Agribusiness & Applied Economics Report No. 593 September 2006

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

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ACKNOWLEDGMENTS

This project was completed with funding assistance for a project titled ‘Traceability and Variety Marketing Strategies for Hard Red Spring Wheat,’ funded by the North Dakota State Board of Agricultural Research and Education (SBARE), the North Dakota Wheat Commission, and the Center of Excellence for Agbiotechnology at North Dakota State University and from a USDA NRI Project 2005-01774 titled "Market Mechanisms to Facilitate Commercialization of Genetically Modified Grains: Test Tolerances, Segregation, Traceability and Contracting." Thanks go to our colleagues Drs. William Nganje, Cheryl Wachenheim, and George Flaskerud for their comments, although errors and omissions remain the responsibility of the authors. Thanks also to Carol Jensen who aided in document preparation.

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ABSTRACT

Development of genetically modified (GM) and specialty crops has had a great impact on the grain handling industry during recent years. Added costs associated with handling these crops have become an important issue for grain handlers. For this study, data were collected from a survey of elevators in the Upper Midwest. The information focused on segregation practices, time requirements, and costs. This study shows the different costs (grading and handling) associated with segregation practices at the grain-handler level. The results revealed that the cost of modifying systems to handle GM is of major importance. A stochastic simulation model of an engineering cost function is developed to analyze costs for segregation and testing using results from the survey. Assuming no modification is required, the total cost of segregation is about 10 cents per bushel. The volume of grain tested also impacts the total segregation cost per bushel. 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.

Key Words: Genetically modified crops, identity preservation, segregation

Marketing Mechanisms to Facilitate Co-existence of GM and Non-GM Crops

Benjamin Henry, William W. Wilson, and Bruce L. Dahl[1]

INTRODUCTION

Production and marketing of transgenic grains (also referred to as biotech, genetically modified, and GM) have provided many opportunities but also challenges for the commodity marketing system. 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 are not well defined, and competition among exporting countries is more intense and compounded by radically different marketing systems (Wilson et al., 2003). The fact that most biotech crops are oriented towards exports increases the need for segregation systems. This has become the new challenge for biotechnologies.

There are four crucial points that motivate marketing research on segregation systems. First, the consequence of segregation, testing, and traceability will eventually be increased costs (costs of segregation, testing, and additional logistical costs). Second, the impact on risks is important. Firms will be willing to take risk(s) if they are compensated for them. Third, it is essential that tolerances are inversely related to costs. Therefore, imposing tight tolerances will reduce risks but will imply higher costs. Finally, new European traceability requirements 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.

The purpose of this paper is to document the extent of segregation currently in the U.S. wheat sector and to estimate the costs and risks of segregation. 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). Results of the survey provide data to evaluate an empirical model of segregation.

Estimation of additional segregation costs were calculated using an economic cost model adapted from 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. However, additional segregation adds costs simply by the additional labor it implies. The results explain the risks, costs, and tradeoffs of segregation, tolerance, and traceability strategies that are essential components to facilitate coexistence of GM and Non-GM crops. Though applied to wheat, the model could be applicable to all types of crops, GM (e.g., herbicide tolerant, fusarium, or drought resistant) or Non-GM (e.g., organic).

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BACKGROUND AND REVIEW OF STUDIES

Prior to adoption of GM varieties, sales were commonly made on grade and non-grade factors. Now buyers require varying types of information regarding varieties, whether they are GM or not and other agronomic information on production practices. Wilson et al. (2003) show the range of possible procurement strategies (Figure 1).

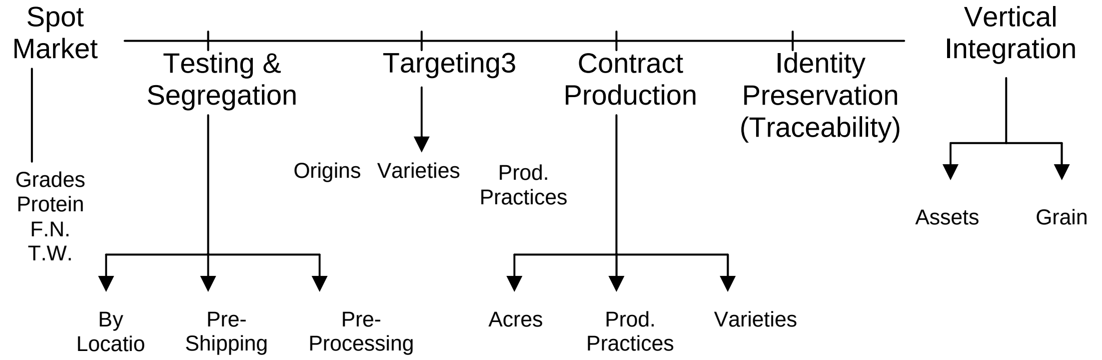

Figure 1. Spectrum of Procurement Strategies

The additional costs implied by several of these different procurement strategies will be discussed. Then, we summarize studies that have used surveys to analyze marketing practices at the grain-handler level and provide a brief summary of all the background information.

IDENTITY PRESERVATION

Identity preservation (IP) is a system of procurement, management, and trade adopted by different countries/firms. IP is an old concept but is increasing in popularity due to the increase in specialty and biotech crops. This control system has evolved over time in the grain and oilseed industry. IP allows the source and/or nature of materials to be identified. IP, also has been referred to as Identity Preserved Production and Marketing (IPPM), and is 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 encompasses the entire marketing channel. Wilcke (2001) describes it as separate storage, handling, and documentation. 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 be kept until the buyer is fully satisfied with the quality of the delivered commodity. Sonka, Schroeder, and Cunningham (2000) define IP as a coordinated transportation and identification system to transfer product and information that makes product more valuable. Buckwell, Brookes, and Bradley (1998) and Lin, Chambers, and Harwood (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 for wheat where sales/segregation are by specific variety/location (e.g., CWB-Wartburtons, Pro-Mar Select Wheat of Idaho, AWWPA).

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 Krejci indicated "… for GMOs, 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." (Wylie, 2001). This is why IP systems are being improved and other operations such as segregation or testing, for instance, are also added to the system.

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 pollen (especially for cross-pollinating crops) or seeds during planting and harvesting with cleaned equipment and separate storage (Boland, p. 15, 2003). All these restrictions are reasons 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 specification. So, IP 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 IP shipments and compared costs of bulk versus container movements. They compared the costs associated with container shipping against transporting with truck, single railcar, and/or unit trains, for shipping soybeans from Iowa to Japan. The cost associated with unit train shipments was found to be 33 cents per bushel (c/bu) less than with containers.

Wilson and Dahl (2005) examined the costs associated with marketing wheat on an IP basis. They surveyed elevator managers on views on the costs of IP systems. According to the survey respondents, the cost of IP ranges from 25 c/bu to 50 c/bu. Major factors impacting IP costs are management and time limitations, testing, time requirements, lot turnover, dispute settlements, and facility modifications. Brester, Biere, and Armvrister (1996) looked at the costs associated with IP in wheat. This research is set as a principal-agent problem. Buyers are unable to know immediately if the delivered product conforms to the required specifications. To assure 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. IP presents complexity to administration; therefore, management costs have a great importance.

Overall, the most important costs included with respect to IP 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

There is a fundamental difference between segregation and IP as components of strategies to market GM crops. Segregation 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 farmers and elevators. The farm level is convenient for segregation due to availability of storage. Many country elevators are not as well suited for segregation purposes because they developed bulk facilities designed for volume throughput and not for smaller lots of specialized products. In addition, incentives for volume shipping have highly influenced the structure of the grain handling industry.

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) argue that these value added activities are relinquished in an IP supply chain.

Segregation presents challenges especially at the elevator level. One of these is adventitious commingling that is difficult to avoid and the other is related to the elevator's efficiency when processing many segregations. Most elevators will be challenged by storage and handling constraints as the number of quality categories handled 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 can be difficult to ensure the full utilization of larger storage bins.

The 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 (Bullock, Desquillet, and Nitsi, 2000). Further, shuttle train technology could be made less feasible with increased categories of grains since elevators may not be able to accumulate the 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 and causes problems for efficiently receiving grain at harvest time and reduces effective storage capacity.

Many studies have focused on this aspect of 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, 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 an extension of the country elevator study by Hurburgh (1994) that examined the costs and benefits of alternative supply chains for soybean segregations.

Another element is the increased costs associated with 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 increased, elevator operations become more complicated which implied problems related to the efficiency of these elevators. Most elevators are built in order to handle large quantities of grain. Therefore, storage configurations are not well-suited to handling a high number of low volume grain categories. Results of this study showed that there is an inverse trade off between the number of grades handled and the elevator's efficiency, and costs increase as more segregations are received.

Wheeler (1998) studied costs associated with grain segregations. 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. 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) found that adding two grades to the system increased average operating costs by 5 cents per ton (c/ton) and average total costs by 13 c/ton. McPhee, Lynn, and Bourget (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 U.S. Department of Agriculture, Economic Research Service (USDA-ERS). The results 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 (Lin, Chambers, and Harwood, 2000). 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, Boland, and Heishman (1999) collected data and developed a stochastic simulation model to analyze the effects of segregation for a country elevator. Different elevator configurations were evaluated. 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 IP of grains at a country elevator. In order to preserve the identity of these grains, they set up different segregation strategies. More stringent or tight tolerance levels increase IP costs. A simulation model found that the costs of segregating high oil corn ranged from 16 c/bu to 37 c/bu.

One major limit of segregation is that it has a negative impact on the system's efficiency. McKeague, Lerohl, and Hawkins (1987) did 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.

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 developed to secure consumer (end-users) and the agents about the development and the process of the product. 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 five years of information on GMOs or GM products (both food and feed). This concept has been used in the EU for several years for the informational process and to govern inter-firm transactions.

"Traceability" was identified by the AC21 (the USDA Advisory Committee on Biotechnology & 21st Century Agriculture) as an immediate issue with long-term implications (i.e., risks, costs). "The liability issues associated with traceability" are said to be crucial, according to the AC21. Traceability systems differ a great deal across sectors of the food industry and, therefore, costs and benefits of traceability are difficult to target.

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. Storage, harvesting, and other equipment are defined for proper use (i.e., cleaning, flushing). To verify that adequate precautions have been taken at the farm level, 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 end-user, each individual must keep records of product identity, volume, lot numbers, and test results, and supplier/consumer should ensure quality and allow for trace back, if necessary.

Costs of traceability vary substantially. 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.

Testing and Tolerances

"Tolerances" are identified as one of the most important areas in the co-existence of GM, Non-GM, and organic grains (Fehr, 2001). 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. 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 have less risk of getting an undesirable item.

Tolerances are used by some firms, specified by some regulatory agencies, and are utilized for many Non-GM characteristics (e.g., vomitoxin). The same type of mechanism could be used for GM products. In some cases, 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 are commercialized, similar sets of tolerances will be specified. Some will be by individual firms, some by countries' regulatory agencies, and others by both of them. Calculating the optimal tolerance level for GM content and evaluating the effects of exogenous factors are important issues. Then, effects of these tolerances on suppliers (grain merchants) and buyers (importers and domestic users) are important.

Different countries, mainly the ones that are GM averse (i.e., EU, Japan) have different policies regarding GM content. 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 EU Scientific Committees as not posing any danger to the environment and health, and 0% tolerance for "unknown" and, therefore, not approved GMOs. Japan requires a 5% tolerance for products coming from the United States and containing GM elements, if the trait is approved (Bean, 2002).

Many aspects of testing are important but most crucial is that testing should only apply to Non-GM shipments. Testing would only occur for those shipments that are "thought to be" Non-GM (Wilson and Dahl, 2005). There are two basic tests that could be used for analyzing the presence of GM material [for our purposes here, Roundup Ready® wheat (RRW)], commonly referred to as strip-tests and PCR tests. 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. 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., 2003). Both these tests are for "single-trait" events.

Several studies used stochastic optimization models of an integrated marketing system handling GM and Non-GM grain to determine costs and risk of segregating GM grains. The models determine optimal testing strategies (where and how intensive to test) and estimate costs and risks of the system over a Non-GM system. Wilson and Dahl (2005) examined this in the context of GM wheat focusing on the U.S. system, Wilson and Dahl (2006) examined this for the Canadian system, and Wilson, Jabs, and Dahl (forthcoming) also jointly determined the optimal supplier tolerance to meet buyer specifications in addition to determining where and how intensive to test. In each of these analyses, buyer and seller risks were minimal and the cost of segregation ranged from 3 to 15 c/bu.

Previous Studies Using Surveys

Previous studies using surveys have focused on the two Non-GM crops, corn and soybeans. Good and Bender (2001) and Good, Bender, and Hill (2000) conducted surveys of specialty crop handlers in Illinois from 1999 to 2001. The majority of specialty crops are produced under contract (except for Non-GMO corn and soybeans). 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) surveyed Iowa grain handlers in order to compare costs of alternative product segregation systems operating within different market structures. They 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).

Qasmi, Wilhelm, and Van der Sluis (2003) conducted a mail survey among more than 200 grain elevator managers in South Dakota. The study 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. 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 c/bu) 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.

SURVEY

In this study, grain elevator managers in the Upper Midwest were surveyed to gather information about the costs associated with segregation, identity preservation, and testing at the elevator level. 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 responses to the questionnaire.

A list of the grain elevators from the four states (North Dakota, South Dakota, Minnesota, and Montana) was used for the survey. For this purpose, information was obtained from the North Dakota Grain Dealers Association for North Dakota. For the state of South Dakota, a list was built using information used by Qasmi, Wilhelm, and Van der Sluis (2003). A list of all the grain dealer facilities was used for the state of Minnesota (Minnesota Department of Agriculture, 2005). For the state of Montana, the current list of licensed commodity dealers and commodity warehouses was used (Montana Department of Agriculture, 2005). The final list was composed of 789 elevators, of which 412 were in North Dakota, 89 in South Dakota, 222 in Minnesota, and 66 in Montana.

The mailed questionnaire sought information about the characteristics of the facility and the current segregation practices. Further information was gathered regarding the additional requirements and costs implied by handling IP, GM, and/or variety-specified grain. The mail survey was first pre-screened 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) and, as a result, several refinements were made to the original questionnaire. On average, 15 minutes was enough for the respondent to complete the questionnaire. A total of 43 elevator managers responded to the survey. The rate of response was about 5% of the elevators surveyed and varied from 3% in Montana to 8% in South Dakota. Only 40 surveys were usable.

EMPIRICAL MODEL

An empirical model was adapted from Hurburgh et al. (2004) to analyze the changes in costs due to segregation and testing practices. The model is developed as a stochastic simulation of an engineering cost model. Information gathered through the mail survey is used as inputs (both values and as distributions) for the engineering cost model. The model was simulated in *@Risk*™ (Palisade Corporation, 2000).

Input Definitions

Input costs included in this model are of various origins, but basically they can be divided into two major cost categories, grading and testing and handling and other operations. The input variable list is shown in Table 1.

Table 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

Variable	Symbol	Units
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
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	%

Grading and Testing

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 recordkeeping, check-testing and standardization of equipment, and dispute with seller. In Hurburgh’s original model, nine costs were included in the grading and testing category. Cost of test equipment and modifications of computer software are not considered in this study. Both of the costs are defined below along with the formula used for it derivation. Variable names are defined in Table 1.

The cost of “operator additional time” is a cost calculated by changes in testing time multiplied by the wage and converted to a per bushel basis. This cost implies that any new tests create extra work.

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

The cost of “data transmission and interfacing” includes the annualized data equipment cost plus repair cost on an after income tax basis. This cost accrues because new tests will require automated data handling.

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

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 testing is done at the scale. Sellers may have to wait additional time for tests to be completed before proceeding to the dump area.

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

The cost of “storage of samples” is 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.

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

The cost of “accounting and recordkeeping” estimates the additional accounting and recordkeeping expenses on a per bushel per record basis, after tax.

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

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 recordkeeping. The costs per bushel decrease with a larger load size. The additional work required will imply monitoring to maintain accuracy and will ultimately consume additional time and expense.

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

The cost of “dispute with seller” corresponds to the time the 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 decide not to adopt 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

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, loss in receiving capacity.

The cost of “additional waiting time at the dump” is not considered as a direct cost to the elevator but it reflects the additional expense for the customer that wait at the dump line.

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

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.

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

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. They are amortized just like the other capital costs.

$$C_{10} = \left[\mathrm{Pm} \left(\frac{a}{P} \right)_{n}^{t} + \left(1 - \frac{\mathrm{Ti}}{100} \right) \left(\frac{\mathrm{Prm}}{100} + \frac{I}{1000} \right) \mathrm{Pm} - \frac{D\,\mathrm{Pm}\,\mathrm{Ti}}{10000} \right] \frac{1}{\mathrm{Vt}} \qquad (10)$$ [2]

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.

$$C_{11} = \frac{F_{14}\,\mathrm{Vs}\,\mathrm{Pgs}}{100\,\mathrm{Vt}} \qquad (11)$$

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.

$$C_{12} = \frac{Pge \Delta P_{G}}{100} \qquad (12)$$

The cost of “addition of new storage space” is due to the fact that some elevators may need to build or purchase additional storage, as well as the related handling equipment. This cost is amortized after tax.

$$C_{13} = \mathrm{Ps} \left(\frac{a}{P} \right)_{n}^{t} + \left(\frac{\mathrm{Prs}}{100} + \frac{I}{1000} + \frac{\mathrm{Tp}}{1000} \right) \mathrm{Ps} \left(1 - \frac{\mathrm{Ti}}{100} \right) - \frac{D\,P_{S}\,\mathrm{Ti}}{10000} \qquad (13)$$

The cost of “loss in receiving capacity” is the opportunity cost related to slow-down which implies direct costs.

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

The model is an engineering-economic model that sums up various costs associated to segregation practices. The empirical model does not consider the cost of test equipment because it is assumed that strip-tests are done. The cost of computer software modifications used by Hurburgh et al. (1994) 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 2 is a summary of the fourteen different equations described previously.

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

Table 2. 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 recordkeeping
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

Other assumptions used in the model are discussed briefly. The gross elevator margin on generic grain is 8 c/bu as in the model used by Hurburgh et al. (1994). The amortization factor is assumed to be 0.1518, based on a 10-ten year useful life. All other tax rates applied in the model are the same as the ones used by Hurburgh et al. (1994). 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. The elasticity of total volume handled relative to dump time is 0.3%. The average number of segregations realized at the elevator level is set to four.

The value of time, in some cases, associated with segregation and testing practices, are also assumed. Customer waiting time for testing is equal to one minute per test, and accounting time for check-testing results is five minutes. These numbers are from Hurburgh et al. (1994) and they correspond to the values found in the literature. The value of customer time is fixed to $20 per hour. 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. (1994). The annual opportunity cost of storage volume is 25 c/bu 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 North Dakota Grain Inspection Service (NDGIS), provided some estimation of cost and percentages regarding testing practices. The cost of grading a submitted sample is $9 per test. According to NDGIS, 1% of samples are sent for check-testing and 3% are misgraded. These numbers are slightly smaller than the ones used by Hurburgh et al. (1994).

Stochastic Simulations Using *@Risk*™

The model was simulated within *@Risk*™ using distributions for several variables which were derived from responses to the survey. Those variables represented by distributions included times for testing, volume handled, percent of grain handled, number of bushels tested, and costs of modification. Responses to the survey for these variables were "fit" to distributions that best represented the data and utilized within the model. Distributions used and their parameters are shown in Table 3.

Table 3. Distributions Associated with Each Variable and Mean and Standard Deviation of Simulated Distribution

Variable	Distribution	Parameters	Mean	Std. Dev.
Time for "classic testing	Truncated Normal	(3;2) truncated at 0	3 min.	2 min.
Time for variety test	Triangular	(0; 4.5; 15)	6.5 min.	3.1 min.
Time for GM test	Exponential	(13.5) + shift(1.0357)	14.5 min.	13.5 min.
Total volume handled	Lognorm2	(14458; 1696)+ shift(44465)	8,020,269 bu	2.87E+07 bu
Percent of grain tested	Triangular	(0; 0; 1.00)	.33	.24
Number of bushels per test	LogLogistic	(1234; 725; 1.317) truncated at 150 and 5,000 bu	1138 bu	997 bu
Cost of modification	Logistic	(.20148; .51658) truncated at 0	.78	.63

* Shift indicates that a fixed value is added to the value estimated from distribution parameters that shifts the distribution rightward for positive shift values and leftward for negative shift values but does not alter the shape of the distribution.

Responses for times for "classic" testing before new tests (i.e., protein, moisture, test weight, dockage, vomitoxin, falling number and germination) were distributed normally with a mean of 3 minutes, a standard deviation of 2 minutes, and was truncated at zero. Times for variety testing were represented by a triangular distribution with a minimum value of 0 minutes, most likely value of 4.5 minutes, and a maximum value of 15 minutes. Time for GM tests were represented by an exponential distribution which reflected a mean value of 14.5 minutes and a standard deviation of 13.5 minutes.

Total volume handled was represented by a lognorm2 distribution with a mean of 8,020,269 bushels/year and a standard deviation of 28,700,000. The percent of grain tested was represented by a triangular distribution with a minimum value of 0 percent, a most likely of 0 percent, and a maximum of 100%. The number of bushels per test was represented by a loglogistic distribution and the cost of modification by a logistic distribution with a mean of .20 and a standard deviation of .52 and was also truncated at 0.

Three outputs were derived from the model. These include the total cost of segregation, the cost of modification, and the total cost of segregation. Models were simulated for 5,000 iterations, at which time appropriate stopping criteria were indicated. Sensitivities of segregation costs were evaluated for selected parameters including labor costs.

Results of the Survey

Characteristics of the Facility

Among the elevators that responded to the survey, physical characteristics vary. Results corresponding to these physical characteristics are in Table 4.

Table 4. Physical Characteristics

	# 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	55,000
Max	100	9	15	60,000	80,000	280	165	7,020,000

Note: The sign "#" in the following tables stands for "number of" and the abbreviation "bu" stands for "bushels."

The number of bins for an elevator ranged from 4 to 100, with a mean of 35. Table 5 shows that 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. 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 3. For the next category, the number of pits does not exceed 6. For facilities with a number of bins between 30 and 39, the number of pits goes up to 7. For elevators with the largest number of bins (40 or more), this number does not exceed nine.

Table 5. 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	

Facilities possess, on average, 2 satellite elevators but some elevators have none, while others have up to 15 satellites. The average receiving capacity (Table 6) is just below 19,000 bushels per hour; and it ranges from 1,500 to 80,000. The average loading (Table 7) capacity is the same (below 19 thousand bushels per hour), and the values range from 700 to 60 thousand bushels per hour.

Table 6. 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%

Table 7. 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%

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 and 15 thousand bushels. Eighteen percent of the respondents have a loading capacity of 15 to 25 thousand bushels, and these same elevators have an equivalent receiving capacity. Similarly, the 11 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 varies across elevators (from 2 to 280). For the track capacity, the average number of cars is 53 and ranging from 2 to 165. Thirty-two responses were obtained for the load-out capacity (Table 8) and 33 for the track capacity (Table 9).

Table 8. 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 9. 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 7 elevators, that have 50 to 99 cars per day as load-out capacity, have a track capacity of 50 to 99 cars. Similarly, the 9 elevators (28%), with 100 or more cars per day as a load-out capacity, are the same as the 9 (27%) with a track capacity of 100 or more cars.

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.

There is a large range of storage capacities. The mean capacity is 950 thousand bushels but ranges from 55 thousand bushels for the smallest, to more than 7 million bushels. In Table 10, the 40 elevators were classified into four separate categories, according to their size.

Table 10. 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%

About one-third of the elevators have a storage capacity between 100 and 500 thousand bushels and another one-third of the facilities is in the range of 500 thousand to 1 million bushels. There are 10 elevators (25%) with a storage capacity above 1 million bushels.

Total volume of grain handled ranged from 76 thousand to 26 million bushels, with a mean of 5 million bushels. Four categories were defined (Table 11).

Table 11. 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%

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. 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 12 provides a summary of these results.

Table 12. 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%
Ask for variety declaration	19%

These results show that 19% of the facilities are approved with ISO 9001 and 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. IP 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.

Only 18% of the elevators handle IP grains. Amongst these facilities, 57% use mechanisms as a proof for traceability and IP confirmation. Eighteen percent of the facilities ask for variety declaration; 86% of the elevators handle GM grains and only 22% of the facilities would have sufficient capacity to segregate 100% of a GM crop.

Segregation Practices at the Elevator Level

Some elevators segregate more than others. Table 13 classifies eleven elements that can be constraints to effective segregation. Each element can be a minor constraint, a major constraint, or not a constraint at all to segregation.

Table 13. Constraint to Effective Segregation

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

Data transmission, storage of samples, and accounting and recordkeeping are not considered as constraints to the implementation of segregation at the elevator level. 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.

Managers were also asked what their ideal or best segregation scenario would be. 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, managers would tend to segregate at least part of their grain.

One of the major constraints to effective segregation is related to the cost of this practice. Table 14 gives information on these costs related to segregation practices.

Table 14. Percentage and Costs Related to Segregation Practices

	% Grain segregated	Cost of segregation ($/bu)	Cost of modification ($/bu)
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. 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 c/bu, ranging from 2 to 30 c/bu. For large elevators that handle greater than one million bushels, the estimated cost of segregation is 6 c/bu and ranges from 1 to 20 c/bu.

Table 14 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/bu. The olympic average is equal to $0.08/bu with a standard deviation of $0.18/bu. 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/bu and ranges from $0 to $5.95/bu; whereas, for larger elevators the average cost of modification is $0.03/bu, with a maximum of $0.16/bu. The results from the survey also show that two-thirds (67% precisely) of respondents have modification costs.

Labor cost and the value of manager's time are given in Table 15. These 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 impacts the cost referred to as "cost of disputes."

Table 15. Labor Cost and Value of Manager's Time

	Value manager's 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/hr and it ranges from $0 to $100. Labor cost is $11/hr with a standard deviation of 7. This cost ranges from $1 to $28/hr.

Testing Practices at the Elevator Level

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 (Table 16). On average, elevator managers tested 93% of the deliveries but this ranges from 10% to 100%. Tests for vomitoxin and falling number are not as frequent, 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. The average number of bushels per test is 1,540, ranging from 150 to 5,000 bushels. The total number of bushels handled by the elevator has no influence on the volume represented per test.

Table 16. Percentages and Costs Related to Testing Practices

	% Deliveries tested for P.M.TW.D	% Deliveries tested for V.F#	Bushels represented per test	Average cost of test c/bu	% 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 cost of "conventional" testing (i.e., testing for protein, moisture, test weight, dockage, vomitoxin , and falling number) is 2.7 c/bu ranging from 0 to 25 c/bu**.** On average, 5% of samples are disputed.

Table 17 provides other details associated with testing practices such as: time for outside testing, time for "conventional" testing, time for testing including GM and variety, manager's time spent on disputes, accounting time, time putting grain in storage, and days the samples are kept in storage.

Table 17. Times Related to Testing Practices (in minutes or days if specified)

	Outside testing	"Conventional" testing	Testing including GM/Variety	Manager's 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

Outside testing takes 33 hours. Getting results for samples sent out for testing usually takes between one and two days. "Conventional" testing only takes, on average, 3 minutes. When testing for GM and variety are added, the time required for doing the testing is 8 minutes. Managers spend on average 15 minutes on disputes. Additional accounting implied by testing practices takes 10 minutes, but never exceeds half an hour. The time spent putting samples in-store ranges from 0 to 150 minutes with a mean of 17 minutes. Finally, samples used for testing are kept in-store for a given number of days (70 days on average). Depending on the facility's policies, this time in-store can go up to 2 years. Keeping samples in-store is costly but provides the elevator with a back up 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 2 shows the location of tests for each category.

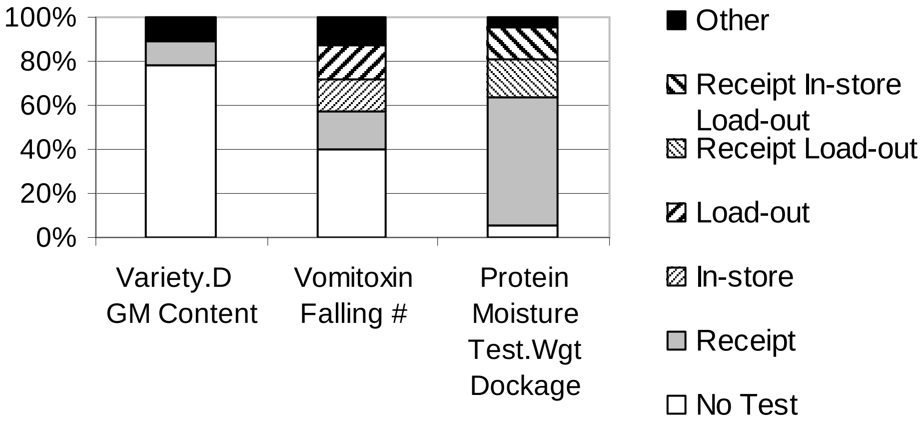

Figure 2. Test Location

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. Other tests (protein, moisture, test weight, and dockage) are realized 95% of the time: 60% at receipt, 15% at load-out, 15% at receipt, in-store, and at load-out, and the rest is realized at another location.

GM content is more often sent out to be tested (Table 18), 57% compared to 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. On average, GM content is more likely to be tested out.

Table 18. GM Test Realized In-house or Sent Out to be Tested

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

Handling of GM Crops and Variety Declaration

Table 19 gives the number of bushels of various GM varieties handled by the different elevators. Five GM varieties were handled: Roundup Ready® corn, Bt® corn, Liberty® corn, Roundup Ready® soybeans, and Roundup Ready® canola.

Table 19. 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	10	5	4	3
Max	8,000	12,000	3,200	5,000	2,500

GM corn is the most widely handled. For facilities that handle Bt® corn, the volume handled is on average 1.4 million bushels, but ranges from 10 thousand to 12 million bushels. The average volume of Roundup Ready® handled is about 900 thousand bushels. This volume is just above 500 thousand bushels for Liberty® corn, almost 1 million bushels for Roundup Ready® soybeans, and above 800 thousand bushels for Roundup Ready® canola.

Table 20 shows the share of Non-GM corn in the total volume of corn handled by these elevators. First, 33% of the corn handled is Non-GM, the remaining two-thirds being GM. Only 16% of the soybeans and 10% of the canola handled are Non-GM.

Table 20. Percentage of Non-GM

	Corn	Soybeans	Canola
	----------------------percent----------------------		
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 c/bu, but varies from 0 to 30 c/bu. Even though this result cannot be considered representative of all elevators, it gives an estimation of the premium received for specialty grain.

Another element of importance for end-users is the variety. Table 21 shows the percentage of each crop for which a variety declaration was requested. For 34% of the soybeans delivered, a variety declaration was requested at delivery, 47% for wheat, 34% for corn, 66% for barley, and 67% for other crops (such as canola or oats).

Table 21. Percentage of Each Crop for Which Variety Declaration is Asked

	Soybeans	Wheat	Corn	Barley	Other
	--percent--				
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

The 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.

Finally, the survey sought to estimate the influence of different factors on the facility's policy to handle a GM crop. These factors included: 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 handling of a 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 it is.

Additional testing and segregation of differentiated quality grains for individual end-uses impose an additional cost for grain handlers. One concern is about the cost of underutilizing the space at their facility. New segregations may lead to loss in the utilization of their storage capacity.

Results and Sensitivities on Cost of Segregation

This section presents results from the empirical model. First, the correlations among important variables are described, then the cost analysis is detailed, and finally the impact of labor cost on the total cost of segregation is discussed.

Correlation

A correlation matrix was estimated 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 of 0.48 between the total volume handled and the number of bushels represented per test. This is the only statistically significant correlation.

Analysis

The distribution of segregation costs are shown in Figure 3.This figure shows that 90% of the time, the total cost of segregation is less than 50 c/bu and 50% of the time, this total cost is equal or less than 20 c/bu. The cost of modification has a large impact on the total cost of segregation. Assuming no modification of the facility, the total cost of segregation is less than 8 c/bu 50% of the time. This cost does not exceed 13 c/bu 75% of the time, and 90% of the time the total cost of segregation less modification costs is less than 25 c/bu.

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% for grading-related costs. Amongst the handling costs, the cost of modification is by far the greatest, followed by the cost of underutilized storage, and the cost of adding 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 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.

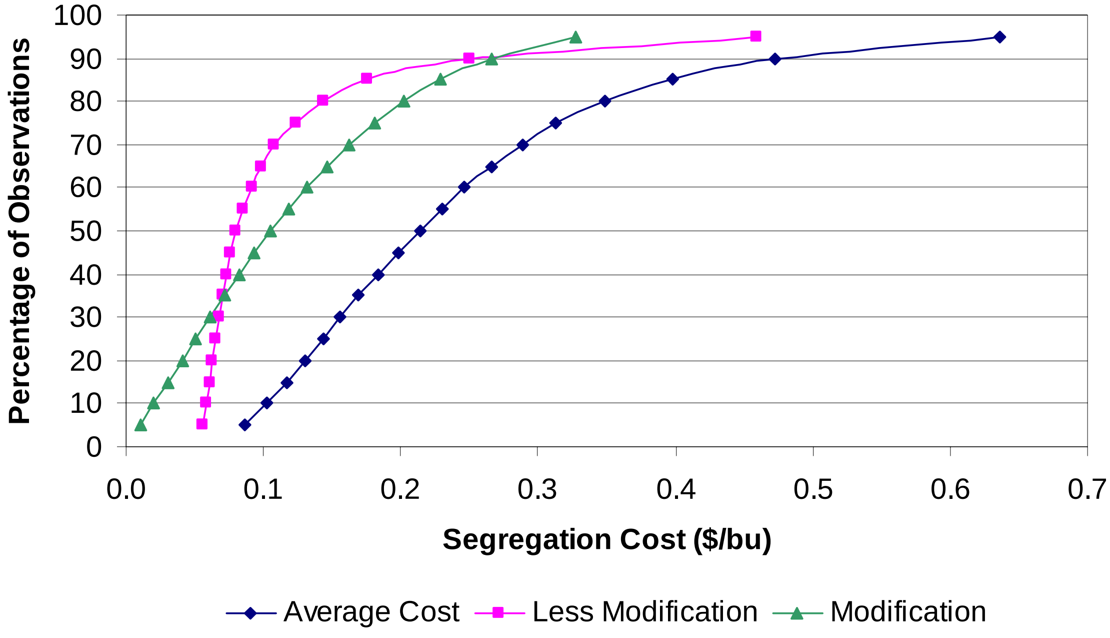

Figure 3. Impact of Modification Costs on the Total Cost of Segregation

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 95%, so costs are almost entirely based on total volume tested. Costs of operator time, waiting time, accounting and recordkeeping, check-testing of equipment, and disputes with 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. Figure 4 shows the cost of segregation versus the total volume handled. 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 c/bu to 13 c/bu. With a volume of grain handled equal to 200 thousand bushels, the cost of segregation decreases to less than 11 c/bu. To summarize, the total cost of segregation decreases sharply as the volume of grain handled increases, but only to a certain point. For a volume of grain handled equal to 400 thousand bushels, the cost of segregation is 10 c/bu. The cost of segregation does not go below 10 c/bu even with a volume handled equal to 1 million bushels. This level of total cost of segregation equal to 10 c/bu 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 greater than 500 thousand bushels. In the survey, grain elevator managers estimated this cost of segregation to 8 c/bu. The results of the simulation show that this cost is slightly greater.

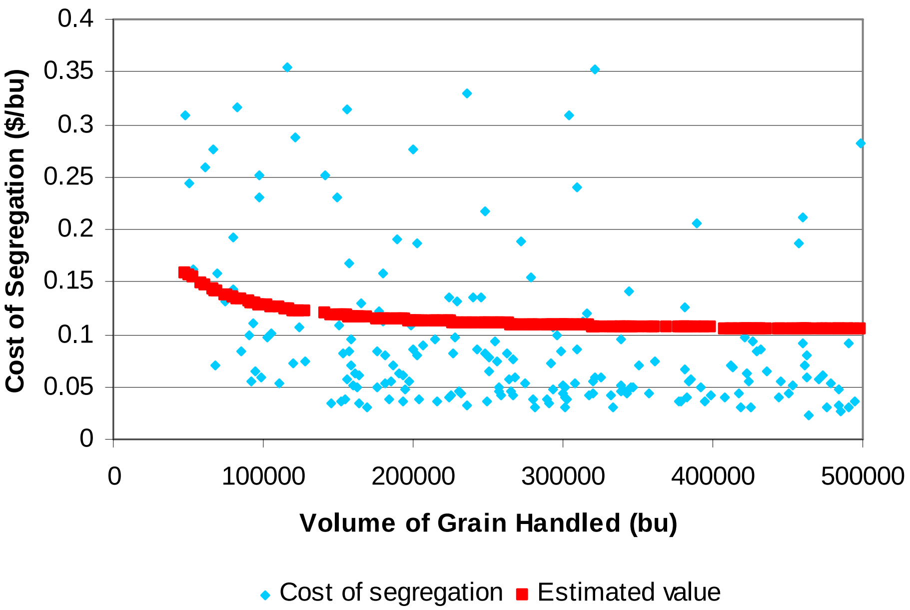

Figure 4. Average Cost of Segregation Versus Changes in Volume of Grain Handled

Figure 4 shows that most of the observations are clustered at values between 5 and 10 c/bu 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 c/bu.

The cost of segregation versus changes in volume of grain tested is shown in Figure 5. The volume of grain tested corresponds to the percentage of grain tested times the total volume of grain handled. There are a few values that are disproportionately greater than the average. Most observations crowd together around 10 c/bu.

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 10 thousand bushels to 50 thousand bushels, decreases the total cost of segregation from 40 c/bu to 16 c/bu. With a volume of grain tested equal to 100 thousand bushels, the total cost of segregation comes down to less than 13 c/bu. 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 c/bu even with a volume tested equal to 1 million bushels.

This level of total cost of segregation equal to 10 c/bu seems to be achievable by a large number of elevators. 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 c/bu). In other words, most grain elevators should be able to segregate at a moderate cost.

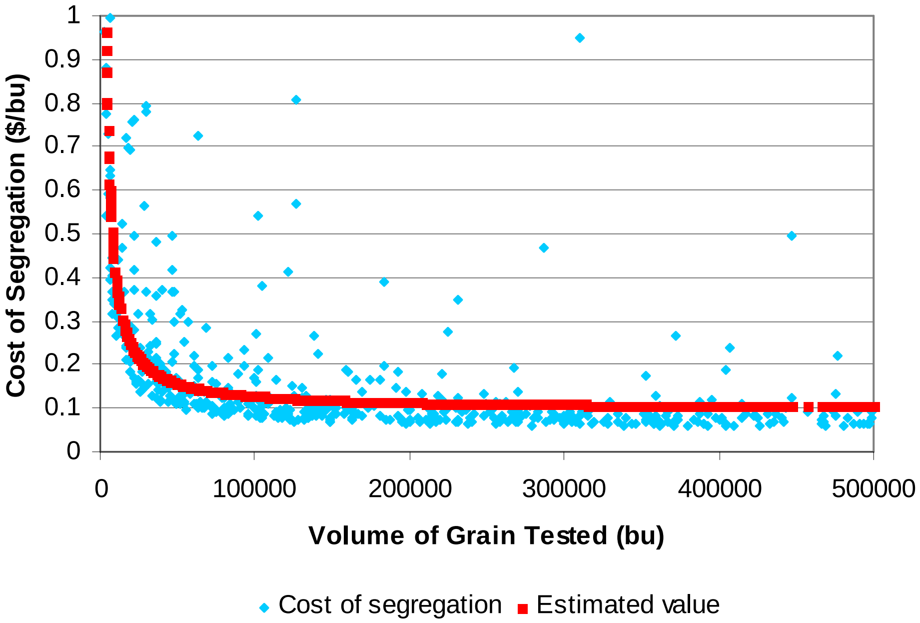

Figure 5. Average Cost of Segregation Versus Changes in Volume of Grain Tested

Figure 6 shows which variables (inputs) have the greatest impact on the total cost of segregation (output). This graph confirms that the cost of modification, the volume of grain handled, and the volume tested are the three most important variables affecting the total cost of segregation. The cost of modification is the variable with the greatest influence on the total cost of segregation. The correlation factor is equal to 0.76. 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 handled. The greater the volumes handled and tested, the lower the total cost of segregation.

Hurburgh et al. (1994) 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 5 c/bu, between 5 and 10 c/bu, between 10 and 20 c/bu, and finally elevators that can segregate for 20 c/bu or more. Figure 7 shows the variability in the storage volume for each of these four categories.

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 19 million bushels segregate at a cost less than 5 c/bu. Elevators with a storage capacity superior to 16 million bushels will be able to segregate for less than 10 c/bu, and elevators with a storage capacity greater than 6 million bushels will most probably be able to segregate for less than 20 c/bu. These results show that larger elevators would tend to segregate at a lower cost than smaller elevators.

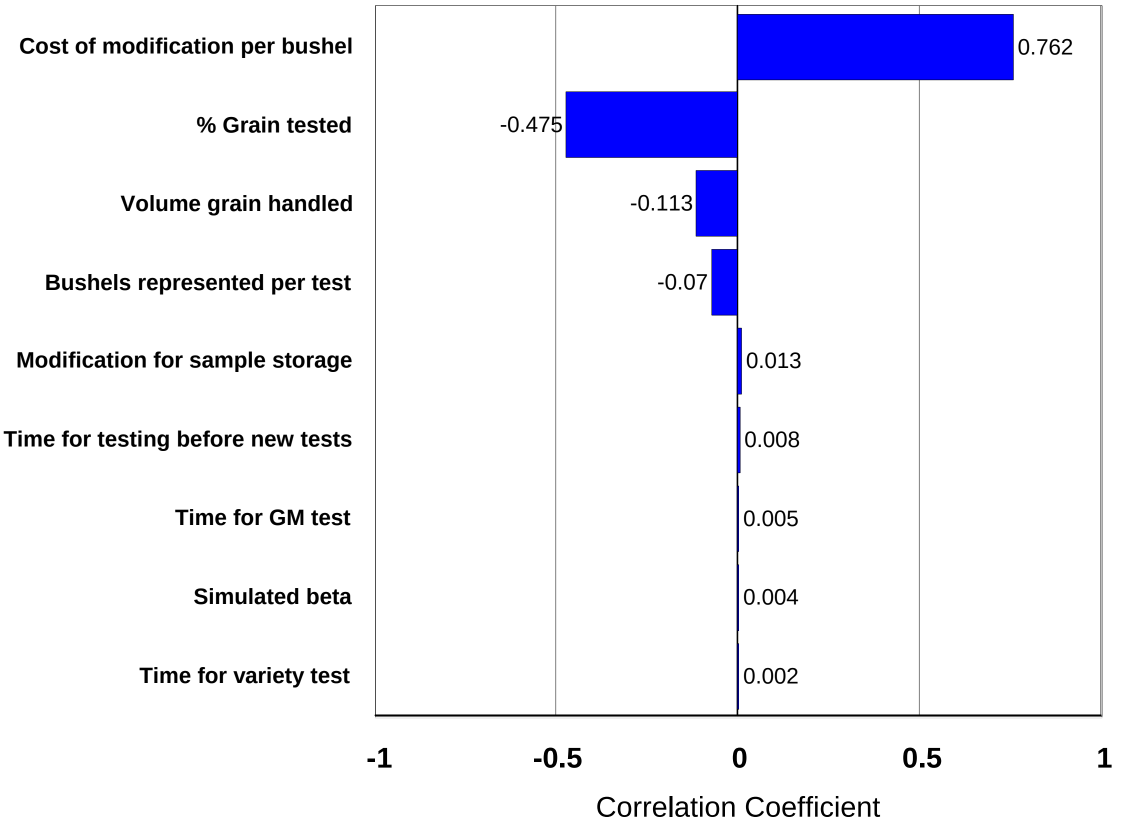

Figure 6. Tornado Graph Illustrating Correlations Between Input Variables and Total Cost of Segregation

Impact of Labor Cost

Simulations were used to analyze the impact of labor on segregation costs. Five different labor costs were used: \$5, \$10, \$15, \$20, and \$25/hr. Figure 8 shows how the total segregation cost varies as labor cost changes. It is clear that greater labor cost implies higher cost of segregation (less modification). For each additional \$5/hr in labor cost, the curve shifts to the right. On average, when labor cost increases by \$5/hr, the total segregation cost (less modification) increases by half a cent.

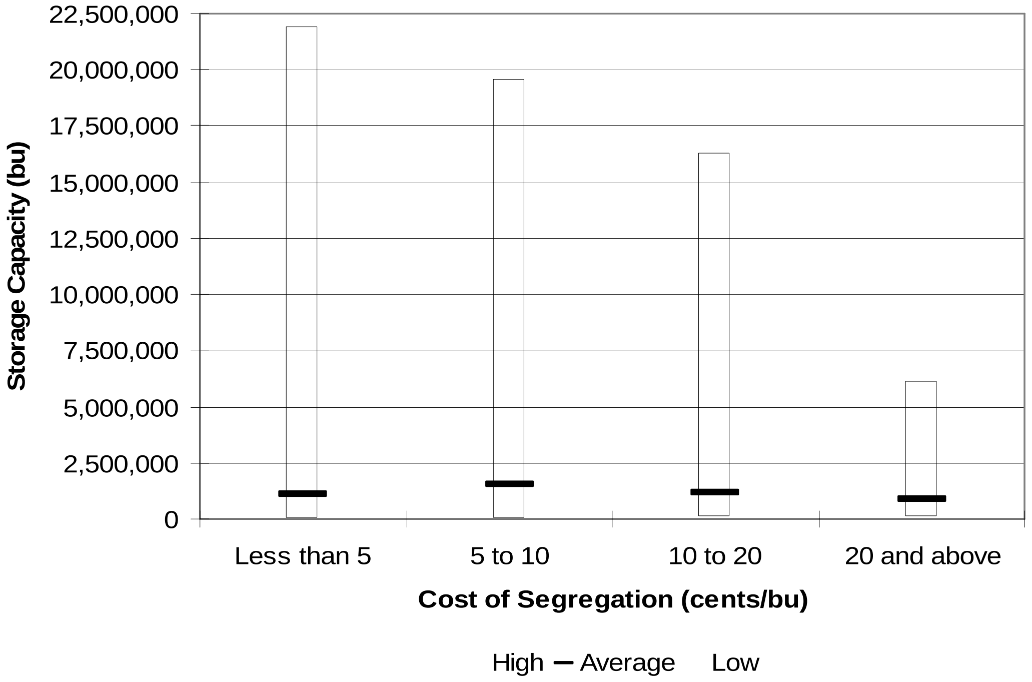

Figure 7. Variability in Storage Capacity with Regards to Cost of Segregation

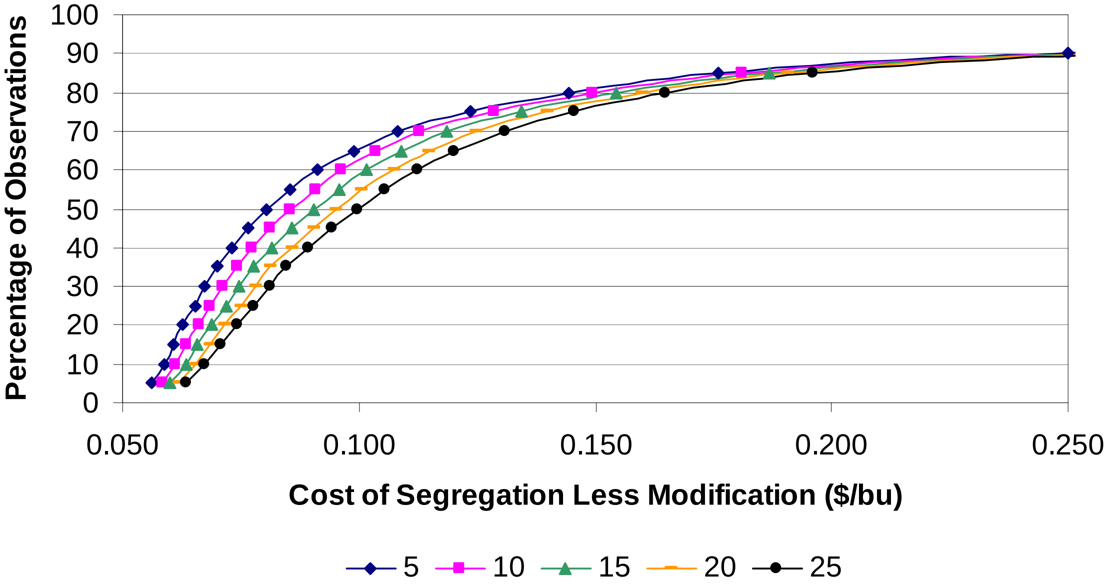

Figure 8. Impact of Different Labor Costs on the Cost of Segregation

SUMMARY AND CONCLUSIONS

The advent of GM grain has important implications for crop producers and grain handlers. Even though many grain handlers are already confronted by issues related to IP, segregation, and/or testing, the impact of such a marketing mechanism on their activity will still be huge. The main impact is the increase in the costs of production due to these new practices. One objective of this study was to document current segregation practices at the elevator level. A survey of grain handlers in the Upper Midwest was realized. The second objective was to analyze changes in costs due to these new segregation practices. Total cost of segregation was calculated and stochastic simulations were conducted to see the impact of random variables on this total cost.

About 20% of elevators are approved with ISO and/or HACCP, and up to 10% of the elevators that are not yet approved, by either one of these certifications, said they anticipate getting their facilities approved. About 18% of the respondents handle IP grains and amongst these, 57% use mechanisms (e.g., U.S. Department of Agriculture or the state seed department) as a proof for IP confirmation. Eighty-nine percent of the facilities handle GM grains. Only 23% have sufficient capacity to segregate 100% of GM crops. Less than 20% of the respondents ask for farmers to declare the variety they are delivering.

Results show that there are two major constraints to effective segregation. These 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. Elevator managers report that the constraint to effective segregation is a physical constraint and imply that they will have to modify their facilities in order to segregate and that these changes have a significantly high cost. The average cost of modification is \$0.78 per bushel or about \$200,000 per elevator. Another result 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 13% would not segregate at all.

The estimated cost of segregation given by the elevator managers is 7 c/bu, plus or minus 7 c/bu. The estimated cost of segregation is smaller for large elevators (6 c/bu) than for small elevators (12 c/bu). The large elevators also have a smaller cost of modification than smaller elevators.

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. Five percent of the samples are said to be disputed and the average cost of test is 2.7 c/bu but it can get as high as 25 c/bu. Adding a test for GM content and/or variety would increase the time required to do the testing. When a test is conducted in-house, it is 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.

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. 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.

Summary of the Model's Results

Modification cost has a huge impact on the total cost of segregation. Assuming there is no modification, the cost of segregation is less than 10 c/bu for 65% of the observations. If the cost of modification is included, then the total cost of segregation is less than 22 c/bu for 50% of the observations.

Costs related to handling and other operations correspond to 90% of the total cost of segregation when 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. As volumes handled or tested increase, the total cost of segregation decreases sharply. A simulation shows that with a volume handled and/or a volume tested equal to 100 thousand bushels, the total cost of segregation (without modification) does not exceed 13 c/bu. 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. An increase of $5/hr in the labor cost increases the total cost of segregation by half a cent. This is quite significant in terms of handling so segregation may be harder to implement at elevators where the cost of labor is high.

This research shows that segregation practices are already implemented at most 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 cost of modification is a major constraint to actual segregation. The average cost of segregation is 8 c/bu assuming no modification and 22 c/bu if some modifications have to be done.

This study also demonstrates that the volume of grain handled and tested are important factors for segregation. It seems it is easier for large elevators to segregate than for elevators of smaller size. The estimated cost of segregation for small elevators is 12 c/bu and only 6 c/bu for large elevators. These estimated costs of segregation are substantially lower than what is found in the literature. Miranowski et al. (2004) obtained a cost equal to 31 to 34 c/bu. Maltsbarger and Kalaitzandonakes (2000) estimated the cost of segregation between 13.4 and 36.6 c/bu, and Reichert and Vachal (2000) found that the estimated cost of segregation was 33 c/bu.

Problems or issues related to segregation are the center of many discussions in the grain handling industry. Failure or success of segregation and testing systems is dependent upon the ability of elevators to implement such systems at the 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.

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