comparison to terminals has been stated as the primary reason for rationalization of the elevator system. These inefficiencies are shown to impact segregation alternatives as well and are dominant enough to rule out the utilization of small elevators as a low-cost option for the entire region regardless of the adoption rate in the region.

6.5 Policy Implications

There are three inherent policy issues revealed in the results of this study. Two of these stem from the discussion surrounding private versus regional costs. The third stems from the realization that segregation costs have the potential to be quite substantial if GM wheat is introduced to prairie production.

6.5.1 Welfare Transfer Policies

The first policy issue resulting from the discussion surrounding private and regional costs has to do with the potential for welfare transfer policies. The results of the model show that in most cases, the non-designated terminals are realizing a cost-reduction benefit (increase in private welfare) after segregation is introduced. This is due to a reduction in handling costs resulting from an increase in the volume of grain they receive, as they handle the GM wheat produced by farmers in Aggasiz's initial catchment area. At the same time, Aggasiz is incurring the entire costs. If the portion of the premium in the market for non-GM wheat being received by the private grain-company is lower than the private costs for segregation, no company will take it upon themselves to introduce segregation strategies. As a result, government or industry intervention may be required to implement a policy requiring the terminals realizing a welfare increase after the introduction of segregation to compensate the designated terminal for some of the costs incurred during segregation. As an example, consider the case where the designated terminal is segregating 120,000 tonnes in the 80% adoption scenario. The costs associated with a reduction in volume moving through the terminal are $1.60 per tonne. Meanwhile the remainder of the terminals in the region are realizing on average a $1.59 per tonne decrease in costs from handling an increased volume in their terminals. The prospective policy would thus require those terminals in the region realizing a net benefit to compensate Aggasiz (the designated terminal) to offset a portion of the costs of segregation. In effect this would result in the region being closer to the optimal outcome and provide the incentive for a terminal in the region to implement a segregation strategy.

6.5.2 Policies to Prevent the Occurrence of Non-Optimal Segregation Strategies

The second policy issue resulting from the discussion surrounding private versus regional costs is that in some cases the costs of segregation incurred by a private firm underestimate the entire costs for the region. If this problem is not dealt with, the strategy adopted by one firm may be costing the region more than if the optimal strategy were introduced. This issue relates to all three 60,000 tonne scenarios where the private cost analysis reveals the multiple designated point option as the optimal strategy. As is shown in the regional cost analysis, after taking the increased handling costs at terminals in the region and the lost rail incentives into consideration, the multiple point scenario becomes more costly than the designated terminal scenario. As a result, government or industry intervention may be required to ensure the optimal strategy is implemented. Grain companies would thus not be permitted to segregate using small elevators, thereby eliminating the added costs to the other terminals in the region.

To illustrate the added cost to the region resulting from the failure to select the optimal strategy, consider the 80% adoption/60,000 tonne scenario. The private costs reveal that the multiple designated point scenario is lower in cost by $6.94 per tonne. In reality, after taking all costs into account for the region, it is actually $2.44 more expensive.

6.5.3 Alterations to the Regulatory Policy

As discussed in chapter 2, the current regulatory process in Canada does not take non-scientific considerations into account. This means that the registration of a variety will not be withheld if the variety meets all scientific requirements for registration.

Although this study only focuses on the segregation costs up to the point where the grain is loaded onto railcars, one can conclude the costs of segregation could potentially outweigh the benefits generated by the introduction of GM wheat. This depends on many factors, some of which are included in this model. These include the adoption rate of GM wheat, the volume of non-GM wheat demanded, the premiums available for non-GM wheat and most importantly the benefits for farmers.

If the expected costs exceed the expected benefits, the regulatory process could be used to block the registration of GM wheat. This would require alterations to the regulatory policy on behalf of CFIA and Health Canada, but considering the potential costs of segregation, this option may be considered. Also, if the expected costs of segregation exceed the expected benefits for the company introducing the GM variety, compensating the company to keep the variety unregistered may be an option.

6.6 Summary

This chapter presented the results of the simulation model conducted in the study. The three segregation alternatives analyzed in the study were compared under each potential adoption rate/demand scenario. The results of the study were discussed and conclusions were drawn as to the optimal strategy for segregation given the circumstances present. Included in this discussion was an analysis including contamination risk for one of the potential strategies. As a result of the risk analysis, the segregation within terminals strategy was eliminated as an optimal segregation option. The final section of the chapter dealt with three policy implications revealed by the study results.

CHAPTER 7 -SUMMARY OF CONCLUSIONS, STUDY LIMITATIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH

7.1 Summary of Conclusions

The introduction of GM wheat to the western Canadian agriculture industry will undoubtedly impact all members of the supply chain for wheat. The magnitude of this impact, and whether or not the impact is positive or negative is the question that needs to be addressed before GM wheat is introduced. GM wheat is expected to be registered for commercial use between 2003 and 2005. With many export markets expressing concern over the presence of GM crops in their food, the negative impact of GM wheat on the profitability of agricultural producers could be substantial.

This study focused on segregation as an option that would allow producers to grow GM wheat, while at the same time satisfying the demand of our export markets. The primary objective of the study was to compare three potential segregation alternatives, all of which utilize the bulk commodity infrastructure already established in western Canada. The uncertainty behind adoption rates of GM wheat and the demand for non-GM wheat led to the second objective, which was to impose variable GM adoption rates and variable non-GM demand levels on the model in an attempt to illustrate the impact these factors have on the relative costs of each system. The final objective of the study was to identify the optimal segregation strategy given a combination of GM wheat adoption rates in the region and non-GM demand from importing nations.

The stated hypotheses for the study were:

1) Segregation within terminals will be the optimal strategy for low volumes of non-GM wheat demanded. 2) Multiple designated points will become optimal as volumes demanded increase until a point where a designated terminal becomes the optimal strategy for high volumes demanded from the region. 3) The adoption rates will not affect the relative costs of segregation and the optimal strategy, but will impact the absolute costs.

A simulation model was constructed to conduct the analysis. The model included a region in southern Manitoba composed of 140 township size farms, all of which were assumed to be homogeneous in their production decision. Individual producer costs for segregation were estimated based on changes in trucking costs and handling costs realized after the introduction of segregation.

The movement of grain from each farm to alternative delivery points (some of which were designated non-GM) in the region was altered through the use of incentive based premiums. These premiums resulted in added costs for the delivery point(s) conducting segregation. Also included in the costs for delivery points were the costs associated with testing, compensating producers for on-farm storage, administering the system, lost rail incentives and lastly the costs associated with changes in handling volumes. Together, the producer and delivery point costs provided a basis for analysis for each segregation alternative.

The results of the model indicated that segregation within terminals was almost always the low-cost option. However, the absence of contamination risk in the model required this option to be analyzed more rigorously. An analysis of contamination risk was conducted that proved this option was most likely the least feasible option.

The remaining two options were thus compared based on private costs and entire region costs. The private costs were those costs incurred by producers and the delivery point(s) conducting segregation. Entire region costs included all the costs for the region and is thus more representative of the total costs of segregation for the region. It was concluded that the entire region costs were more representative of actual segregation costs for a region as they include the costs for all members of the supply chain for wheat.

Based on the entire region costs, the hypothesis that adoption rates would not affect the relative cost comparison could not be rejected as the adoption rate did not impact the optimal strategy. This hypothesis also could not be rejected due to the fact adoption rates did affect the absolute costs of segregation. The hypothesis that segregation within terminals would be the low cost option for segregating low volumes was inconclusive as it depends heavily on the contamination risk. The hypothesis that the multiple designated point option would be the optimal strategy for intermediary demand levels and the designated terminal option would be the optimal strategy for high volumes could be rejected as the designated terminal was the optimal, low cost strategy for each scenario when compared at a regional level.

The results of this study are important in the information they provide for future policy decisions surrounding the introduction of GM wheat, future segregation strategies and future marketing situations. From a policy standpoint, the importance of the inclusion of all costs for the region is illustrated and must be kept in mind when determining the costs of segregation. Without the entire region costs, underestimation of actual segregation costs is inevitable. Similarly, the benefits realized by terminals other than the designated terminal must be considered, as the potential welfare-transfer policy discussed in chapter six may be the deciding factor for a grain handling company to initiate a segregation system. The results of the study may be helpful for future segregation planning as they underline the importance of a number of cost factors that must be considered before concluding which option is the optimal strategy.

7.2 Study Limitations

The methodology used to generate the results for the simulation model contains a number of limitations. These limitations are revealed below. The following section on recommendations for further research discusses potential areas of research that would address these study limitations.

The first limitation of the study is a direct result of the inability to determine what the adoption rate for GM wheat will be should it be registered, as well as the inability to determine what the demand will be for non-GM wheat. To address this doubt, both were allowed to vary to a certain degree in the model, attempting to draw conclusions based on best and worst case scenarios. This presents limitations due to the fact the actual adoption rates may be less than 20% or greater than 80%. Similarly, the volume demanded might be significantly less than 60,000 tonnes or significantly greater than 180,000 tonnes. If the actual adoption rates and volumes demanded fall outside the range examined, the optimal strategies may differ than those resulting from the simulation process.

The second limitation is a result of the absence of contamination risk from the model. This issue was dealt with briefly in chapter six with respect to the segregation within alternative, but was not considered for the other two segregation options. The brief discussion in chapter six illustrated that contamination risk has the potential to add significant costs to a segregation system. Presumably, each segregation option would have varying degrees of contamination risk. Not dealing with these contamination risks has the potential to result in incorrect conclusions over the low cost segregation alternative. The absence of this factor could also result in underestimation of the absolute costs of segregation.

The third limitation of the study results from the fact that only a portion of the supply chain was analyzed to determine segregation costs. As a result, the costs estimated do not reveal what the entire costs of segregation will be. In order to compare the costs associated with segregation and the benefits accruing to producers one must expand the study. To determine whether producers and other members of the supply chain will benefit from the introduction of GM wheat, the remainder of the costs accruing to the supply chain, beyond the point of rail car loading must be estimated.

The fourth limitation is that the study does not recognize one potential segregation option for non-GM wheat. The use of producer cars to segregate is not included in the model even though it could potentially be a feasible alternative. The inclusion of this option in the model may have resulted in significantly different results and conclusions than those estimated. As a result, the producer car option should be examined.

The fifth limitation relates to the absence of the U.S. as a market for our wheat. To simplify the model, all wheat was assumed to move through the Thunder Bay port, allowing for the use of one freight cost for each terminal. The inclusion of the U.S. market would complicate the model as it introduces the potential for grain movement from terminals by truck, most presumably at a lower cost than the rail freight costs used in the model.

Lastly, the model focuses on one region in southern Manitoba for the simulation process. The prairie region is a very large region with considerable differences in farming practices, acreage allocation and logistics. Therefore, the results of this model may be different than if a region in Saskatchewan or Alberta was chosen for the analysis.

7.3 Recommendations for Further Research

The recommendations for further research are based on the study limitations presented above as well as the perceived objective for most studies analyzing segregation. Presumably, each limitation could be dealt with in future studies to add value to the results of this and other studies conducted in the area.

The first recommendation would be to further this research by analyzing the remaining portion of the supply chain not analyzed in this study. This would include and require an estimation of the costs for rail transport to port terminals followed by the estimation of segregation costs for port and transfer terminals. A similar methodology as the one used in this study could be used to analyze segregation options at port. This would include a comparison of segregation within terminals as well as the designation of terminals.

The second recommendation would be to do a more in depth analysis of contamination risks. This would allow for a better comparison of the three options in the presence of the risk of contamination. One could include the potential for randomized testing, as is done in quality systems in other industries. This would no doubt impact the point of detection for contamination as randomized testing would increase the probability of failure to detect contamination further up the chain. A study of this nature could potentially provide recommendations for the optimal number of tests to be conducted at each point based on the costs associated with contamination further down the chain.

The final recommendation would be to include the producer car option in a study. Hypothetically, the multiple designated point scenario examined in this study could provide a basis for this study. The handling costs associated with operating small elevators limit the potential for the multiple point strategy. The handling tariffs, combined with the costs associated with the average cost of operating above the handling tariff charged, make up approximately $13/tonne of the costs of this scenario. Estimating the costs of administering a producer car system could be compared with this cost to determine its potential as an optimal strategy. By removing the $13/tonne cost associated with handling and replacing it with the cost of administering a producer car system, the optimal outcome may become quite different.

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APPENDIX A - THE DERIVATION OF CIRCULAR CATCHMENT AREAS

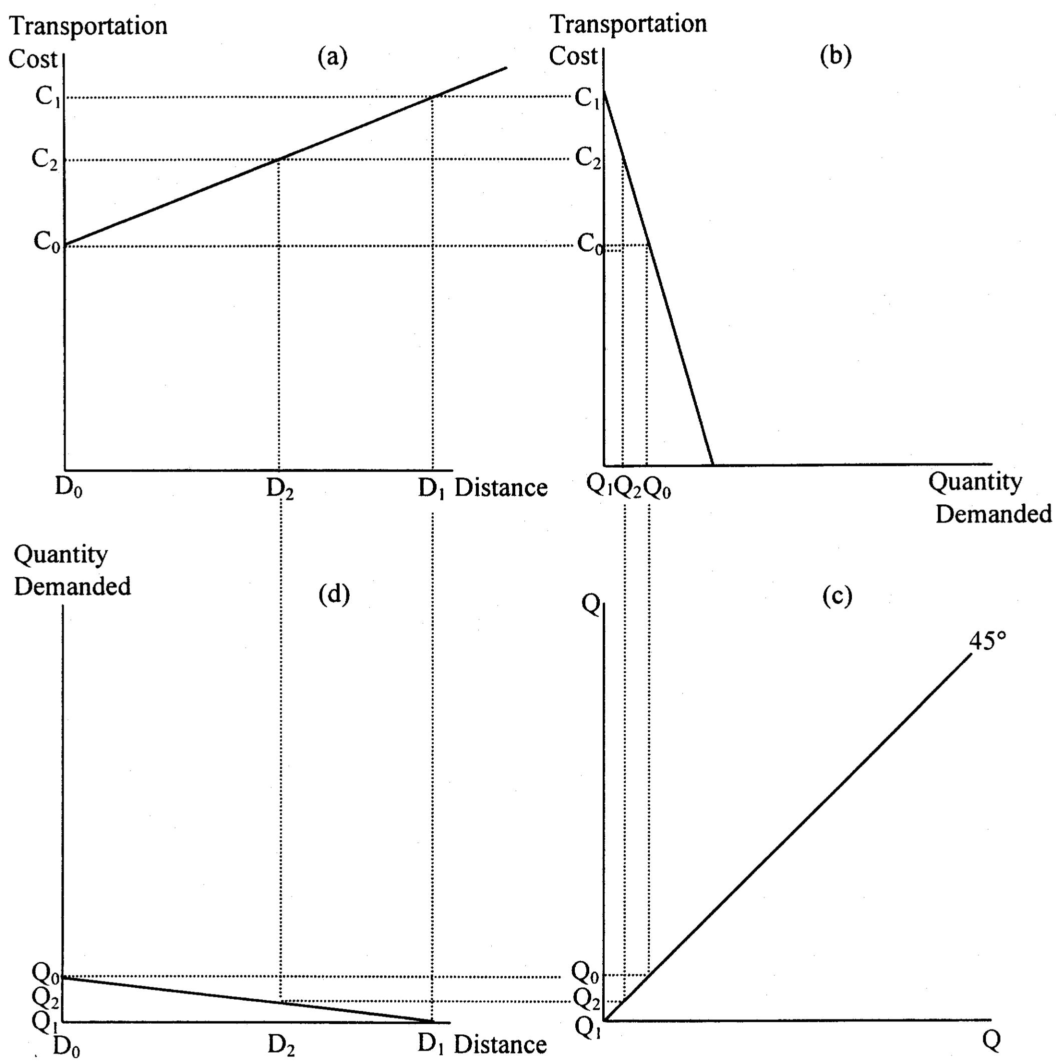

Figure A.1 – The Formation of a Circular Catchment Area.

Panel (a) represents transportation costs faced by any given producer, increasing with distance. Panel (b) illustrates the demand for grain handling services at any given delivery point as a function of the transportation costs to that point. Note the steepness of the demand curve for grain handling services. This indicates that producers' demand for grain handling services is fairly inelastic, due to the fact that there aren't many alternatives available for grain farmers other than to deliver their product to an elevator. The demand for grain handling services by those producers closest to the elevator might not be much higher than the demand by producers furthest away from the elevator. Panel (c) is utilized as a mapping device to get to panel (d), which illustrates the quantity/distance function for the delivery point. The producer located at D_2 whose transportation cost is C_2, will demand Q_2. The flat curve in panel (d) is indicative of the thoughts discussed earlier in that the quantity demanded by producers on the edge of the catchment area will not be zero and will most likely be fairly close to the quantity demanded by producers directly beside the delivery point. Panel (d) is illustrated in chapter 4 by figure 4.4 and is the catchment area for the delivery point being examined (Hoover and Giarratani 1985).

APPENDIX B - MODEL REGION CHARACTERISTICS

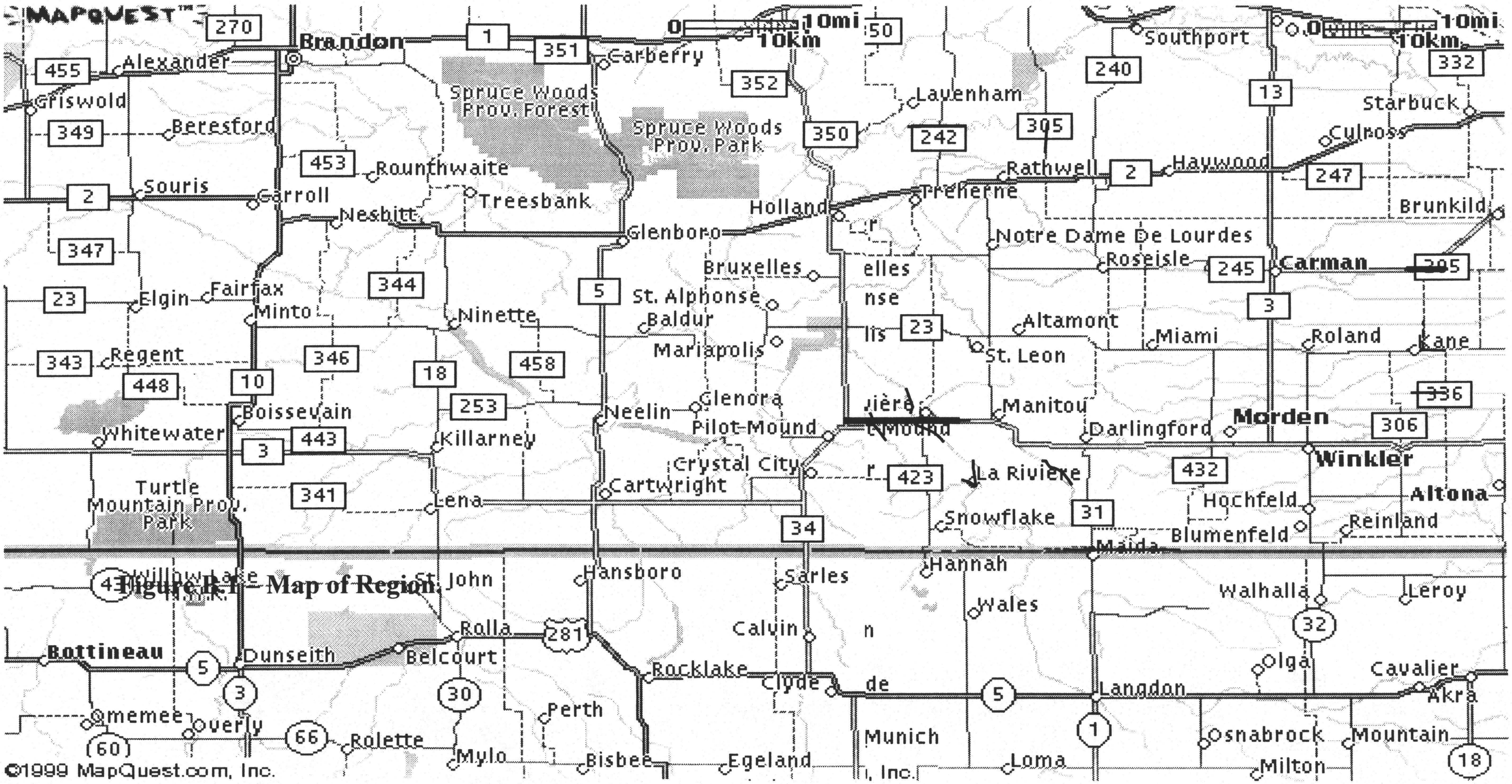

Figure B.1 – Map of Region

Table B.1 – Derivation of Wheat Acreage Averages.

	Total Acres in all Crops	Total Wheat Acres (excluding durum)	Percentage of Crop Acreage in Wheat
Census Division 3			
Dufferin	172,387	40,406	23.5%
Thompson	84,859	33,242	39.2%
Roland	101,053	39,461	39.0%
Stanley	166,639	52,166	31.3%
Rhineland	224,307	86,732	38.7%
Census Division 4			
Argyle	118,175	47,559	40.2%
Lorne	180,972	61,880	34.2%
Roblin	110,762	48,262	43.6%
Louise	171,100	61,812	36.1%
Pembina	180,935	66,359	36.7%
Census Division 5			
Whitewater	110,304	48,454	43.9%
Riverside	83,692	37,881	45.3%
Strathcona	57,606	25,038	43.5%
Morton	139,248	58,248	41.8%
Turtle Mountain	160,208	77,920	48.6%
Census Division 7			
Glenwood	97,104	32,557	33.5%
Oakland	99,440	42,089	42.3%
South Cypress	71,076	24,358	34.3%
Census Division 8			
Victoria	80,829	25,287	31.3%
South Norfolk	114,395	40,187	35.1%
Census Division 9			
Grey	162,917	36,463	22.4%
Total	2,668,008	986,361	37.0%

Source: Statistics Canada (1996), Author's calculations.

APPENDIX C – MODEL RESULTS

Table C.1 – Results for the 80% Adoption Rate Scenario.

	Segregation Options		
	Designated Terminal ($/tonne)	Multiple Points ($/tonne)	Segregation Within ($/tonne)
60,000 Tonnes Demanded			
Producer Costs			
Trucking[1,2]	($0.13)	$0.28	n/a
Handling & Freight[3,4]	$3.59	($0.68)	n/a
Delivery Point Costs			
Administration[5]	$1.00	$1.17	$.93
Cost-Recovery Premium[6]	$3.66	$4.26	$3.27
Trucking Premium[7]	($0.27)	($2.32)	n/a
Acreage Re-allocation Premium[8]	n/a	n/a	$1.25
Testing[9]	$0.20	$0.20	$0.20
Change in Handling Cost[10]	$7.31	n/a	n/a
Average Cost above Tariff Rate[11]	n/a	$5.51	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives[12,13]	$6.55	$4.60	n/a
Change in Handling Cost[14]	($7.23)	$4.10	n/a
Total			
Designated Point(s)[15]	**$15.36**	**$8.42**	**$5.65**
Entire Region[16]	**$14.68**	**$17.12**	**n/a**
120,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.33	($0.61)	n/a
Handling & Freight	$0.61	$0.19	n/a
Delivery Point Costs			
Administration	$0.95	$1.16	$0.93
Cost-Recovery Premium	$3.46	$4.22	$3.27
Trucking Premium	$1.01	($0.40)	n/a
Acreage Re-allocation Premium	n/a	n/a	$1.24
Testing	$0.20	$0.20	$0.20
Change in Handling Cost	$1.60	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.44	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$1.71	$4.70	n/a
Change in Handling Cost	($1.59)	$4.05	n/a
Total			
Designated Point(s)	**$8.16**	**$10.20**	**$5.64**
Entire Region	**$8.28**	**$18.95**	**n/a**
180,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.52	($0.83)	n/a
Handling & Freight	($0.46)	$0.03	n/a
Delivery Point(s) Costs			
Administration	$0.92	$1.05	$0.93
Cost-Recovery Premium	$3.35	$3.80	$3.27
Trucking Premium	$2.02	$0.13	n/a
Acreage Re-allocation Premium	n/a	n/a	$1.23
Testing	$0.20	$0.20	$0.20
Change in Handling Cost	($0.29)	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.45	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$0.31	$4.56	n/a
Change in Handling Cost	$0.28	$4.04	n/a
Total			
Designated Point(s)	**$6.26**	**$9.83**	**$5.63**
Entire Region	**$6.85**	**$18.42**	**n/a**

Source: Author's calculations

Table C.2 – Results for the 50% Adoption Rate Scenario.

	Segregation Options		
	Designated Terminal ($/tonne)	**Multiple Points ($/tonne)**	**Segregation Within ($/tonne)**
60,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.45	($0.43)	n/a
Handling & Freight	$3.41	$0.14	n/a
Delivery Point Costs			
Administration	$0.51	$0.51	$2.10
Cost-Recovery Premium	$1.86	$1.88	$0.60
Trucking Premium	($1.46)	($2.46)	n/a
Acreage Re-allocation Premium	n/a	n/a	$0.02
Testing	$0.20	$0.20	$0.23
Change in Handling Cost	$6.77	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.46	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$3.29	$5.56	n/a
Change in Handling Cost	($6.67)	$4.10	n/a
Total			
Designated Point(s)	**$11.74**	**$5.30**	**$2.95**
Entire Region	**$8.36**	**$14.96**	**n/a**
120,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.81	($0.35)	n/a
Handling & Freight	$0.69	$0	n/a
Delivery Point Costs			
Administration	$0.50	$0.51	$1.93
Cost-Recovery Premium	$1.82	$1.86	$0.55
Trucking Premium	($0.42)	($0.93)	n/a
Acreage Re-allocation Premium	n/a	n/a	$0.09
Testing	$0.20	$0.20	$0.21
Change in Handling Cost	$1.57	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.43	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$1.43	$4.87	n/a
Change in Handling Cost	($1.60)	$4.02	n/a
Total			
Designated Point(s)	**$5.17**	**$6.72**	**$2.78**
Entire Region	**$5.00**	**$15.61**	**n/a**
180,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.87	($0.03)	n/a
Handling & Freight	($0.35)	($0.19)	n/a
Delivery Point(s) Costs			
Administration	$0.49	$0.51	$1.94
Cost-Recovery Premium	$1.78	$1.87	$0.56
Trucking Premium	$0.43	($0.80)	n/a
Acreage Re-allocation Premium	n/a	n/a	$0.04
Testing	$0.20	$0.20	$0.21
Change in Handling Cost	($0.30)	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.44	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$0.15	$4.53	n/a
Change in Handling Cost	$0.27	$4.04	n/a
Total			
Designated Point(s)	**$3.12**	**$7.00**	**$2.75**
Entire Region	**$3.54**	**$15.57**	**n/a**

Source: Author's calculations

Table C.3 – Results for the 20% Adoption Rate Scenario.

	Segregation Options		
	Designated Terminal ($/tonne)	**Multiple Points ($/tonne)**	**Segregation Within ($/tonne)**
60,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.39	($0.10)	n/a
Handling & Freight	$3.57	($0.01)	n/a
Delivery Point Costs			
Administration	$0.33	$0.33	$0.50
Cost-Recovery Premium	$1.19	$1.20	$1.75
Trucking Premium	($1.63)	($2.78)	n/a
Acreage Re-allocation Premium	n/a	n/a	n/a
Testing	$0.20	$0.20	$0.20
Change in Handling Cost	$7.06	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.49	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$0.77	$5.30	n/a
Change in Handling Cost	($7.00)	$4.09	n/a
Total			
Designated Point(s)	**$11.11**	**$4.33**	**$2.45**
Entire Region	**$4.88**	**$13.72**	**n/a**
120,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.85	($0.10)	n/a
Handling & Freight	$0.67	($0.08)	n/a
Delivery Point Costs			
Administration	$0.32	$0.33	$0.42
Cost-Recovery Premium	$1.19	$1.19	$1.46
Trucking Premium	($1.04)	($1.29)	n/a
Acreage Re-allocation Premium	n/a	n/a	n/a
Testing	$0.20	$0.20	$0.25
Change in Handling Cost	$1.46	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.41	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$0.70	$4.95	n/a
Change in Handling Cost	($1.44)	$4.00	n/a
Total			
Designated Point(s)	**$3.65**	**$5.66**	**$2.13**
Entire Region	**$2.91**	**$14.61**	**n/a**
180,000 Tonnes Demanded			
Producer Costs			
Trucking	$0.75	$0.11	n/a
Handling & Freight	($0.26)	($0.22)	n/a
Delivery Point(s) Costs			
Administration	$0.32	$0.33	$0.37
Cost-Recovery Premium	$1.18	$1.19	$1.28
Trucking Premium	($0.23)	($0.98)	n/a
Acreage Re-allocation Premium	n/a	n/a	n/a
Testing	$0.20	$0.20	$0.22
Change in Handling Cost	($0.29)	n/a	n/a
Average Cost above Tariff Rate	n/a	$5.39	n/a
Other Terminal and Region Costs			
Loss of Rail Incentives	$0.01	$4.61	n/a
Change in Handling Cost	$0.26	$4.02	n/a
Total			
Designated Point(s)	**$1.67**	**$6.02**	**$1.87**
Entire Region	**$1.94**	**$14.65**	**n/a**

Source: Author's calculations

Notes to Tables C.1 – C.3

[1] Calculated as the sum of change in trucking costs for producers outside the designated terminal's initial catchment area plus the sum of change in trucking costs for producers within the designated terminal's initial catchment area with the total being divided by the quantity of non-GM wheat being segregated to determine the per tonne cost. For producers outside the initial catchment area, the change in trucking costs is calculated using the following equation where T_i is the designated terminal's trucking charge, T_j is the original low-cost terminal's trucking charge, TP_i is the trucking premium offered by the designated terminal and $Q_{non\text{-}GM}$ is the quantity of non-GM being contracted:

$$((T_i - T_j) - TP_i) \times Q_{non\text{-}GM}$$

For producers within the initial catchment area, the change in trucking costs is calculated using the following equation where Q_{GM} is the quantity of GM wheat that must now be delivered to an alternative point:

$$((T_j - T_i) \times Q_{GM} + (T_i - TP_i) \times Q_{non\text{-}GM})$$

[2] For the multiple designated point system, producer trucking costs are calculated as the sum of the change in trucking costs for all producers, divided by the quantity of non-GM wheat being segregated. Each producer's change in trucking costs is calculated using the following equation where T_i is the designated point's trucking charge, T_j is the original low-cost terminal's trucking charge TP_i is the trucking premium offered by the designated point and $Q_{non\text{-}GM}$ is the quantity of non-GM being contracted:

$$((T_i - T_j) - TP_i) \times Q_{non\text{-}GM}$$

[3] Calculated as the sum of change in handling and freight costs for producers outside the designated terminal's initial catchment area plus the sum of change in handling and freight costs for producers within the designated terminal's initial catchment area with the total being divided by the quantity of non-GM wheat being segregated. For producers outside the initial catchment area, the change in handling and freight costs is calculated using the following equation where HC_i is the designated terminal's handling charge, HC_j is the original low-cost terminal's handling charge, F_i is the designated terminal's freight charge, F_j is the original low-cost terminal's freight charge and $Q_{non\text{-}GM}$ is the quantity of non-GM being contracted:

$$((HC_i - HC_j) + (F_i - F_j)) \times Q_{non\text{-}GM}$$

For producers within the initial catchment area, the change in handling and freight costs is calculated using the following equation where Q_{GM} is the quantity of GM wheat that must now be delivered to an alternative point:

$$((HC_j - HC_i) + (F_j - F_i)) \times Q_{GM}$$

[4] For the multiple designated point system, changes in producer handling and freight costs are calculated as the sum of the change in handling and freight costs for all producers, divided by the quantity of non-GM wheat being segregated to determine the per tonne cost. Each producer's change in handling and freight costs is calculated using the following equation where HC_i is the designated point's handling charge, HC_j is the original low-cost terminal's handling charge, Fi is the designated point's freight charge, Fj is the originial low-cost terminal's freight charge and $Q_{non\text{-}GM}$ is the quantity of non-GM being contracted:

$$((HC_i - HC_j)+(F_i - F_j)) \times Q_{non\text{-}GM}$$

[5] Calculated based on an administration cost of $2000 per farm under contract, divided by the total quantity of non-GM wheat being segregated to determine the per tonne cost.

[6] Calculated based on a cost-recovery premium of $7000 plus the cost of an additional 40 tonne truckload of wheat per farm under contract, divided by the total quantity of non-GM wheat being segregated to determine the per tonne cost.

[7] Calculated based on the estimated intercept and slope parameters and is sum of the total trucking premium paid to each farm, divided by the total quantity of non-GM wheat being segregated to determine the per tonne cost.

[8] Calculated as the sum of acreage re-allocation premium paid to producers, divided by the total quantity of non-GM wheat being segregated to determine the per tonne cost.

[9] Calculated based on a testing cost of $8 per truckload of non-GM wheat. The $8 consists of 3 tests at $1 each plus $5 of labour to conduct the tests.

[10] Calculated as the total change in handling costs (EC_i) resulting from a change in the volume of grain handled, divided by the total quantity of non-GM wheat being segregated to determine the per tonne cost. The calculation is based on the following equation where HC_i is the handling tariff charged by the designated terminal, $Q_{non\text{-}GM}$ is the quantity of non-gM wheat being segregated, Q_{other} is the quantity of other grain handled at the terminal, MC_i is the marginal cost of operations at the designated terminal, and FC_i is the fixed costs of the designated terminal:

$$\Delta EC_i = HC_i - ((Q_{non\text{-}GM} + Q_{other} \times MC_i) + FC_i) / (Q_{non\text{-}GM} + Q_{other})$$

[11] Calculated as the average cost of operations above the handling tariff charged based on the assumption that the small elevators will have to charge the same handling tariff as the terminals even though their cost of operations are higher. Calculation is based on the following equation where $Q_{non\text{-}GM}$ is the total quantity of non-GM wheat being segregated, MC_i is the marginal cost of the elevator, FC_i is the fixed cost of the elevator and HC_i is the handling tariff charged. The sum of the average costs of

operations above the handling tariff charged (EC_i) for all elevator's i, is divided by the total quantity of non-GM wheat being segregated to determine the per tonne cost:

$$EC_i = ((Q_{non\text{-}GM} \times MC_i) + FC_i) / (Q_{non\text{-}GM} - HC_i)$$

[12] For the designated terminal scenario, calculated as the costs associated with the net loss in rail incentives when grain is moving among terminals with differing rail incentives. The total loss (LRI) is divided by the total quantity of non-GM being segregated to determine the cost per tonne of non-GM wheat being segregated. The calculation is based on the following equation where QE_{GM} is the quantity of GM wheat moving from the designated terminal's initial catchment area to the Elm Creek terminal, $QE_{non\text{-}GM}$ is the quantity of non-GM wheat moving from the Elm Creek region to the designated terminal, QR_{GM} is the quantity of GM wheat moving from the designated terminal region to the Rathwell terminal, $QR_{non\text{-}GM}$ is the quantity of non-GM wheat moving from the Rathwell region to the designated terminal and $QK_{non\text{-}GM}$ is the quantity of non-GM wheat moving from the Killarney region to the designated terminal (the dollar figures are the difference in rail incentives):

$$LRI = ((QE_{GM} - QE_{non\text{-}GM}) \times \$5) + ((QR_{GM} - QR_{non\text{-}GM}) \times \$2) - (QK_{non\text{-}GM} \times \$2)$$

[13] For the multiple designated point scenario, calculated as the total cost of lost rail incentives when grain moves from terminals with a rail incentive to small elevators with no rail incentive. The calculation is based on the following equation where TC_j is the total cost of lost rail incentives for terminal j, RI_j is the rail incentive available at terminal j and $Q_{non\text{-}GM}$ is the quantity of non-GM wheat moving from the catchment area of terminal j to one of the small elevators in the multiple point system. The sum of TC_j for all j is divided by the total quantity of non-GM wheat being segregated to determine the cost per tonne of lost rail incentives:

$$TC_j = RI_j \times Q_{non\text{-}GM}$$

[14] Calculated as the total change in handling costs at other terminals in the region with grain moving to the designated terminal or the small elevators in the multiple designated point system. The sum of the total costs for each terminal is divided by the total quantity of non-GM wheat being segregated to determine the cost per tonne. The calculation is based on the following equation where TCj is the total cost for terminal j, HCj is the handling charge at terminal j, QGM is the total quantity of GM wheat being handled at terminal j, Qother is the total quantity of other commodities handled at terminal j, MCj is the marginal cost of operations at terminal j and FCj is the fixed costs of terminal j.

$$TC_j = (HC_j - ((((Q_{GM} + Q_{other}) \times MC_j) + FC_j) / (Q_{GM} + Q_{other}))) \times (Q_{GM} + Q_{other})$$

[15] Consists of the sum of producer costs and delivery point(s) costs.

[16] Consists of the sum of producer costs and delivery point(s) costs, less other terminal and region costs.

Negative Costs

A number of the costs reported in tables 6.2 to 6.4 contain negative values, signified by the presence of brackets. Due to the expectation that all costs would increase for the parties involved in the segregation process, the negative values warrant explanation.

Producer Trucking Costs

The first negative costs of note are the trucking costs faced by producers after the introduction of segregation. These negative values can be explained by two factors.

First, the trucking premiums offered by the designated point(s) are factored into the trucking costs paid by producers, thereby reducing the added cost of delivery for those producers receiving a premium.

Second, variable trucking rates charged by terminals and elevators in the region will, in some cases, reduce the trucking costs faced by producers after segregation is introduced. As can be seen in table 4.1, the transportation constants estimated for Elm Creek and Rathwell are lower than the estimate for Aggasiz. Therefore, producers in the Aggasiz region who must deliver their GM wheat to Elm Creek and Rathwell may end up paying less in transportation costs than was initially the case.

In the multiple designated point scenario, producers may end up paying less for transportation if they are close to one of the small elevators, or if they are in a region where the transportation constant for the terminal is higher than that for the small elevator.

These factors all influence the trucking costs paid by producers and explain why in some cases the trucking costs are on average lower after segregation is introduced.

Producer Handling and Freight Costs

Like producer trucking costs, negative values for producer handling and freight costs can be explained by the variability in handling and freight charges across the region.

For the designated point alternative, negative handling and freight costs appear only in the 180,000 tonne scenario. This can be explained by two factors. First, Aggasiz, who has the lowest freight rates in the region, is handling non-GM wheat from a large portion of the producers in the region. For those producers outside Aggasiz's initial catchment who are now delivering non-GM wheat to Aggasiz, freight costs are lower than what they pay for GM wheat delivered to their closest point. Second, producers in the initial Aggasiz catchment area are able to grow more non-GM wheat and thus deliver less GM wheat to the higher cost Elm Creek and Rathwell terminals.

For the 60,000 and 120,000 tonne scenarios, the number of producers delivering to Aggasiz is reduced, thereby reducing the number of producers benefiting from lower freight costs to Aggasiz. Also, the volume of grain moving from the Aggasiz region to Elm Creek and Rathwell increases at a cost equal to the differential in freight rates.

For the multiple designated point scenario, negative costs for handling and freight are fully explained by the variance in these charges across the region. Negative values appear under circumstances where, on average, more producers pay less handling and freight at the small elevators in comparison to their original low-cost terminal.

Trucking Premiums

The presence of negative values for trucking premiums paid by the designated points stems from the discussion surrounding discriminatory premiums in chapters 4 and 5.

For the designated terminal scenario, the ability to discriminate against those producers captive to the Aggasiz terminal has the potential to result in negative premium costs. In the event that the amount gained discriminating against producers exceeds the amount of premiums paid to producers outside the original catchment area, negative trucking premium costs result. The occurrence of negative trucking premium costs increases as the volume being segregated decreases and also as adoption rates of GM varieties increases. In both instances, the designated terminal is able to source a large portion of the required amount of non-GM wheat from within its initial catchment area. Because those producers are captive to the point, the designated terminal is able to discriminate against them. The more non-GM wheat that has to be sourced from outside the initial catchment area (in cases where demand is high, or availability of non-GM wheat is low), the higher the trucking premium cost will be.

For the multiple designated point scenario the presence of negative premium costs once again stems from the variations in trucking rates across the region. When the designated small elevator is in a region where trucking rates charged by the terminals are high, they will be able to discriminate against the producers in the region. However, if the elevator is in a region where trucking rates are low, they will have to offer a positive premium to attract producer's non-GM wheat. The presence of negative trucking premium costs for the system thus arises when the ability to discriminate outweighs the premiums required for the system to operate.

Changes in Handling Costs

Negative values for changes in handling costs were not unexpected as they relate to the volume handled by the terminals in the region. Negative values for Aggasiz appear in the 180,000 tonne scenarios as they are handling a greater volume of grain than initially. The increase in volume lowers their operating costs, resulting in a negative change in handling costs. For the remainder of the scenarios in the designated terminal alternative, the other terminals in the region have reduced operating costs on average due to the increase in volume at the Elm Creek and Rathwell terminals.

APPENDIX D - FIGURES PERTAINING TO THE MODEL RESULTS

Note: For all figures in Appendix D, the first letter of each terminal name (Souris, Boissevain, Nesbitt, Killarney, Rathwell, Aggasiz and Elm Creek) represents their location on the grid.

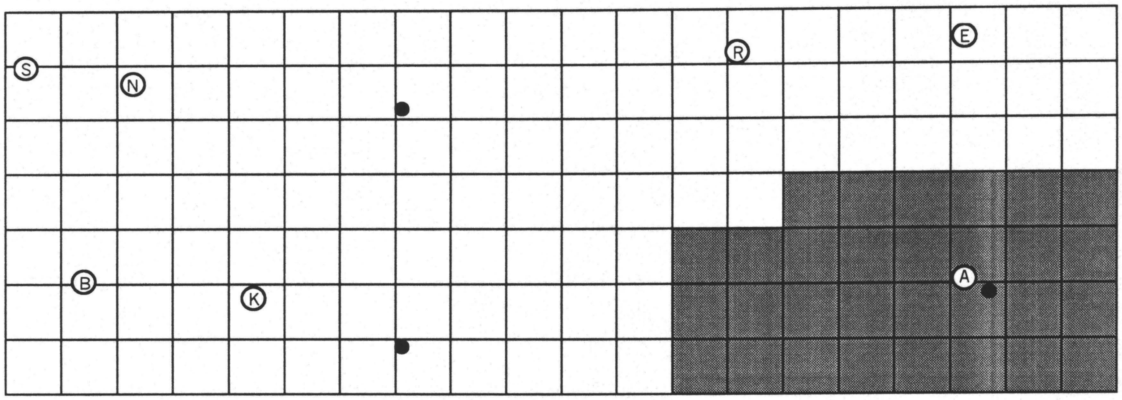

Figure D.1 – Catchment Area for Designated Point System: 80%/60,000 tonnes.

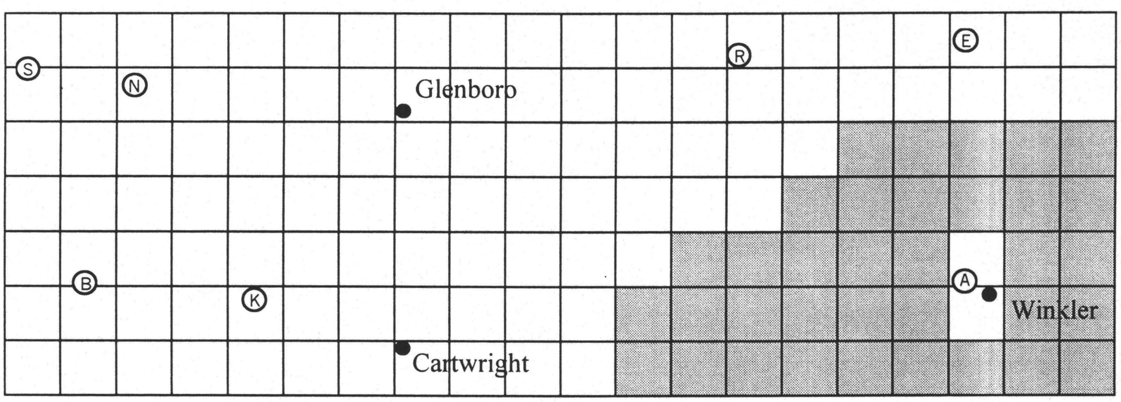

Figure D.2 – Catchment Area for Multiple Point System: 80%/60,000 tonnes.

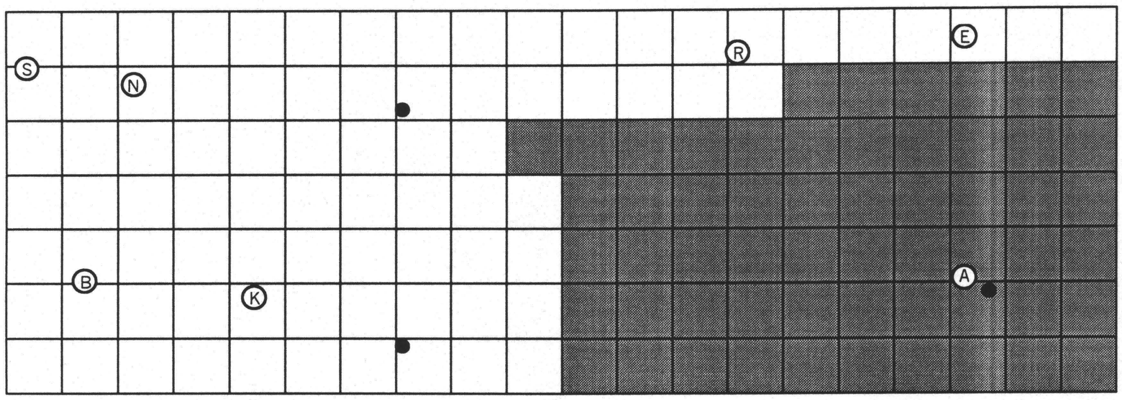

Figure D.3 – Catchment Area for Designated Point System: 80%/120,000 tonnes.

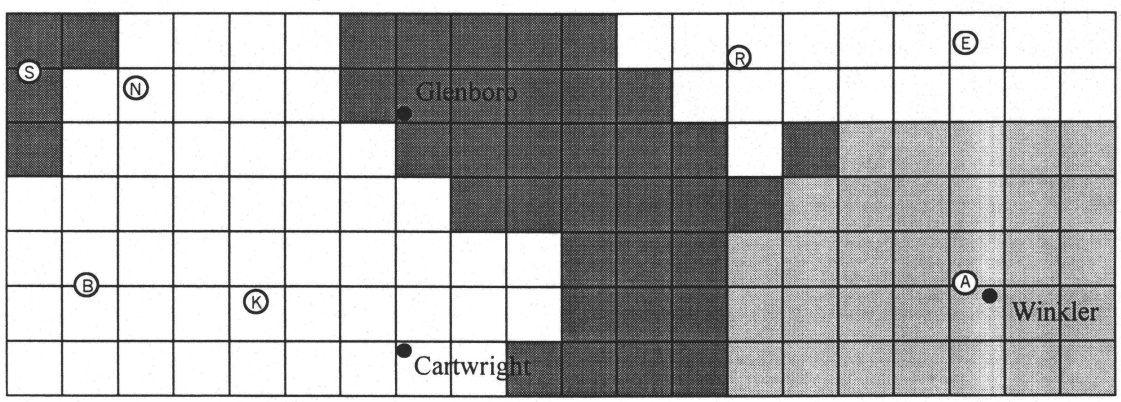

Figure D.4 – Catchment Areas for Multiple Point System: 80%/120,000 tonnes.

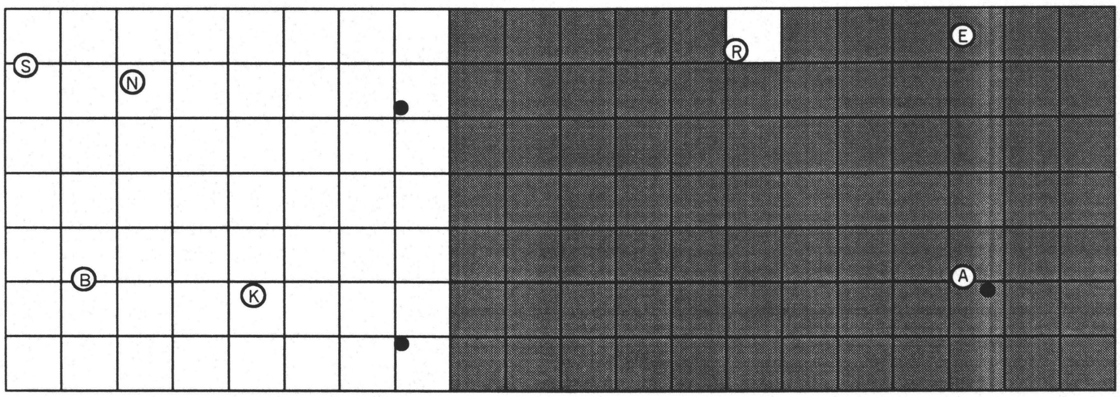

Figure D.5 – Catchment Area for Designated Point System: 80%/180,000 tonnes.

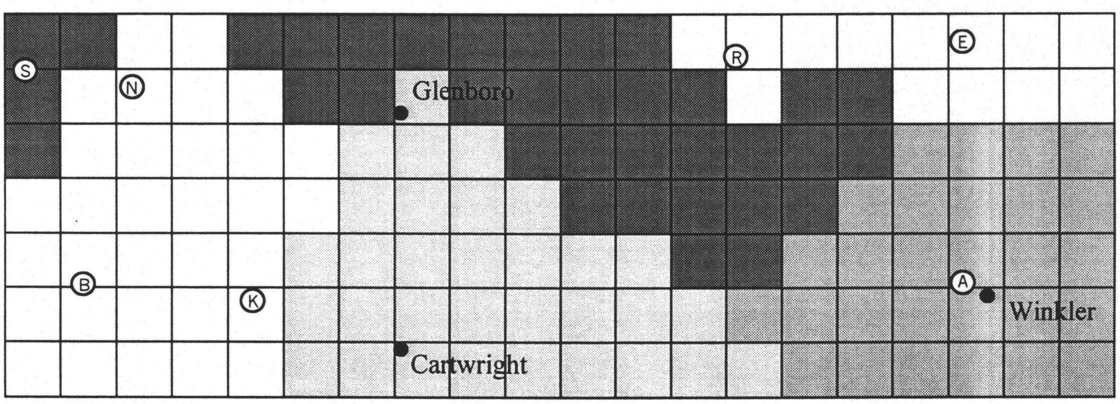

Figure D.6 – Catchment Areas for Multiple Point System: 80%/180,000 tonnes.

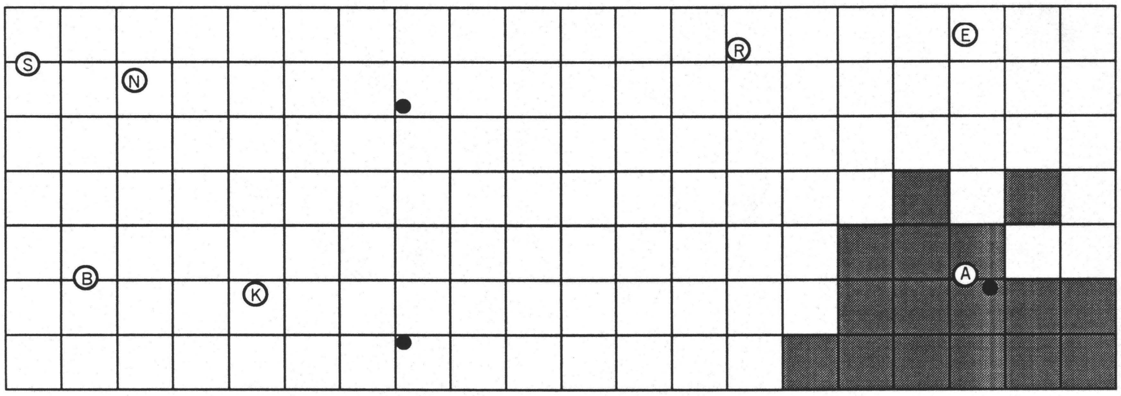

Figure D.7 – Catchment Area for Designated Point System: 50%/60,000 tonnes.

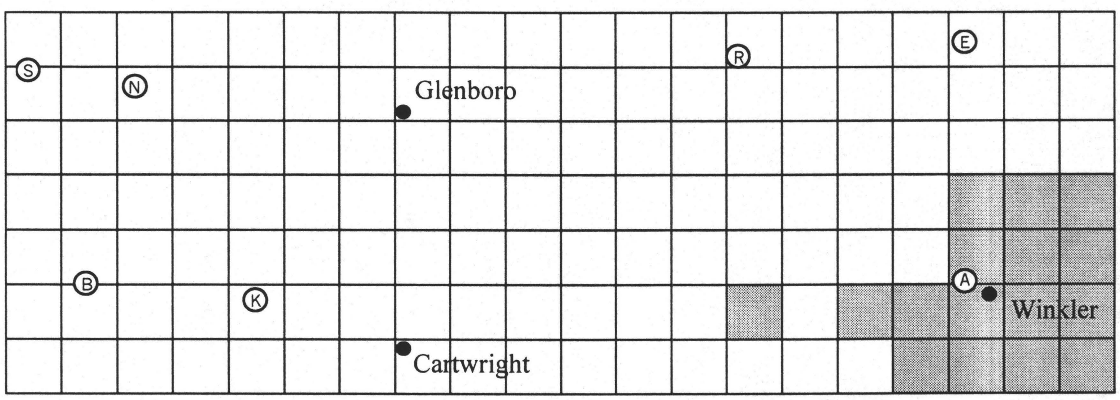

Figure D.8 – Catchment Area for Multiple Point System: 50%/60,000 tonnes.

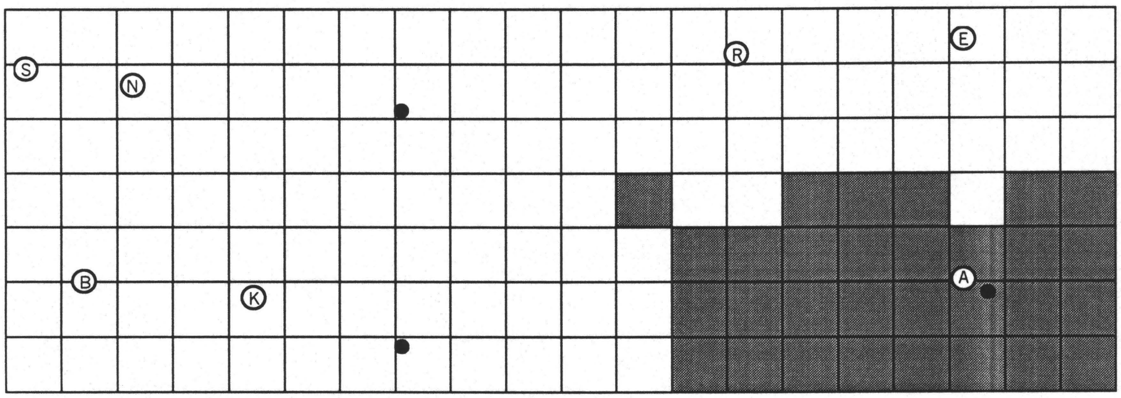

Figure D.9 – Catchment Area for Designated Point System: 50%/120,000 tonnes.

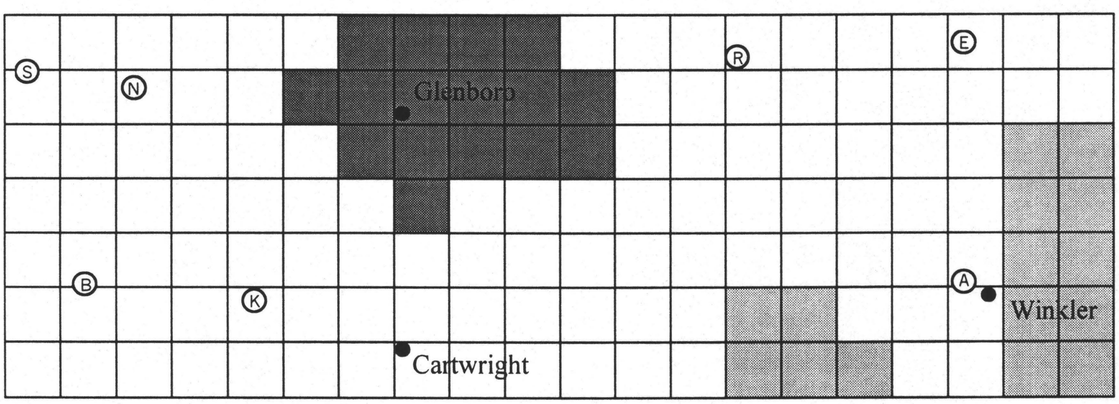

Figure D.10 – Catchment Areas for Multiple Point System: 50%/120,000 tonnes.

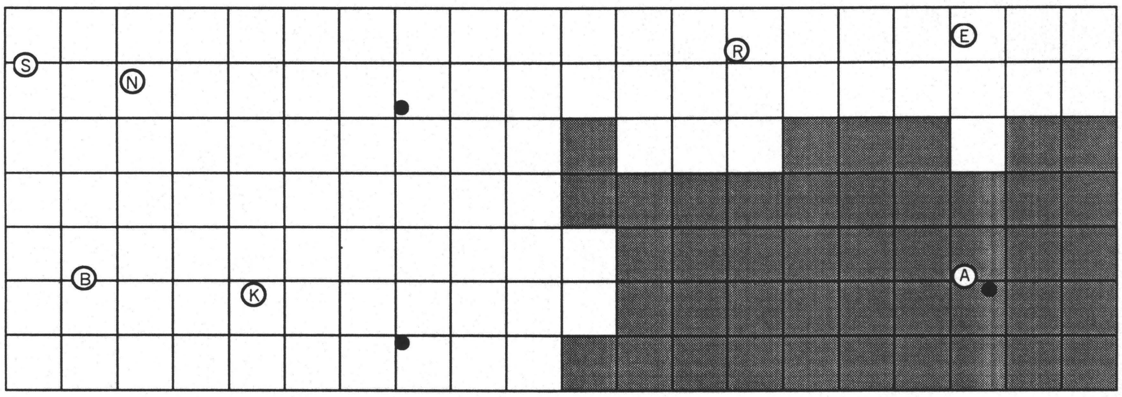

Figure D.11 – Catchment Area for Designated Point System: 50%/180,000 tonnes.

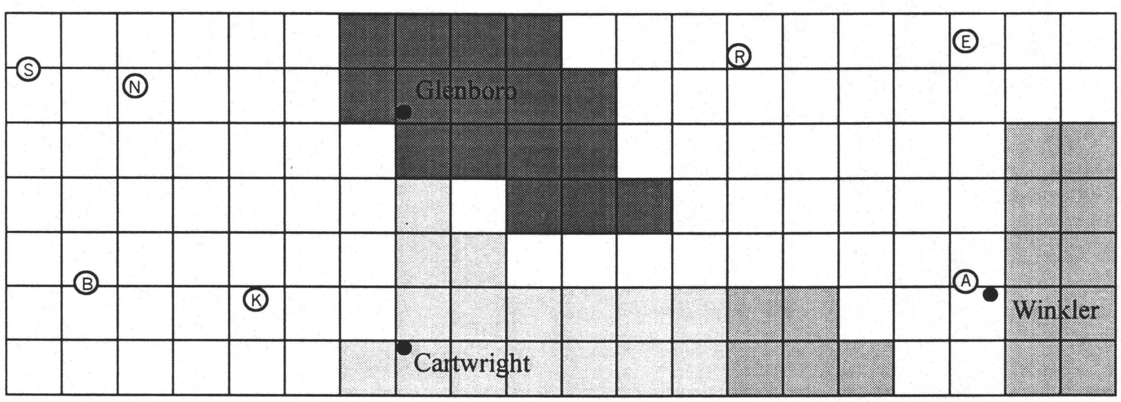

Figure D.12 – Catchment Areas for Multiple Point System: 50%/180,000 tonnes.

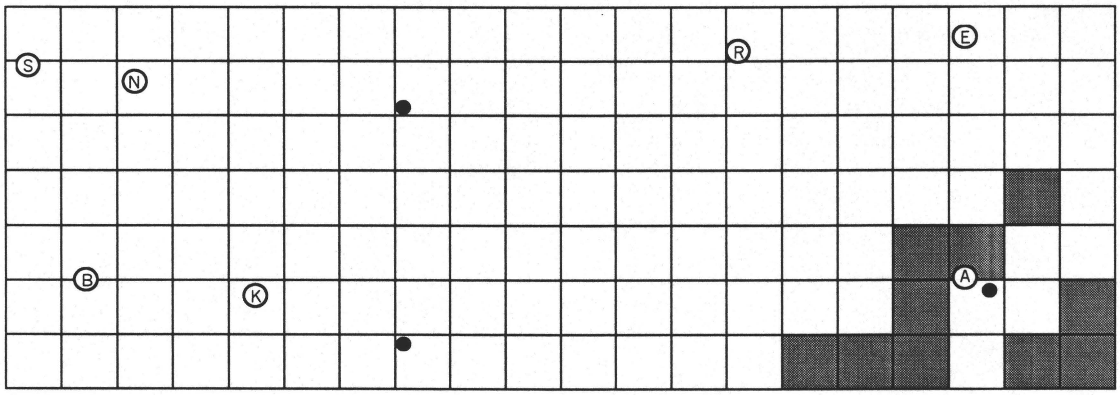

Figure D.13 – Catchment Area for Designated Point System: 20%/60,000 tonnes.

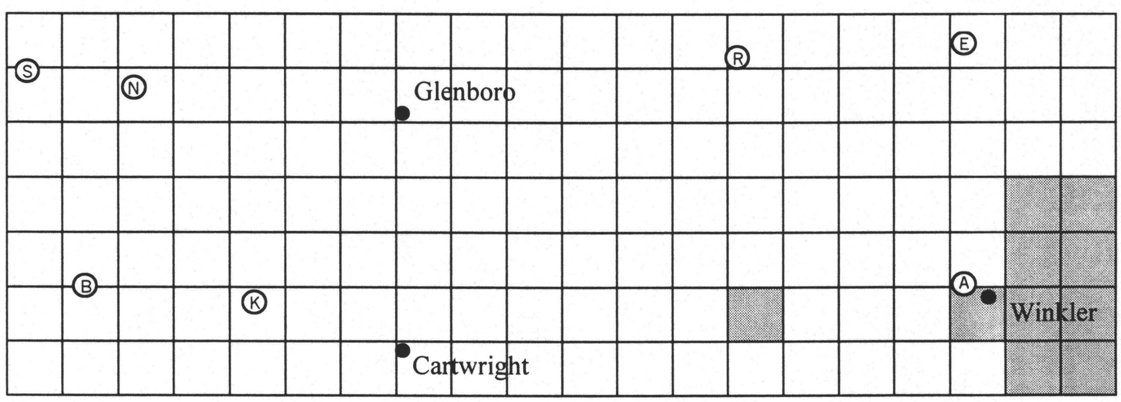

Figure D.14 – Catchment Area for Multiple Point System: 20%/60,000 tonnes.

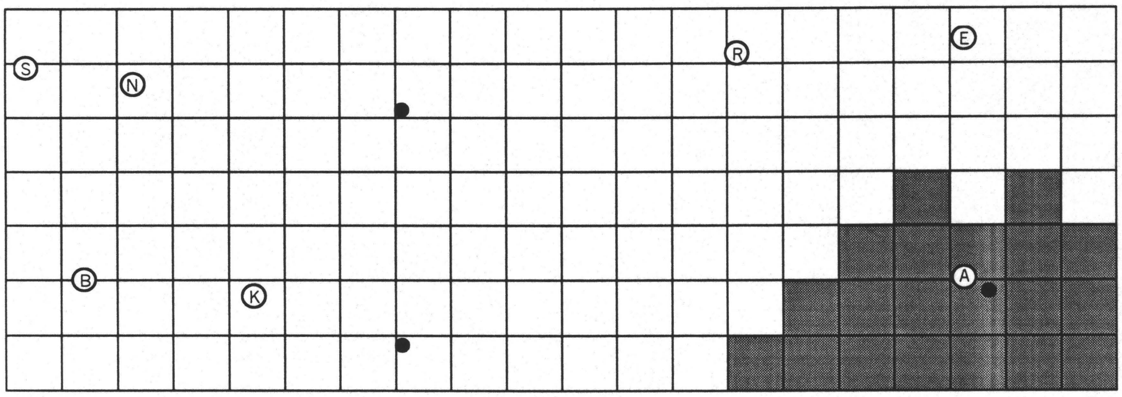

Figure D.15 – Catchment Area for Designated Point System: 20%/120,000 tonnes.

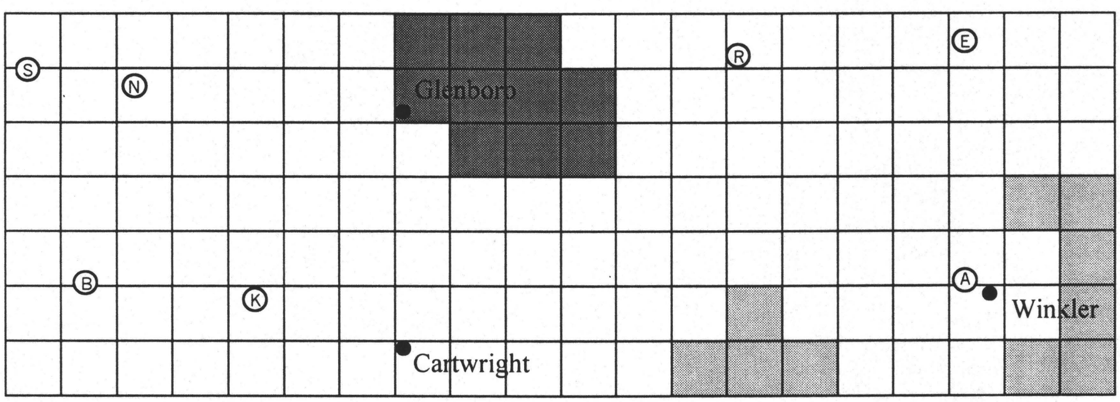

Figure D.16 – Catchment Areas for Multiple Point System: 20%/120,000 tonnes.

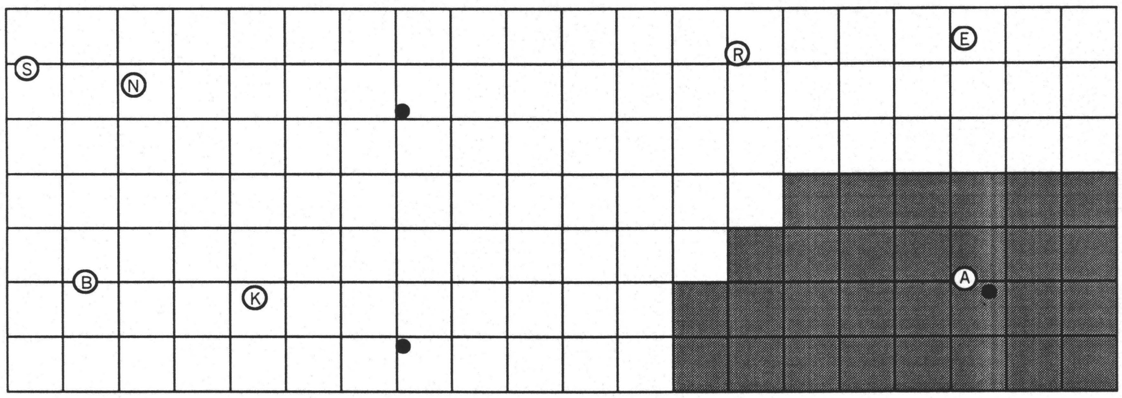

Figure D.17 – Catchment Area for Designated Point System: 20%/180,000 tonnes.

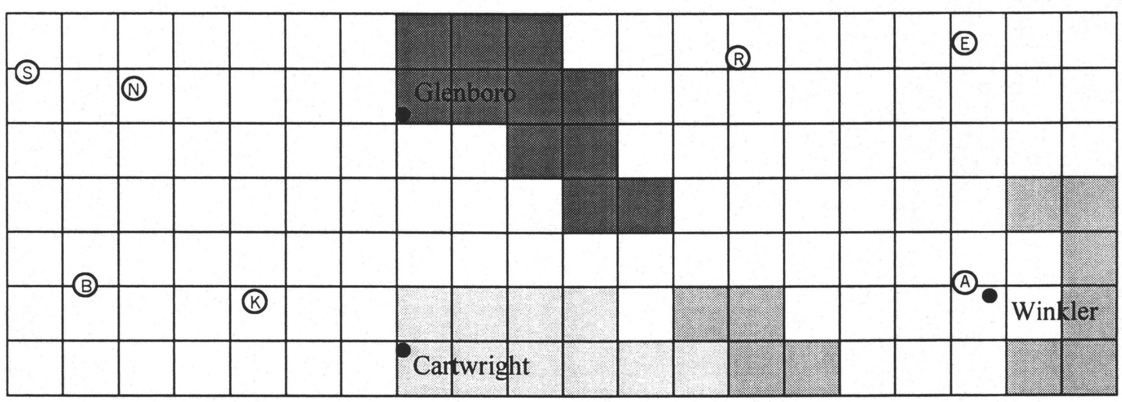

Figure D.18 – Catchment Areas for Multiple Point System: 20%/180,000 tonnes.