

Cost of Segregating Non-transgenic Grains at Country Elevators in South Dakota

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Abstract

Genetically modified grains have rapidly become popular among producers across U.S. Some consumers, particularly in the EU, South Korea, and Japan, are unwilling to purchase products containing ingredients from genetically modified or transgenic crops. This paper develops a model to represent costs of segregating non-transgenic grains at country elevators and simulates these costs at representative elevators in South Dakota under alternative scenarios employing a case study approach. The overall cost of segregating non-transgenic grains under a zero rejection rate ranged from 1.5 to 21.7, 1.2 to 11.3, and 1.3 to 16.4 cents per bushel, for corn, soybeans, and wheat, respectively.

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The three most important crops grown in South Dakota are soybeans, corn, and wheat. In 2002, South Dakota ranked seventh in terms of corn, eighth in soybean, and 11th in wheat production among all crop producing states. Jointly, these three crops accounted for more than three-quarters of the state's cash receipts from marketing crops in 2002 (South Dakota Agricultural Statistics Service, 2003). The heavy reliance on grain production requires an efficient and dynamic grain handling system, and the state's economic vitality depends in part on the ability of the grain handling system to adapt to changing market conditions and to stay competitive.

South Dakota's grain handling industry has changed over the last half-century. The number of commercial grain elevators in the state decreased considerably, and the average capacities and transportation capabilities of existing facilities have increased over the last three decades. These trends are in line with the American grain handling industry as a whole, which is geared to moving large quantities of bulk commodities efficiently.

South Dakota leads the nation in the adoption of transgenic corn and soybean varieties at the farm level (U.S. Department of Agriculture, 2002). Many consumer groups, however, are unwilling to purchase products containing ingredients from genetically modified or transgenic crops (Gaskill, 2000). In response, governments around the world are considering how to approach the issue of transgenic grains. For example, in 2000, the EU mandated that products containing more than one percent genetically modified (GM) material be labeled as such (Rousu, *et al.*, 2002). Thus, consumer reluctance to accept transgenic products and their governments' responses may lead to a market system where non-transgenic grains are handled and processed separately from commodity grains that may contain transgenic material.

The possible establishment of segregated markets for non-transgenic and commodity grains have important implications for South Dakota grain elevators. Keeping non-transgenic grains separate commodity lots by way of segregation or identity preservation requires producers, handlers, and processors to implement a system to assure the integrity of the final product. This process involves increased costs at all levels of the marketing chain.

Lin (2002) reported that the demand for both non-transgenic corn and soybeans accounted for one to two percent of the total U.S. production of corn and soybeans in 1999, respectively. The largest shares of the demand for these two non-transgenic crops were from Japan and the EU. Although the non-transgenic corn and soybean markets remain relatively small, some U.S. processors have adopted a policy of not accepting transgenic corn varieties that are not approved by the EU. These processors fear transgenic contamination would compromise their export market (Lin, 2002).

In 2001, less than four percent of South Dakota elevators participated in segregating or identity preservation of corn and soybeans. The bin space utilization, lack of sufficient premiums, and cross-contamination concerns were the major factors influencing the elevator manager's decision to not to participate in grain segregation. However, the managers of a one-third of grain elevators in South Dakota indicated that they could physically segregate their storage capacity into units dedicated to at least four different types of grain (Qasmi, *et al.*, 2003).

Price premiums serve as compensation for additional costs involved with segregating non-commodity grains, over and above the usual costs incurred with handling conventional commodity. In 2000, common price premiums to crop producers ranged from \$0.05 to \$0.10 per bushel for segregated non-transgenic corn and \$0.10 to \$0.15 per bushel for segregated non-transgenic soybeans (Lin, 2002). The premiums tended to increase with more restrictive

tolerance thresholds, allowing buyers to accept with a greater degree of certainty that no genetically engineered product would be present.

The objective of this study is to estimate the additional costs of handling segregated non-transgenic corn, soybeans, and wheat at country elevators in South Dakota. We develop a model to depict these costs, select six representative grain elevators located in various parts of the state, and simulate the additional costs of segregating non-transgenic grains at these elevators under alternative scenarios. We conclude by discussing implications for grain elevator managers.

Previous Work

In efforts to estimate additional cost of handling identity preserved (IP) grains at three elevators located in Illinois and Missouri, Maltsbarger and Kalaitzandonakes (2000) developed an elevator asset configuration module to represent the elevators' physical infrastructures. Their results indicated that the cost of handling IP grain at the most efficient of the three elevators studied ranged from \$0.16 to \$0.27 per bushel under different scenarios. The presence of several small bins at this elevator provided flexibility and allowed the manager to participate in IP without sacrificing much storage space. Herrman, *et al.* (1999) conducted an economic engineering study of country elevators in Kansas regarding the feasibility of segregating different varieties of non-transgenic wheat. They estimated that in case of an average harvest, the cost of segregating two wheat varieties ranged from \$0.019 to \$0.056 per bushel, depending upon the facility configuration and burden rates (total quantity handled in a year divided by the storage capacity of the facility). High burden rates – indicating higher operating efficiency – resulted in low segregation costs. The cost of segregating three varieties of wheat ranged from \$0.019 to \$0.065 per bushel. Dahl and Wilson (2002) examined identity preservation in the North Dakota

wheat market. Their study focused on the prospective additional costs of IP sales and their allocation across market participants (producers, grain handlers, and millers).

In sum, these three studies indicate that lost margin revenues from not handling commodity grain potentially account for a large portion of the costs of segregating non-commodity grain among elevators. Also, the available quantity of specialty grain is important. That is, the more specialty grain available, the lower the overall cost of segregating IP and non-transgenic grains. The three studies further suggest that bin configuration plays an important role in any type of grain segregation. Facilities with several small storage units are potentially more efficient in handling segregated non-transgenic grains than those having only large storage units. Although large facilities with large bins face a high likelihood of underutilizing storage space, they often have more receiving points. Multiple receiving points allow for more flexibility and fewer bottlenecks when unloading grain trucks during peak seasons. Due to their flexibility and relatively high operating efficiencies, large facilities are able to efficiently handle segregated grains if sufficient quantities of these specialized grains are available.

Segregation Cost Model

Costs related to testing and segregating non-transgenic grains from other grains at country elevators can be broken into boot cleaning costs, additional probing costs, sample testing costs, and lost storage opportunity costs.

Boot Cleaning Costs. These are costs associated with sweeping the grain boot and cleaning the conveyer system prior to unloading grain trucks containing the non-transgenic lot, to remove any grain left from the preceding lot that may contain transgenic material. Assuming this cleaning process is performed prior to every 800-bushel truck of non-transgenic grain and

that it is similar for all three non-transgenic grains (corn, soybeans, and wheat), the boot cleaning cost is as follows.

$$BCC_i = LB_i * \left(\frac{W}{60}\right) * \left(\frac{1}{800}\right) \quad (1)$$

Where BCC_i = Boot cleaning cost (in cents/bu.) for grain i ,
 LB_i = Labor for boot cleaning in minutes for grain i ,
 W = Wage rate (in cents per hour), and
 i = 1, 2, 3 denoting non-transgenic corn, soybeans, and wheat, respectively.

Additional Probing Costs. Elevators routinely take two probes from an 800-bushel semi-truck (one probe for each of the two 400-bushel compartments) to obtain a representative sample of the lot to test for moisture content, foreign material, and broken kernels. To obtain a sample for genetic testing, the Federal Grain Inspection Service recommends that two sample probes be taken from each compartment of a hopper-bottom truck or container (U.S. Department of Agriculture, 2003). The cost of collecting these two additional sample probes per 800-bushel truck is the additional probing cost of segregating non-transgenic grain. Because not all lots tested may pass as non-transgenic at the specified confidence level and threshold, a rejection rate other than zero increases the additional probing cost per bushel as follows.

$$APC_i = LP_i * \left(\frac{W}{60}\right) * \left(\frac{1}{800}\right) * \left(\frac{1}{1-r_i}\right) \quad (2)$$

Where APC_i = Additional probing cost (in cents/bu.) for grain i ,
 LP_i = Labor for probing in minutes for grain i ,
 W = Wage rate (in cents per hour),
 r_i = Rejection rate for grain i , and
 i = 1, 2, 3 denoting non-transgenic corn, soybeans, and wheat, respectively.

Sample Testing Costs. Scientific testing to detect the presence of perpetrating genes or related proteins is often necessary to substantiate a claim that a particular lot of grain does not

contain GM material beyond the specified threshold. These costs include those associated with the testing kits and labor involved in testing. Here we assume that the genetic testing is done on-site using a protein assay test, commonly known as lateral flow tests.¹

Genetic testing involves preparation, handling of the test kits, and waiting for the development of results. Preparation time for conducting these tests varies depending upon the type and number of tests conducted on a given sample. Lateral flow strip tests require sub-samples of grain to be ground in a food processor for varying amounts of time, depending on the type of grain, non-transgenic threshold, and the desired confidence level. In some cases, multiple genetic tests are needed to either detect more than one transgenic trait (event) or to increase the confidence level that a particular lot of grain does not contain transgenic material at or exceeding a specified threshold. The more restrictive confidence and threshold levels usually call for more replications of the tests increasing the cost of test kits and the labor involved in these tests. Grinding appliances need to be thoroughly cleaned before grinding each new sub-sample, even if the preceding and following sub-samples are from the same lot of grain.² Additional labor is involved in handling test kits, waiting for, and recording the results from each test. As in the case of additional probing costs, a rejection rate other than zero will increase sample testing costs per bushel. Assuming all non-transgenic grains are delivered in 800-bushel trucks, the sample testing cost will be as follows.

$$STC_i = \left(TKC_i + (LCG_i + LG_i + LKH_i + LWR_i) * \frac{W}{60} \right) * \left(\frac{1}{800} \right) * \left(\frac{1}{1-r_i} \right) \quad (3)$$

Where STC_i = Sample testing cost (in cents/bu.) for grain i ,

¹In extraordinary cases, it may be necessary to have a grain sample sent to a laboratory for more sensitive analysis involving the polymerase chain reaction (PCR) test, requiring several days until the results are returned (Lin, *et al.*, 2000). On balance, on-site lateral flow tests are more practical at the elevator level. Lateral flow strip test kits are easily available for use at the elevator and are recommended for export shipment analysis.

²However, if multiple kinds of genetic tests are being conducted on the same lot of grain, the same grind can be used.

TKC_i = Testing kit cost (in cents) for grain i ,
 LCG_i = Labor for cleaning grinder for grain i ,
 LG_i = Labor for grinding samples for grain i ,
 LKH_i = Labor for kit handling for grain i ,
 LWR_i = Labor for waiting and recording results for grain i ,
 W = Wage rate (in cents per hour),
 r_i = Rejection rate (proportion of lots failing the tests), and
 i = 1, 2, 3 denoting non-transgenic corn, soybeans, and wheat, respectively.

Lost Storage Opportunity Costs. Grain elevators segregating non-transgenic grains from commodity grains will use separate storage bins dedicated for storing the non-transgenic grains. Depending upon non-transgenic grains availability to the elevator and storage bin capacity for bins dedicated to store non-transgenic grains, the elevator may encounter underutilization of storage bin space. Any unused storage capacity in bins set aside for non-transgenic grains will constitute opportunity costs to the elevator if conventional commodity grain arrives at the elevator in excess of its allocated storage capacity and is either turned away or stored in outdoor piles. Piling grain outdoors often requires some sort of covering, may result in some spoilage, and will involve additional handling.

The opportunity costs of lost storage space is reflected in a reduction in the net margin per bushel of either commodity grain that had to be turned away, or the commodity grain that had to be piled outside while bins designated for non-transgenic grains remain at less than full capacity. In either case, the opportunity cost associated with the lost storage space is limited by the amount of empty space in the non-transgenic bin where the commodity grain could otherwise have been stored. The lost storage opportunity cost for non-transgenic grains will be as follows.

$$LSOC_i = \text{Min}[(SD_i - TQ_i), (TQ_j - SD_j)] * \left(\frac{NM_j}{TQ_i} \right) \text{ if } (TQ_j - SD_j) > 0 \text{ else } 0 \quad (4)$$

for $(i=1, j=4)$; $(i=2, j=5)$; and $(i=3, j=6)$

Where $LSOC_i$ = Lost storage opportunity cost (in cents/bu.) for grain i ,

- SD_i = Storage capacity (throughput in bushels) dedicated for grain i,
 TQ_i = Total quantity (bushels received) of grain i,
 TQ_j = Total quantity (bushels received) of grain j,
 SD_j = Storage capacity (throughput in bushels) dedicated for grain j,
 NM_j = Net margin of the elevator (a decrease in the net margin when the elevator can pile additional grain, in cents/bu.) for grain j,
i = 1, 2, 3 denoting non-transgenic corn, soybeans, & wheat, respectively,
and
j = 4, 5, 6 denoting commodity corn, soybeans, and wheat, respectively.

The combined additional costs per bushel of handling non-transgenic grains separated from other grains can be obtained by simply adding the four components.

$$TAC_i = BCC_i + APC_i + STC_i + LSOC_i \quad (5)$$

Where TAC_i = Total additional cost (in cents/bu.) for handling grain i.

Research Method

The cost of segregating non-transgenic grains varies by elevator, and depends on its physical infrastructure, quantities of different grains handled, testing regime, threshold level, statistical confidence level, and the rejection rate for the lots tested. To ensure that these costs were simulated under conditions similar to those faced by grain elevators operating in South Dakota, we adopted a case study approach. This approach involved selecting representative elevators, specifying alternative scenarios with regards to the expected and actual quantities of different grains handled by the elevators, specifying appropriate testing regimes determining the threshold level, statistical confidence level, and the rejection rate.

Selecting Representative Elevators. We selected six representative grain elevators located across the state, ranging from small to large in terms of storage capacity. Each elevator operated industry-standard equipment such as bucket elevators and drag chain conveyor systems connecting primary dumping pits to various storage units, and each facility selected handled at

least one of the three primary grains (corn, soybeans, or wheat) produced in South Dakota during calendar year 2001.

Elevator-specific data required for the cost simulation model was collected through on-site interviews with facility managers. In particular, we collected information about each elevator's storage units, capacity and configuration, number of dumping pits, its ability to pile grain outdoors, and its total throughput of different grains handled during the calendar year 2001. The interviews also provided information on the estimated average net margins for handling different commodity grains, additional costs of piling grain outdoors, wage rates, and the receiving area cleaning time, grain boots, conveyer systems, and collecting sample probes. Profiles of these selected case elevators are documented in Table 1.

Specifying Alternative Scenarios. To segregate non-transgenic grains, an elevator needs to dedicate a set of storage bins for different non-transgenic grains and commodity grains based on the expected quantities of each type of grains. Once different bins are dedicated to handle non-transgenic or commodity grains, the segregation costs depend on the quantities of different types of grains arriving at the elevator. We assumed that each selected elevator expected 20% of each grain handled during 2001 would be non-transgenic and the remaining 80% to be commodity grain.³ We further assumed that each storage bin at an elevator has a turnover rate equal to the average turnover rate for all storage bins at the elevator during 2001.⁴ The needed storage space dedicated for each type of non-transgenic grain was calculated by dividing the

³ Lin (2002) reported that the demand for non-transgenic grain constituted about 1% to 2% of corn and 2% to 3% of soybean production in the United States during 1999. For a widespread adoption of segregating non-transgenic grains, the market demand for non-transgenic grains will need to expand significantly. Even then, only a small fraction of grain elevators are likely to participate in a segregated non-transgenic grain market. Thus, if an elevator is to participate, its management expects a larger grain proportion to be non-transgenic. Under these circumstances, we assume that participating elevators would expect 20% of their grain handled would be non-transgenic.

⁴ We assume the annual turnover rate for storage bins to remain the same irrespective of whether handling only commodity grain or both non-transgenic and commodity grains. In some cases, the turnover rates may be lower for bins dedicated to handling non-transgenic grain.

expected quantities by the average storage turnover rate for the elevator during the year 2001 (Table 2).

In practice, however, elevator managers do not have perfect information, and actual quantities of different types of grain received may deviate from their expected quantities due to varying harvest yields and loss of business to competing elevators. Such quantity deviations may affect the cost of segregating non-transgenic grains. To allow for these deviations we specified six alternative scenarios, listed in Table 3.

Specifying Testing Regimes. Testing regime deals with the test types and the number of replications for each test, which, in turn, depend upon the events (different genetic materials) for which the sample is tested, the threshold levels of tolerance for these materials, and the levels of statistical confidence. For this study, we identified five transgenic grains of interest to the South Dakota grain handling industry.⁵ They are glyphosate-tolerant or Roundup Ready® corn; Cry9C Bt9 or YieldGuard Corn Borer® corn resistant to the European corn borer and engineered with a *Bacillus thuringiensis* (Bt) gene; Cry3Bb or YieldGuard Rootworm® corn resistant to rootworm; glyphosate-tolerant or Roundup Ready® soybeans; and glyphosate-tolerant or Roundup Ready® wheat. Roundup Ready® corn, YieldGuard Corn Borer® corn, and Roundup Ready® soybeans are commercially available and widely grown in South Dakota and elsewhere in United States. Further, Strategic Diagnostics, Inc. (SDI) has developed test kits for these transgenic grains (SDI, 2003). The presence of Roundup Ready® corn and Roundup Ready® soybeans can be tested by RUR lateral flow test kits while the presence of Cry9C Bt9 corn can be tested by using Bt9 test kits. YieldGuard Rootworm® corn was still in development at the time of this study,

⁵ For a comprehensive database of all transgenic grain varieties and their international approval status, see the website of Agbios (www.agbios.com).

but its commercial release may be near. SDI has already developed a lateral flow kit to test for the Cry3Bb protein found in Yield Guard Rootworm® corn.

Facing resistance from some consumer and producer groups, Monsanto recently abandoned its plan for worldwide commercial release of Roundup Ready® wheat.⁶ If Roundup Ready® wheat were to be commercially released in the future, the RUR lateral flow test for Roundup Ready® wheat – similar to the one for Roundup Ready® soybeans – can be used to test for the presence of this transgenic wheat.⁷ Methodology and cost estimates of segregating non-transgenic wheat reported here can easily be adopted for other types of transgenic wheat if and when such varieties are commercially released.

Common thresholds used by elevators conducting genetic testing are 1% and 0.5%, which indicate the presence of a transgenic material not exceeding 1% and 0.5% levels, respectively (SDI, 2003). Common confidence levels used are 95% and 99%. Most likely, elevators will use a threshold of 1% and confidence level of 99%. This is partly due to labeling requirements in most EU countries specifying that food products containing 1% or more transgenic material be labeled as such (Rousu, *et al.*, 2002). To test corn at a 1% threshold and 99% level of confidence, SDI recommends the use of three test kits (for the presence of each of RUR, Bt9, and Cry3Bb). Similarly, for testing soybeans or wheat at a 1% threshold and 99% confidence level, SDI recommends the use of two RUR test kits. Changing the threshold or confidence level may require changing the number of test kits. SDI's recommendations for the number of test kits for alternate threshold and confidence levels are listed in Table 4.

⁶ Monsanto's decision not to introduce the world's first GM wheat followed pressure from U.S. and Canadian farmers fearing the introduction of GM wheat would lead to the collapse of their billion-dollar market in Europe and Japan. Monsanto representatives acknowledged that there was not a sufficient market to make the introduction of its GM wheat worthwhile and said it was concentrating on corn, cotton and oilseeds such as rape, where it already has a large seed market (The Guardian, 2004).

⁷ A lateral flow strip test for Roundup Ready® wheat has already been developed by Strategic Diagnostics Inc., and is very similar to the test used for Roundup Ready® soybeans, because both transgenic grains contain the same protein that triggers a positive test Strategic Diagnostics, Inc. (2003).

For a given threshold and confidence level, not every grain lot tested for a claim of non-transgenic will pass the tests. If elevators adopt a policy of absorbing testing related costs only if the test results are negative (i.e. the non-transgenic claim is established), it will, in effect, imply a rejection rate of zero for the purpose of estimating segregation costs for the elevator. In the long run, this seems to be a reasonable policy for elevators. In the short run, some elevators may decide to absorb the probing and testing costs even when the tests are positive in order to attract the delivery of more non-transgenic grain. In such cases, the costs of segregating non-transgenic grains can be easily recalculated by an appropriate increase of the additional probing and sample testing costs. For example, a rejection rate of 0.33 will increase testing related costs by 50% as the elevator ends up paying for testing three lots to procure two lots of non-transgenic grain. The rejection rate, however, does not impact the opportunity cost of unused storage space.

Cost Simulation Data

Data needs for simulating the costs of segregating non-transgenic grains at the elevator level can be divided into two categories. The first includes elevator-specific data collected from the managers of the selected elevators, and documented in Tables 1 and 2. The second data category includes those not specific to the selected elevators, including labor for boot cleaning; labor for added sample probing; cost of testing kits; and labor related to testing. Some of these data varied, while others remained the same across different testing regimes. These data for four alternate testing regimes are listed in Table 4.

Based on the elevator managers' opinions, we assumed that the labor needs for boot and conveyer system cleaning are about four minutes, and the labor requirements for probing two additional samples are two minutes per 800-bushel truck for all non-transgenic grains and at all selected elevators.

The recommended number, type, and labor associated with each testing kit vary by testing regime and grain type (SDI, 2003). For example, to test an 800-bushel lot of non-transgenic corn at a 1% threshold and 99% confidence level, SDI recommends three test kits (one kit each of the RUR, Bt9, and Cry3Bb tests). These test kits, in turn, dictate the time required for cleaning the grinder, grinding the sample, kit handling, and waiting for the results to develop (a total of 11 minutes of labor time in this case). Testing the same lot of corn at a 0.5% threshold and 99% confidence level requires six test kits and a total of 17 minutes of labor time.

To test an 800-bushel lot of soybeans at a 1% threshold and 99% level of confidence, SDI recommends two RUR test kits, requiring 12 minutes of total labor time. Testing the same lot of soybeans at a 0.5% threshold and 99% confidence level requires three RUR test kits involving 15.5 minutes of total labor time (Table 4). The required test kits and labor times for wheat for different testing regimes are similar to those of soybeans.

Testing kit costs vary by location depending on supply and demand conditions and the quantity discount available at the time of purchase. In this study, the cost of each type of testing kit was assumed at \$3.50 per kit based on the cost of test kits purchased in boxes of 100 kits as of April 2003 (Envirologix, 2003).

Cost Simulation Results

The cost of segregating non-transgenic grains at the elevator level in South Dakota were simulated under six alternative scenarios and two rejection rates (zero and 0.33). If an elevator absorbs the testing-related costs only for lots that pass the non-transgenic test, the rejection rate is effectively zero. The opportunity cost of segregation depends on the quantities of different types of grains handled relative to the throughput capacity of the storage bins dedicated to the respective grain; the additional costs involved in piling the excess commodity grains outside; and

the potential loss associated with the grain turned away due to lack of storage space as a consequence of dedicating storage to non-transgenic grains. The opportunity cost of segregation does not depend upon the rejection rate.

Segregation Costs of Non-Transgenic Corn. Without considering the opportunity cost of unused storage space, segregation costs of non-transgenic corn at selected elevators vary from 1.5 to 1.7 cents per bushel under a zero rejection rate. This essentially represents testing-related costs, and includes variations due to wage rate differences across elevators.⁸ The opportunity cost of unused storage space ranged from 0.1 to 20.0 cents per bushel, so that the overall cost of segregating non-transgenic corn ranged from 1.5 to 21.7 cents per bushel (Table 5).

Careful review of the cost estimates reported in Table 5 along with the characteristics of selected elevators shows that the size configuration of storage bins and the elevator's ability to store excess grain in outdoor piles play a key role in determining the corn segregating costs. In scenario-6, the opportunity cost of unused storage is a major factor. Here, elevators able to store excess commodity corn outdoors (elevators 2, 4, and 6) show relatively modest increases in the costs of segregating non-transgenic corn due to lower opportunity cost of unused storage. Elevators with storage bins of varying sizes (elevators 3 and 5) are able to limit the opportunity cost of unused storage space by closely matching the dedicated storage capacities to the expected quantities of non-transgenic and commodity corn. The bin configuration at elevator 1 provides little flexibility when dedicating storage to the expected quantities of non-transgenic and

⁸ The costs for segregating non-transgenic grain were simulated for a 1% threshold at a 99% level of confidence. If the elevators were to lower the confidence level to 95% for corn, the testing costs would not decrease, because the required number of testing kits and labor do not change (Table 4). If, on the other hand, corn testing is done at a 95% confidence level for a more stringent threshold of 0.5%, one additional corn testing kit and some additional labor would be required, resulting in increased testing costs of about 0.5 cents per bushel. Similarly, testing corn at a 99% confidence level for a threshold of 0.5% would increase testing costs by about 1.03 cents per bushel. For a detailed breakdown of the costs, see Wilhelm (2003), Appendix D.

commodity corn. This lack of flexibility, combined with the inability to pile corn outside, results in very high unused storage space opportunity costs under this scenario.

With a rejection rate of 0.33 and elevators paying for all lots tested, the testing related costs increase by 50%, and range from 2.3 to 2.5 cents per bushel. With the opportunity cost of unused storage space, the overall cost of segregating non-transgenic corn ranges from 2.3 to 22.5 cents per bushel under a rejection rate of 0.33 at the selected elevators (Table 6).

Cost of Segregating Non-Transgenic Soybeans. Ignoring the opportunity costs of unused storage space, the cost of segregating non-transgenic soybeans at selected elevators ranges from 1.2 to 1.4 cents per bushel under a zero rejection rate. As in the case of corn, these essentially represent testing-related costs, which vary due to wage rate differences across elevators.⁹ Three of the selected elevators also display additional opportunity costs resulting from unused storage space, under some scenarios, ranging from 0.3 to 10.1 cents per bushel. Thus, the overall cost of segregating non-transgenic soybeans at the six selected elevators ranges from 1.2 to 11.3 cents per bushel (Table 5).

The bin configuration at elevator 3 consists of several storage bins ranging in size from small to large. Again, this flexibility enables the elevator to avoid opportunity costs of unused storage under all but scenarios 5 and 6 when segregating soybeans. Elevator 6, on the other hand, has only a few very large storage bins. Consequently, the opportunity cost of unused storage space is a major factor in determining the overall cost of segregating soybeans at this

⁹ At given threshold and confidence levels, testing soybeans generally requires fewer testing kits than testing corn. As in the case of corn, costs for segregating non-transgenic soybeans were simulated for a 1% threshold at a 99% confidence. Lowering the confidence level to 95% for a threshold of 1% would require one less test kit and less labor, decreasing the cost of testing soybeans by about 0.5 cents per bushel (Table 4). Testing soybeans for a 0.5% threshold at a 95% confidence level would not increase testing costs, because the same number of test kits and labor would be required. If, however, soybeans were tested at a threshold of 0.5% and a 99% level of confidence, one additional test kit and additional labor would be involved, increasing testing costs by about 0.5 cents per bushel. For a detailed breakdown of the costs, see Wilhelm (2003), Appendix D.

elevator under most scenarios. The ability to pile excess grain outdoors, however, helps the elevator limit the impact of this cost.

With a 0.33 rejection rate, the testing and labor cost for non-transgenic soybeans increases by 50% if the elevator pays for all lots tested. Consequently, the testing related costs range from 1.7 cents to 2.5 cents per bushel. The overall cost of segregating non-transgenic soybeans ranges from 1.7 cents to 11.8 cents per bushel under a rejection rate of 0.33 at the selected elevators (Table 6).

Cost of Segregating Non-Transgenic Wheat. The testing-related costs of segregating non-transgenic wheat from commodity wheat are identical to that of soybeans and mostly vary from 1.2 cents to 1.4 cents per bushel under a rejection rate of zero.¹⁰ The quantities of wheat handled at some elevators are small in relation to the bin throughput capacities, making it difficult to match the bins to the expected quantities of non-transgenic wheat. Consequently, the opportunity costs of unused storage space in case of segregating wheat ranged from 1.0 to 15.1 cents per bushel, resulting in overall costs of segregating non-transgenic wheat from 1.3 cents to 16.4 cents per bushel (Table 5).

Under all scenarios, the cost of segregating non-transgenic wheat from commodity wheat is consistently highest at elevator 2. The limited quantity of wheat handled relative to the throughput capacities of storage bins at this elevator make it difficult to avoid large opportunity costs. With a rejection rate of 0.33, and elevators paying for all lots tested, the testing related

¹⁰ Testing wheat is assumed to require the type and number of testing kits similar to those needed for testing soybeans. As in the case of corn and soybeans, costs for segregating non-transgenic wheat were simulated for a 1% threshold at a 99% confidence level. Lowering the confidence level to 95% for a threshold of 1% would require one less test kit and less labor, decreasing the cost of testing wheat by about 0.5 cents per bushel (Table 4). Testing wheat for a 0.5% threshold at a 95% confidence level would not increase testing costs, as the same number of test kits and same labor would be required. If, however, wheat were tested at a threshold of 0.5% at a 99% confidence level, one additional test kit and additional labor would be involved, increasing testing costs by about 0.5 cents per bushel. For a detailed breakdown of the costs, see Wilhelm (2003), Appendix D.

costs range from 1.8 to 2.5 cents per bushel. In this case, the overall costs of segregating non-transgenic wheat range from 1.8 cents to 16.9 cents per bushel at the selected elevators (Table 6).

Implications for Elevator Managers

Generally, elevators with several storage bins of varying size and the ability to pile grain outdoors are better suited for segregating non-transgenic grains from commodity grains than those not having these capabilities. The testing-related costs associated with segregating non-transgenic grains at these better-suited elevators range from 1.2 to 1.7 cents per bushel of non-transgenic grain. However, the opportunity costs of unused storage space can add up to another 20 cents per bushel when handling segregated grains. With good planning and coordination, an elevator manager can significantly reduce the uncertainty regarding the receipt of non-transgenic grains by contracting with local producers for supply of non-transgenic grains. However, finding producers to participate in a contract specifying crop variety, production methods, and quantity to be sold would entail some additional costs. Elevator managers may have to dedicate a portion of their time for such coordination. This coordination could, however, play a significant role in reducing the opportunity cost of unused storage space.

For example, if the total expected quantity of non-transgenic grain (corn, soybeans, and wheat) at elevator 5 were 1,400,000 bushels, and its manager were paid an annual salary of \$40,000, and allocated 15% of his or her time to coordinating non-transgenic producer contracts, labor costs associated with coordinating direct contracts would add approximately 0.4 cents per bushel of non-transgenic grain handled ($\$6,000/1,400,000 \text{ bu.}$). In this case, direct contracting would be a worthwhile tool to avoid the opportunity costs of unused storage space, which, in the case of elevator 5, could be as high as 7.9 cents per bushel when segregating non-transgenic corn under scenario-6.

Elevators receiving premiums for handling segregated non-transgenic grains must, in turn, offer a premium to farmers to produce the specialty crops. According to industry estimates, common price premiums offered by elevators for the supply of segregated non-transgenic corn ranged from 5.0 to 10.0 cents per bushel, and 10.0 to 15.0 cents per bushel for segregated non-transgenic soybeans in the year 2000 (Lin, 2002).

A recent study indicated South Dakota elevator managers are willing to consider handling segregated non-transgenic corn for an average premium of 28 cents per bushel (Van der Sluis. *et al.*, 2004). Out of 28 cents per bushel premium, after paying 1.2 to 1.7 cents segregating cost, 0.4 cents per bushel coordination cost, and 10 cents producer' premium, the elevator would be left with a net profit of 16 cents per bushel. This is in addition to the net margin the elevator would receive for handling commodity corn. Likewise, elevator managers in South Dakota desired an average premium of 37 cents per bushel to consider segregating non-transgenic soybeans. Again, additional costs would include 1.2 to 1.7 cents per bushel for sampling and testing, about 0.5 cents per bushel of coordination costs, and 15.0 cents per bushel premium to producers of non-transgenic soybeans. With a 37 cent per bushel premium, the elevator would end up with a net profit of 20 cents per bushel over and above the net margin for handling commodity soybeans. Elevator managers in South Dakota indicated a willingness to segregate non-transgenic wheat for 38 cents per bushel. Because transgenic wheat is not commercially produced, it is difficult to estimate premium levels farmers would demand to supply non-transgenic wheat. However, additional testing and handling costs at the elevator level would be similar to those of segregating non-transgenic soybeans. Assuming producer premiums for non-transgenic wheat would be similar to those of soybeans (10.0 to 15.0 cents per bushel), the

average desired premium of 38 cents per bushel appears, again, to be higher than what would be necessary to participate in the wheat segregation.

These discrepancies indicate that elevator managers are either overestimating the cost of segregating non-transgenic grains from commodity grains, or they are expecting a much higher premium for producers to entice them to supply sufficient quantities of non-transgenic grains.

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Table 1. Profiles of Selected Elevators

Elevator/ Region	Case 1 NC	Case 2 Cent.	Case 3 SE	Case 4 W. River	Case 5 NE	Case 6 Cent.
Total No. of Bins	11	11	38	11	31	11
Total Storage Capacity (th. bu.)	380	330	663	755	1,400	2,500
Total Grain Handled in 2001 (th. bu.)	380.0	660.0	1,326.0	4,907.5	7,000.0	25,000.0
Total Grain Stored in Piles in 2001 (th. bu.)	-	82.5	-	1,887.5	-	5,000.0
Total Grain Stored in Bins in 2001(th. bu.)	380.0	577.5	1,326.0	3,020.0	7,000.0	20,000.0
Avg. Net Margin ^a (per bu.)	\$0.20	\$0.18	\$0.11	\$0.10	\$0.09	\$0.15
Additional Cost for Piling ^b (per bu.)	-	\$0.05	-	\$0.05	-	\$0.05
Wage Rate (per hr.)	\$8.00	\$7.00	\$7.00	\$8.00	\$9.00	\$10.00

^aReported net margin was same for all three commodity grains (corn, soybeans, or wheat)

^bCases 1, 3, and 5 did not pile grain outdoors.

Table 2. Calculation of the Dedicated Storage Capacities

<u>Elevator/Region</u>	<u>Case 1</u> <u>NC</u>	<u>Case 2</u> <u>Cent.</u>	<u>Case 3</u> <u>SE</u>	<u>Case 4</u> <u>W. River</u>	<u>Case 5</u> <u>NE</u>	<u>Case 6</u> <u>Cent.</u>
<u>Grain Handled in 2001:</u>						
All Corn (th. bu.)	380.0	264.0	941.0	3435.0	462.0	15000.0
All Soybns. (th. bu.)	-	264.0	385.0	638.0	1610.0	7500.0
All Wheat (th. bu.)	-	132.0	-	834.0	770.0	2500.0
<u>Avg. Annual</u> <u>BinTurnovever^a</u>	1.00	1.75	2.00	4.00	5.00	8.00
<u>Expected</u> <u>Non-transgenic Grain:</u>						
Corn (th. bu.)	76.0	52.8	188.2	687.0	924.0	3000.0
Soybeans (th. bu.)	-	52.8	77.0	127.6	322.0	1500.0
Wheat (th. bu.)	-	26.4	-	41.7	154.0	500.0
<u>Needed Non-</u> <u>transgenic Bin Capacity:</u>						
Corn (th. bu.)	76.0	30.2	94.1	171.8	184.8	375.0
Soybeans (th. bu.)	-	30.2	38.5	31.9	64.4	187.5
Wheat (th. bu.)	-	15.1	-	166.8	30.8	62.5
<u>Dedicated Non-transgenic</u> <u>Bin Capacity:</u>						
Corn (th. bu.)	76.0	30.2	95.0	195.0	186.0	420.0
Soybeans (th. bu.)	-	30.2	39.5	50.0	70.0	240.0
Wheat (th. bu.)	-	30.2	-	50.0	40.0	60.0

^a When piling is included, the avg. annual bin turnover for cases 2, 4, and 6 rises to 2.0, 6.5, and 10.0, respectively.

Table 3: Alternative Scenarios Depicting Expected and Received Quantities of Different Types of Grain

Type of Grain	Expected Quantity ^a	Quantity ^a Received Under Scenario:					
		1	2	3	4	5	6
Non-Transgenic	20%	20%	10%	20%	10%	20%	10%
Commodity	80%	80%	80%	70%	70%	90%	90%

^aAll quantities are as a percent of the respective grain handled by the elevator during the year 2001.

Table 4: Required Testing Kits, Testing Labor, and Miscellaneous Labor Under Alternative Testing Regimes

Threshold Level ^a / Confidence level	Non-Transgenic Corn				Non-Transgenic Soybeans & Wheat			
	<1% 95%	<1% 99%	<0.5% 95%	<0.5% 99%	<1% 95%	<1% 99%	<0.5% 95%	<0.5% 99%
Misc. Labor for:								
Boot Cleaning (Minutes)	4	4	4	4	4	4	4	4
Added Sample Probing (Minutes)	2	2	2	2	2	2	2	2
Testing Kits:								
RUR Test Kits (No.)	1	1	2	2	1	2	2	3
Bt9 Test Kits (No.)	1	1	1	2	0	0	0	0
Cry3Bb Test Kits (No.)	1	1	1	2	0	0	0	0
Testing Kits Cost (in \$)	10.50	10.50	14.00	21.00	3.50	7.00	7.00	10.50
Testing Labor for:								
Cleaning Grinder (Minutes)	2	2	4	4	2	4	4	6
Grinding (Minutes)	1	1	2	2	0.5	1	1	1.5
Kit Handling (Minutes)	3	3	4	6	1	2	2	3
Waiting for Results (Minutes)	5	5	5	5	5	5	5	5
Total Testing Labor (Minutes)	11	11	15	17	8.5	12	12	15.5

^aIndicates the tolerance level of transgenic material in non-transgenic grains.
Source: Strategic Diagnostics, Inc. (2003)

Table 5: Cost of Segregating Non-Transgenic Grains Under Zero Rejection Rate at Selected Elevators in South Dakota (Cents /bu.)

Scenario	Elevator 1^a	Elevator 2	Elevator 3^b	Elevator 4	Elevator 5	Elevator 6
.....Costs of Segregating Non-Transgenic Corn (cents/bu)						
1	1.7	1.5	1.6	2.4	1.7	1.7
2	1.7	1.5	2.4	5.8	1.7	1.7
3	1.7	1.5	1.5	1.7	1.7	1.7
4	1.7	1.5	1.5	1.7	1.7	1.7
5	1.7	1.5	1.6	2.4	1.7	1.7
6	21.7	1.5	12.7	8.1	9.6	5.8
..... Costs of Segregating Non-Transgenic Soybeans (cents/bu)						
1	-	1.2	1.2	1.3	1.3	2.4
2	-	1.2	1.2	1.3	1.3	3.4
3	-	1.2	1.2	1.3	1.3	1.4
4	-	1.2	1.2	1.3	1.3	1.4
5	-	1.2	1.5	1.3	1.3	2.8
6	-	1.2	11.3	1.3	8.0	8.4
..... Costs of Segregating Non-Transgenic Wheat (cents/bu)						
1	-	6.3	-	2.3	1.3	1.4
2	-	16.4	-	3.6	1.3	6.0
3	-	6.3	-	1.3	1.3	1.4
4	-	16.4	-	1.3	1.3	6.0
5	-	6.3	-	2.3	1.3	6.0
6	-	16.4	-	8.3	6.3	6.0

^aElevator 1 did not handle soybeans or wheat.

^bElevator 3 did not handle wheat.

Table 6: Cost of Segregating Non-Transgenic grains Under a Rejection Rate of 33% at Selected Elevators in South Dakota (Cents /bu.)

Scenario	Elevator 1^a	Elevator 2	Elevator 3^b	Elevator 4	Elevator 5	Elevator 6
.....Costs of Segregating Non-Transgenic Corn (cents/bu)						
1	2.5	2.3	2.4	3.2	2.5	2.4
2	2.5	2.3	3.2	6.6	2.5	2.4
3	2.5	2.3	2.3	2.5	2.5	2.4
4	2.5	2.3	2.3	2.5	2.5	2.4
5	2.5	2.3	2.4	3.2	2.5	2.4
6	25.5	2.3	13.5	8.9	10.4	9.8
..... Costs of Segregating Non-Transgenic Soybeans (cents/bu)						
1	-	1.7	1.7	1.8	1.8	3.5
2	-	1.7	1.7	1.8	1.8	4.5
3	-	1.7	1.7	1.8	1.8	2.5
4	-	1.7	1.7	1.8	1.8	2.5
5	-	1.7	2.0	1.8	1.8	3.9
6	-	1.7	11.8	1.8	8.5	9.5
..... Costs of Segregating Non-Transgenic Wheat (cents/bu)						
1	-	6.8	-	2.8	1.8	2.5
2	-	16.9	-	4.1	1.8	7.1
3	-	6.8	-	1.8	1.8	2.5
4	-	16.9	-	1.8	1.8	7.1
5	-	6.8	-	2.8	1.8	7.1
6	-	16.9	-	8.8	8.5	7.1

^aElevator 1 did not handle soybeans or wheat.

^bElevator 3 did not handle wheat.