# MARKETING MECHANISMS TO FACILITATE CO-EXISTENCE OF GM AND NON-GM CROPS

A Paper
Submitted to the Graduate Faculty
of the
North Dakota State University
Of Agriculture and Applied Science

By

Benjamin Henry

In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Agribusiness and Applied Economics

July 2005

Fargo, North Dakota

# North Dakota State University
## Graduate School

**Title**

MARKETING MECHANISMS TO FACILITATE CO-EXISTENCE

OF GM AND NON-GM CROPS

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

**MASTER OF SCIENCE**

SUPERVISORY COMMITTEE:

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July 28, 2005

Date

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## ABSTRACT

Henry, Benjamin; M.S.; Department of Agribusiness and Applied Economics; College of Agriculture, Food Systems, and Natural Resources; North Dakota State University; July 2005. Marketing Mechanisms to Facilitate Co-Existence of GM and Non-GM crops. Major Professor: Dr. William Wilson.

Development of specialty crops and GM products has had a great impact on the grain handling industry during past years. Added costs associated with handling these crops have become an issue of major importance for grain-handlers. For this study, data were collected from a survey of elevators in the Upper Midwest. The information gathered concerned their segregation practices, and the associated time and costs. This study shows the different costs (grading and handling) associated with segregation practices at the grain-handler level. The results obtained by using the empirical model based on the framework by Hurburgh et al. (1994) revealed that the cost of modifying systems to handle GM is of major importance. Assuming no modification is realized, the total cost of segregation is about 10 cents per bushel. The volume of grain tested also has an important impact on the total cost of segregation per bushel. As volumes handled and/or tested increase, the cost of segregation decreases. Finally, the gross elevator margin and the premium for quality seem to be large enough to offset the increase in handling costs due to these new segregation practices.

## ACKNOWLEDGEMENTS

I would like to express sincere gratitude to my advisor, Dr. William Wilson, for his support, his guidance, and his motivation. I really appreciated his help during this project. I would also like to thank my thesis committee members: Dr. Edward Deckard, Dr. William Nganje and Dr. Cheryl Wachenheim for their sacrifice of time, their comments and helpful suggestions. I would like to thank Bruce Dahl for his willingness to discuss relevant issues and for all his efforts throughout the completion of this study. Finally, thank you to my colleagues from the agribusiness department: Xavier, Jean-Sebastien, Chancel and Mounir.

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# CHAPTER 1
# STATEMENT OF PROBLEM

## Introduction

Over the past decade, biotechnologies have become more important in agriculture and agribusiness. Production and marketing of the so-called transgenic grains (also referred to as biotech, genetically modified, or GM) have provided many opportunities and challenges for the commodity marketing system.

Reduced costs and increased yields ($1^{st}$ phase benefits) as well as prospects of $2^{nd}$ phase benefits or traits are advantages that have prompted fairly wide-scale adoption of GM crops but only after traits have been approved by appropriate regulatory agencies. Commercialization of GM products raises many public concerns such as agronomic competitiveness, consumer acceptance, effects of international trade, issues related to identity preservation (IP), segregation, and testing. The overall objective of this paper is to analyze alternative marketing mechanisms to facilitate the co-existence of GM and non-GM crops in order to satisfy customers' requirements.

As of 2005, the four agronomic crops with commercial value in biotech varieties are corn, soybean, cotton, and canola (Runge and Ryan, 2003; National Agricultural Statistics Service [NASS], 2004). Development of new biotech crops, such as GM wheat, is underway. The main issue is the acceptance of these biotech crops by different governments and the demand for these goods by consumers.

Some countries such as Japan or the nations of the European Union (EU), adverse to biotech products have adopted different policies to deal with GM products. They require testing, segregation, labeling, tolerance levels, and/or other restrictive conditions to protect themselves against any potential danger or offensiveness of the genetic manipulation on human health even though no scientific proof has yet been provided that may suggest any threat (Agence Science-Presse, 1999). The procedures chosen are specific to one country because Japan does not have the same requirements regarding biotech products. The different positions held by the governments of these countries are just the political expression of the consumers who reject GM products because of the risks for human health.

On the other hand, countries in favor of GM development try to find the best ways to commercialize their products. The United States, Argentina, China, and Brazil are the four main countries that use biotech crops in their production and marketing systems. In Argentina, 90% of the soybeans are from biotech varieties. This may be explained by the fact that the savings generated by the herbicide-tolerant and the environmental preoccupations (less use of herbicides) are several elements that encourage producers to choose these seeds (Schnepf, 2001).

Nevertheless, the United States is still considered as the leading country that stimulates the worldwide development of this type of biotechnologies with 97% of the world's GM productions originating from this country (Seralini, 1999). GM production is already widely spread in theUnited Statesand over the last few years, planting of biotech crops (corn, soybean, and canola) has increased, which suggests that producers would be willing to accept new GM crops such as wheat when it becomes available; providing that it is the same type of genetic modification as for the other crops. This is a major issue, since GM wheat is planned to be the next genetically modified crop to be commercialized. Development of GM wheat is far behind other crops for many reasons: its genetic complexity, wheat is a smaller volume crop, exports are of greater relative importance, import country regulations aren't well defined, competition among exporting countries is more intense and compounded by radically different marketing systems (Wilson et al., 2003a). The fact that most of these biotech crops are oriented towards exportation enforces the idea of a need for an international commercial agreement. This has now become the new challenge for biotechnologies.

Research is done to find marketing mechanisms and new associated practices to facilitate co-existence of GM and non-GM crops. Many concepts have been and are experienced theoretically or/and in practice to enable producers to respond to the differentiation in demands from their buyers. Indeed, each country has its own policies and there are also many different requirements from various firms inside the same country (e.g., organic sector in the US). Among these, there are mechanisms related to segregation, testing, and traceability.

There are four crucial points that motivate research on these mechanisms. First, the consequence of these practices will eventually be increased costs (costs of segregation, testing, and additional logistical costs…). Second, the impact on risks is an important factor of these marketing mechanisms. Firms will be willing to take risk if they are compensated for it. Third, it is essential to see tolerances as inversely related to costs. Therefore, imposing tight tolerances will reduce risks but will ultimately imply higher costs. Finally, the new European proposal of adopting traceability will affect both buyers and sellers, and raise issues about global competitiveness and liability. Future world trading regimes and marketing practices will be highly influenced by these different elements.

These issues are the same as those discussed in this paper. The research and results of the survey will provide sufficient elements and data to run the theoretical model. By running simulations, the results will help understand better the risks, costs, and tradeoffs in determination of segregation, tolerance, and traceability strategies that are essential components to facilitate coexistence of GM and non-GM crops. The model will be applicable to all types of crops: GM (e.g., herbicide tolerant, fusarium, or drought resistant) or non-GM (e.g., organic).

## Problem statement

Fundamental issues confronting commercialization of GM traits in crops grown in North Dakota are related to the co-existence of GM and non-GM crops. This is due to the markets to which these crops are intended.

Due in part to the different regulatory mechanisms in each country, there will ultimately be a system that facilitates co-existence. For example, even though GM crops are received without resistance as ingredients in theUnited Statesfood industry, many countries will propose limits on GM content. Notably, this will be due to traceability requirements by the EU, as well as tolerance limits for Japan, and likewise for many other countries, as well asUnited Statesorganic sector.

To make sure that the delivered products meet the requirements set by customers (tolerance level for example), the whole production and marketing channel will have to propose mechanisms that ensure identity preservation of the grain (segregation, traceability, testing, etc). At the grain-handler level, the organization of the entire business will have to be oriented towards these customer specifications. Management measures for co-existence should build on and take into account already existing segregation practices and available experience about handling of identity preserved crops and seed production practices (Commission Recommendation, 2003). These new organization methods will reduce the costs of the products. The main problem, here, is the additional costs that these new methods will imply for the grain-handler. Whatever the degree of segregation or the level of testing, there will always be additional associated costs. In addition to the direct costs of testing and labor costs, these new segregations due to the handling of GM products may mean costs of construction for the grain-handler, which will need more storage volume, and also various hidden costs due to the extra time these segregations require. Truly, the impact of these mechanisms on the retailer's activity might be enormous.

An estimation of these additional segregation costs will be calculated using the model by Hurburgh et al. (1994). Most grain-handlers have already adopted identity preserved methods for other non-GM products so for some of them, these new restrictions should not mean too many changes in the business. However, an extra segregation means additional costs simply by the additional labor it implies. Other grain-handlers might decide not to accept any GM product if the costs of segregating are too high. It will be up to the grain-handler to decide how to react to customers' pressure on traceability of their products.

## Objectives and hypothesis

The overall objective of this paper is to analyze alternatives that can facilitate the co-existence in the marketing and production systems for both GM and non-GM crops. In achieving this objective, the specific objectives include 1) document current practices at the elevator level, by surveying grain-handlers in the Upper Midwest, to document their current and projected segregation practices; 2) estimate a model to analyze the changes in costs due to segregation practices. In order to illustrate the impact of segregating and testing for GM presence, the data collected from elevators in the Upper Midwest is used to run a model similar to the one built by Hurburgh et al. (1994) but with several changes regarding the inputs used. This will provide us with an estimation of the additional costs and risks related to these new practices.

Grain-handlers are already facing issues related to identity preservation and segregation of grain. The increasing number of GM crops in the market is reinforcing this obligation of grain-handlers to prove that their product conforms to the customers' requirements. Therefore, marketing mechanisms that facilitate co-existence of GM and non-GM crops will soon have to be provided to grain-handlers in order to help them respond to the demand of the market.

## Organization

Chapter 2 explains in detail different mechanisms used to provide for the co-existence of GM and non-GM crops especially at the grain-handler level. This review of previous studies builds a background on the topic and provides the current understanding of what has already been done in this area. Then, chapter 3 will provide a theoretical construct of marketing mechanisms based on what is currently done by grain-handlers in the Upper Midwest (information being collected by survey). An estimation of risks and costs related to segregation practices will be tackled in chapter 4, including the empirical model. In chapter 5, results and sensitivities will be exposed. Chapter 6 will include conclusion, summary, implications, and limitations.

## Methodology

The first step of this study was to analyze the numerous previous studies related to the topic, in order to build a solid background before pursuing additional information directly from grain-handlers in the Upper Midwest. Data related to segregation practices and identity preservation at the grain-handler level were collected by doing a survey of elevators and marketers of grain, and oilseeds (traders) in the Upper Midwest region (North-Dakota, South-Dakota, Minnesota, and Montana). Sufficient information was collected to run a model similar to the framework realized by Hurburgh et al. (1994) that estimates the additional costs related to segregating and testing for GM presence. Grading and handling are the two main cost categories used in this model. The grading cost is estimated by the sum of the cost of waiting, the sample storage cost, the data equipment cost, and the cost of disputes, amongst others.

The handling cost category includes costs related to waiting time, pit labor, underutilization, storage, and others. These different elements show that if segregation is not already implemented at the grain-handler, the additional costs arising from this new practice will be significant.

The goal of this study is to estimate the impact of the presence of GM products in the production and marketing channel. The different requirements of customers all over the world, but also from different sectors within the US, cause most grain-handlers to plan more efforts on the identity preservation of the products they handle. This study should improve our understanding on how and to what extent GM crops impact the costs of the grain handling process.

# CHAPTER 2
# BACKGROUND AND REVIEW OF STUDIES

## Introduction

This chapter summarizes background information collected on market mechanisms. During the last decade, several genetically modified crops were developed (corn, soybean, canola, and cotton). Development, adoption, and commercialization of these GM crops have had many implications for the production and marketing system. Furthermore, the issues that arise are different among countries and among sectors inside the same country.

Different mechanisms have been developed to make sure the end users are satisfied with their products, i.e., if these goods correspond to the pre-established requirements (Wilson et al., 2003b). These mechanisms will have to be improved because the idea of new GM crops arriving on the market has raised many more concerns. Prior to adoption of GM varieties, sales were commonly made on grade and non-grade factors. Nowadays, buyers require varying types of information regarding varieties, whether they are GM or not, and other agronomic information on production practices. In the following spectrum, Figure 2.1, Wilson et al. show different possible procurement strategies.

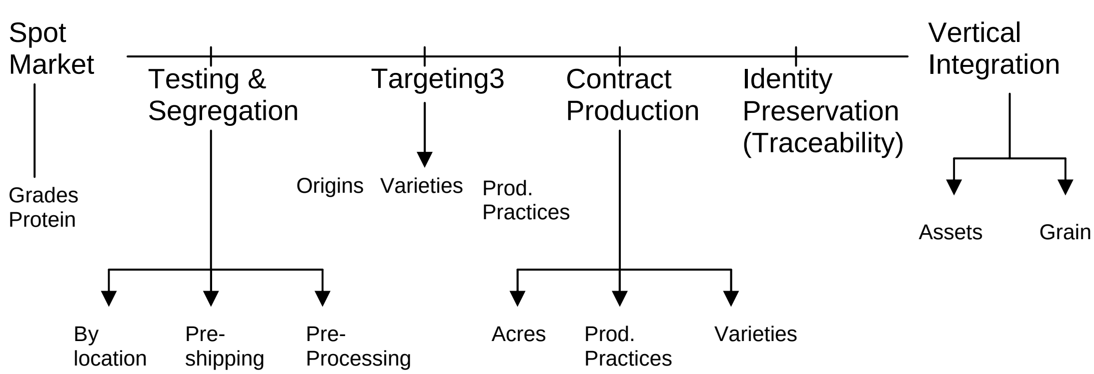


Figure 2.1. Spectrum of Procurement Strategies.

Several explanations help our understanding of these mechanisms; first, the definition of identity preservation will be given as well as its origin and implications on the marketing system. Segregation will be defined next because both operations are strongly related to each other. Next, a definition of traceability will be established and a brief summary of its history will be described. This concept of traceability is relatively new and will drive future practices in the market. Finally, the last practice is testing and it is based on the notion of tolerances. Each of the previous mechanisms is related to this idea of tolerances.

The additional costs implied by these different operations will be discussed and will give the possibility to choose the optimal marketing mechanism to facilitate coexistence of GM and non GM crops. Then, a section will summarize studies that have used surveys to analyze marketing practices at the grain-handler level. As a conclusion to this second chapter, a brief summary of all this background information will be given.

## Identity preservation (IP)

Identity preservation (IP) is one of the alternative systems of procurement, management, and trade adopted by different countries since the introduction of biotech crops. IP is an old concept but is increasing in popularity in recent years due to the increase in specialty and biotech crops. This control system has evolved over time in the grain and oilseed industry. IP is used to facilitate commercialization of GM crops and to facilitate their way through the marketing channel. It allows the source, and/or nature of materials to be identified. IP, also called Identity Preserved Production and Marketing (IPPM), is currently used to identify crop varieties that provide additional features concerning their content or composition (such as GM crops).

Dye (2000) defined IP as a “traceable chain of custody that begins with the farmer’s choice of seed and continues through the shipping and handling system”. This illustrates the fact that IP concerns the entire marketing channel.

Wilcke (1999) describes it as separate storage, handling, and documentation of separation. In addition, Wilcke emphasizes that detailed records of planting date, field location and size, seed identity, inputs used, harvest date, crop yield, the storage bin number, crop delivery date, vehicles used, and the name of the person delivering the crop need to be recorded. Samples of the crop should also be kept until the buyer is fully satisfied with the quality of the delivered commodity.

Sonka et al. (2000) define IP as a coordinated transportation and identification system to transfer product and information that makes the product more valuable. Buckwell et al. (1998) and Lin et al. (2000) refer to it as a “closed loop” channel that facilitates production and delivery of an assured quality by allowing traceability of a commodity from germplasm or breeding stock to the processed product on retail shelves.

Several firms have initiated IP programs where sales/segregation are by specific variety/location (e.g., CWB-Wartburtons, Pro-Mar Select Wheat of Idaho, AWWPA, etc.) An increase in the IP practices is taking place because consumers are becoming more specific about what they want (and, in fact, what they do not want), Anderson (1999).

IP systems provide process verification and retain segregations but they are not capable of assuring end-users about tolerances for adventitious materials. This is a major problem and Mr. Krejci, Executive vice-president of the Grain Elevator Processing Society (Milling and Baking News) insisted on the fact that “… for GMO’s, grain-handlers are being asked to assure that end-users are not getting something… and IP as it has evolved does not function well to exclude something." This is why IP systems are being improved and other operations are also added to the system such as segregation or testing, for instance.

Identity preservation is a strong tool and it is more than just segregating crops during transportation and at the elevator. The idea of separation between GM and non-GM crops is the same as for separating food grade white corn from yellow corn or separating two qualities of soybeans. This kind of system implies no mixing of seeds or pollen (especially for cross-pollinating crops) during planting and harvesting with cleaned equipment, Boland (2003).

All these restrictions imply additional costs of IP; and this is why IP systems have greater costs than generic commodity systems. These expenditures are attributed to the strict specifications that must occur for example, extra labor and capital are needed to clean equipment and build new structures for the proper preservation of products. The costs of IP increase when tolerance levels get tighter because the needs are more specific and there is more risk of being out of the bounder limits. So, Identity preservation and certification programs increase logistical costs but also reduce the risk of not meeting quality conformance to strict specifications.

Reichert and Vachal (2000) focused their study on identity preservation shipments and compared costs of bulk versus container movements. Alternative types of transport were compared for a shipping of soybeans from Iowa to Japan. They weighed the costs associated to container shipping against transporting with truck single railcar, and/or unit trains. Truck transportation is the most expensive ($4.05/bushel) and unit trains the least expensive ($1.65/bushel). The cost associated to the unit train was found to be 33 cents per bushel (c/bu) less than with the container shipment. McVey (1996) pointed out the idea of quality in the grain supply chain and he found that elevator handling costs for generic goods ranged from 10.9 c/bu to 12.2 c/bu. According to his study, incremental handling costs were estimated at 1.42 c/bu to 3.13 c/bu.

Wilson and Dahl (2002) examined the costs associated with marketing wheat on an identity preserved basis. The results of a survey they realized expressed that the segregation of wheat is completed on the basis of grade, protein, and location. According to the survey respondents, the cost of IP ranges from 25 c/bu to 50 c/bu. Estimates of identity preservation costs were included in this study. They also pointed out major factors to consider for implementing an identity preservation program such as management and time limitations. Furthermore, testing, time requirements, lot turnover, dispute settlements, and facility modifications must be included as additional costs to any identity preservation system.

Similarly, Brester et al. (1996) also looked at the costs associated with identity preservation in wheat. Basically, this research is set as a principal agent problem where there is an information trouble because buyers are unable to know immediately if the delivered product conforms to the required specifications. To make sure that these requirements are met, testing and sampling must be conducted. If the given product does not match the requests, it is sold on a scrap market at a lower price. Identity preservation presents a lot of complexity to administration; therefore management costs have a great importance.

Overall, the most important costs included with respect to identity preservation are testing and storage requirements. Another important area of reflection is the quality costs, including rejected lots that meet the requirements but are rejected and also include the opportunity cost of selling a high quality grain for the price of an average or poor quality one; that is, grain that possesses quality traits above the specifications.

## Segregation

Segregation can be defined as a product differentiation alternative just like IP or traceability. Nevertheless, there is a fundamental difference between segregation and identity preservation as components of strategies to market GM crops. Segregation is distinct from IP in the sense that it is the isolation of like products with particular attributes but there is no preservation of the grain's identity.

To be efficient, segregation must occur through the entire production and marketing chain. The first stage of segregation is represented by the farmers and the elevators. The farm level is convenient for segregation practices due to relatively small storage facilities. On the other hand, many country elevators are not as well suited for segregation purposes because they have developed into bulk facilities designed for volume throughput and not for smaller lots of specialized products. In addition, incentives for volume shipping, such as unit and shuttle trains, have highly influenced the structure of the grain handling industry, not helping the segregating mechanisms.

In a system in which only small numbers of segregations are required, elevators consolidate shipments by blending various qualities together. Amalgamation increases elevators margins, because quality is not given away and various qualities of grain are mixed to achieve a given minimum quality standard. Blending also allows for small lots of varying quality to be consolidated into larger lots, which may lead to lower transportation costs. Maltsbarger and Kalaitzandonakes (2000) found that these value added activities are relinquished in an identity preserved supply chain.

Segregation presents important limits, especially at the elevator level. One of these is the problem of adventitious commingling that is difficult to avoid. Another limit is the trouble related to the elevator's efficiency when processing many segregations.

There are many possible spots where commingling of products may occur. Commingling is referred to as the inadvertent mixing of products that increases the chance of the product losing its unique identity and becoming an undesirable product. It is difficult for many existing elevators to segregate commodities with a minimum of mixing. Most elevators will be challenged by storage and handling constraints as the number of quality categories required for them to handle increases because most elevator storage configurations are not well adapted to handling small lot sizes. If lower volumes of more quality categories or products with unique identities are added, it might be difficult to ensure the full utilization of the large storage bins.

Bullock, et al. (2000) state that a rise in segregations may exploit problems at elevators and export facilities that are inefficiently located and have too few and too large storage bins, too few separate grain paths per facility and inefficient types of equipment which are more difficult to clean than would be economically feasible. Furthermore, shuttle train technology could be made less feasible with increased categories of grains since elevators may not be able to accumulate sufficient quantities to meet the volumes required by this low-cost transportation method. Baumel (1999) adds that handling more types of grains reduces elevator capacity, causes problems for efficiently receiving grain at harvest time, and reduces effective storage capacity.

The different steps related to segregation imply additional costs at the country elevator level. Over the past decade, many studies have focused on this aspect of the additional expenses created by segregation.

Hurburgh (1994) analyzed the segregation of soybeans at an Iowa elevator and estimated the costs of segregating high oil soybeans from regular ones. When the soybean was delivered by the farmer, a test determined its right classification as either, high oil or regular. The test adds two components of cost. The first one being the actual cost associated with testing the product and the second would be a queuing cost. Hurburgh (1994) determined the cost of segregating high oil/protein soybeans from regular soybeans as equal to 3.7 c/bu.

Lentz and Akridge (1997) provided a sort of extension of the country elevator study by Hurburgh (1994) that examined the costs and benefits of alternative supply chains for soybean segregations. Lentz and Arkridge included in their analysis, transportation and marketing expenses.

Another element that previous studies have pointed out is the increased costs associated to an increasing number of segregations or greater number of grain types. Krueger et al. (2000) studied the costs associated with receiving an increasing number of grains. A stochastic simulation model was used to quantify segregation costs. When the number of grain types handled increases, elevator operations become more complicated which implies problems related to the efficiency of these elevators. Most elevators are built in order to handle large quantities of grain. Therefore, their storage configurations does not suit well handling of a high number of low volume grain categories. Krueger et al. described quality testing for genetic material as a bottleneck system that involved a queuing cost. Results of this study showed that there is an inverse trade off between the number of grades handled and the elevator's efficiency. Furthermore, costs increased as more segregation are received at a country elevator.

Wheeler (1998) also realized a study related to costs associated with grain segregations. For this purpose, he identified variables relevant to the higher costs associated with increased grain segregations. Transportation, handling, and marketing were all impacted by the number of segregations. In addition, costs of segregating grains were also affected by storage capacity, turnover ratios, and logistics. As an example, he showed that the number of wheat segregations received at west coast Canadian ports increased from 81 to 112 in four years (from 1992 to 1996). He also reported that only 43 segregations were in fact shipped from west coast Canadian elevators in 1996. The results show that each additional segregation resulted in diminishing marginal returns and increasing marginal costs.

Askin (1998) put some numbers on this idea of increasing costs and found that adding two grades to system receipts increased average operating costs by 5 cents per ton (c/ton) and average total costs by 13 c/ton. McPhee et al. (1995) examined the costs associated with an increasing number of grain segregations. They formulated models to determine the relationship between the number of grains and grades handled to operating costs in the Canadian terminal elevator handling system. A 10% increase in the number of grades handled increased average operating costs by 2.57%.

The cost of segregation for the grain pipeline was estimated by the Economic Research Service (ERS). The results (USDA-ERS, 2005) ranged from 22 c/bu to 54 c/bu. Segregation costs come from various sources; they include additional costs of storage, handling, risk management, analysis/testing, and marketing. This estimate was based on data collected by a University of Illinois survey on specialty grain handling. A pipeline consisting of three sections (country elevator, sub-terminal, and export elevator) was examined by the ERS. The results show that an increase in the number of segregations implies increasing costs at all three points. The cost estimates for segregating non-GM are 22 c/bu for corn and 54 c/bu for soybeans.

Herrman et al. (1999) based their research on segregation at a country elevator. They collected data and a stochastic simulation model was developed to analyze the effects of segregation. Different elevator configurations were evaluated. They differed by the number of dump pits, drives, and bucket elevators. The crop was divided in three different ways to estimate the costs of increased segregations; with zero (generic commodity), two, or three segregations. The combination of segregations, the elevator configuration, and the elevator operating efficiency (burden) are various reasons that cause variation in the results of this study. These results show that the cost of segregating two grades ranges from 1.88 c/bu to 5.58 c/bu and this range is greater for three grades where it varies from 1.93 c/bu to 6.4 c/bu.

Maltsbarger and Kalaitzandonakes (2000) looked at the costs associated with identity preservation of grains at a country elevator. In order to preserve the identity of these grains, they set up different segregation strategies. The major focus was on the loss in revenue due to hidden or opportunity costs such as the inability to grind and blend grains. They also paid attention to how various elevator asset configurations affect costs. One conclusion is that more stringent or tight tolerance levels increase identity preservation costs. A simulation model found that the costs of segregating high oil corn ranged from 16.4 c/bu to 36.6 c/bu.

One major limit of segregation is that it has a negative impact on the system's efficiency. McKeague et al. (1987) made a study to illustrate how operational efficiency is affected by a number of factors, including unloading and grading, weighing, cleaning, storage, and shipping. The results showed that the number of storage bins is critical to efficient operations. They also found that demurrage charges increase when small parcels of grain are introduced into the terminal elevator. These additional charges are due to the extra time required to build up adequate stocks for shipping volumes. Table 2.1 summarizes the estimated costs associated to segregation practices collected in the different studies reviewed as well as the methodology used for the research.

Table 2.1. Segregation/Identity Preservation Costs

| Researcher | Estimated cost of segregation or identity preservation | Methodology / scope of analysis |
|---|---|---|
| Reichert and Vachal (2000) | 33c/bu | Economic Decision Model |
| Wilson and Dahl (2002) | 25 to 50 c/bu | Survey |
| Hurburgh (1994) | 3.7 c/bu | Economic Engineering Model |
| Lentz and Akridge (1997) | 6.8 c/bu | Simulation Budget Model |
| Krueger et al. (2000) | $3.04 per truck | Simulation |
| Askin (1988) | 13 c/mt | Econometric |
| USDA-ERS (2005) | 22 to 54 c/bu | Survey and Estimations |
| Herrman et al. (1999) | 1.88 to 6.47 c/bu | Simulation |
| Maltsbarger and Kalaitzandonakes (2000) | 16.4 to 36.6 c/bu | Simulation |

Furthermore, a major conclusion of the study by Schlecht et al. (2004) was that increased specificity in strategies had the most impact on the change in shipper costs. They noticed that as economic costs increase, it increases the incentive for shippers to segregate in order to reduce these economic costs.

In the grain market, there is no possible postponement, so grain is differentiated as soon as possible. At its first stage, the demarcation is based on quality characteristics such as protein, grade factor and _ this is our case study _.on genetic content. For an optimum separation and in order to assure end-users that tolerances are met, testing protocols should be part of the segregation channel.

## Traceability

The first definition of traceability was given in 1987 by an international norm (NF EN ISO 8402). Traceability was identified as "the ability to retrace history, use or location of an entity by the means of recorded identification". Within a firm, all the agents of the production and marketing chain must cooperate to make this traceability concept as efficient as possible. More than just for a purpose of firm efficiency, traceability has recently been democratized to secure consumer (end-users) and the agents about the development and the process of the product.

A study by the French consumer magazine *Que choisir*, showed that, on average and in most EU countries, 70% of the consumers were still opposed to GMO (International Institute for Beet research, 2003). This justifies the need of a new version of traceability applied to biotechnologies. In this case, traceability means the ability to trace GMOs and GMO based products at all stages in the market through the production and distribution chains (European Parliament, 2003).

In September 2003, traceability was formally adopted for GMO Food and Feed products to govern both intra-EU trade and imports (Ferriere, 2003). The idea of the traceability system is to be able to transmit and retain 5 years of information on GMOs or GM products (both food and feed). This concept has been used in the EU for several years for informational processes and to govern inter-firm transactions.

The fact that a 2004 European directive opened the European market to grains from countries growing GM materials does not mean that the European Union has changed its ideas regarding GM products. This raises more concerns, and it is a new challenge for the food industry. Hence, using traceability, the grain industry must try to bring back confidence to consumers.

For its major implications in world trade, "traceability" was identified by the USDA Advisory Committee on Biotechnology & $21^{st}$ Century Agriculture (USDA-AC21, 2005) as an immediate issue with long-term implications (risks, costs, etc). "The liability issues associated with traceability" are said to be crucial according to the AC21. Traceability systems differ a lot across sectors of the food industry, and, therefore, costs and benefits of traceability are difficult to target.

Three main points govern every traceability system: *the breadth,* meaning the amount of information collected and transmitted; *the depth,* meaning the degree of tracing forward and backward the information. Breadth and depth are highly correlated; and *the precision* of the information and/or precision of the traceability system, corresponding to the last important component of the traceability method. For GM production, these three elements correspond to the level of efficiency of the required traceability system.

The main problem in biotech production is the high chance of potential commingling along the entire channel. An article published by Rosenwald, in "The Washington Post" (March $23^{rd}$, 2005), suggested that agribusiness company Syngenta has been subject to problems of unintended commingling. Over the past four years, this company has been selling an unapproved strain of GM corn seed to farmers.

Figure 2.2 shows the movement of cereals for export in the United States. Each step on this supply chain corresponds to an extra chance of adventitious commingling. Even though complete traceability is not possible, most of these problems can be substantially offset by setting a high depth and breadth.

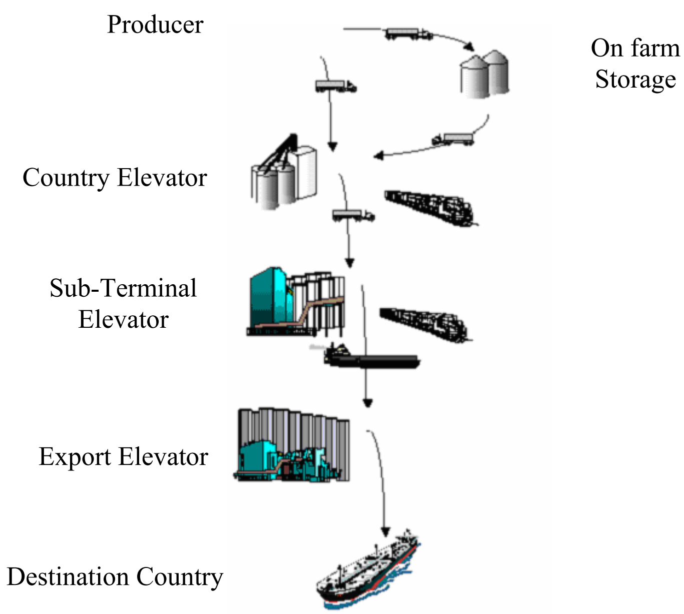


Figure 2.2. Movement of Cereals and Oilseeds for Export in the United States.
Source: U.S. Grains Council, 2001.

Along the supply chain, firms develop traceability systems to complete three objectives: supply management, food safety and quality control. As mentioned before, traceability is a way to increase firm efficiency in production and the resources management.

Food safety management is the second goal of this type of system. Tracing systems helps identify the origin of any safety problem. Furthermore, losses in terms of costs of production and reputation of the firm can be prevented by the removal of unsafe production. Traceability reduces risk and enforces safety and quality control. Traceability systems are a source of market differentiation, especially concerning grains where it is required to enter the European market, for example.

The important point is that traceability must be applied all the way from the farm to the consumer, so that documentation is as complete as possible. At the farm level, documents should verify the existence of specific traits and purity levels, and farmers must make sure that there is no cross-pollination by segregating crops. All the storage, harvesting and other equipment is defined for a proper use and handling (i.e., cleaning, flushing…). To verify that adequate precautions have been taken at the farm level to assure the quality of the grain, farmers may be asked to provide elevators with a third-party certification (certified by the U.S. Department of Agriculture for example). Then, from the elevator to the producer or end-user, each individual must keep records of product identity, volume, lot numbers, test results and supplier/consumer should ensure quality and allow for trace back if necessary.

Costs of traceability vary substantially across different sectors. The USDA did an investigation that deals with costs of traceability. Across the grain industry, costs of recordkeeping and product differentiation are included. Recordkeeping for conventional grains should include "one step forward, one step backward" while segregation and traceability may begin as early as the seed (Golan et al., 2004). As the supply chain gets more complex or the number of segregations increase, the costs increase. On the other hand, if demand for differentiated products is sufficient, the costs are less. Vertical integration and contracting also are methods for reducing the costs of tracing and supply management.

These costs require that consumers are willing to pay a premium in addition to the price of the commodity. The production chain provides a safe product but this implies higher costs. A few examples of studies on non-GM corn and soybean productions show the importance of setting the right premium to incentive farmers and agents on the segregated production and distribution.

See Figure 2.3 for an illustration of the interrelation among IP, segregation, and traceability by Smyth and Phillips (2002). These interrelations are essential because all these methods work together to make sure the consumer gets the product he asked for.

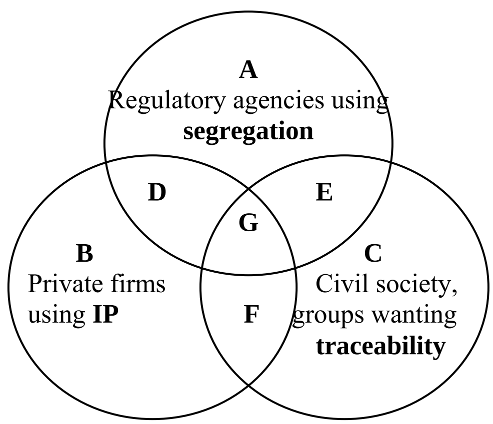


Figure 2.3. Interrelation Among IP, Segregation, and Traceability.
Source: Smyth and Phillips, 2002.

Circle A (Figure 2.3) corresponds to firms that are concerned with potential health hazards due to adventitious commingling. B regroups mainly private firms whose initiatives are to capture a share of the value associated with a trait. C represents the products present in the marketplace with traceability systems for food safety concerns (i.e., meat and dairy sectors). Part D is the compromise between A and B, it could correspond for example to HACCP (Hazard Analysis Critical Control Point). E refers to product labeled for health safety reasons associated with more regulatory (mandatory) nutrition labeling related to health improvement reasons. Labeling is done simply to respond to consumers need in some countries. A study by Boland (2003) says Japan, Taiwan, South Korea, the EU, and Australia have announced plans to begin labeling of foods containing ingredients that contained GM food or feed grains. In the F section, are small niche market products that have IP and are labeled as in traceability (e.g., GM-free and organic products). The introduction of GM wheat would fit in the G part with aspects of traceability, segregation and identity preservation.

These different methods provide efficient ways of ensuring a good quality product that meets the requirements. Nevertheless, tests must be realized to make sure the tolerance limits are not violated.

## Testing and tolerances

*Tolerances*

"Tolerances" is identified as one of the most important areas in the co-existence of GM, non-GM, and organic grains (Fehr, 2001). In his presentation, Fehr points out issues related to inconsistency in the value of tolerances, interpretation, and frequency of nil-tolerance. These tolerances are frequently established ignoring risks, costs, and buyer implications associated with violations.

In the production and marketing system, tolerances should be used as a tool to improve quality and/or mitigate risks. They help by limiting the prospect of either producing or receiving an item that does not meet the desired requirements. There is a tradeoff between tolerance levels and costs. As tolerance levels become tighter, they impose more costs on the system to the benefit of buyers that has less risk of getting an undesirable item. Oppositely, as tolerance levels become less restrictive, suppliers are subject to lower costs. In this case, buyers may experience higher numbers of rejections. Tolerances are also highly subject to other factors such as, where they are applied, sampling plans, costs, measurement error, etc.

Tolerances are currently used by some firms and specified by some regulatory agencies, and are currently specified for many non-GM characteristics (e.g., vomitoxin). The same type of mechanism could be used for GM products. In some cases, these tolerances are governed by regulatory agencies, in others they are specified by commercial firms and sometimes both regulatory and commercial tolerances apply. As new GM crops start to be commercialized, similar set of different tolerances will be specified. Some will be by individual firms, some by countries' regulatory agencies, and others by both of them. Calculate the optimal tolerance level for GM content and evaluate the effects of exogenous factors is an important issue. Then, effects of these tolerances on suppliers (grain merchants) and buyers (importers, domestic users) can be analyzed.

In the past years, different countries, mainly the ones that are GM adverse (several nations of the European Union or Japan) have set different policies regarding GM content in order to reassure their consumers. The European commission established a tolerance level equal to 0.9% for any adventitious presence of approved GMOs; 0.5% for not-yet-approved GMOs (pre-approved) which have been assessed by the European Union Scientific Committees as not posing any danger to the environment and health; and 0% for "unknown" and, therefore, not approved GMOs. Obviously, these tolerance levels seem too restrictive in terms of technical handling and economic costs for the pro-GM. On the other hand, the opponents find them too lax because it means opening the market to unlabeled products that may contain a low proportion of GM material. Japan requires a 5% tolerance for products coming from the United States and containing GM elements, if the trait is approved (Bean, 2002).

These tolerances correspond to the global national requirements for these countries, but individual marketing and processing firms will set their own tolerances. The relation buyers/sellers will be governed by these specific decisions taken by each company.

*Testing*

In order to verify that the tolerance levels are not violated, companies have decided to realize various types of testing. Many aspects of testing are important but most crucial is that testing should only apply to non-GM shipments. It would be unnecessary to conduct tests on shipments/lots that are already known to be GM. Thus, testing would only occur for those shipments that are “thought to be” non-GM (Wilson and Dahl, 2002). This is referred to as “The Precautionary Principle”; tests are realized to give more certainty to the end-user even though it is not proven that there is any risk.

According to this study by Wilson and Dahl (2002), there are two basic tests that could be used for analyzing the presence of GM material (here, RRW wheat). These are commonly referred to as strip-tests and PCR tests. Even though PCR tests give greater certainty in their results, the use is less justified because of high PCR costs and, in the case of wheat, sufficiently accurate results of strip-tests (95% confidence level versus 99% for the PCR tests). PCR testing is about $120 versus only $7.50 for a strip-test. These costs were estimated to range from 0.2 to 3.6 c/bu (Wilson et al., 2003a). Both these tests are for “single-trait” events. The PCR is a DNA technology based test and is more commonly used in international contracting. Strip-tests are, or would be, more widely used domestically.

In order to sell their product, grain-handlers will have to be able to prove that their product meets the requirements. For this purpose, their items will need to be certificated. So, to get a certification, companies will have to do testing even though tests increase the costs of handling GM and non-GM grains. The more tests and the more different locations are applied the higher the cost. Testing reduces the risk of delivery of undesirable quality lots but, as mentioned before, there is still the risk of adventitious commingling that may occur at different stages in the marketing system. Testing is costly and risky, because subject to error. There is a fundamental tradeoff between these two issues, i.e., tighter tolerances result in increased costs and decreased risks.

Wilson and Dahl (2002) developed a simulation model of the grain marketing system in order to analyze the potential costs and risks associated with a marketing system. The model determined optimal testing strategies _ where and how intensive to test _ for a dual (GM/non-GM) marketing system for wheat compared to an existing non-GM system. The model incorporates utility derived from a portfolio representing GM and non-GM flows, and estimates a grain-handlers’ risk premium and additional system costs for testing and rejection. According to this study, the optimal strategy would be to test every fifth rail car at the country elevator when loading and to test every sub lot when loading at the export elevator. The problem with these strategies is that they are not 100% efficient and therefore there is always some kind of risk: either buyer’s risk or seller’s risk. With this strategy, there is a 0.02% seller’s risk of accepting quality that does not meet tolerances and 10% seller’s risk of non-GM shipments to be rejected. Most diversions are due to adventitious commingling. In addition, it is clear that with no variety declaration, seller's risk and costs increase. No-testing could seem to be the optimal strategy because it does not imply costs of testing but the results show that with this plan, the rejection rates increase a lot (10%), leading to higher costs (13.4 c/bu).

### Previous studies using surveys

With the development of non-GM corn and soybeans, in response to export demand, there is a need for further information about contracting practices, pricing strategies, handlers cost and returns, and premiums associated with such specialty crops. The previous studies using surveys related to this topic have focused on the two crops, non-GM corn and soybean.

In order to gather this information, Good and Bender (2000, 2001) conducted several surveys of specialty crop handlers in Illinois from 1999 to 2001. First, a telephone survey was done, in 1999, to determine the extent to which these firms are participating in the handling and marketing of specialty corn and soybean. Then, two mail surveys were sent out in July and December 2000. The first one asked questions about: the organization of the firm; which specialty crops from the 2000 harvest would be handled and/or merchandised; contractual arrangements with producers and buyers of specialty; premiums to be paid and received; delivery arrangements for specialty crops; and end-users of specialty crops for which contracts had been made. The December survey focused more on additional cost, by category of handling and/or merchandising each specialty crop compared to conventional corn and soybeans crops; compensation received for handling specialty crops; percent of each specialty crop produced under contract; percent of each crop used in domestic market and export market; and type of investment that had been made to handle specialty crops.

Results of these studies showed that receiving specialty crops at a separate facility facilitates receiving, segregation, and transporting the specialty crop, therefore avoiding or limiting contamination. One conclusion was also that the majority of specialty crops are produced under contract (exception for non-GMO corn and soybeans). Producer premiums are generally based on local cash bids for the relevant market (domestic or export). Finally, on average, specialty crops handlers continue to report that they incur significant additional costs for handling those crops and that the gross margin or returns received do not cover those additional costs (Good and Bender, 2001).

Miranowski et al. (2004) did a survey of Iowa grain-handlers in order to compare costs of alternative product segregation systems operating within different market structures. Grain-handlers are identified by their form of business organization. They provide information relative to the added costs of product segregation for corn and soybeans, including testing, handling, and storage. Results of this study allow detailed analysis of transaction costs for alternative business organizations and market structures. Relative to commodities that are co-mingled in the grain handling process, segregated inputs and products will have additional transaction costs associated with preserving their identity and marketed qualities. Miranowski et al. found that the average added cost per bushel of specialty crop handled ranged from 31 c/bu to 34 c/bu depending on the organization type; private and corporate firms having an operating cost advantage. The investment cost ranged from $0.63 /bu to $1.01 /bu (in this case, cooperatives have a lower investment cost than private and corporate firms).

In 2002, Qasmi et al. (2003) conducted a mail survey among more than 200 grain elevator managers in South Dakota. The main goal was to analyze the degree to which elevators were prepared to segregate non-transgenic from commodity grain. For this purpose, Qasmi et al. asked questions relative to the current level of participation in segregating non-transgenic grains and IP systems among grain elevators in South Dakota. They also gathered information to inventory the physical infrastructure and storage facilities at country elevators in South Dakota. Results of this study showed that elevator managers feel that a type of market segmentation, with GM on one side and non-GM on the other, will play some role in the grain market in the near future. However, they are reluctant to play the role of early adopters. The study by Qasmi et al. showed that there is an overall attitude of uncertainty regarding the role of segregated non-transgenic and IP grains in the near future; and for the time being, there are very few elevators that handle non-GM grains. The main concerns for handling specialty grains are: concerns regarding efficient storage space utilization, lack of market demand/premium, and risk of contamination. Finally, the premium expectations by the elevator managers (about 30 cents per bushel) seem to be large enough to offset the increased handling costs, to provide some additional return to the elevators, and to enable the elevators to pass a portion of the premium to producers to compensate them for altering their production and handling practices.

## Summary

Development of GM crops in the past years has strongly impacted both the production and marketing systems. There are several marketing mechanisms used to help commercialization of these specialty crops. As described in this chapter, identity preservation, segregation, traceability, testing and tolerances are different methods that have been developed to make sure that the product delivered meets the specified requirements of the end-user. These different methods should be used together in order to limit the risk of adventitious commingling and therefore ensure an identity preserved crop at the end of the channel.

As shown by Good and Bender, Miranowski et al., and Qasmi et al., these mechanisms have a cost. They affect negatively the operation costs at the grain-handler level. Unfortunately, segregation and testing of crops do not only imply direct costs of segregating and testing. Grain-handlers also have to support waiting costs, accounting costs, costs of disputes, costs of modification of the facility if additional storage is required, among others.

The survey conducted in the late spring of 2005 will provide information relative to the different segregation practices at the grain-handler level. Estimates of the costs associated with these practices will be provided.

# CHAPTER 3
# RESEARCH METHODOLOGY

## Introduction

With the advent of agbiotechnology and the introduction of new specialty crops in the market, elevators have to use new marketing mechanisms to identity preserve the crops they handle. In order to gather sufficient information about the costs associated with these practices at the elevator level (segregation, identity preservation, testing, etc), a survey was distributed to grain elevator managers in the Upper Midwest. Data from each grain elevator were collected and treated separately. The mail survey involved several steps: 1) creating a list of grain elevators in the four states concerned, 2) developing the questionnaire, 3) pre-testing and administrating the mail survey, and 4) analyzing the response to the questionnaire. These four sections will be described throughout this chapter.

## Creating a list of grain elevators in the Upper Midwest region

A list of all the grain elevators from the four states (North Dakota, South Dakota, Minnesota, and Montana) had to be created in order to sendout the survey. For this purpose, information was given by the North Dakota Grain Dealers Association for North Dakota. For the state of South Dakota, a list was built by merging information from a previous list and information used by Qasmi et al. (2003) in their study. A list of all the grain dealer facilities was used for the state of Minnesota. This list was provided by the Minnesota Department of Agriculture (2005). For the state of Montana, the current list of state licensed commodity dealers and warehouses was used. This list is given in a report by the Montana Department of Agriculture (2005). The final list used was composed of 412 elevators in North Dakota, 89 in South Dakota, 222 in Minnesota, and 66 in Montana. The survey was sent to a total of 789 grain elevators in these 4 states.

## Developing the questionnaire

The mail questionnaire sought information about the characteristics of the facility and the current segregation practices used by the local grain-handler. Further information was gathered regarding the additional requirements and costs implied by handling identity preserved, GM and/or variety specified grain. A copy of the survey instrument used to collect data is included in the appendix of this report (Appendix A). The questionnaire was designed so that elevator managers could complete it accurately and without any difficulties. The respondent has the possibility to skip a section if the questions do not correspond to his facility.

The grain-handler managers are first asked to indicate the name and location of the facility. Then, the actual questions related to the survey begin. Four different sections compose this questionnaire.

*Section 1*

Question 1.1 is a table where the managers were asked to write down information concerning their facility and their handling capacity. They have to indicate the number of bins and pits, and the loading, load-out, track, storage, and receiving capacities. The respondent also has to note the total volume of crop handled per year, for each crop handled. Question 1.2 refers to the number of other elevator facilities that the firm operates. Question 1.3 and 1.4 relate to quality certification (ISO and HACCP). Is the facility approved with these certifications and if not, does the manager anticipate getting his facility approved?

*Section 2*

This second section is the core of the questionnaire. It focuses on the segregation, identity preservation and testing of current crops handled by the elevator. If there is no segregation applied at the facility, the respondent has the possibility to skip some questions that do not concern his firm. In the case where segregation is realized, information was sought concerning the time and costs associated to this practice.

First, question 2.1 asks for the percentage of the total volume handled that is segregated. Question 2.2 is a table that shows crops that could be segregated and/tested at the grain-handler level (e.g., wheat, durum, barley, corn, soybeans, or canola). The respondent is requested to check boxes to indicate which segregation or testing criteria applies for each crop (protein, moisture, test weight, dockage, vomitoxin, falling number, germination, variety, and GM content).

The third question of this section is another table. The manager is inquired to circle one magnitude level to indicate for each factor listed, how big of a constraint it is to effective segregation. The factors are the following: time, testing equipment cost, data transmission, samples storage, accounting and record keeping, risk of testing error inbound and outbound, cost of modification of handling system, number of bins, loading capabilities and load out capabilities.

Question 2.4 seeks for the estimated cost of segregation. Question 2.5 asks what would be the ideal segregation scenario at their facility. The manager chooses between no segregation, segregating some grains or segregating all grains. Question 2.6 is a table that looks for information regarding the testing practices (e.g., percentage, time, and cost). For each factor (protein, moisture, test weight, dockage, vomitoxin, and falling number), the respondent should give an answer to five different questions. First, they denote the percentage of farmer deliveries where test is conducted; then they indicate the time required to conduct the test or prepare the sample for outside testing, the time required for the test to be conducted by the outside agency, the cost of test, and finally mention the manager's time spent on disputes.

This second section of the questionnaire is continued by 7 questions from 2.7 to 2.13. The respondent must note the number of bushels represented per test, the average labor cost for testing or preparing the sample, the percentage of samples disputed by sellers, the value of manager's time spent on disputes. He must also indicate how long they store the grain samples used for test; the time spent putting samples in storage, and the cost estimate of modification of the facility due to extra storage required. After this list of questions, another one regarding tests is asked. For each of the tests listed, the respondent must signify where the test is applied (At receipt, in store, at load-out, or if they do not test for a specific factor).

Questions 2.15 to 2.17 refer to identity preservation of crops at the elevator level. The first question requests if any of the grains handled at the facility are identity preserved. Question 2.16 asks the manager if any institutions, such as USDA or the state seed department, are used as a proof for traceability or identity preservation confirmation. In the case where an institution is utilized, the respondent should indicate the name of this organization. The last question of this section is question 2.17. For each of the following crops (wheat, durum, corn, soybeans, barley, canola, or other), the respondent must indicate for which trait the crop is identity preserved and the volume that is identity preserved, as a percentage of the total bushels of this crop handled in the year.

*Section 3*

The third section of this questionnaire deals with genetically modified crops currently handled at the facility. Question 3.1 asks if the facility has handled GM crops. If the answer is yes to this first question, respondents answer question 3.2 by writing for each GM crop handled, the volume handled during the 2003/2004 season. They also have to indicate what percentage of each crop is GM. The third question of this section refers to the premiums attributed for handling non-GM crops. For corn, soybeans, and canola, the respondent notes the percentage of total bushels for the commodity that is non-GM and the average premium given for non-GM.

The third and fourth parts dealt with GM crops, regarding respectively the crops that are currently handled and the prospective GM crops. Once again, the respondents could bypass the questions that did not apply to their facility. In these last sections, the managers were asked to give quantities and varieties of crops handled. The premium received for handling non-GM crop was also asked for. Finally, time and costs associated with testing for GM or variety were requested in these last sections.

*Section 4*

The fourth and last section of the survey regards prospective GM crops. Question 4.1 asks whether testing for GM content is realized in house or sent out to be tested, and the percentage corresponding to each one. In question 4.2, managers that handle or were to handle GM content are asked to give an estimate of the additional time needed for handling samples, for disputes, for testing GM content, and for accounting and records. Question 4.3 is a table used to estimate the influence of several factors on the facility’s policy to handle a GM crop. The factors referred to are the following: external factors (such as foreign market demand), internal factors (such as domestic regulatory policy), the facility capacity, the capability to segregate, and the costs of segregation. The respondent must choose the level of influence of each given factor. These factors can either have no influence at all, a small, an average, or a high influence.

The fourth question of this section assumes that a new testing technology is available to do a GM crop test at the elevator, for 4$/test. The managers are questioned to know whether their facility has the adequate capacity to allow for 100% segregation of GM crop in the case of the introduction of this type of tests.

Questions 4.5 to 4.8 deal with variety declaration. The first question requests whether farmers that deliver at the facility are asked to declare or indicate the variety they are delivering. Question 4.6 occurs in the case that a variety declaration is asked for. In this case, managers must estimate the additional time needed for handling samples, for disputes, for accounting and records and for testing variety identification. In question 4.7, respondents must indicate for what percentage of the following commodities (soybean, wheat, corn, barley, canola, or others), a variety declaration is required before delivery at the facility. In the final question, the managers are asked to tell how difficult it would be for their facility to implement a variety declaration system for a commodity they do not currently require declaration for. It can either be impossible, somewhat difficult, or not difficult at all.

As a conclusion to this questionnaire, the respondent writes down his/her name and signs the document. He is also asked to give a phone number if any additional information was required. If the grain-handler manager wishes to receive a copy of the research results, he has to indicate an email address where we can send him these results.

### Pre-testing and administrating the mail survey

The mail survey was first pre-tested by professors from North Dakota State University (Dr. Les Backer and Dr. Duane Berglund) and professionals (Steve Strege from the North Dakota Grain Dealers Association and Jim Swanson from the North Dakota State Seed Department). As a result, several refinements were made to the original questionnaire. On average, 15 minutes were enough for the respondent to fill in the questionnaire.

The final version of the questionnaire, accompanied by a cover letter, was sent to the elevator managers on June 2, 2005. Previously, the Institutional Review Board of NDSU gave its authorization to send out this survey. Completed surveys were returned to the department of Agribusiness and Applied Economics at NDSU. A second copy of the survey was not sent to the non-responding elevator managers, although this might have increased the rate of response. Telephone calls were made to follow up in case of incomplete surveys and to try and improve the rate of response.

### Distribution of responding elevators

A total of 43 elevator managers responded to the survey. Therefore, the rate of response was about 5% of the elevators surveyed. The rates of response were relatively stable across the four states. They varied from 3% in Montana to 8% in South Dakota (Table 3.1). Only 40 surveys were usable among the 43 collected.

Table 3.1. Distribution of Responding Elevators

| Region | Total number of elevators | Responding elevators | |
|---|---|---|---|
| | | (Number) | (%) |
| North-Dakota | 412 | 24 | 6 |
| South-Dakota | 89 | 7 | 8 |
| Minnesota | 222 | 10 | 5 |
| Montana | 66 | 2 | 3 |
| Total | 789 | 43 | 5 |

## Summary

This chapter discussed the different elements that are associated with the construction of the survey. More precisely, this third chapter talks about the building of the mailing list, i.e., the creation of a complete list of grain elevators in the Upper Midwest. Then, the developing of the questionnaire was detailed. Every question of each of the four sections that compose the questionnaire was explained. The third part of this chapter pointed out the methodology used to pre-test and administrate the mail survey. The pre-testing is an important part because the questionnaire has to be clear and simple. The managers that respond want to spend as less time as possible. Finally, this third chapter provided a table that summarized the distribution of responding elevators.

As expressed above, the purpose of all these questions was to document on current segregation practices at the elevator level. The information collected should be sufficient to run the empirical model based on Hurburgh et al. (1994). The description of this empirical model is the object of the following chapter.

# CHAPTER 4
# EMPIRICAL MODEL

## Introduction

Additional testing and segregation of differentiated quality grains for individual end-uses impose an additional cost for grain-handlers. One major concern of elevator managers is about the cost of underutilizing the space at their facility. New segregations may lead to loss in the utilization of their storage capacity. These problems can be somewhat lessened by careful management of shipping logistics from country elevators.

High variability exists in grain delivered to country elevators. These country elevators have techniques to successfully differentiate the grain handled. Of course, depending on their configuration, it may be easier for some elevators to differentiate than for others. According to Hurburgh et al. (1994), there is no approach for estimating differentiation costs, or for measuring the potential of elevators to manage differentiated marketing.

The cost of segregating different quality grains will be highly impacted by the configuration and organization of elevators. Any additional subdivision of grain, beyond those currently applied, ultimately complicate receiving operations. Several parameters help determine what additional costs will be incurred, e.g., the number of pits and bins, or the location of the testing laboratory, amongst others. An engineering-economic analysis was used to estimate the costs of testing and segregating differentiated quality grains at country elevators.

## Model specifications

The overall purpose of the empirical model presented in this chapter is to analyze the changes in costs due to new segregation and testing practices. In other words, the output given by this model is an estimate of the total cost of grain segregation at the elevator level. The information gathered through the mail survey is used to run the model based on Hurburgh et al. (1994). A list of all the inputs necessary to run this model was recapitulated in an Excel spreadsheet. These inputs are defined in the next subsection. The answers to the survey questions provided sufficient information for the model.

Hurburgh et al. (1994) clearly explain in their study how they built this model. They developed it for cost analysis of testing and segregating grain by end-user related factors. They used different operating parameters that have a major impact on segregation costs. With the software package @RISK® (Palisade Corporation, 2000), stochastic simulation was included in the model.

### Input definitions

The input costs that are included in this model are of various origins but basically, they can be divided into two major cost categories that are: grading and testing, and handling and other operations. The mathematical derivation of these different costs is given in the next two subsections. The input variable list, necessary to understand the following formulas, is given in Table B.1.

*Grading and testing*

The grading corresponds to the sum of seven different costs: additional operator time, data transmission and interfacing, waiting time for test, storage of samples, accounting and record-keeping, check-testing and standardization of equipment, dispute with seller. In Hurburgh's original model nine costs were included in the grading and testing category. Cost of test equipment and cost of modifications of computer software are not considered in this study.

1) The cost of "operator additional time" is a cost calculated by the changes in testing time multiplied by the wage and converted to a per bushel basis. This cost is the expression that any new tests create extra work in the testing area.

$$C_1 = \frac{(Tt - Tt')\, P_L\, (1 - Ti / 100)}{60\, B} \tag{1}$$

2) The cost of "data transmission and interfacing" includes the annualized data equipment cost plus repair cost on an after income tax basis. This cost is explained by the fact that new tests will require automated data handling.

$$C_2 = \left[ Pd \left( \frac{a}{P} \right)_n^t + \left( \frac{Prd}{100} + \frac{I}{1000} \right) Pd \left( 1 - \frac{Ti}{100} \right) - \frac{D\, Pd\, Ti}{10000} \right] \frac{1}{Vt} \tag{2}$$

3) The cost of "waiting time for test" is a function of the time to make the new test and the travel time between the dispatch and the test site _ this time is equal to zero for elevators where test is done at the scale. Sellers may have to wait additional time for tests to be completed before proceeding to the dump area.

$$C_3 = \frac{T_{wt}\, P_{LC}}{60\, B} \tag{3}$$

4) The cost of "storage of samples" are the expression of the annualized cost of the storage equipment plus hourly labor cost on a per bushel after income tax basis. The addition of new tests will cause the elevator to retain samples to have a backup in the case of disputes.

$$C_4 = \left[ P_{ss} \left( \frac{a}{P} \right)_n^t - \frac{D\, P_{ss}\, Ti}{10000} \right] \frac{1}{Vt} + \frac{Ts\, P_L \left( 1 - \frac{Ti}{100} \right)}{60\, B} \tag{4}$$

5) The cost of "accounting and record-keeping" estimates the additional accounting and record-keeping expenses on a per bushel per record basis, after tax.

$$C_5 = \frac{Ta\, P_L \left( 1 - \frac{Ti}{100} \right)}{60\, B} \tag{5}$$

6) The cost of "check-testing and standardization of equipment" is the sum of actual expenses for the samples submitted for check-testing and the in-house record-keeping. This costs per bushel decreases with larger load size. The additional work required by the new tests will imply monitoring to maintain accuracy, and will ultimately consume additional time and expense.

$$C_6 = \frac{F7\, P_G \left( 1 - \frac{Ti}{100} \right)}{100\, B} + \frac{TaG\, P_L\, F7 \left( 1 - \frac{Ti}{100} \right)}{6000\, B} \tag{6}$$

7) The cost of "dispute with seller" corresponds to the time the elevator manager spends discussing questioned results, times the average value of manager's time spent on these disputes. This cost is not negligible because this potential for disputes with sellers is one of the major reasons elevators do not decide to realize new tests.

$$C_7 = \frac{F9 \left[ P_{LM} \left( \frac{Tm}{60} \right) + P_G \right]}{100\, B} \tag{7}$$

*Handling and other operations*

The handling is composed of additional waiting time at the dump, additional labor at the dump area, modification of handling system, underutilized storage, risk of misgrading, addition of new storage space, and loss in receiving capacity.

1) The cost of "additional waiting time at the dump" is not considered as a direct cost to the elevator. It reflects the additional expense for the customer that waits at the dump line.

$$C_8 = \left(\frac{B}{V_B} + \frac{F_{11}}{60}\right)\left(\frac{P_{LC}}{B}\right) \qquad (8)$$

2) The cost of "additional labor at the dump area" corresponds to the extra expenses due to the additional labor needed to accomplish the supplementary functions at the dump pit.

$$C_9 = \left(\frac{B}{V_B} + \frac{F_{11}}{60}\right)\left(\frac{P_L}{B}\right) \qquad (9)$$

3) The cost of "modification of handling system" represents the additional expenses related to the modification of pits, legs, etc. to make them more flexible and to switch more rapidly. These costs will not concern all elevators. They are amortized just like the other capital costs.

$$C_{10} = \left[ Pm \left(\frac{a}{P}\right)_n^t + \left(1 - \frac{Ti}{100}\right)\left(\frac{Prm}{100} + \frac{I}{1000}\right) Pm - \frac{D\, Pm\, Ti}{10000} \right] \frac{1}{Vt} \text{[1]} \qquad (10)$$

[1] This formula differs slightly compared to the original one reported in Hurburgh et al. (1994).

4) The cost of "underutilized storage" is a function of the storage capacity and the number of segregations. This component may be zero in the case of excess storage capacity.

$$C_{11} = \frac{F_{14}\ Vs\ Pgs}{100\ Vt} \tag{11}$$

5) The cost of "risk of misgrading" is estimated as the opportunity cost of lost premiums, i.e., a fraction of misgrades times the average pricing error caused by misgrades. This cost exists because misgrades and incorrect data entry will cause errors in the segregation process.

$$C_{12} = \frac{Pge \Delta P_G}{100} \tag{12}$$

6) The cost of "addition of new storage space" is due to the fact that some elevators may need to build or purchase additional individual storage, as well as the related handling equipment; even when the elevator is in overall excess. This cost is amortized after tax. This is one of the greatest threats for elevators.

$$C_{13} = Ps\left(\frac{a}{P}\right)_n^t + \left(\frac{Prs}{100} + \frac{I}{1000} + \frac{Tp}{1000}\right)Ps\left(1 - \frac{Ti}{100}\right) - \frac{D\ P_S\ Ti}{10000} \tag{13}$$

7) The cost of "loss in receiving capacity" is the opportunity cost related to the fact that receiving and testing slow-downs drive away business. This slow-down will imply direct cash costs.

$$C_{14} = \frac{Evt\ M\ Vh\left[Twt + \left(\frac{60\ B}{V_B} + F11\right)\right]}{100\ Vt} \tag{14}$$

## Summary of inputs

As explained above, the model created by Hurburgh et al. (1994) is an engineering-economic model that sums up various costs associated to segregation practices. The empirical model built for this study does not consider the cost of test equipment because it is assumed that strip-tests will be done so there is no purchase of additional equipment. The cost of computer software modifications used by Hurburgh et al. is not considered in this model either. This empirical model is used for cost analysis of testing and segregating grain at the elevator level. Table 4.1 is a summary of the fourteen different equations described previously.

Table 4.1. Costs Included in Grain Segregation Model

| Variable | Item |
|---|---|
| Grading and testing | |
| C1 | Operator additional time |
| C2 | Data transmission and interfacing |
| C3 | Waiting time for test |
| C4 | Storage of samples |
| C5 | Accounting and record-keeping |
| C6 | Check-testing of equipment, |
| C7 | Disputes with seller. |
| Handling and other operations | |
| C8 | Additional waiting time at the dump |
| C9 | Additional labor at the dump area |
| C10 | Modification of handling system |
| C11 | Underutilized storage |
| C12 | Risk of misgrading |
| C13 | Addition of new storage space |
| C14 | Loss in receiving capacity |

In order to obtain a total cost of segregation in dollars per bushel, the data collected through the mail survey was used to run the model but a certain number of assumptions had to be made and some information had to be taken directly from Hurburgh's original model. This section summarizes the values of inputs used to run the model.

The gross elevator margin on generic grain is fixed to eight cents per bushel like in the model used by Hurburgh et al. The amortization factor is assumed to be 0.1518, based on a ten year useful life. All the rates applied in the model are the same as the ones used by Hurburgh et al. In fact, these rates correspond to average rates across the four states represented in the study (10% for the interest rate, 10% for the income premium rate, 30% for the income tax, 10% for the annual depreciation rate, and 20% for the property tax rate). The purchase price of data handling equipment is set to 10,000 dollars. The elasticity of total volume handled relative to dump time is 0.3%. This value is also replicated from the model by Hurburgh. The average number of segregations realized at the elevator level is set to four.

Some values of times, associated with segregation and testing practices, are also assumed. Customer waiting time for test is equal to one minute per test; subjective customer waiting time addition based is set to one minute, and accounting time for checktest results is five minutes. These numbers are given in Hurburgh's study and they correspond to the values found in the literature. The value of customer time is fixed to twenty dollars per hour. Furthermore, the reparation costs of data handling equipment, elevator modification, and storage facilities are said to be equal to 5% of the original price. Information regarding the storage was taken from the model by Hurburgh et al. The annual opportunity cost of storage volume is 25 cents per bushel and 2% loss of efficiency in storage use is a generalized assumption, even though it is not the actual situation at all the elevators.

Finally, the NDGIS, North Dakota Grain Inspection Service, provided us with some estimation of cost and percentage regarding testing practices. The cost of submitted sample grade is estimated at nine dollars per test. According to this administration, 1% of samples are sent for checktest and 3% are misgraded. These numbers are slightly smaller than the ones used by Hurburgh et al.in 1994.

### Stochastic simulations using @RISK®

The simulation modeling software package @RISK® is used in this study to analyze variability using the data collected in the survey as a basis. The data collected from the 40 respondents is used as a base. By using the command "Fit distribution to data", the software chooses a distribution that best represents the original data collected. This command was used to fit distributions that estimate times, volumes, and costs associated with testing.

Time for testing before new tests (i.e. protein, moisture, test weight, dockage, vomitoxin, falling number, and germination) and time for testing including new tests (other tests plus GM content and variety) are simulated using @RISK® distributions. Time for testing before new tests is given using a normal distribution, with its classic bell shape, with a mean of three and a standard deviation of two; plus it is truncated so that no negative values are obtained. The time for testing including new tests is calculated as the sum of the testing time before new tests and the average of the time for variety test and GM test. Time for variety test is given by a triangular distribution with a minimum of zero, most likely value of 4.5, and a maximum of 15. The probabilities of occurrence of the minimum and maximum values are zero. Time for GM test is given by an exponential distribution with a parameter equal to 13.5.

The total volume of grain handled is estimated using a lognormal distribution. The mean is 14,458 bushels and the standard deviation is 1,696 bushels. These arguments correspond to the mean and standard deviation of the normal distribution for which an exponential of the values in the distribution is taken to generate the desired lognormal. The percentage of grain tested is represented by a triangular distribution with a minimum of zero, a most likely value of zero, and a maximum of one hundred. The number of bushels represented per test is given by a logistic distribution with location parameter, gamma, equal to 134.73, and shape parameters, alpha and beta, equal to 725.25 and 1.3167.

The cost of modification per bushel is calculated using a logistic distribution with parameters equal to 0.20148 and 0.51658. Then, this cost is multiplied by the number of bushels tested to get a total cost of modification. Finally, sensitivity simulation is used for the labor cost. Five simulations are run using five different labor costs (5, 10, 15, 20, and 25 dollars). The results of these simulations provide information on the impact of labor cost on the total cost of segregation. A summary of these distributions is provided in Table 4.2.

Table 4.2. Distribution Associated with Each Variable

| Variable | Distribution type | Parameter |
|---|---|---|
| Time for “classic” testing | Normal | (3; 2) |
| Time for variety test | Triangular | (0; 4.5; 15) |
| Time for GM test | Exponential | (13.5) |
| Total volume handled | Lognormal | (14,458; 1,696) |
| Percentage of grain tested | Triangular | (0; 0; 100) |
| Number of bushels per test | Logistic | (1234.73; 725.25; 1.317) |
| Cost of modification | Logistic | (0.20148; 0.51658) |

Hurburgh et al. analyzed variability in storage capacity by dividing the elevators into four groups according to their cost of segregation. It was found that elevators with a small storage capacity (less than five hundred thousand bushels) had a cost of segregation of four cents per bushel or above. Elevators with a storage capacity above five hundred thousand bushel but below one million bushels had a cost of segregation between 3 and 3.9 cents per bushel. Elevators having a cost of segregation between 2 and 2.9 cents per bushel corresponded to a high range of storage capacities (from one to million bushels) and the elevators that were able to segregate at a cost inferior to 1.9 cents per bushel had a storage capacity between one and seven million bushels. As a summary, it is clear that elevators with large storage capacities are more likely to be able to segregate at a lower cost than elevators with storage capacities less than one million.

Three outputs are chosen in order to run simulations with @RISK®. These outputs correspond to the spreadsheet cells for which data will be collected. The first output is the total cost of segregation. The cost of modification and the total cost of segregation less the modification cost are the other two outputs. Each cell containing an @RISK® formula is considered as an input variable for the software. Several simulation settings were adjusted. @RISK® was asked to simulate five thousand times the spreadsheet. In other words, for each simulation, five thousand iterations were run. This seemed to be high enough to obtain correct results. The Monte Carlo option was also chosen so that the spreadsheet would always recalculate the value of the outputs instead of just keeping the expected value.

# CHAPTER 5
# RESULTS AND SENSITIVITIES

## Introduction

This chapter presents the results of both the theoretical and the empirical model. The first section describes the results of the mail survey of grain elevators in the Upper Midwest regarding their segregation practices. All respondents were elevator managers from North Dakota, South Dakota, Minnesota, or Montana. This survey instrument enables us to respond to one of the objectives of this study, which is to document and analyze the marketing mechanisms currently used in the system.

In the second section, results and sensitivities of the model based on Hurburgh et al. (1994) are detailed. These results provide us with answers relative to the total costs of grain segregation at the country elevator level. The other goals of this project are to estimate a model and to analyze the changes in costs due to these new practices (handling, grading, etc). The Hurburgh model is a useful way to determine the additional costs implied by this specific type of handling system.

## Results of the survey

The results presented in this subsection are grouped per topic. First, all the results relative to the actual characteristics of the facility are described (physical characteristics, share of each crop handled, certifications, and policies regarding grain quality). The second part focuses more precisely on segregation mechanisms. Constraints to effective segregation and further elements related to these practices are explained. A third part gives information with regards to testing (time, cost, and test location). Results regarding specific GM crops and variety declaration are described in this subsection.

*Characteristics of the facility*

Among the 40 grain elevators in the region that responded to the survey, physical characteristics vary a lot. The results corresponding to these physical characteristics are illustrated in Table 5.1.

Table 5.1. Physical Characteristics[2]

| | # Bins | # Pits | # Satellites | Loading (bu/hour) | Receiving (bu/hour) | Load out (cars/day) | Track (cars) | Storage (bu) |
|---|---|---|---|---|---|---|---|---|
| Mean | 35 | 3 | 2 | 18,850 | 18,777 | 59 | 53 | 949,075 |
| St dev | 23 | 1.77 | 2.82 | 17,308 | 16,332 | 63 | 43 | 1,233,180 |
| Min | 4 | 1 | 0 | 700 | 1,500 | 2 | 2 | 55000 |
| Max | 100 | 9 | 15 | 60,000 | 80,000 | 280 | 165 | 7,020,000 |

[2] The "#" sign in the following tables stands for "Number of," and the abbreviation "bu" stands for "bushels."

Information on the number of bins was collected from 39 elevators. This number ranges from 4 to 100, with a mean of 35. Table 5.2 shows that, out of the 39 respondents, 23% have up to 20 bins, 23% have between 20 and 29 bins, 18% have between 30 and 39 bins, and 36% have 40 bins or more. In this same table, it is shown that the number of pits at the facility gets greater as the number of bins increases. For elevators with fewer bins (less than 20), the number of pits does not exceed three. For the next category, the number of pits does not exceed six. For facilities with a number of bins between 30 and 39, the number of pits goes up to seven. For elevators with the largest number of bins (40 or more), this number does not exceed nine.

Table 5.2. Number of Bins and Pits

| # Bins | < 20 | 20-29 | 30-39 | 40 + | Total |
|---|---|---|---|---|---|
| # Elevators | 9 | 9 | 7 | 14 | 39 |
| Share | 23% | 23% | 18% | 36% | 100% |
| # Pits | Up to 3 | Up to 6 | Up to 7 | Up to 9 | |

As shown in Table 5.1, facilities possess, on average, two satellite elevators but some elevators have none, while others have up to fifteen satellites. The next results concern the capacities of the facility. Thirty-eight responses were obtained for the loading capacity (Table 5.3) and thirty-nine for the receiving capacity (Table 5.4). Loading and receiving capacities can be interpreted together. The average receiving capacity is just below 19 thousand bushels per hour; and it ranges from 1.5 to 80 thousand. The average loading capacity is the same (below 19 thousand bushels per hour), and the values range from 700 to 60 thousand bushels per hour.

Table 5.3. Loading Capacity (in thousands of bushels per hour)

| Loading capacity | ≤ 5 | 5-15 | 15-25 | > 25 | Total |
|---|---|---|---|---|---|
| # Elevators | 12 | 8 | 7 | 11 | 38 |
| Share | 32% | 21% | 18% | 29% | 100% |

Table 5.4. Receiving Capacity (in thousands of bushels per hour)

| Receiving capacity | ≤ 5 | 5-15 | 15-25 | > 25 | Total |
|---|---|---|---|---|---|
| # Elevators | 8 | 13 | 7 | 11 | 39 |
| Share | 21% | 33% | 18% | 28% | 100% |

Elevators were separated into four groups: elevators with loading and receiving capacities up to 5 thousand bushels, between 5 and 15 thousand, between 15 and 25 thousand, and more than 25 thousand bushels. About one third and one fifth of the elevators, for loading and receiving capacities respectively, can be classified in the category of small capacities. One fifth and one third have loading and receiving capacities between 5 to 15 thousand bushels range. Seven elevators representing 18% of the respondents have a loading capacity of 15 to 25 thousand bushels, and these same elevators have an equivalent receiving capacity. Similarly, the eleven elevators (about 29% of respondents) that have the greatest loading capacity (25 thousand bushels or more) also have the greatest receiving capacity.

The load-out and track capacities are compared the same way as loading and receiving capacities were associated. The mean for the load-out capacity is 59 cars per day but it varies a lot from one elevator to another (from 2 to 280). For the track capacity, the average number of cars is 53 and it ranges from 2 to 165. Thirty-two responses were obtained for the load-out capacity (Table 5.5) and thirty-three for the track capacity (Table 5.6); both of these are expressed as a number of cars.

Table 5.5. Load-Out Capacity (in number of cars per day)

| Load-out capacity | 1-49 | 50-99 | 100-100+ | Total |
|---|---|---|---|---|
| # Elevators | 16 | 7 | 9 | 32 |
| Share | 50% | 22% | 28% | 100% |

Table 5.6. Track Capacity (in number of cars)

| Track capacity | 1-49 | 50-99 | 100-100+ | Total |
|---|---|---|---|---|
| # Elevators | 17 | 7 | 9 | 33 |
| Share | 52% | 21% | 27% | 100% |

Elevators were separated into three groups: elevators with load-out and track capacities up to 49 cars, from 50 to 99 cars, or 100 or more cars. Respectively for load-out and track capacities, 50% and 52% of the elevators are characterized by a number of cars smaller than 50. The same seven elevators, that have 50 to 99 cars per day as load-out capacity, have a track capacity of 50 to 99 cars. Similarly, the nine elevators (28%), with 100 or more cars per day as a load-out capacity, are the same as the nine (27%) with a track capacity of 100 or more cars.

Moreover, by looking carefully through the data collected, it is clear that all the elevators (but one), with the greatest load-out and track capacities, correspond to the elevators with loading and receiving capacities superior to 25 thousand bushels.

Information regarding the storage capacity was also collected. There is a huge range of capacities. The mean capacity is 950 thousand bushels but it ranges from 55 thousand bushels for the smallest, to more than 7 million bushels. In Table 5.7, the 40 elevators were classified into four separate categories, according to their size.

Table 5.7. Storage Capacity (in thousands of bushels)

| Storage capacity | ≤ 100 | 100-500 | 500-1,000 | >1,000 | Total |
|---|---|---|---|---|---|
| # Elevators | 3 | 14 | 13 | 10 | 40 |
| Share | 8% | 35% | 32% | 25% | 100% |

As Table 5.7 shows, there is not one particular storage size that represents well all the elevators responding to this survey. Only 8% of the respondents have a storage capacity up to 100 thousand bushels. About one third of the elevators have a storage capacity between 100 and 500 thousand bushels and another third of the facilities is in the range 500 thousand to one million bushels. There are ten elevators (25%) with a storage capacity above one million bushels.

The last physical characteristic is the total volume of grain handled in the past year. These volumes handled range from 76 thousand to 26 million bushels, with a mean of 5 million bushels. Once again, four categories were defined (Table 5.8): up to 500 thousand bushels, from 500 thousand to one million bushels, from one to five million bushels, and five million bushels or more.

Table 5.8. Total Volume Handled (in thousands of bushels)

| Total volume handled | ≤ 500 | 500-1,000 | 1,000-5,000 | > 5,000 | Total |
|---|---|---|---|---|---|
| # elevators | 7 | 6 | 16 | 11 | 40 |
| Share | 18% | 15% | 40% | 27% | 100% |

Out of the 40 respondents, seven (18%) handled up to 500 thousand bushels in the past year. Six elevators, representing 15% of the total respondents, have a total volume handled between 500 thousand and one million bushels. More than two thirds of the elevators handled a volume greater than one million bushels, 40% handled a volume between one and five million bushels and 27% a volume greater than five million.

Wheat, soybeans, and corn are the three main crops handled in the four regions studied; but elevators also deal with other crops in this area. The share of each crop handled is represented in Figure 5.1.

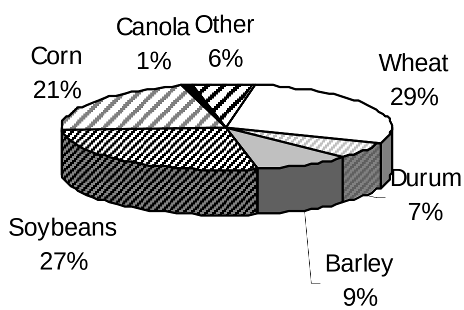


Figure 5.1. Share of Each Crop in the Total Volume of Grain Handled.

This figure shows that wheat, soybeans, and corn represent more than three quarters of the volume handled, with 29%, 27%, and 21%, respectively, of the total volume handled.

The rest of the volume is shared by barley (9%); durum (7%); canola (1%); and others (6%), among which oats have the largest part.

The survey instrument also asked questions relative to certifications and policies regarding grain quality. Table 5.9 provides us with a summary of results regarding these two areas.

Table 5.9. Certifications and Policies Regarding Grain Quality

| Certifications | % of yes |
|---|---|
| ISO | 19% |
| Facilities that anticipate getting ISO | 7% |
| HACCP | 22% |
| Facilities that anticipate getting HACCP | 10% |
| Policies regarding grain quality | |
| Handle IP grains | 18% |
| Use mechanisms as proof | 57% |
| Handle GM grains | 89% |
| Sufficient capacity to segregate 100% of GM crop | 23% |
| Do you ask for variety declaration | 19% |

Thirty-nine managers answered the questions regarding ISO and HACCP. Analyzing these responses, results show that 19% of the facilities are approved with ISO 9001 and that 22% are approved with HACCP. Within the 81% of elevators that are not yet approved with ISO 9001, 7% said they would anticipate getting their facility approved. Within the 88% of elevators that are not yet approved with HACCP, 10% said they would anticipate getting their facility approved. These results are of importance because both of these certifications provide guidelines for producers to meet end-user or customer specifications. Identity preservation is an important base of the HACCP system. Moreover, 86% of the facilities that are certified ISO are also approved HACCP, and the 14% left anticipate getting their facility approved with HACCP.

The second section of the table informs us on the facility's policies regarding grain quality. Only 18% of the elevators handle identity preserved grains and amongst these facilities, 57% use mechanisms as a proof for traceability and IP confirmation. Concerning GM products, 86% of the elevators handle GM grains and only 22% of the facilities would have the sufficient capacity to segregate 100% of GM crop. Only 18% of the facilities ask for variety declaration. In other words, farmers have to indicate the variety of the product they are delivering.

*Segregation practices at the elevator level*

Some elevators have a higher tendency to segregate than others. Amongst the ones that do not segregate at all, several elements may hold them from segregating. Table 5.10 classifies eleven elements susceptible to be constraints to effective segregation. Each element can be a minor constraint, major constraint or not a constraint at all to segregation.

Table 5.10. Constraint to Effective Segregation

| No constraint | Minor constraint | Major constraint |
|---|---|---|
| Data transmission | Time | Cost of modification |
| Samples storage | Testing equipment cost | # bins |
| Accounting and record keeping | Risk testing error IN | |
| | Risk testing error OUT | |
| | Loading capabilities | |
| | Load-out capabilities | |

As shown in the table, data transmission, storage of samples, and accounting and record keeping are not considered as constraints to the implementation of segregation at the elevator level. This was given by 52 to 57% of the elevators that responded to the survey. Time, testing equipment cost, risk of testing error (inbound and outbound), and loading and load-out capabilities are described as minor constraints to effective segregation, by more than 50% of the respondents. Our goal was to find what the major constraints were, and two answers were obtained: the number of bins and the cost of modification of the handling system. According to 52% of the respondents, the limit to effective segregation is a physical limit. Their facilities would need to be modified in order to realize segregation and these changes would ultimately have a cost that is seen as a major constraint.

Elevator managers were also asked what their ideal or best segregation scenario would be. In other words, without thinking of the constraints mentioned previously, would they decide not to segregate any of their grain, part of the grain, or all grains handled. As a result, one third would decide to segregate all grains, 54% would segregate only some of their grains, and 13% would not segregate at all. Through these results, it is clearly shown that overall, grain-handler managers would tend to segregate at least part or all their grain if they could.

One of the major constraints to effective segregation is related to the cost of this practice. Table 5.11 gives information on these costs related to segregation practices.

Table 5.11. Percentage and Costs Related to Segregation Practices

| | % grain segregated | Cost of segregation ($/bu) | Cost of modification ($) |
|---|---|---|---|
| Mean | 36% | 0.07 | 0.08 (Olympic average) |
| St dev | 35% | 0.08 | 0.18 |
| Min | 0% | 0.01 | 0 |
| Max | 100% | 0.3 | 5.95 |

On average, 36% of the total volume handled is segregated. The high standard deviation suggests that this percentage varies substantially from one elevator to the other. In fact amongst the 38 elevator managers that responded, this value ranged from 0 to 100%. There is no significant difference between small and large elevators; i.e., the size of the facility does not affect the percentage of grain segregated. The managers were also asked to give an estimated cost of segregation. This cost ranged from 1 to 30 c/bu, with a mean of 7 c/bu and a standard deviation of 8 c/bu. This estimated cost of segregation is greater for small elevators than for large elevators. The average estimated cost of segregation, for elevators that handle less than a million bushels of grain, is 12 cents per bushel. It ranges from 2 to 30 cents per bushel. For large elevators, that handle a volume of grain greater than one million bushels, the estimated cost of segregation is on average 6 cents per bushel and ranges from 1 to 20 cents per bushel. In summary, according to elevator managers, the cost of segregation would be smaller for large facilities than for small ones.

The results of cost of segregation obtained through the empirical model are described in the second section of this chapter. These results, obtained by using Hurburgh's model (1994), are the actual cost of segregation. These values can be compared to the estimated cost of segregation given directly by the elevator managers.

Table 5.11 provides information regarding the cost of modification of the facility. This cost, viewed as a major constraint to effective segregation, is expressed as a number of dollars per bushel. It ranges from \$0 to \$5.95 per bushel. The olympic average is equal to \$0.08 per bushel with a standard deviation of 0.18. This cost is of significant importance in terms of handling where margins are not very high. Analyzing the results more precisely, it is shown that the cost of modification is greater for small elevators (less than one million bushels handled) than for large elevators. The average cost of modification for smaller elevators is \$1.67 and it ranges from \$0 to \$5.95 whereas for larger elevators the average cost of modification is \$0.03, with a maximum of \$0.16 per bushel. The results from the survey also show that two thirds (67% precisely) of respondents have modification cost or it is negligible (cost of modification less than one cent per bushel). The cost of segregation

Labor cost and the value of manager's time are given in Table 5.12. These two values are important because they are used in calculating the different costs associated with segregation practices. Labor cost has an influence on the costs referred to as "pit labor cost," "accounting cost," "testing cost," and "cost of sample storage." The value of manager's time impact the cost referred to as "cost of disputes."

Table 5.12. Labor Cost and Value of Manager's Time

| | Value managers time ($/hr) | Labor cost ($/hr) |
|---|---|---|
| Mean | 37 | 11 |
| St dev | 30 | 7 |
| Min | 0 | 1 |
| Max | 100 | 28 |

The average value of manager's time is $37 per hour and it ranges from $0 to $100. Labor cost is $11 per hour with a standard deviation of 7. This cost ranges from $1 to $28 per hour.

*Testing practices at the elevator level*

Information regarding testing practices is detailed in this subsection. First, percentages and cost of testing are explained. These results are summarized in Table 5.13. Several tests can be applied to the commodity handled: protein (P), moisture (M), test weight (TW), dockage (D), vomitoxin (V), and falling number (F#). The percentage of farmer deliveries tested for protein, moisture, test weight, and dockage is almost always the same. On average, elevator managers tested 93% of the deliveries but this number ranges from 10 to 100%. Tests for vomitoxin and falling number are not as frequently applied, only 34% of the time on average. Some elevators do not test any of their grain for these factors and other facilities test 100% of the farmer deliveries for both vomitoxin and falling number.

Table 5.13. Percentages and Cost Related to Testing Practices

| | % deliveries tested for P.M.TW.D | % deliveries tested for V.F# | Bushels represented per test | Average cost of test | % samples disputed |
|---|---|---|---|---|---|
| Mean | 93 | 34 | 1,540 | 2.69 | 5 |
| St dev | 17 | 33 | 1,474 | 6.45 | 6 |
| Min | 10 | 0 | 150 | 0 | 0 |
| Max | 100 | 100 | 5,000 | 25 | 25 |

The average number of bushels represented per test is 1,540 but the standard deviation is large (1,474 bushels). This volume represented ranges from 150 to 5000 bushels depending on the elevator. The total number of bushels handled by the elevator has no influence on the volume represented per test.

The average cost of “classic” testing (i.e. testing for protein, moisture, test weight, dockage, vomitoxin , and falling number) is $2.69 with a standard deviation of $6.45. This cost ranges from $0 to $25. The last information provided by this table is the percentage of samples disputed. The results for this survey showed that on average, 5% of samples are disputed with a standard deviation of 6%. This percentage is close to what can be found in the literature.

Table 5.14 provides other details associated with testing practices, such as: time for outside testing, time for “classic” testing, time for testing including GM and variety, manager’s time spent on disputes, accounting time, time putting grain in storage, and days the sample are kept in storage.

Table 5.14. Times Related to Testing Practices (in minutes or days if specified)

| | Outside testing | “Classic” testing | Testing including GM/Variety | Manager time spent on disputes | Accounting time | Putting grain in storage | Days sample stored (days) |
|---|---|---|---|---|---|---|---|
| Mean | 33 | 3 | 8 | 15 | 10 | 17 | 70 |
| St dev | 20 | 2 | 9 | 21 | 13 | 31 | 140 |
| Min | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 72 | 20 | 60 | 120 | 30 | 150 | 720 |

On average, outside testing takes 33 hours. The standard deviation is equal to 20 hours. In other words, getting results for samples sent out for testing usually takes between one and two days. “Classic” testing only takes, on average, 3 minutes, but there is one elevator for which these testing practices take 20 minutes. When testing for GM and variety are added, the time required for doing the testing jumps up to 8 minutes. Managers spend, on average, 15 minutes on disputes. The standard deviation is large (21 minutes). This shows that this time spent on disputes may be greater, up to 120 minutes according to the survey results. Additional accounting implied by testing practices takes 10 minutes with a standard deviation of 13 minutes. The accounting time never exceeds half an hour. The time spent putting samples in storage ranges from 0 to 150 minutes with a mean of 17 minutes. Finally, samples used for testing are kept in storage for a given number of days (70 days on average). Depending on the facility’s policies this time in storage can go up to 2 years. Keeping samples in storage is costly but provides the elevator with a backup in case of disputes.

The different tests applied on the grain handled can be realized at various locations in the actual facility (at receipt, in-store, at load-out, or all locations). Figure 5.2 shows where this one is applied for each category of tests.

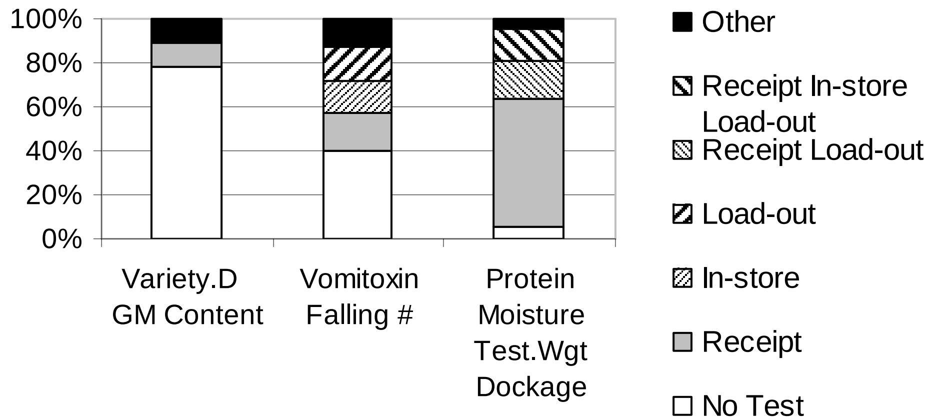


Figure 5.2. Test Location.

Almost 80% of the time, variety declaration and GM content are not tested. When tested, they are tested at receipt. Vomitoxin and falling number are tested 60% of the time: 15% of the time, the test is realized at receipt; 15% of the time in-store, 15% of the time, at load-out and the rest of the time at another location. The other tests (protein, moisture, test weight, and dockage) are realized 95% of the time: 60% is achieved at receipt, 15% at receipt and at load-out, 15% at receipt, in-store, and at load-out, and the rest is realized at another location.

The last table showed where the different tests were realized at the elevator but Table 5.15 demonstrates that GM content is more often sent out to be tested, 57% against 43% for in-house testing. Nevertheless, particular attention must be given when interpreting these results because some elevators have up to 90% of their grain tested in-house when others have all tests for GM content sent out. So, on average GM content is more likely to be tested out but the decision to do it in-house or not really depends on the elevator’s policies regarding GM.

Table 5.15. GM Test Realized In-House or Sent Out to be Tested

| | In-house | Tested out |
|---|---|---|
| Mean | 43% | 57% |
| St dev | 48% | 48% |
| Min | 0% | 10% |
| Max | 90% | 100% |

*Handling of GM crops and variety declaration*

This last subsection focuses more precisely on GM crops and variety declaration at the elevator level. First, information regarding genetically modified grain will be described. Table 5.16 gives the number of bushels of various GM varieties handled by the different elevators. Five GM varieties were said to be handled: Roundup Ready® corn, Bt® corn, Liberty® corn, Roundup Ready® soybeans, and Roundup Ready® canola.

Table 5.16. Bushels of GM Grain Handled (in thousands of bushels)

| | RR®corn | Bt®Corn | Liberty®Corn | RR®soybeans | RR®canola |
|---|---|---|---|---|---|
| Mean | 883 | 1,400 | 519 | 975 | 839 |
| St dev | 1,800 | 3,300 | 1,000 | 1,200 | 1,400 |
| Min | 8 th | 10 th | 5 th | 4 th | 3 th |
| Max | 8M | 12M | 3.2M | 5M | 2.5M |

Within the elevators that handled GM products, GM corn is the commodity that is most widely handled. For facilities that handle Bt® corn, the volume handled is on average, 1.4 million bushels. This volume ranges from 10 thousand to 12 million bushels. Bt® corn is the most largely handled variety. The average volume of Roundup Ready® handled is about 900 thousand bushels. This volume is just above 500 thousand bushels for Liberty® corn, almost one million bushels for Roundup Ready® soybeans, and above 800 thousand bushels for Roundup Ready® canola.

The previous table showed that a large volume of GM crops was handled by elevators. Table 5.17 shows the share of non-GM corn in the total volume of corn handled by these elevators. The same way, the share of non-GM soybean and non-GM canola is given. First of all, 33% of the corn handled is non-GM, the remaining two thirds being genetically modified. Only 16% of the soybeans and 10% of the canola handled are non-GM.

Table 5.17. Percentage of Non-GM

| | Corn (%) | Soybeans (%) | Canola (%) |
|---|---|---|---|
| Mean | 33 | 16 | 10 |
| St dev | 23 | 17 | 14 |
| Min | 0 | 0 | 0 |
| Max | 80 | 75 | 20 |

Information concerning the average premium received for non-GM was also asked for three commodities (corn, soybeans, and canola). Results were obtained regarding soybeans. The average premium received is 13 cents per bushel, but it varies from 0 to 30 cents. Even though this result cannot be considered as representative of all elevators, it gives an estimation of the premium received for specialty grain.

After GM content, another element of importance for end-users is the variety of the product delivered. Table 5.18 shows the percentage of each crop for which a variety declaration is asked. For 34% of the soybeans delivered, a variety declaration is asked at delivery, 47% for wheat, 34% for corn, 66% for barley, and 67% for other crops (such as canola or oat).

The mail survey also provides information regarding the implementation of a variety declaration system for a new crop variety, for a new crop or, one where no declaration is currently required. The results show that 58% of the respondents estimate that it is impossible to realize the implementation of such a system, while 26% think that the implementation will be somewhat difficult, and 16% believe that it will not be difficult at all to realize this new implementation.

Table 5.18. Percentage of Each Crop for Which Variety Declaration is Asked

| | Soybeans (%) | Wheat (%) | Corn (%) | Barley (%) | Other (%) |
|---|---|---|---|---|---|
| Mean | 34 | 47 | 34 | 66 | 67 |
| St dev | 57 | 49 | 57 | 42 | 58 |
| Min | 0 | 2 | 0 | 0 | 0 |
| Max | 100 | 100 | 100 | 100 | 100 |

Finally, the survey had a question in order to estimate the influence of different factors on the facility's policy to handle a GM crop. The list of these factors is as follows: external factors (such as foreign market demand), internal factors (such as domestic regulatory policy), facility capacity and capability to segregate, and the cost of segregation. The capacity of the facility and its capability to segregate, as well as the cost of segregation are seen as having a large influence on the facility's policy with regards to the handling of GM crop. Concerning the influence of external and internal factors, there is no significant result. It is not clear whether these elements have an impact or not, and if they have an influence, how important this one is.

## Results and sensitivities on cost of segregation

This section presents the results obtained by running the model based on the study by Hurburgh et al. It is divided into several subsections. First, the test for correlation between important variables is explained; then, the cost analysis is detailed, and finally the impact of labor cost on the total cost of segregation is discussed.

*Correlation*

Before running any simulation using @RISK®, the presence of correlations between each of the inputs of the model was checked. A correlation matrix was built using the following inputs: the total volume handled, the cost of modification in dollars per bushel, and the number of bushels represented per test. There is a positive correlation between the total volume handled and the number of bushels represented per test. The correlation factor is 0.48. This is the only significant correlation obtained. The value obtained by the t-test is 2.84. It is greater than the t-critical value (2.02), so this result is significant at a level of significance equal to 95%.

*Analysis*

Outputs were chosen in order to run simulations with @RISK®. The first output is the total cost of segregation. The cost of modification and the total cost of segregation less the modification cost are the other two outputs. Each cell containing an @RISK® formula is considered as an input for the software. The simulation settings were set to five thousand iterations. This has to be high enough to obtain correct results. The first results obtained are shown in Figure 5.3.

This figure shows that 90% of the time, the total cost of segregation is less than 50 cents per bushel. Three quarters of the time, the total cost of segregation does not exceed 30 cents per bushel, and 50% of the time, this total cost is equal or less than 20 cents per bushel. This figure also shows that the cost of modification has a large impact on the total cost of segregation. Therefore, results for total cost of segregation less modification costs are plotted in the graph. Assuming no modification of the facility is realized; the total cost of segregation is less than 8 cents per bushel, 50% of the time. This cost does not exceed 13 cents per bushel, 75% of the time, and 90% of the time the total cost of segregation less modification costs is less than 25 cents. These values of total cost are quite significant in grain handling terms, where total margins average 8 cents per bushel (for undifferentiated grains). Knowing that the margins are small, the average premium must exceed segregation cost per bushel receiving a premium for the segregation to be profitable.

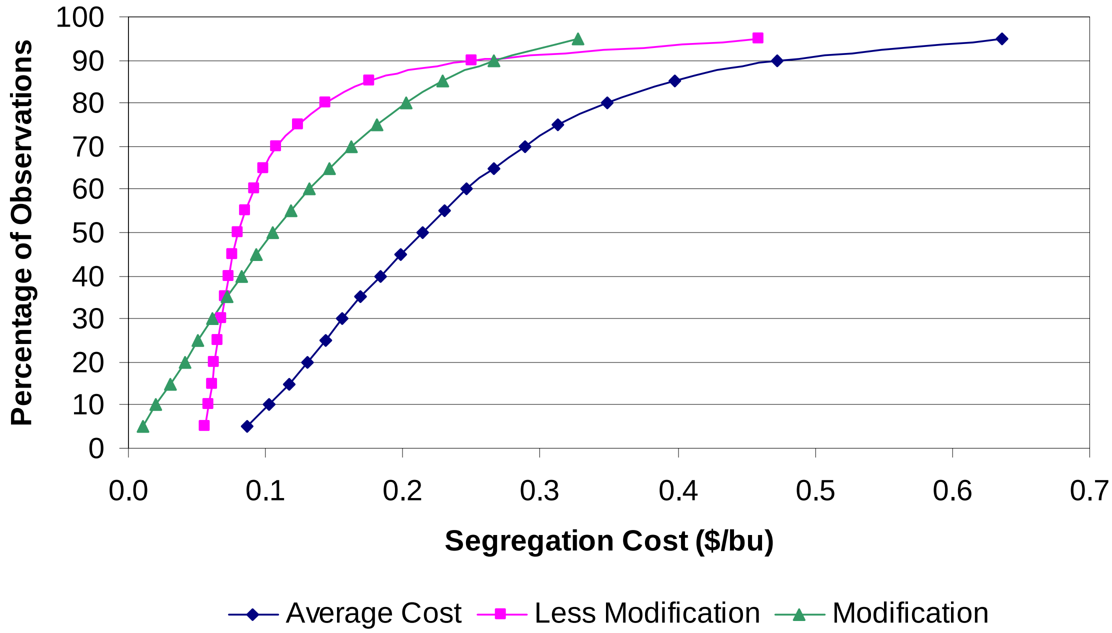


Figure 5.3. Impact of Modification Costs on the Total Cost of Segregation.

As explained previously, the total cost of segregation is divided into two categories: grading and testing on one side, and handling and other operations on the other. Results show that costs are predominantly handling-related, 90.6% as compared with 9.4% grading-related. Amongst the handling costs, the cost of modification is by far the greatest, followed by the cost of underutilized storage, and the cost of addition of new storage space. Cost of data equipment and cost of sample storage are the two largest grading costs.

The fourteen different costs included in the model were also divided into three groups. Costs can be described as "volume based," if they decrease with increasing total volume tested; as "load size based," if they become lower as load sizes get larger; or as "across the board" or fixed costs, if they are not affected by either volume or load size of total segregation cost.

Costs of data equipment, sample storage, modifications, underutilized storage, addition of new storage and loss in receiving capacity are all volume based. These volume-based costs represent 94.6%, so costs are almost entirely based on total volume tested. Costs of operator additional time, waiting time for test, accounting and record-keeping, check testing of equipment, and disputes with a seller are all dependent upon the load size. These costs represent 2.2% of total segregation cost. Costs of additional waiting time at the dump, additional labor at the pit and misgrades are all "across the board" costs. They represent 3.2% of total segregation cost.

Volume-based costs represent the largest share, which means that increasing volume handled and volume tested lowers costs sharply. Most costs being constant over volume, the amount of grain handled and tested are key criteria. Figure 5.4 shows the cost of segregation versus changes in the total volume handled. Values for the cost of segregation, as well as for the volume of grain handled, were simulated using @RISK®. Estimated values were calculated, and the relationship was represented on the graph. As a result, the figure shows that, as the volume of grain handled increases, the total cost of segregation decreases.

Increasing the volume handled from 50 thousand bushels to 100 thousand bushels decreases the cost of segregation from 16 cents per bushel to 13 cents per bushel. Then, with a volume of grain handled equal to two hundred thousand bushels, the cost of segregation comes down to less than 11 cents per bushel. To summarize, the total cost of segregation decreases sharply as the volume of grain handled increases, but only until a certain point. For a volume of grain handled equal to four hundred thousand bushels, the cost of segregation is down to its lowest level of 10 cents per bushel. The cost of segregation does not go below 10 cents a bushel even with a volume handled equal to one million bushels. This level of total cost of segregation equal to 10 cents per bushel seems to be achievable by a large number of elevators; given that, according to the model, about 80% of the elevators handle a volume of grain superior to five hundred thousand bushels. In other words, most grain elevators should be able to segregate at a moderate cost. In the survey, grain elevator managers estimated this cost of segregation to 8 cents per bushel. The results of the simulation show that this cost is slightly greater.

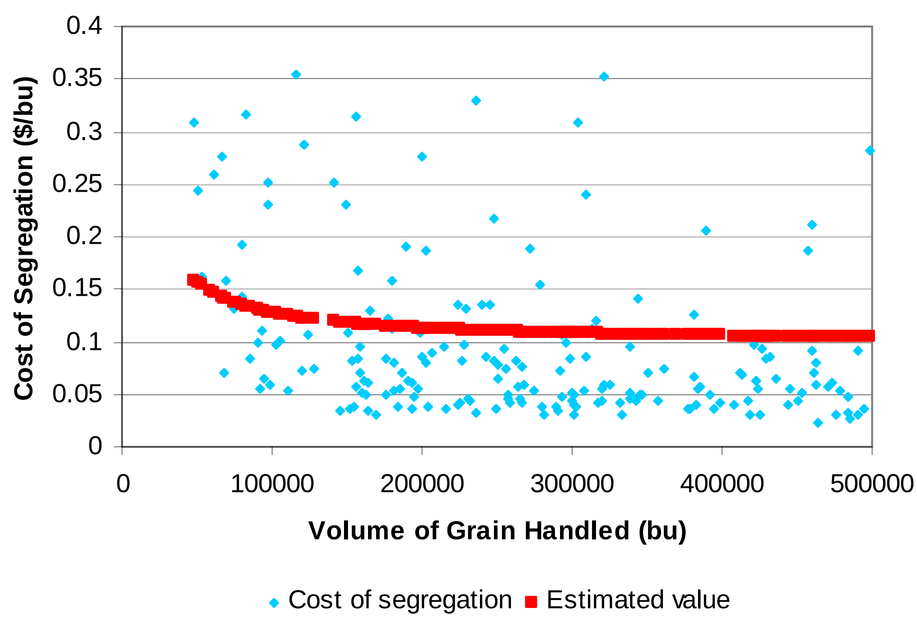


Figure 5.4. Average Cost of Segregation Versus Changes in Volume of Grain Handled.

Figure 5.4 shows that most of the observations are clustered at values between five and ten cents per bushel but the range of values is very wide. A few values are disproportionately skewed upwards and this is why the line for the estimated value is above 10 cents per bushel.

The volume of grain tested is also a criterion of major importance. The cost of segregation versus changes in volume of grain tested is shown in Figure 5.5. The volume of grain tested corresponds to the percentage of grain tested times the total volume of grain handled. In this figure, there are a few values that are disproportionately greater than the average. Most observations crowd together around ten cents per bushel.

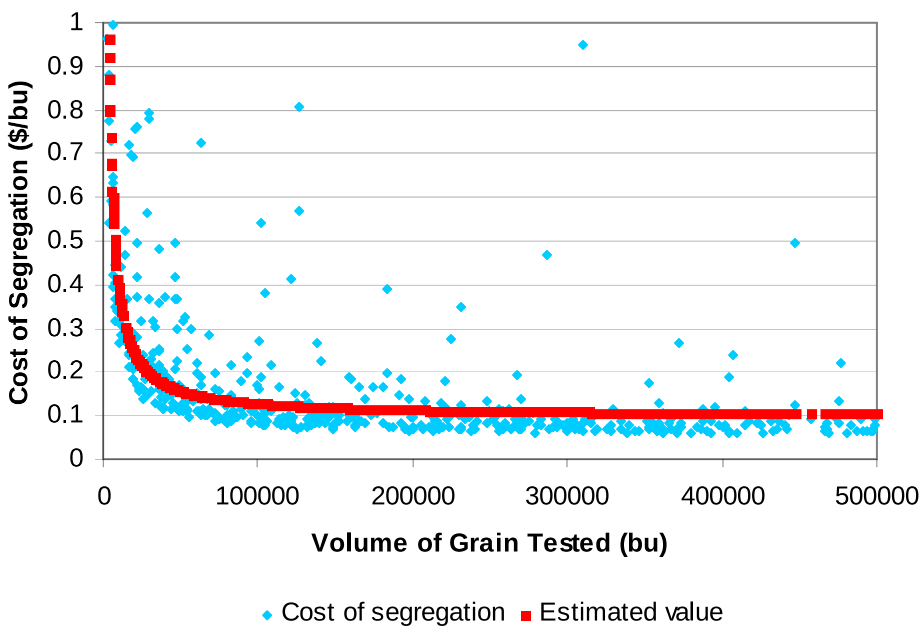


Figure 5.5. Average Cost of Segregation Versus Changes in Volume of Grain Tested.

In the same way as the total volume of grain handled, it is clear that increasing the volume of grain tested ultimately decreases the cost of segregation. Increasing the volume tested from ten thousand bushels to fifty thousand bushels, decreases the total cost of segregation from 40 cents per bushel to 16 cents per bushel. Then, with a volume of grain tested equal to one hundred thousand bushels, the total cost of segregation comes down to less than 13 cents per bushel. To summarize, the total cost of segregation decreases sharply as the volume of grain tested increases, but only until a certain point. The total cost of segregation does not go below 10 cents a bushel even with a volume tested equal to one million bushels.

This level of total cost of segregation equal to 10 cents per bushel seems to be achievable by a large number of elevators; given that, according to the model, 75% of the elevators test a volume of grain greater than 125 thousand bushels (125 thousand bushels corresponds to a total cost of segregation equal to 12 cents per bushel). In other words, most grain elevators should be able to segregate at a moderate cost.

Figure 5.6 is a tornado graph that shows, through correlation factors, which variables (inputs) have the greatest impact on the total cost of segregation (output).

To create this tornado graph, @RISK® calculates the correlation between the output (dependent variable) and the values of the cells that are “random” or simulated by an @RISK® distribution (independent variables). The variables with the most influence on the dependent variable are those with the largest (in absolute value) correlation with the dependent variable. This graph confirms that the cost of modification, the volume of grain handled, and the volume tested are the three most important variables with regards to the total cost of segregation. The cost of modification is the variable with the most influence on the total cost of segregation. The correlation factor is equal to 0.76. Then, the volume of grain tested and volume of grain handled are the next two variables with the most impact. The correlation coefficients are -0.47 and -0.11, respectively, for the volume of grain tested and the volume handled. This negative sign shows that these two volumes have a negative correlation with the total cost of segregation. In other words, the greater the volumes handled and tested, the smaller the total cost of segregation.

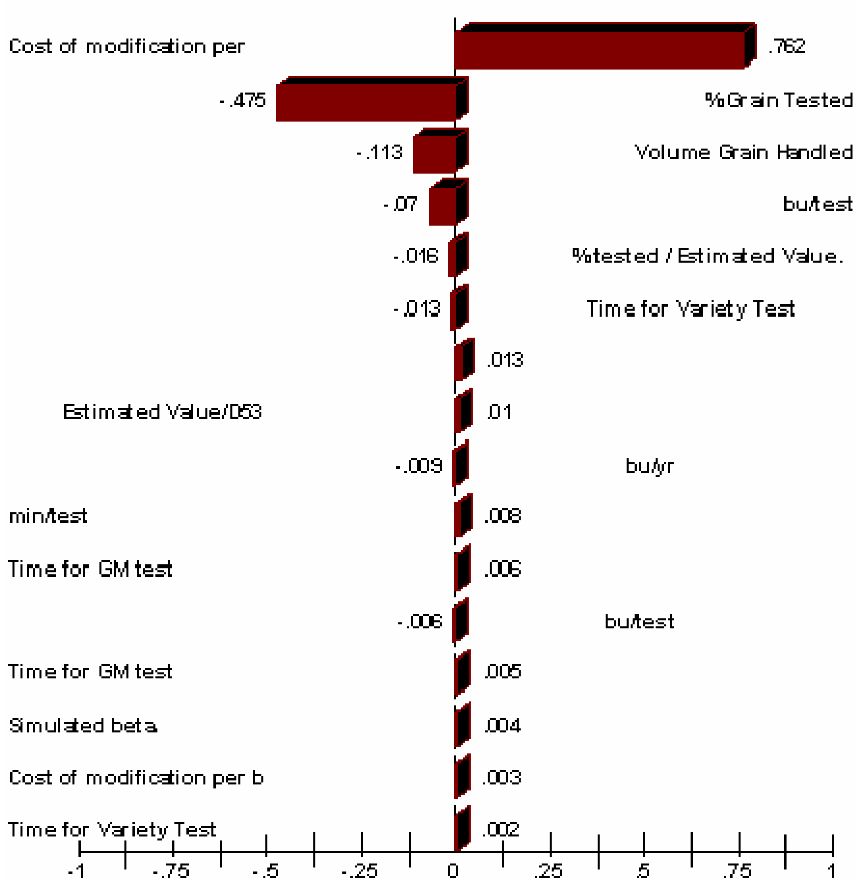


Figure 5.6. Tornado Graph Illustrating Correlations Between Input Variables and Total Cost of Segregation.

In their study, Hurburgh et al. analyzed variability in storage volume by dividing elevators into four groups according to their cost of segregation. In this study, elevators were also divided into four groups: elevators with segregation cost less than five cents per bushel, between five and ten cents per bushel, between ten and twenty cents per bushel, and finally elevators that can segregate for twenty cents per bushel or more. Figure 5.7 shows the variability in the storage volume for each of these four categories.

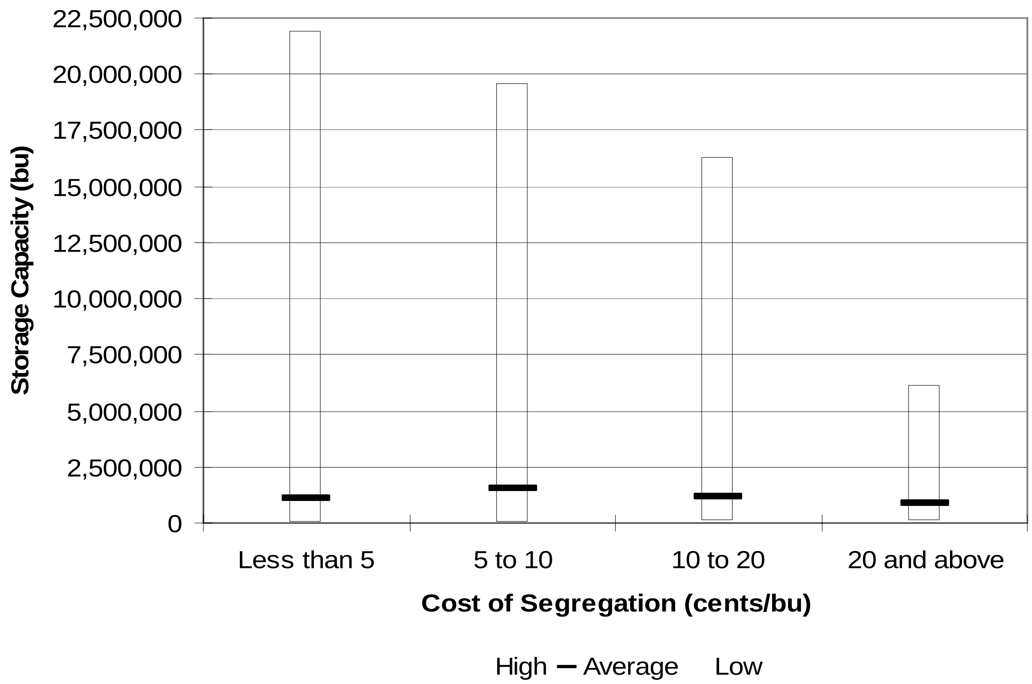


Figure 5.7. Variability in Storage Capacity with Regards to Cost of Segregation.

This figure gives several results concerning the capability of segregating at low cost with regards to the storage capacity. Elevators with a storage capacity greater than nineteen million bushels segregate at a cost less than five cents. Elevators with a storage capacity superior to sixteen million bushels will be able to segregate for less than ten cents per bushel, and elevators with a storage capacity greater than six million bushels will most probably be able to segregate for less than twenty cents per bushel. So, these results show that larger elevators would tend to segregate at a lower cost than smaller elevators.

Nevertheless, as for the average storage capacity there is no significant difference between each category. The average storage capacity of elevators that can segregate for less than five cents per bushel is about one million bushels. One million bushels of storage capacity is also the average size for elevators that can segregate for five to ten cents per bushel, ten to twenty and, twenty cents per bushel and above. According to these results, the size of the storage capacity does not reflect a particular level of cost of segregation, unless this storage capacity is very large (superior to six million bushels). Very large elevators will tend to segregate at lower cost.

*Impact of labor cost*

Simulations were used to show the impact of labor cost on the total cost of segregation. Five different labor costs were used: 5, 10, 15, 20, and 25 dollars per hour. For each simulation, five thousand iterations were run. Figure 5.8 shows how the total segregation cost varies as labor cost changes.

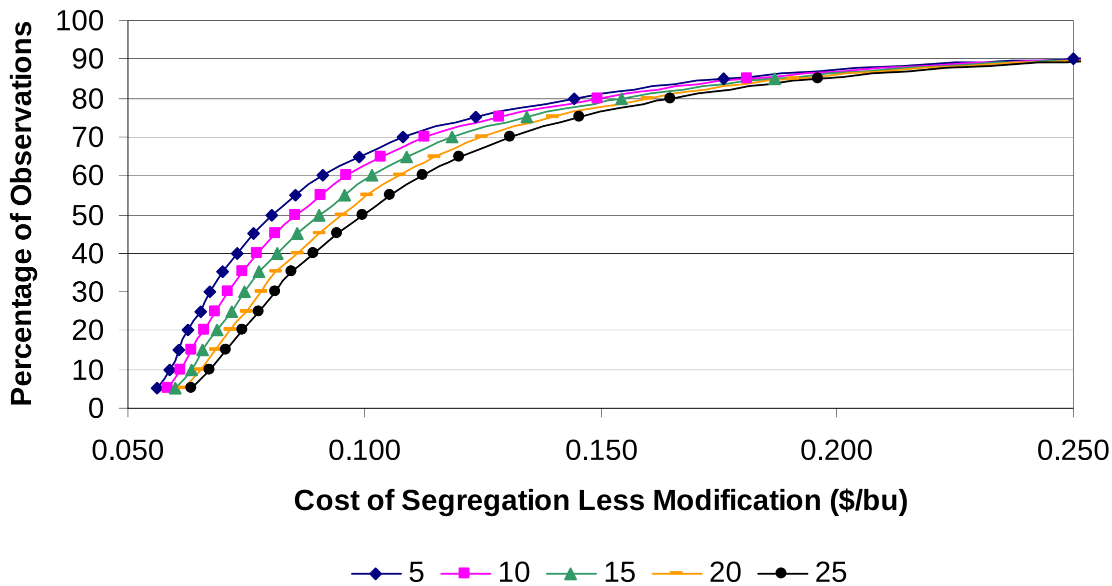


Figure 5.8. Impact of Different Labor Costs on the Cost of Segregation.

Overall, it is clear that greater labor cost implies higher cost of segregation (less modification). For each additional five dollars per hour in labor cost, the curve shifts to the right. On average (for 50% of the observations), when labor cost increases by five dollars per hour, the total segregation cost (less modification) increases by half a cent. For a level greater than 75% of observations, this additional cost is still half a cent for an extra five dollars per hour in labor cost, but this extra cost represents a smaller share of the total segregation cost.

## Summary

There is a relationship among the number of bins, number of pits, and the different capacities of the elevator (loading, receiving, load-out, and track). More precisely, elevators with a large number of bins have a large number of pits; and also have large loading, receiving, load-out, and track capacities. The three main crops handled in the Upper Midwest are wheat, soybeans, and corn. Roundup Ready® corn, Bt® corn, and Roundup Ready® soybeans are the most largely handled GM crops. Bt® corn represents the largest volume.

Concerning the facility's certifications and policies regarding grain quality, it was found that 20% of elevators are approved ISO or HACCP, and 10% said they would anticipate getting their facility approved. Less than 20% of elevators handle IP grains or ask for farmers to declare the variety they are delivering.

On average, 93% of deliveries are tested for protein, moisture, test weight, and dockage; but only 34% for falling number and vomitoxin. The average cost for all these tests is $2.69. Almost 80% of the time, neither GM content nor variety is tested. When testing is conducted, it is most usually applied at receipt.

The total cost of segregation is mostly impacted by the cost of modifications. Elevator managers consider this cost as a major constraint to effective segregation. This cost is smaller for large elevators. A simulation showed that, assuming no modification was realized, segregation cost was less than 10 cents for 65% of the observations. Costs of segregation are mostly handling-related (90%), in large part due to the importance of the cost of modification. Almost 95% of the costs of segregation are volume based, so the volume of grain handled and tested are also two key criterions. Another simulation showed that with a volume of grain handled or tested equal to one hundred thousand bushels; the total cost of segregation (without modification) does not exceed 13 cents per bushel. The last simulation that was run demonstrated that an increase of five dollars per hour in the labor cost increases the total cost of segregation by half a cent.

# CHAPTER 6
# SUMMARY AND CONCLUSIONS

## Problem

The importance of biotechnologies in agriculture and agribusiness has grown in the past decades. The advent of genetically modified grain varieties has important implications for crop producers and grain-handlers. Production and marketing systems of genetically modified crops are now facing new challenges. The development of new biotech varieties and other specialty crops is underway, and one of the main issues is the acceptance of these by different governments. Requirements regarding biotech crops vary from one country to another (tolerance levels, labeling, etc.). Some countries are in favor of the development and commercialization of GM products when others are more adverse to these new technologies. Since none of the regulatory mechanisms are the same and the demand for these specialty products depends on the countries aversion to GM crops and their own regulations; it becomes more and more difficult to deliver products that meet customers' specifications. There is a real need for new marketing mechanisms that facilitate the co-existence of GM and non-GM crops. Even though many grain-handlers are already confronted by issues related to identity preservation, segregation, or/and testing; the impact of such a marketing mechanism on their activity will still be huge. The main impact is certainly the increase in the costs of production due to these new practices.

## Objectives

The first objective of this study was to document current segregation practices at the elevator level. For this purpose, a survey of grain-handlers in the Upper Midwest was realized. Questions were asked regarding their facilities and their current and prospective practices. The second objective was to estimate a model to analyze the changes in costs due to these new segregation practices. The model used in this study was based on the engineering-economic model built by Hurburgh et al. (1994). Total cost of segregation was calculated. Stochastic simulations were conducted to see the impact of random variables on this total cost.

## Procedures

The first step was to analyze the numerous previous studies related to marketing mechanisms. A questionnaire was then built, pre-tested, and finally sent out in order to collect information directly from grain-handlers in the Upper Midwest (North Dakota, South Dakota, Minnesota, and Montana). The data collected were used to run the model. Some inputs were taken directly from Hurburgh's model, and several assumptions had to be made to run the model. The result for the total cost of segregation was interpreted as well as the importance of the grading costs compared to the handling expenses. The simulation modeling package @RISK® was used to achieve sensitivities. The impact of a number of inputs on the total cost of segregation was shown through these sensitivities.

## Results

Of the 789 elevators that received a mail survey, 43 responded, representing 5% of all elevators. Only 40 of these surveys were actually usable.

*Summary of survey results*

According to the results regarding the physical characteristics of the facilities, all sizes of elevators seem to be well represented. As for the number of bins, the respondents are divided into 4 groups, representing about 25% each. Elevators with a greater number of bins also have a great number of pits. Elevators with fewer than 20 bins have no more than 3 pits. Elevators that have between 20 and 30 bins have up to 6 pits; from 30 to 40 bins, the number of pits goes up to 7, and the elevators with a large number of bins (more than 40) have up to 9 pits. About half of the elevators have loading and receiving capacities less than fifteen thousand bushels per hour, and the other half have larger capacities. Concerning the load out and track capacity, about 50% of the elevators are considered as small (less than fifty cars), 21% are medium size (fifty to hundred cars), and 28% have more than one hundred cars.

The important idea is that there is a link between number of bins, number of pits, and the different capacities of the elevator (loading, receiving, load-out, and track). By analyzing carefully the results of the survey, it was shown that the elevators with a large number of bins have a large number of pits, but also that these elevators are the same that have large loading, receiving, load-out, and track capacities.

Concerning the storage capacity, 43% of the elevators have a capacity less than five hundred thousand bushels, 32% have a storage capacity between five hundred thousand and one million, and 25% have a capacity superior to one million bushels. There is no direct link between the storage capacity and the total volume handled per year even though elevators that have a large storage capacity should be able to handle more grain per year. The results demonstrate that one third of the elevators have a total volume handled less than one million bushels, 40% are between one and five million, and 27% handle more than five million bushels of grain per year.

Wheat, soybeans, and corn are the three main crops handled in the Upper Midwest, representing, 29, 27, and 21% of the total volume handled, respectively. Elevators also handle smaller volumes of barley, durum, canola, and other crops.

Concerning the elevators certifications, about 20% of elevators are approved with ISO or/and HACCP; and up to 10% of the elevators that are not yet approved, by either one of these certifications, said they would anticipate getting their facilities approved. Elevators do not have the same policies regarding grain quality. About 18% of the respondents handle IP grains, and amongst these, 57% use a mechanism such as USDA or the state seed department as a proof for IP confirmation. 89% of the facilities handle GM grains but only 23% would have the sufficient capacity to segregate 100% of GM crops. Less than 20% of the respondents ask for farmers to declare the variety they are delivering.

With regards to segregation practices at the elevator level, results show that there are two major constraints to effective segregation, which are the cost of modification and the number of bins. Time, testing equipment cost, risk of errors, and loading and load-out capabilities are considered as minor constraints. So, elevator managers report that the constraint to effective segregation is a physical constraint. Elevators imply that they will have to modify their facilities in order to segregate and these changes have a significantly high cost. The average cost of modification per bushel is $0.78 or about $200,000 for the total number of bushels. Another result of the survey shows that 33% of respondents declare that their ideal segregation scenario would be to segregate all grains, 54% would segregate only some of their grains, and only 13% would not segregate at all. Without taking into account any constraints, these results indicate that grain-handlers would tend to segregate at least part of their grain if they could.

On average elevators said they segregated 36% of their grain but this percentage ranges from 0 to 100%. The estimated cost of segregation given by the elevator managers is seven cents a bushel, plus or minus seven cents. The estimated cost of segregation is smaller for large elevators (6 cents per bushel) than for small elevators (12 cents per bushel). Furthermore these large elevators also have a smaller cost of modification than for elevators with smaller size.

Information regarding the labor cost (around $11 per hour) and the value of manager's time (about $37 per hour) was also collected in the survey. These data were used as inputs for the model. As to the information on testing practices, results show that on average, 93% of deliveries are tested for protein, moisture, test weight, and dockage. Tests for falling number and vomitoxin are realized on 34% of total deliveries. The average number of bushels represented per test is 1,540 bushels but this number varies a lot from one elevator to another (from 150 to 5,000 bushels). 5% of the samples are said to be disputed and the average cost of test is$2.69 but it can get as high as $25. These data are used as inputs for the model. Adding a test for GM content and/or variety will significantly increase the time required to do the testing. Further information was gathered with regard to the accounting time, time to store grain, and manager's time spent on disputes but these do not have a major importance and are not considered as major constraints to segregation or testing practices.

When a test is conducted in-house, it is most usually applied at receipt whether it is for a "classic" test or for GM content or variety. Almost 80% of the time, GM content and variety are not tested. This percentage will probably tend to decrease with the growing importance of specialty crops, such as non-GM corn or soybeans for example.

At the time of the survey, five GM crops were handled. Roundup Ready® corn, Bt® corn, and Roundup Ready® soybeans are the most largely handled followed by Roundup Ready® canola and Liberty® corn. This number of varieties handled, will most probably increase in the next years. For these three crops (corn, soybeans, and canola), the percentage of non-GM handled has become very small in the Upper Midwest, between 0 and 30% of the total volume handled.

On average, variety declaration is asked for less than 50% of the crops received at the elevator. Almost 60% of the elevators declare that it is impossible to implement a variety declaration system for a crop for which variety declaration is not currently required.

Finally, the capacity of the facility or its capability to segregate, as well as the cost of segregation are seen as having a large influence on the facility's policy with regards to the handling of GM crop.

*Summary of the model's results*

Across the inputs used in the model, the only correlation that was found is between the total volume handled and the number of bushels represented per test. The correlation factor is positive (0.48), and shows that if the total volume handled is high, the number of bushels represented per test will tend to greater too.

The first result is that the modification cost has a huge impact on the total cost of segregation. Assuming there is no modification to be done, the cost of segregation is less than 10 cents per bushel for 65% of the observations. This cost does not exceed 12.5 cents per bushel for 75% of the observations. If the cost of modification is included, then the total cost of segregation is less than 22 cents per bushel for 50% of the observations and less than 32 cents, 75% of the time. These costs are of significant importance but when assuming no modification costs, the premiums received for quality should offset these extra expenses.

The results also point out the importance of the handling-related costs compared to the grading-related. The costs related to handling and other operations correspond to 90% of the total cost of segregation while the costs related to grading and testing represent 10%. This large difference is mainly due to the modification costs. The total cost of segregation was also divided according to cost basis terms (volume based, size load based, or across the board). Almost 95% of the costs of segregation are volume based. The volume of grain handled and tested are key criteria. As these volumes of grain handled or tested increase, the total cost of segregation decreases sharply. A simulation shows that with a volume handled or/and a volume tested equal to 100 thousand bushels, the total cost of segregation (without modification) does not exceed 13 cents per bushel. Knowing that about 75% of the elevators test a volume of grain at least equal to 125 thousand bushels, the cost of segregation should not be too high.

The last simulation that was run illustrated the impact of labor cost on the total cost of segregation. The result is that an increase of five dollars per hour in the labor cost increases the total cost of segregation by half a cent. This is quite significant in terms of handling. Segregation may be harder to implement at elevators where the cost of labor is high.

The results for the cost of segregation obtained through the model and the estimated cost of segregation given by the elevator managers in the survey are not significantly different from one another. Elevator managers seem to be well informed about costs of segregation; therefore, the implementation of such practices would not be a surprise for them.

## Contributions

This research, in the same way as other articles in the academic literature, shows that segregation practices are already implemented at a certain number of country elevators. Additional segregation or testing practices due to GM content, for example, should not be too difficult to implement at these facilities; i.e., the costs associated with these practices should not be too high. The survey results showed that the cost of modification is a major constraint to actual segregation. The average cost of segregation is 8 cents per bushel assuming no modification, and 22 cents per bushel if some modifications have to be done. No previous studies, showing the importance of this element in the cost of segregation, were found.

This study also demonstrates that the volume of grain handled and tested are important factors for segregation. According to the results of both the survey and the model, it seems to be easier for large elevators to segregate than for elevators with smaller size. The model by Hurburgh et al. showed that elevators that handle or test large volumes of grain tend to have smaller segregation costs per bushel. The survey showed that the estimated cost of segregation for small elevators is 12 cents per bushel and only 6 cents per bushel for large elevators. These estimated costs of segregation obtained by the survey are substantially lower than what is found in the literature. Miranowski et al. (2004) obtained a cost equal to 31 to 34 cents per bushel. Maltsbarger and Kalaitzandonakes (2000) estimated the cost of segregation between 13.4 and 36.6 cents per bushel, and Reichert and Vachal (2000) found that the estimated cost of segregation was 33 cents per bushel.

Problems or issues related to segregation are the center of many discussions in the grain handling industry. One important idea is that the failure or success of segregation and testing systems is dependent upon the ability of elevators to implement such systems at lowest costs. However important these costs are, they will always be considered as additional costs of production for the elevator. Unless premiums attributed for grain quality are high enough to offset these extra expenses, very few elevators will decide to segregate and test, even though it is clear that for most elevators, implementing segregation and testing would not be very costly.

## Limitations and need for further studies

The low rate of response to the survey can be considered as a limitation of this study. Sending a second questionnaire to the non respondents could have improved this result. The responses provided sufficient information to run the model, and the use of simulations with the software package @RISK® was a good way to offset the problem of too few observations.

Further research could focus more on the premiums attributed for grain quality. Another important issue is the risk related to the implementation of new practices, such as segregation or testing.

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**APPENDIX A**
**MAIL SURVEY**

May 27, 2005

Dear Elevator Manager:

The Department of Agribusiness and Applied Economics of North Dakota State University is analyzing segregation mechanisms to document current practices used by grain local handlers and to gather views on additional requirements and costs imposed on you if handling Identity Preserved, Genetically Modified and/or Variety Specified grains.

In order to get accurate results, we are gathering information on current segregation practices of grain-handlers in North Dakota, South Dakota, Minnesota and Montana. To accomplish this, we are conducting a mail survey of elevator managers. Your participation is entirely voluntary; however, your assistance would be greatly appreciated in making this a meaningful survey. Your identity will not be revealed in any experimental results, only average results for the survey will be reported.

If you have any questions about this project, please call William Wilson at 701-231-7441. Thank you for your participation in this study. If you wish to receive a copy of the research results, please check the appropriate box on the last page of the survey. If you have questions about the rights of human research subjects, you should contact the NDSU IRB Office, 701-231-8908.

Sincerely,

William Wilson
Professor

# MIDWEST GRAIN ELEVATORS SURVEY

# INFORMATION RELATIVE TO SEGREGATION PRACTICES

**Please return your completed questionnaire in the enclosed business reply envelope to:**


**Agribusiness Department**

**Department of Agribusiness and Applied Economics**

**P.O. Box 5636**

**Fargo, ND 58105-5636**


**Name and Location of your Main Facility:__________________ Zip:________**

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**Section 1 – Physical Plant/Location: The following section asks specific questions on your plant/facility and handling capabilities.**

1.1 Main Plant characteristics (Please fill in the characteristics for your firm below)

| Characteristic | Units | Number |
|---|---|---|
| Number of Bins | | |
| Number of Pits | | |
| Loading Capacity | Bushels/hour | |
| Load –out Capacity | Cars/day | |
| Track Capacity | Cars | |
| Storage Capacity | Bushels | |
| Receiving Capacity | Bushels/hour | |
| Grain Handled in 2003/2004 | | |
| Total Volume Handled / year | Bushels | |
| Wheat Handled | Bushels | |
| Durum Handled | Bushels | |
| Barley Handled | Bushels | |
| Soybeans Handled | Bushels | |
| Corn Handled | Bushels | |
| Canola Handled | Bushels | |
| Other | Bushels | |

1.2 How many other elevator facilities does your firm operate?___________________

1.3 International Standards Organization "ISO" and Hazard Analysis Critical Control Points "HACCP" provide guidelines for producers to meet end-user or customer specifications

| | | |
|---|---|---|
| Is your facility approved with ISO 9000? | ☐ Yes | ☐ No |
| If No, Do you anticipate getting your facility approved? | ☐ Yes | ☐ No |

| | | | |
|---|---|---|---|
| 1.4 | Is your facility approved with HACCP? | ☐ Yes | ☐ No |
| | If No, Do you anticipate getting your facility approved? | ☐ Yes | ☐ No |

**Section 2 – Segregation and Identity Preservation of Current Crops Handled: This section asks specific questions on current segregation practices at your facility**

2.1 What percentage of your total volume handled (bu/yr) is segregated or kept separate for specific reasons?________% ***If none, skip to question 2.6***

2.2 The following table shows crops which might be segregated and/or tested at your facility. Please check the segregation (Seg.) and testing (Test) criteria(s) that apply for each crop

| Segregated or Tested by | Wheat | | Durum | | Barley | | Corn | | Soybeans | | Canola | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seg | Test | Seg | Test | Seg | Test | Seg | Test | Seg | Test | Seg | Test |
| Protein | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Moisture | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Test weight | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dockage | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Vomitoxin | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Falling Number | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Germination | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Variety | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| GM Content | | | | | | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

2.3 What is the biggest constraint to effective segregation? Please circle ONE magnitude level of the constraint on the scale of 1 to 3

| Factor | No constraint | Minor constraint | Major constraint |
|---|---|---|---|
| Time | 1 | 2 | 3 |
| Testing Equipment Cost | 1 | 2 | 3 |
| Data Transmission | 1 | 2 | 3 |
| Storage of samples | 1 | 2 | 3 |
| Accounting and record keeping | 1 | 2 | 3 |
| Risk of testing error: Inbound | 1 | 2 | 3 |
| Risk of testing error: Outbound | 1 | 2 | 3 |
| Cost of modification of handling system | 1 | 2 | 3 |
| Number of bins | 1 | 2 | 3 |
| Loading capabilities | 1 | 2 | 3 |
| Load out capabilities | 1 | 2 | 3 |

2.4 What is your estimated cost of segregation? ____________$/bu

2.5 What would be your ideal or best segregation scenario at your facility? (check one)

- ☐ Segregate all grains and oilseeds
- ☐ Segregate some grains and oilseeds
- ☐ Not segregate at all

2.6 Please indicate the information relative to each test applied (%, time, cost)

| Factor | % of farmer deliveries where test is conducted | Time required to conduct test or prepare sample for outside testing<br>minutes | Time required for outside agency to conduct test<br>Hours or days | Cost of test<br>$/test or ¢/bu tested | Manager's time spent on disputes<br>minutes |
|---|---|---|---|---|---|
| Protein | % | | | | |
| Moisture | % | | | | |
| Test weight | % | | | | |
| Dockage | % | | | | |
| Vomitoxin | % | | | | |
| Falling Number | % | | | | |

2.7 Bushels represented per test______________bu/test

2.8 Average Labor Cost for testing or for preparing the sample?____________$/hr

2.9 Percentage of samples disputed by sellers ____________%

2.10 Value of Manager's Time spent on disputes_____________$/hr

2.11 How long do you store grain samples used for tests?____________

2.12 Time spent putting samples in storage?___________Min

2.13 Cost estimate of modification of your facility due to extra storage required______$

2.14 For the following tests, indicate where the test is applied? (place an ✓ in the correct box)

| Tests | At Receipt | In-Store | At Load-Out | Do not Test |
|---|---|---|---|---|
| Protein | | | | |
| Moisture | | | | |
| Test weight | | | | |
| Dockage | | | | |
| Vomitoxin | | | | |
| Falling Number | | | | |
| Variety Identification | | | | |
| GM content | | | | |

2.15 Are any of your grains handled as Identity Preserved? ☐ Yes ☐ No

***If none, skip to section 3***

2.16 Does your facility use any mechanisms such as USDA or the State Seed Department as a proof for traceability and/or for IP confirmation? ☐ Yes ☐ No

If Yes, what is the method used? ___________________

2.17 Which crops are Identity Preserved and for which trait? Please, indicate the volume per year as percentage

| Commodity | Trait Identity Preserved | % of total bushels |
|---|---|---|
| Wheat | | |
| Durum | | |
| Corn | | |
| Soybeans | | |
| Barley | | |
| Canola | | |
| Other (List) | | |

**Section 3 – Genetically Modified Crops: This section asks questions on the GM crops that are currently handled at your facility**

3.1 Has your facility handled any GM crops? ☐ Yes ☐ No ***if No, skip to 3.3***

3.2 If yes, what GM crops have been handled at your facility, and how many bushels (2003/2004)? What percentage of each crop is GM?

| GM commodity | Bushels | % of grain that is GM |
|---|---|---|
| Roundup Ready® Corn | | |
| Bt® Corn | | |
| Liberty Link® Corn | | |
| Roundup Ready® Soybeans | | |
| Roundup Ready® Canola | | |
| Liberty Link® Canola | | |
| Other: (please list) | | |

3.3 Indicate the volume of non-GM varieties handled in 2003/04 as a percentage of total volume for each commodity and give an estimate of the average premium for Non-GM

| | % of total bushels for the commodity that is Non-GM | Average Premium for non-GM ($/bu) |
|---|---|---|
| Corn | % | |
| Soybeans | % | |
| Canola | % | |

**Section 4 – GM crops: This section asks questions on prospective GM crops**

4.1 If you **test** for GM content, indicate what part is tested in house and what is sent out to be tested?

______% tested in house
______% sent out to be tested

4.2 If you **handle or were to handle** GM content, what is the estimated additional time needed for:

Handling samples__________min Disputes_________________min
Testing GM content________min Accounting / Record_______min

4.3 Assuming that a testing technology is available to do a GM crop test at the elevator, such as a strip test for $4/test; does your facility have the adequate capacity to allow for 100% segregation of GM crop if it is introduced? ☐ Yes ☐ No

4.4 To what extent are the following factors an influence on your facility's policy to handle a GM crop? (Please circle one for each)

| Factor | No Influence | Small Influence | Average Influence | Large Influence |
|---|---|---|---|---|
| External factors such as foreign market demand | 1 | 2 | 3 | 4 |
| Internal factors such as domestic regulatory policy | 1 | 2 | 3 | 4 |
| Facility capacity and capability to segregate | 1 | 2 | 3 | 4 |
| Costs of segregation | 1 | 2 | 3 | 4 |

4.5 Variety Declaration is a marketing mechanism whereby the farmer indicates the variety of the commodity being delivered to the elevator

When farmers deliver to your facility, do you have them declare or indicate the variety they are delivering? ☐ Yes ☐ No ***if No, skip to question 4.8***

4.6 If you ask for Variety Declaration, what is the estimated additional time needed for:

Handling samples__________min Disputes_________min
Accounting / Record________min Testing Variety Identification____min

4.7 What percentage of these commodities, if any, is a variety declaration asked for before delivery at your facility?

| | | | |
|---|---|---|---|
| Soybeans | ______% | Wheat | ______% |
| Corn | ______% | Barley | ______% |
| Canola | ______% | Other (Specify_____) | ______% |

4.8 How difficult would it be for your facility to implement a variety declaration system for a commodity you do not currently require declaration for? (Check ONE only)

☐ Not difficult at all

☐ Somewhat difficult to implement

☐ Impossible, it won't work

Survey completed by: Name: ____________Signature:________________Tel._________

Do you wish to receive a copy of the research results? ☐ Yes (email________________)
☐ No

*Please return the completed survey using the enclosed business reply envelope*
*Thank you for responding to this survey*

# APPENDIX B
# INPUT VARIABLES

Table B.1. Input Variables for Cost Model with Symbols and Units

| Variable | Symbol | Units |
|---|---|---|
| **Capacity** | | |
| Grain elevation | Vb | bu/hr |
| **Margin and premium** | | |
| Gross elevator margin on generic grain | M | $/bu |
| Premium for quality | Change Pg | $/bu |
| **Amortization** | | |
| Amortization factor for capital | $(a/p)^{t}_{n}$ | |
| Useful life | n | years |
| **Rates** | | |
| Interest rate | i | % |
| Insurance premium rate | I | $/1000 |
| Income tax rate | Ti | % |
| Annual depreciation rate | D | % of P, per year |
| Property tax rate | Tp | $/1000 |
| **Price** | | |
| Purchase price of data handling equipment | Pd | $ |
| **Volume** | | |
| Volume of grain handled per year | Vh | bu |
| Volume of grain tested per year | Vt | bu/yr |
| Bushels represented per test | B | bu/test |
| Total elevator storage volume | Vs | bu |
| Elasticity of total volume handled relative to dump time | Evt | % |
| **Number** | | |
| Number of segregations | Ns | |
| Number of pits | Np | |
| **Time** | | |
| Time for testing | Tt | min/test |
| Time for testing before new equipment | Tt’ | min/test |
| Customer waiting time for test | Twt | min/test |
| Value of customer time | PLC | $/hr |
| Subjective customer waiting time addition based | F11 | min |
| Time spent putting samples in storage | Ts | min |
| Accounting time | Ta | min |
| Accounting time for check test results | TaG | min |
| Manager’s time spent on disputes | Tm | min |

Table B.1. (continued)

| Variable | Symbol | Units |
|---|---|---|
| **Reparation** | | |
| Repair old data handling equip | Prd | % of Pd |
| Repair cost of elevator modifications | Prm | % of Pm |
| Repair cost of storage, handling facilities | Prs | % of Ps |
| Cost of submitted sample grade | PG | $/test |
| **Costs** | | |
| Cost of elevator modification | Pm | $ |
| Cost of manager's time | PLM | $/hr |
| Labor cost | PL | $/hr |
| Annual opportunity cost of storage volume | Pgs | $/bu |
| Construction cost of storage | Ps | $/bu |
| **Storage** | | |
| Incremental fraction of storage not utilized | F14 | % |
| Modification for sample storage | Pss | $ |
| **Percentage** | | |
| Percentage of samples disputed by sellers | F9 | % |
| Percentage of samples sent for checktest | F7 | % |
| Percentage of misgrades | Pge | % |