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The Logistical Costs of Marketing Identity Preserved Wheat

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ABSTRACT

This study examines prospective additional costs associated with identity preserved (IP) transactions and their allocation among participants in the wheat marketing system (farmers, grain handlers, and millers). Cost allocations for participants are computed across a range of potential specifications for IP transactions. As strategies become more specific (moved toward either location, variety, or variety and location), the probability of lots meeting quality specifications for the desired end-use characteristic (absorption) generally increased and changes in costs for mills declined. The exception is for strategies that include varieties which involve a premium paid by millers. As strategies become more specific, higher economic costs are imposed on shippers. These economic costs are substantial and provide incentives for shippers to develop techniques that would allow segregation of lots based on quality to recapture this unrealized value. The other change in costs among participants is the shifting of revenue to farmers from mills for variety specific strategies. This analysis indicates that when the desired quality characteristic is absorption, premiums paid for specific varieties quickly offset any reduction in procurement costs achieved by mills.

Key Words: identity preserved, wheat, quality, growers, grain handlers, end-users

HIGHLIGHTS

There has been increasing interest in "Identity Preserved" or IP transactions both within the United States and competitor countries. Initiation of variety specific sales and calls for use of IP systems have increased concern over additional costs associated with IP sales and their allocation among market participants. This study examines prospective additional costs associated with IP sales and their allocation among participants in the wheat marketing system (farmers, grain handlers, and millers). A range of potential specifications for IP sales are examined to compare cost allocations for participants.

Changes in payoffs were compared across participants in the wheat marketing chain for a range of purchase strategies that could be considered within the continuum of IP transactions. As strategies became more specific (moved toward either location, variety, or variety and location), the probability of lots meeting quality specifications for the desired end-use characteristic (absorption) generally increase. The lowest levels of rejection for absorption occurred when wheat was purchased by protein level in western North Dakota and by protein and variety in western North Dakota. Changes in payoffs for mills generally followed this relationship: as strategies became more specific and quality improved, the size of the change in payoffs for mills declined. However, strategies that included varieties had higher mill costs due to the increased premiums required. Strategies that specified location or location and variety generally had lower variability in the change in mill payoffs across the range of protein levels examined than did strategies that focused only on protein, or protein and variety.

The increase in specificity in strategies had the greatest impact on the change in shipper payoffs. As strategies became more specific, higher economic costs were imposed on shippers with product that exceeded minimum quality specifications. These economic costs in many cases were substantial and would provide incentives to segregate lots based on quality.

The other change in payoffs among participants was the shifting of revenue to farmers from buyers for variety specific strategies. This analysis indicates that when the desired quality characteristic is absorption, premiums paid for specific varieties quickly offset any reduction in procurement costs achieved by mills.

This analysis focused on absorption as the end-use quality characteristic desired by millers. Other end-use quality factors such as loaf volumes, wet gluten, and farinograph measures (mix tolerance, peak time, etc.) could also be end-use quality factors that determine whether lots are accepted or rejected. For example, one of the major concerns by some buyers about the variety '2375' is its low dough strength. Results for this analysis show that when Grandin, a higher dough strength variety, is compared with 2375, there is little difference in quality acceptance/rejection and costs to shippers, mills, and the system. However, if a measure of dough strength was utilized, these results would change.

Another question that should be examined is the applicability of assuming quality costs are the same for both quality shortages (where product is rejected) and quality giveaways (product exceeds desired specifications but can be blended with lower quality to increase profitability). Shippers who may be able to segregate based on end-use quality may be able to capture premiums. If asymmetry in quality costs exists between quality shortages and quality excesses, these results would likely change.

The Logistical Costs of Marketing Identity Preserved Wheat

Bruce L. Dahl and William W. Wilson*

INTRODUCTION

There has been a trend toward increased demand for quality and specificity within the wheat marketing system in recent years (Dahl and Wilson). In general, this trend has been toward increased specificity of quality parameters. Concurrent, millers and bakers have reported that the strength and performance of spring wheats are trending lower and becoming more variable (North Dakota Wheat Commission and Minnesota Association of Wheat Growers and Minnesota Wheat Research & Promotion Council). In 1996 and 1997, one lower quality end-use variety was grown on 40 to 42 percent of the North Dakota spring wheat area. The reduction and increase in variability of wheat quality impacts millers' and bakers' costs. All these factors have increased interest in changes in wheat marketing strategies like identity preserved (IP). Not only is this an important evolution in the United States, but similar pressures are evolving in competitor countries. A number of other countries include variety identification within their grain system and procedures. Recently, both Australia and Canada (as described below) have initiated strategies with a greater focus on identity preservation (Drynan). This trend is in response to the combined influence of buyer demands and competition among sellers.

In Canada, the Manitoba Pool Elevators has been selling wheat on a limited basis to specific customers as "Identity Preserved." Other companies in the United States (primarily in Kansas and the Pacific Northwest) have started to sell specific red and white wheat varieties on an IP basis. IP strategies have also been advanced as a method of handling genetically modified wheats in the marketing system (U.S. Wheat Associates, Inc. and Canadian Grain Commission). Initiation of variety specific sales and calls for IP strategies for genetically modified wheats have increased concern over additional costs associated with IP sales and their allocation among market participants.

This study examines prospective additional costs associated with IP preserved sales and their allocation among participants in the wheat marketing system (farmers, grain handlers, and millers). A range of potential specifications for IP sales are examined to compare cost allocations for participants across specifications.

In the first section, previous studies and industry practices about identity preservation are reviewed. The second section describes various logistical models that can be used to analyze IP strategies. In the third section, an empirical model based on the Taguchi loss function is specified to analyze changes in costs for participants in the marketing system. The fourth section presents results based on a stochastic simulation model. The final section provides a summary and discusses implications.

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BACKGROUND

Industrialization is the "process by which consumer's wants and needs are fed back into a production and distribution system in order to improve quality, availability, and price," (Urban). Branded and IP products are methods of reducing costs and/or improving health and are the key to the industrialization process.[1] This process results in a change in the way firms interact in open market trading to vertical linkages so they are better able to control variability. This results in firms having a better idea of what they will receive (Figure 1).

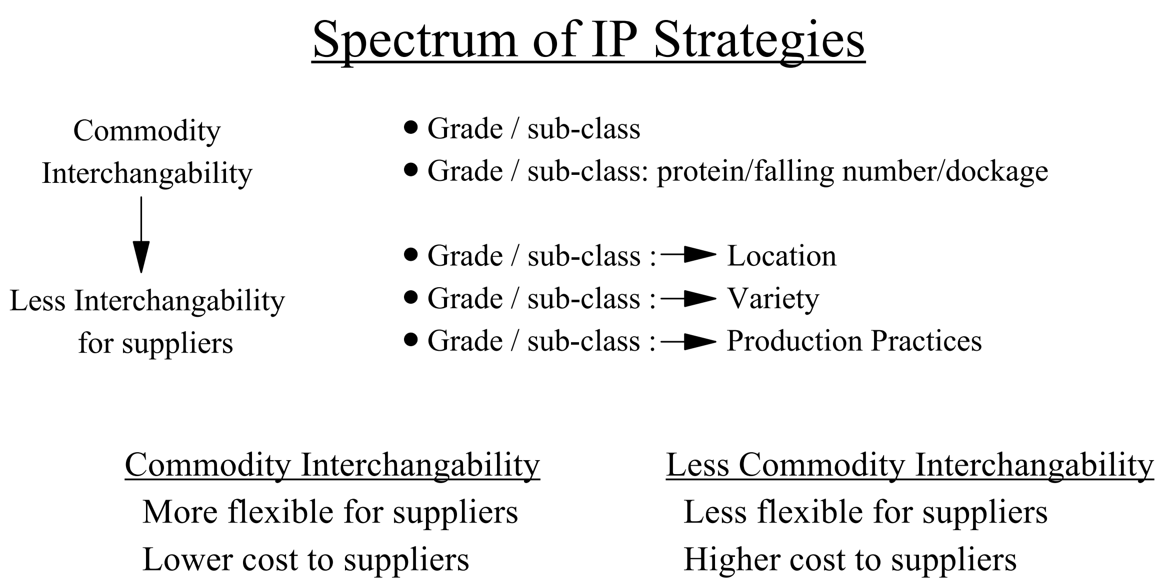

Figure 1. Relationship among Spectrum of IP Strategies, Commodity Interchangeability, and Impacts on Suppliers

Identity preservation strategies have been advanced as a method of reducing quality variability. In recent years, much of the attention in identity preservation in the case of grains has been prompted by the corn sector. In that case, value added or hybrids with specific traits desired by end-users marketed either as specialty grains or IP have been estimated by some to account for 10 percent of the corn acreage by the year 2000 and 25 to 50 percent by 2025 (Zdrojewski).

The demand for the escalation in IP shipments emanates from the increased variability in varieties and demands: "End users and technologists, presented with a wider range of varieties,

[1] This is a slightly different characterization of identity preservation made by Dan Dye who defined it as "a 'traceable chain' of custody that begins with the farmer's choice of seed and continues throughout the shipping and handling system" (DTN).

were able to recognize varieties with desirable attributes in the contexts of their products, even though cereal chemists were unable to define the properties in chemical terms. This has promoted an increased interest in IP wheats, whereby purchasers can buy samples of individual varieties known to best fit their needs. Sometimes the requirement may be less specific and blending may be acceptable, but it is not unusual for a customer to insist that certain varieties be excluded . . ." (Evers, pp. 33).

IP strategies represent a continuum ranging from specification of grades, classes, and/or subclasses to specifications that include locations, varieties, and/or production practices (Figure 1). At one end of this continuum, specifications that focus on grades, classes, subclasses, protein, etc., reflect high commodity interchangeability resulting in higher flexibility and lower costs for sellers.[2] At the other extreme, strategies are less interchangeable and impose less flexibility and higher costs on sellers. This continuum is evidenced in the vast array of definitions for IP strategies across users.

In 1991, Pioneer introduced an IP product "Better-Life Grains." Their product was produced in fields free of herbicides and pesticides (Urban). This represents one aspect of IP where specific characteristics of the product at the farm level are maintained throughout the marketing system to the end-user.

Currently, a number of agricultural products are sold on either an IP or variety basis. Malting barley has been bought and sold on a variety basis for many years. Specific varieties identified by malsters through the American Malting Barley Association (AMBA) are classified as acceptable quality. These varieties are then produced by growers and production of acceptable quality is sold into the market. Production not meeting quality specifications is sold into a lower quality feed market where varieties are commingled. The market provides premiums and discounts for quality characteristics and varieties. Varieties are segregated throughout the marketing system. This system is currently operating in the spring wheat production areas and provides a basis for comparisons to IP spring wheat. Further, it provides a picture of what a mature IP spring wheat marketing system might look like.

Seed production is another product produced on an IP basis. Identity is preserved in this system through a registration process with field inspections. If fields do not meet requirements of the inspection process, they cannot be sold in the system as certified, registered, or foundation seed. The Minnesota Crop Improvement Association defined identity preserved as identification of a field crop variety through the marketing channels so the end user of the crop is assured that the specific variety is delivered. They indicate that sometimes identity preserved is taken to mean the identification of crops with specific characteristics sought by users (MCIA).

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[2] Costs for storage, handling, segregation, inventory, etc., should be lower for firms selling highly standardized/substitutable products than for firms selling highly differentiated products that are not substituable.

The U.S. Feed Grains Council has advanced the term "value enhanced grains." They define this as 1) grains planted based on quality demands of end-users, 2) grain valued on specific attributes or quality characteristics, and 3) grain that is IP throughout the marketing system. This suggests a broader use but maintains much of the spirit of other definitions (U.S. Feed Grains Council).

Wheat and Wilson examined the case of high oil corn and its potential for use as livestock feed. They indicated that advances in breeding would allow for varieties to be developed with specific characteristics for specific uses. These specific end-use varieties would allow for marketing them as IP rather than through the general market. They indicated that in the case of high oil corn, increased costs would be in the range of one cent to several cents per bushel. However, the use of high oil corn in swine rations would provide savings of 15 cents per bushel of corn used in the feed ration. They further indicate that Pioneer has been providing specific end-use varieties sold as IP for use in the baking and pet food sectors.

A number of firms have adopted the variety specific definition for IP grains. Firms in Kansas, Washington, and Arizona have reported selling hard white, durum, and hard red winter wheats by variety. The Manitoba Pool Elevators has adopted a more specific definition for recent sales to a United Kingdom company. There, varieties are sold on a variety and location basis. Recently, several internet-based firms are seeking to essentially sell IP grains (e.g., Farmer Connect, Amerigrains, IP.com, ICE.com).

A major problem for IP sales and variety development is that millers have been unable to communicate to plant breeders, handlers, etc., what quality parameters are important. This is primarily a problem when communicating with plant breeders' quality parameters that are important for processing and is compounded by yield quality tradeoffs and weather. This reduces the development of specialty varieties or varieties with specific customer demanded traits (*Milling and Baking News*, pp. 7, April 15, 1997).

Drynan, however, views IP sales not as niche markets, but as a phenomena where characteristics of wheat desired by end-users are not available in the current market in adequate supplies. IP is a method for determining which characteristics are important in the market and what are the driving forces to make those characteristics more commonplace, in essence, a window onto the future.

These all provide different views on what IP strategies encompass. However, it is important to distinguish among different strategies. Greater specificity of grain quality and end-use characteristics (e.g., protein, etc, as well as No. 1 factor limits, mix tolerance, etc.) can be accomplished without IP. In the limit, as the degree of specificity escalates, it may converge to have similar characteristics as an IP transaction. Indeed, this is what is most likely occurring in the case of malting barley. In contrast, IP (i.e., where the identity is kept intact, preserved, and traceable) may attempt to accomplish the same goal. However, without accompanying specifications, IP may be less efficient.

Description of IP Wheat Marketing Practices

Trends toward lower end-use performance, increased variability in end-use performance, and increasing reliance by farmers on lower end-use quality varieties have fostered discussion on alternative marketing mechanisms in the case of wheat. Identity preservation has been advanced as a strategy of reducing variability of end-use performance of wheat purchases.

In Kansas, growers formed a cooperative to market hard white winter (HWW) wheat varieties. The cooperative is based in Atchison, Kansas. Farmers are required to purchase stock valued at $100 per share for each 100 acres or part thereof for wheat to be marketed through the co-op. Farmers sign a contract specifying conditions for HWW wheat production. HWW wheat 1) must be planted on clean ground, 2) must use good agricultural practices, 3) must use certified seed from an American White Wheat Producers Association (AWWPA)-certified seed dealer, and 4) farmers must comply with the marketing agreement. Fields are inspected for diseases and the presence of weeds, volunteer red wheat, and volunteer rye. Farmers are required to submit samples from each field after harvest. After harvest, each sample undergoes a standard mill and bake test. If quality does not meet specifications, wheat is rejected and sold through the cooperative as feed. Wheat is priced using three options, flat cash price, cash price, and pool option. The flat cash price is one price basis Hutchinson. The cash price was 15 cents over the local red wheat price on the day specified by grower basis Hutchinson. The pool price represented an initial payment and five additional payments throughout the marketing year based on returns to the pool. This averaged 30 cents per bushel over local hard red wheat prices. In 1994-1995, three varieties were being contracted. HWW from the cooperative was toll-milled under agreements with local millers and sold as a finished product (Brester, Biere, and Armbrister).

Producers in the Pacific Northwest sold a variety of soft white wheat (377) to Korea in 1995 and 1996. The variety was developed to compete against Australian varieties of noodle wheat that had captured most of the Korean noodle wheat market. To market the specific variety, a new marketing co-op was established (Pro-Mar Select Wheat of Idaho). Growers contributed $200 to set up the cooperative. This co-op contracts with producers to grow wheat varieties with all production sold back to the cooperative (*Agweek* Staff and Wire Reports, Fritz).

In Arizona and California, selected durum varieties have been sold as variety specific to Italy. Italian millers contract with growers through local grain companies for specific varieties. These sales are known as "desert" durums (Oades) and have occurred since the early 1980s (Drynan, pp. 32).

Manitoba Pool Elevators (MPE) has been conducting IP sales since 1995. They contract with a processor to deliver quantities of specific varieties from specific production areas. Producers sign a contract to grow specific varieties in their region. The varieties and volumes to be contracted vary by region and are determined by the importer. Producers are required to use certified seed, employ good farming practices, and are expected to store the wheat until called for by MPE. They must also provide information on weather conditions, yields, crop inputs, and a representative sample. Production is sampled at the farm level with a portion being sent to the miller, and sampled at the elevator and terminal levels. Producers were paid a premium of $CA30/MT in 1995 (or about 85 cents Canadian per bushel) over the final pool price. The premium declined to $CA20/MT in 1996. Now, part of the premium also has taken the form of credits toward the purchase of inputs from MPE (Kennet et al.). Production not meeting quality requirements is rejected and can be sold into the normal pool. The MPE does the selection and quality testing and is paid a management fee by the processor for administering production contracts and for identity preservation services. In 1996, 90,000 metric tonnes of IP Canadian Western Red Spring were contracted for delivery through this program (Canadian Wheat Board).

The Canadian Wheat Board also offers special grower contracts for specialty wheats. Initially these contracts were for production of Glenlea and AC Karma, two high gluten strength wheat varieties. In 1998, another special grower contract was developed for AC Melita, a high gluten strength durum wheat. Contracts provide for acceptance of all production of AC Melita that meets the top two grades. Contracts also provide a storage payment scale similar to that used for malting barley. These contracts have been advanced to increase production of specialty wheats (McMillan).

Recent Studies

Dahl and Wilson examined grades and classes of hard wheats exported from the United States and Canada. They found that Hard Red Spring (HRS), Canadian Western Red Spring (CWRS), and Canadian Western Amber Durum (CWAD) were the fastest growing segments of wheat exports while Hard Red Winter (HRW) was the largest loser. Changes in grades exported also were identified for all hard wheats with shifts toward increased exports of No. 1 and away from lower grades. Japan and other countries have increased the number and type of specifications for wheat tenders (specifically dockage, etc.). Further, the study identified market segments for U.S. exports and compared these over time. They found increases in the number of market segments and changes in composition of segments have occurred for HRS, HRW, and Hard Amber Durum (HAD) from 1986-1989 to 1991-1994. These changes indicate an increase in market segmentation among importers of U.S. hard wheats.

Kennet et al. developed a rationale for small IP sales by processors who have a limited impact on supply and demand conditions (niche markets). They indicate the potential for specific cases where typical grades do not segregate quality to desired levels of individual consumers. In these cases, depending on the additional costs incurred, segregation of higher qualities can be economic for limited quantities. They advanced this as a potential justification for recent IP purchases by processors.

Jirik surveyed North Dakota and Minnesota growers, merchandisers, and processors to elicit attitudes toward an IP marketing system. All respondents indicated support for this type of system. Sixty-five percent of respondents indicated a need for an IP marketing system. However, there was a divergence in participants' views on premiums associated with the system. A majority of farmers and merchandisers believed that processors would have to pay premiums of 11 to 15 cents per bushel for IP grain. However, a majority of processors indicated that they would pay premiums of 1 to 5 cents per bushel for IP grain. Jirik also found that additional expense, increased management, and time are limitations to establishment of an IP marketing system.

A study by E-Markets and Context Consulting surveyed elevator managers on their perceptions of IP (*Feedstuffs,* Pfeifer, August 11, 1997, pps. 16, 19). This study found that managers felt the importance of IP was increasing and the authors concluded that significant changes would occur in the grain industry over the next years that could impact all portions of the marketing chain. They found that 67 percent of elevator managers surveyed did not think that identity preservation was important today; however, more than 80 percent thought it would be very important within five years. Over 86 percent of managers think it will be necessary for grain companies to be able to identity preserve grains in the future and 83 percent of the managers expect to be compensated for handling specialty grains.

Hurburgh et al. examined the costs of segregating grain by intrinsic quality. They developed an engineering model of the costs of segregation and applied it for soybeans. They examined costs of additional testing equipment, additional time required, lost turnover, additional dispute settlements, modifications required for handling, new facilities, etc. Then they surveyed firms in three areas. These observations were applied to the model to establish costs. They found that for the 50 elevators in Iowa surveyed, 50 percent of the firms were capable of segregating for less than 3 cents per bushel. These firms accounted for 75 percent of the storage capacity of the elevators surveyed. Ten percent of the firms had costs over 4 cents per bushel. These firms had less than 5 percent of the storage capacity for firms surveyed. Further, since most of the additional costs were fixed, larger firms or firms with larger turnovers had lower estimated costs. They found additional costs for segregation were largely for operations and financial management. Therefore, they concluded that personnel skills would be more important than investment in new facilities in these systems.[3]

Other studies have examined the effect of the number of grades handled on costs for primary elevators. Askin evaluated effects on average operating and average total costs for primary elevators in Canada. He used a double log regression model to estimate effects of factors affecting average operating and total costs. Askin found an increase of two grade segregations for the number of grades handled by primary elevators increased average operating costs by C$0.05/MT and average total costs by C$0.13/MT. These effects amount to less than 0.5 cents (U.S.)/bu in 1986 and are lower than those established by Hurburgh. Further, this analysis did not specifically account for the effect of changes in the number of grades handled on turnover.

The effects of number of grains and grades handled have also been examined for terminal elevators in Canada (McPhee and Bourget). They examined the effects of the number of grades and grains handled on average operating costs and elevator turnover for a period in the early 1980s. Average operating costs increased as the number of grades handled increased for terminal elevators. A 10 percent increase in the number of grades handled at Vancouver terminal elevators increased average operating costs by 2.57 percent. This translated to approximately an increase of C$0.043/MT for an additional grade handled. Similarly, a 10 percent increase in the number of grains handled at Thunder Bay terminal elevators increased average operating costs by 1.07 percent. Adding one grade handled for Thunder Bay terminal elevators increased average operating costs by C$0.082/MT. Effects of changes in the number of grades handled exhibited an increasing and then decreasing relationship with turnover. As the number of grades handled increased initially, turnover increased and costs declined because these conditions were primarily related to the number of receipts. As the volume of shipments

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[3] Another recent study by Bullock et al. examined economics of GMO/Non-GMO segregation and identity preservation.

increased, increases in the number of grains handled resulted in lowering of turnovers and increased costs. This study evaluated the break points where the effect of increasing grades changed from increasing turnovers and cost to reducing turnovers and costs.

Finally, the Canadian Grain Commission advanced a discussion on IP marketing systems in which they developed potential aspects that should be contained in an IP system. These include aspects of risk transference, accountability, and procedures. They review where IP systems are in use in Canada and list a range of potential uses for discussion which include, for example, use for genetically modified crops and to segregate varieties within classes, etc.

MODEL DEVELOPMENT

The trends in wheat toward increased variability in end-use performance and increasing reliance by farmers on lower end-use quality varieties, especially in the northern spring wheat production areas of the United States, have fostered discussion on mechanisms to increase quality and reduce variability (Dahl, Wilson, and Wilson). Identity preservation has been advanced as one strategy of reducing variability of end-use performance of wheat purchases. The following sections review analytical methods that examine the economics of quality improvement (logistical models and costing of defects). Empirical models are then developed to estimate logistical costs of marketing IP wheats.

Logistical Models

The economics of quality improvement have been developed extensively in the literature of industrial/production economics. Many of these models have focused on categorization of costs with Feignbuam's PAF (prevention, appraisal, and failure costs) being the most widely adapted. Feignbuam's PAF model describes the tradeoff among prevention, appraisal, and failure costs on optimal quality. As firms' product quality increases, defects decline but costs of handling, prevention, and inspection increase (Figure 2). Other methods of costing quality, including process costing models and loss functions, have also been utilized (Porter and Rayner). However, many of these costing models ignore investment costs for quality improvement. Porter and Rayner advanced a TQM method for costing quality which incorporates costing quality improvement throughout the system and incorporates investment costs in plants, facilities, and training.

Logistical costs of quality uncertainty have been incorporated into economic order quantity (EOQ) models. In the logistics literature, EOQ models have been used to assess optimal ordering strategies, stockholding, etc. In the EOQ model, lots are assumed perfectly interchangeable and are added to inventory one at a time, lots are withdrawn at a constant known rate, and total annual cost is minimized (Larson).

$$T = UC + US/Q + hCQ/2$$

where

T is total annual cost,
U is expected annual usage in units,
C is purchase price per unit,
S is cost per order,
h is annual holding cost (percent of unit cost), and
Q is economic order quantity.

Under the EOQ model, the following relationships are calculated as:

Orders per year = U/Q,
Average stocks in inventory = Q/2,

and the Economic Order Quantity is defined as: $EOQ = (2SU/hC)^{1/2}$.

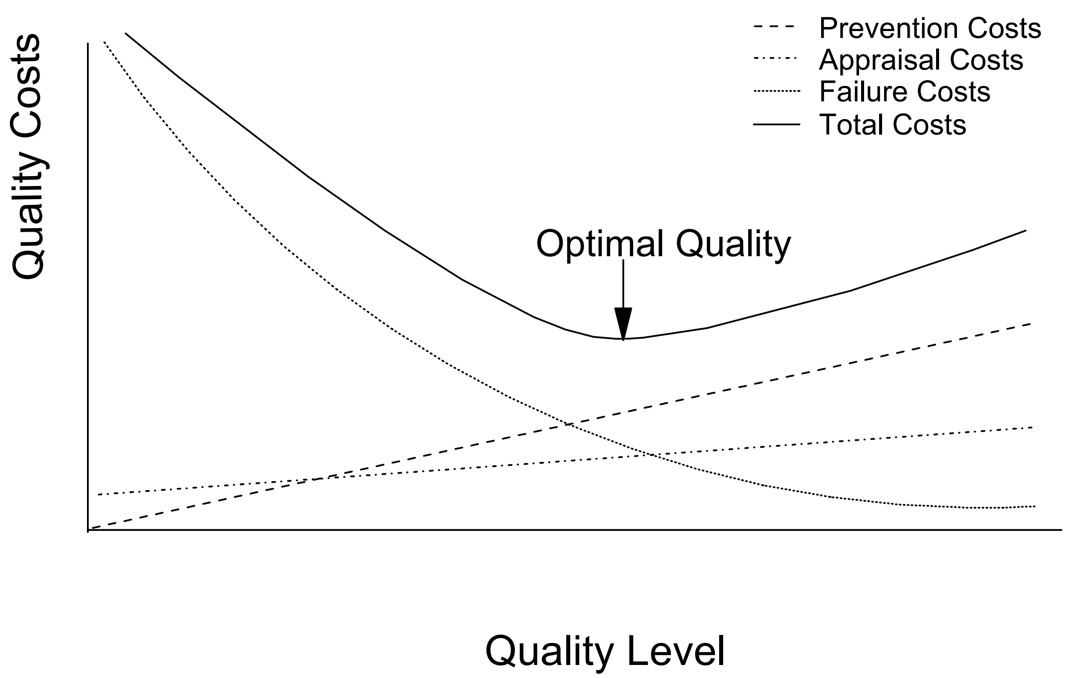

Figure 2. Relationship Between Prevention, Appraisal, and Failure Costs
Source: Porter and Rayner

Uncertainty in demand and lead time have been incorporated into EOQ models by inclusion of safety stocks (stocks held in case of adequate quality shortages in supplies ordered) (Ballou). Quality uncertainty affects logistical costs by inducing firms to sample and test to reduce defects and to carry/buy more items than their actual demand in anticipation of quality failure. Larson examined inventory/quality decisions in EOQ models for different inspection and defect handling strategies. He developed EOQ implementations that examined four strategies: no inspection, inspection and scrap, inspection and rework, and sampling inspection.

Strategies of inspection with scrap and inspection and rework entail inspecting all products and scrapping lots that fail quality requirements in the case of inspection with scrap and sending products back to be reworked till they meet quality specifications in the inspection with rework. In the final case, not all products are inspected, only a portion or subset are sampled and inspected. In all four cases, as defect rates increased, total costs and economic order quantities increased. Porteus examines the effects of increasing quality and reducing setup costs on economic order quantities considering setup costs, rework, and investment required for increasing quality. Both of these studies indicate increased logistical costs of increased quality uncertainty that must be borne by system participants.

Costing of Defects

Costing of quality has been examined extensively in manufacturing where variation is a primary cause of rejecting parts. Costs for quality have been identified by Feigenbaum to include prevention costs (costs of actions to investigate, prevent, or reduce non-conformity), appraisal costs (costs of evaluation quality achievement), and failure costs (non-conformity costs both internal and external to the firm) as illustrated in Figure 1. Porter and Rayner indicate that reviews of literature have found that this categorization of quality costs is the most widely adapted. Methodologies for costing quality range from Feigenbaum's PAF model to process approaches to quality. However, Porter argues that costs (investment, etc. to improve quality) and benefits of increasing quality must be evaluated over the entire system when examining quality issues.

Variation in product quality (inconsistency) has been identified as a major factor in both rejecting parts (Roy) and the perception of customers of poor quality (Ross). Roy argues that controlling for quality is best achieved by minimizing deviations from a target (increasing conformity). Costs of quality non-conformance should be measured as a function of the deviation from the standard and the losses should be measured system-wide. The magnitudes of losses from not meeting target values is dependent on the target value, the manufacturing process, cost of rework, scrap, and warranty.

The typical method of costing quality is based on the number of defects and cost of rework. This method generally involves establishing upper and lower control limits beyond which parts are rejected and costs are attributed. This method is incapable of discerning between samples within limits with different distribution functions.

One methodology advanced to incorporate these differences of distributions has been the introduction of a loss function. Here quality costs are defined as the total loss imparted to the system from the time a product is shipped to the customer. Monetary terms include all costs in excess of the cost of a perfect product. One type of loss function is the Taguchi loss function. Taguchi asserts that there is no such cutoff in the real world (e.g., fixed penalties only if control limits are exceeded). Performance begins to deteriorate as the design parameter deviates from the target value(s). The loss function is measured by deviations from the ideal value(s) and allows for more than 100 percent loss imparted by the product. Taguchi's definition places more emphasis on customer satisfaction, whereas previous definitions were related to the producer (Roy). Roy indicated it is important to note that Taguchi's Loss Function assumes: 1) the quality loss function is a continuous function and is a measure of deviation from the target value, 2) quality loss is related to product performance characteristics and can best be minimized by designing quality into the product, 3) quality loss results from customer dissatisfaction and should be measured system-wide rather than at a discrete point in the manufacturing process, and 4) quality loss is a financial and social loss.

When nominal values are better, the Taguchi Loss Function is estimated as:

$$L(X) = k\,(X-T)^2$$

where

L(X) is the value of the loss in quality,
k is the adjustment factor,
X is the observed parameter, and
T is the target value for the parameter.

Alternate formulations for the Taguchi Loss Function include when higher values are better:

$$L(X) = k / X^2$$

and where lower values are better:

$$L(X) = k * X^2$$

Empirical Model

A model of the changes in payoffs for IP transactions was developed in this study by aggregating costs and changes in costs (both increasing and decreasing) for each of three participants in the wheat marketing chain. Changes in payoffs are developed for farmers, grain handlers, and processors in the next sections.

Farmers

Farmers incur costs of IP sales for additional storage including time and segregation and any tests required by other participants in the marketing chain. The change in payoffs to the farmer for improved quality consistency are specified as

$$\Delta P_F = Premium_F - Storage_F - Test_F$$

where ΔP_F is the net change in farmer payoffs, $Premium_F$ is premiums paid to farmers for improved quality/consistency, $Storage_F$ is additional storage cost per unit (time + segregation), and $Test_F$ is the cost of additional testing required.[4]

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[4] When originally developed, additional costs for farm production were not a major concern. With the advent of GMO's additional cleaning costs (cleaning farm equipment such as combines, planters, trucks, and storage facilities) for farmers are more important. For a discussion of these costs see Bullock.

Grain Handlers

Cost for grain handlers include increased storage costs for time and segregation to aggregate quality in significant quantities, costs for additional testing, additional premiums paid and received for increased quality, changes in shipping costs, and changes in costs for potential rejection of lots at end-users. Changes in payoff, or margin, for grain handlers were defined as:

$$\Delta P_{GH} = \text{Prem Recieved}_{GH} - \text{Prem Paid}_{GH} - \text{Storage}_{GH} - \text{Test}_{GH} - \text{DefectR}_{GH} * \text{DefectC}_{GH} - \text{Origination}_{GH}$$

where ΔP_{GH} is the net change in payoff to grain handlers, Prem Recieved_{GH} is additional premiums paid to grain handlers for increased quality/consistency, Prem Paid_{GH} is additional premiums paid to farmers for increased quality/consistency, Storage_{GH} is additional storage costs for grain handlers, Test_{GH} is the cost of additional testing required by grain handlers, DefectR_{GH} is the change in the defect rate for grain handlers, DefectC_{GH} is the cost of defects per unit, and Origination_{GH} is additional costs of grain handlers for origination.

Millers/Processors

Processors would have additional costs and benefits from increases in quality consistency. Premiums paid to elevators and/or farmers would increase procurement costs. Reduced variability should reduce safety stocks held and in turn lower storage costs. Testing costs may be lowered. Costs of defects should be lower as more product should be of the desired quality; however, origination (search costs) may increase as processors search for suppliers with desired qualities.

The net change in the millers/processors payoff is:

$$\Delta P_{EU} = - \text{Prem Paid}_{EU} - \text{Storage}_{EU} - \text{Test}_{EU} - \text{DefectR}_{EU} * \text{DefectC}_{EU} - \text{Origination}_{EU}$$

where ΔP_{EU} is the net change in payoff for the end-user, Prem Paid_{EU} is premiums paid to farmers and elevators, Test_{EU} is the cost of additional/reduced testing, DefectR_{EU} is the change in defect rate for the end-user, DefectC_{EU} is the cost of defects, and Origination_{EU} is the additional search costs for higher quality/consistency. The change in payoffs for millers was modified to include the Taguchi loss function to estimate costs for defects.

$$\Delta P_{EU} = - \text{Prem Paid}_{EU} - \text{Storage}_{EU} - \text{Test}_{EU} + (k*(X-T)^2_{EU}) - \text{Origination}_{EU} \text{ (Search Costs)}$$

where k is calibrated to an established cost at the rejection rate.

The net change in payoffs across participants in the system is the aggregation of the above three payoffs:

$$\Delta P_S = \Delta P_F + \Delta P_{GH} + \Delta P_{EU}$$

Survey

Representative millers, grain handlers, farmers, and industry representatives were surveyed informally by phone to elicit information on their views and costs of IP sales. Questions focused on if they had participated in or knew of others participating in IP sales, what additional processes would be required for IP sales, what additional costs would be incurred, are there any restrictions on IP sales like storage capacity, etc. Responses were gathered from 15 respondents in these areas and were used to establish baseline parameters for the model.

Handlers indicated that segregations by protein, grade, and location is a current practice. Limited segregations were made for varieties with most mentioning specific durum variety sales being conducted by firms in Arizona and California. Most handlers described variety specific sales for wheat as niche markets. Handlers indicated that some variety specific sales had been tried in the region. Programs were tried on a limited basis to contract for specific varieties in the HRS production area. These programs failed due to limited acceptance and low premiums (10 cents per bushel or less).

One handler indicated that the HRS production area is dominated by smaller capacity elevators that typically handle a larger number of crops. Due to the large number of crops competing for elevator space, it would be costly to dedicate space exclusively to wheat segregations. Therefore, these elevators would have a greater difficulty segregating wheat due to quality/variety. This is in contrast to the HRW production area where larger capacity elevators dominate and fewer crops are grown.

Costs of IP sales were reported. One handler indicated costs associated with IP would be approximately 25 cents per bushel. If storage and other costs are included, these could reach to 50 cents per bushel or higher. Adoption of IP sales would require someone to store product for delivery year round and handlers indicated this would require significant storage costs. One indicated that it was also significant in that, spring wheat prices typically exhibit an inverted market in spring resulting in excessive storage or opportunity costs of forgone sales.

Data

A number of end-use quality parameters are utilized to assess the suitability of wheat for milling and baking. Many of these parameters are to some extent correlated with each other and most are correlated to some extent with wheat protein levels. The most widely used parameters include absorption, peak times, mix tolerance, loaf volumes, wet gluten, ash, and flour extraction, among others. Of these, absorption is probably the most prominently utilized of these parameters and as such will be the end-use characteristic used in this study.

Data on absorption values from North Dakota Varietal Trials were gathered from 1989 to 1995. These data include observations for end-use characteristics of varieties tested in the varietal trials at each of the state's experiment stations. Data were then gathered on varietal adoption (shares of planted acres devoted to variety x) for the same time frame (North Dakota Agricultural Statistics Service). Using this data, functional relationships were estimated between absorption values and wheat protein levels. Observations were weighted based on the adoption of variety within the adjacent crop reporting district to the experiment stations to arrive at a representative relationship between absorption values and protein reflecting the state. Additional functional relationships were estimated between absorption and protein levels while controlling for location (Western North Dakota, Central North Dakota, and Eastern North Dakota). Finally, functional relationships were estimated between protein and absorption at the variety level for five varieties grown prominently during the time period (Grandin, 2375, Amidon, Stoa, and Len). All of these different functional relationships are utilized within a simulation framework to represent the relationship between wheat protein and end-use quality for alternative buying strategies representing different levels of specificity.

Estimated relationships generally increased in explanatory power as they became more specific. For example, 31 percent of the variability in absorption could be explained with protein only (Table 1). Adding binary variables for location (Western and Central North Dakota) increased the explanatory power to 39 percent. Examination of the variety Grandin only explained 39 percent of the variability in absorption while adding effects for location increased this to 44 percent (Tables 2 and 3). In addition, there was substantial variability among relationships for individual varieties both with and without the effects of location (Figure 3).

Table 1. Estimated Relationships Between Absorption and Wheat Protein, by Location, 1989-1995

	Model 1	Model 2	Model 3
Constant	44.03	46.3	48.01
Protein	1.39*	1.19*	1.07*
D1		1.91*	-0.17
D2		0.07	-2.80
D1*Protein			0.14
D2*Protein			0.19
RMSE	2.68	2.53	2.53
R-Square	0.31	0.39	0.38

D1 is a binary variable representing Western North Dakota.
D2 is a binary variable representing Central North Dakota.
* Significant at $p > 0.05$.
Observations include only those varieties adopted (variety shares > 0).

Table 2. Estimated Relationships Between Absorption and Wheat Protein, by Variety, 1989-1995

	Grandin	2375	Amidon	Stoa	Len
Constant	40.81	43.10	52.27	35.77	40.07
Protein	1.68*	1.50*	0.83*	1.88*	1.64*
RMSE	2.59	2.46	2.47	2.16	2.75
R-Square	.39	.37	.15	.48	.30

* Significant at p > 0.05.

Table 3. Estimated Relationships Between Absorption and Wheat Protein, by Variety and Location, 1989-1995

	Grandin	2375	Amidon	Stoa	Len
Constant	44.06	44.33	54.94	38.60	43.74
Protein	1.42*	1.38*	0.59	1.64*	1.37*
D1	1.83*	1.12	1.99*	1.81*	1.46
D2	0.01	0.50	0.68	0.21	-0.74
RMSE	2.50	2.47	2.39	2.05	2.65
R-Square	.44	.37	.20	.54	.34

* Significant at p > 0.05.

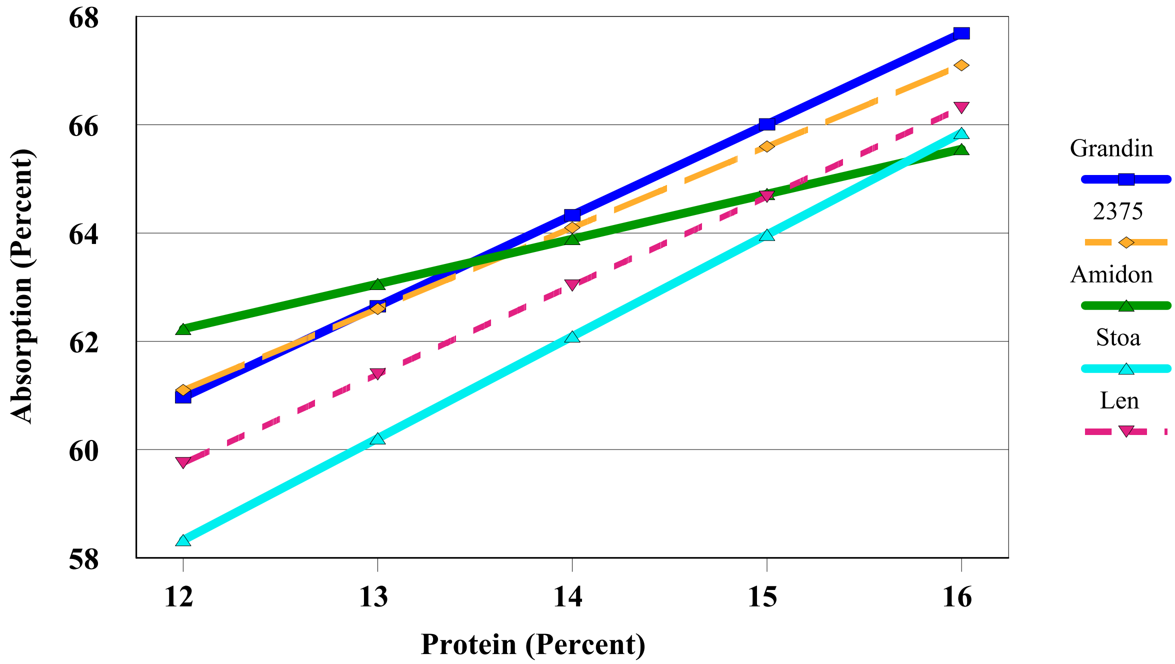

Figure 3. Estimated Relationship Between Protein and Absorption, by Variety, 1989-1995

North Dakota Wheat Commission Data

The North Dakota Wheat Commission (NDWC) has also collected data to investigate wheat quality produced in North Dakota in 1996. They conducted a survey of farm production quality and collected samples on a variety level across the state. Wheat, flour, dough, and baking quality characteristics were determined for each sample.

Using this data, relationships between protein content of wheat and absorption were estimated for four of the varieties sampled (2375, Grandin, Amidon, and Butte 86) (Figures 4 and 5). Relationships suggest a lower increase in absorption as protein levels increase. Further, absorption levels for lower protein samples where higher in this data from 1996 than for the variety trial data. However, this represents only one year, whereas, the variety trial data represents a seven-year time frame.

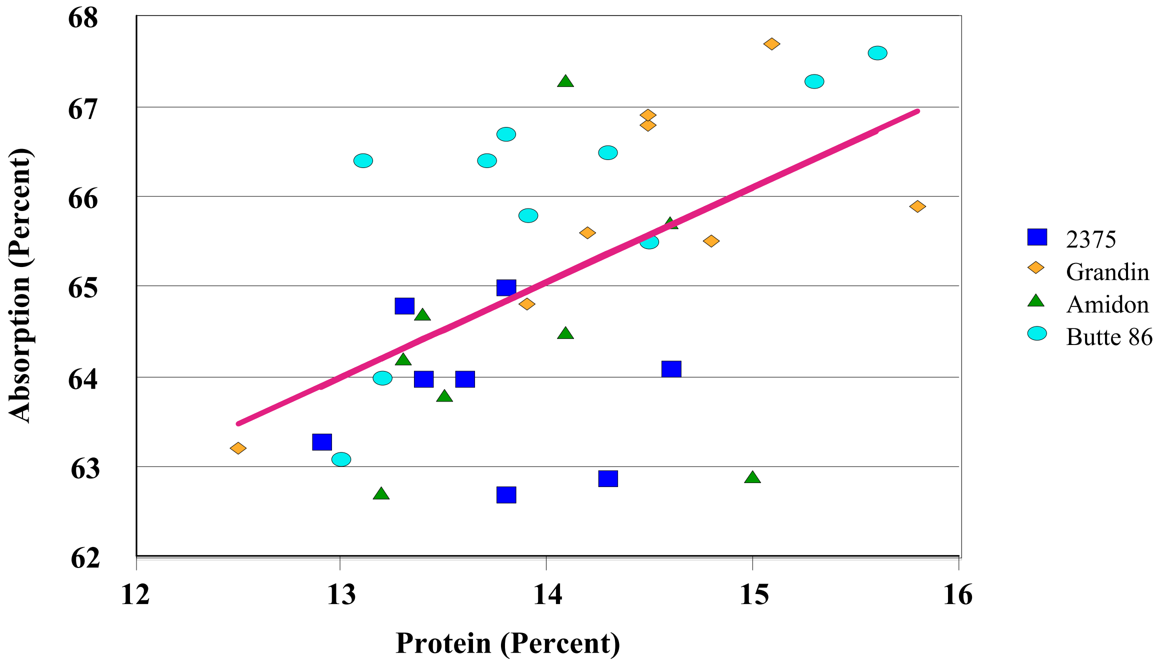

Figure 4. Plot of Protein and Absorption Relationships, North Dakota Wheat Commission, 1996 Survey Data

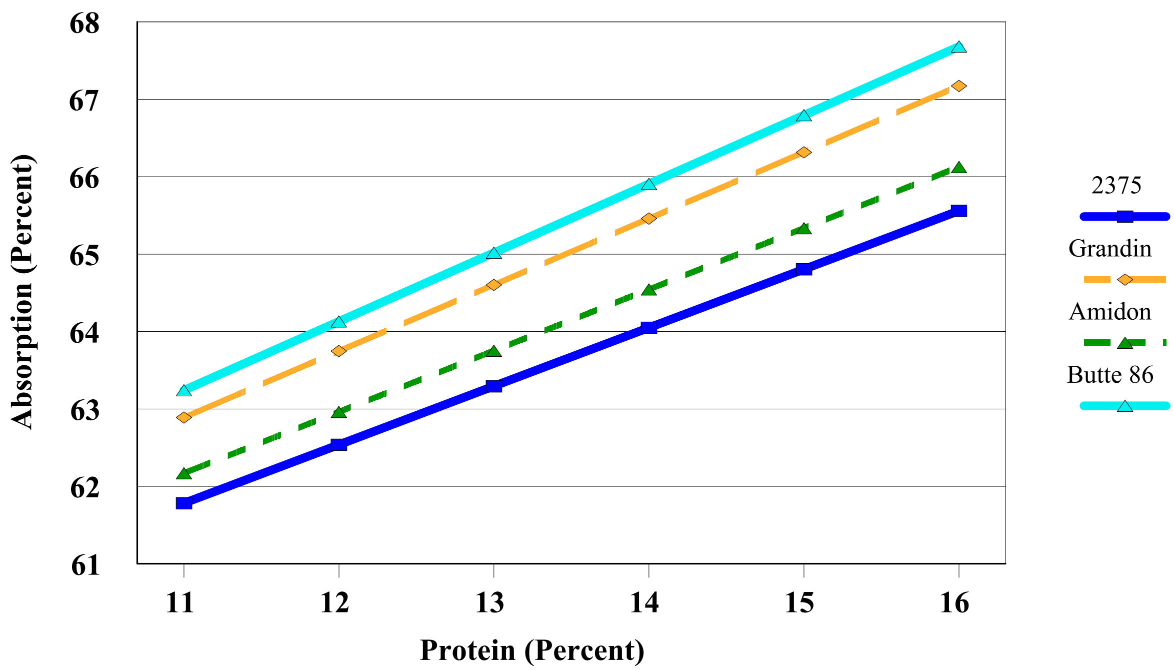

Figure 5. Estimated Relationships Between Protein and Absorption, by Variety, North Dakota Wheat Commission, 1996 Survey Data

Model Description

Simulation models were developed using the functional relationships estimated between protein and absorption values for the different buying strategies. These models were utilized to estimate the probability of wheat purchases meeting specifications for absorption and to determine the change in payoffs for farmers and shippers per bushel utilized. Initial parameters for the simulation models utilized data from the survey of market participants and are listed in Table 4.[5] Base case and buying by location only strategies included no additional costs for producers and grain handlers (except for rejection). This assumes that these purchase strategies would not alter costs for either farmers or handlers from current practices. Additional costs were associated with strategies that included buying by location and variety. These largely represent higher costs for segregation, inspection, etc., for both farmers and grain handlers.

Functional relationships between protein and absorption were also used to estimate the average quality cost for deviations from specifications for millers. The probability of meeting specifications was determined differently for mills and shippers. Mills were assumed to accept wheat with quality above a minimum specification and because they test prior to use, have the ability to blend/segregate qualities that are higher than flour requirements. However, probability of acceptable quality was valued as a target value with an acceptable range (high and low). Quality below the minimum specifications represent lots rejected by the miller and impose direct cash costs. Quality higher than specifications (absorption > 65%) represents value that shippers are not able to obtain because they are either not able to identify higher quality or blend and/or segregate it. Therefore, quality higher than specifications represents an "economic cost" or profit foregone because shippers are unable to capture it; whereas, quality lower than specifications represents a direct or cash cost to shippers.

An EOQ model following Larson was developed to estimate the change in logistical costs for millers for the different buying strategies. This model was an EOQ model that incorporates inspection prior to use where lots not meeting quality specifications were rejected and sold as scrap (sold into next best alternative). This model estimates the impact of changes in quality on optimum order quantities, safety stocks, etc. The model determines the optimal order quantity (how much should be ordered each period) for the user. From this, total procurement costs and an average cost per unit are estimated. Inputs into the model are annual volume, interest cost, wheat price, scrap value, inspection cost, ordering costs, and probability of rejection. The model defines the EOQ (Q) as:

$$Q = (2\ S\ U / h\ C\ (1-p)^2\ )^{1/2}$$

and total costs as:

$$TC = U\ ((1-p)\ C + p\ (C-w) + i)/(1-p) + U\ S\ /(1-p)\ Q + h\ C\ Q\ (1-p)/2$$

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[5] Protein premiums were not considered because they are a normal cost of operation and would not vary by procurement specification. Inclusion of the effect of protein premiums would increase payoffs to farmers and reduce payoffs for millers.

where

Q is the economic order quantity,
TC is the total cost of input procurement,
S is the cost per order,
U is annual demand,
h is the storage cost per unit (as a percent of unit value),
C is the cost per unit,
p is the probability that a unit is defective,
w is the salvage value for units rejected, and
i is interest cost.

Table 4. Initial Simulation Model Parameters by Specification

	Base Case	Location	Location[1] Variety
<u>Producer</u>			
Inspection ($/bu)	0.00	0.00	0.01
Storage ($/bu)	0.00	0.00	0.02
<u>Handler</u>			
Handling ($/bu)	0.00	0.00	0.00
Transportation ($/bu)	0.00	0.00	0.06
Inspection ($/bu)	0.00	0.00	0.01
Segregation ($/bu)	0.00	0.00	0.04
Quality cost at rejection point[1] ($/bu)	0.30	0.30	0.30
Quality minimum[2]	61%	61%	61%
Quality maximum[2]	65%	65%	65%
<u>Miller</u>			
Premium paid ($/bu)	0.00	0.00	0.20
Inspection ($/bu)	0.00	0.00	0.00
Quality cost at rejection point[1] ($/bu)	0.30	0.30	0.30
Quality minimum[3]	61%	61%	61%

[1] Assumes cost is $0.30 at absorption = 61% (approximate spread 1 vs 2).
[2] Assumes target level of absorption = 63% (+-2%).
[3] Assumes target level of absorption = 63% with reject = 61%.

Parameters were those of a representative miller. Representative wheat values, scrap values, and defect rates were derived from the results of the simulation model. Wheat prices were set at $4.50, plus any additional premiums paid by the miller for purchase by variety. Scrap values were estimated as $4.50 minus the average quality cost for millers derived in the simulation. The probability that a unit is defective was also derived as 1 minus the probability that wheat would be acceptable for milling (quality higher than a minimum specification for absorption estimated in the simulation model).[6] Initial parameters for the base case (protein only buying strategy) are presented in Table 5.

Table 5. Initial EOQ Milling Model Parameters	
Annual usage	1,150,000 bu/year
Interest cost	10%
Inspection cost	$.00/bu
Wheat price	$4.50/bu
Scrap value	$4.22/bu
Order cost	$75/order
Probability of defective unit	17.6%

To arrive at final change in payoff estimates for each participant in the marketing chain, average change in costs for farmers and shippers estimated in the simulation model were adjusted by the percent of shipments meeting milling specifications for absorption to arrive at average changes in payoff per unit of miller demand. Average procurement costs for millers were derived by estimating total procurement costs and dividing by annual demand. Then the change in miller costs was derived by subtracting the average cost per unit ($4.50) from average total procurement costs. The change in total system payoffs was then the summation of changes in payoffs for farmers, shippers, and mills.

RESULTS

To compare and contrast the effects of different purchase strategies on payoffs for participants in the wheat marketing chain, simulations were conducted for buying based on protein only (the base case); protein and location; protein and variety; and protein, location and variety. Results for all strategies were compared to the base case strategy. Results represent potential savings from procurement and do not represent operational efficiencies from improved quality/consistency in milling which are beyond the scope of this study.

[6] Estimated values for the probability of defective units across purchase strategies are shown in Appendix Table 3.

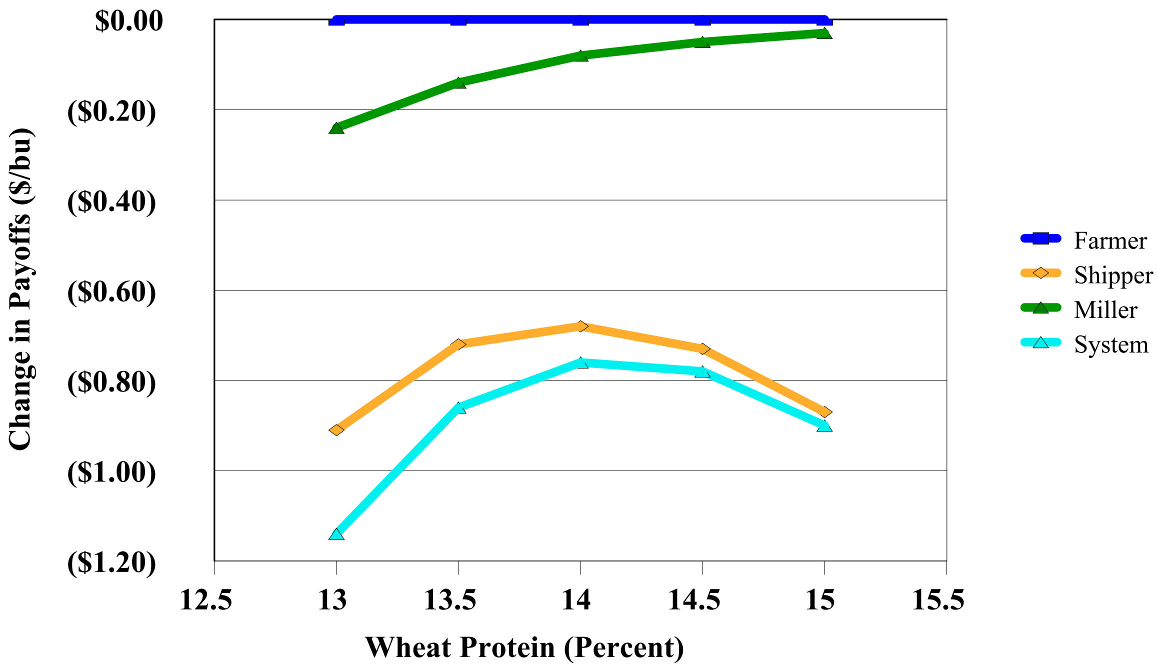

Figure 6. Change in Payoffs for Base Case (Purchase by Protein Only)

The change in payoffs for the base case represents costs due to quality considerations that exist for each participant in the marketing chain and allows for comparison to alternative strategies. Results illustrate that quality costs (both economic and direct or cash costs) can be substantial for both shippers and millers, yet had no impact on payoffs for farmers. Effects on payoffs of farmers are nil because no additional costs/revenues are attributable to the current practice of buying by protein level. However, quality costs for purchase of 14 percent protein wheat reduced payoffs by $0.68/bu for shippers and $0.08 for millers (Figure 6). The high quality cost for shippers represents both the loss of actual cash revenue for lots rejected by millers which are sold at a 30 cents per bushel discount and the economic cost of supplying quality over and above specifications to the miller [i.e., quality giveaways (absorption > 65%)]. Miller costs increase as the purchase strategy targets lower protein wheat because fewer wheat lots meet specifications for absorption (see Appendix Table 3 for probability of defective lots at mill). As such, higher levels of inventories have to be held at the mill as safety stocks and EOQ's increase. EOQ's for the miller in the base case by protein level are 13%-29,695 bu; 13.5%-26,160 bu; 14%-23,770 bu; 14.5%-22,177 bu; and 15% 21,136 bu (Table 6). Shipper costs increase (change in payoffs becomes more negative) as strategies target both lower and higher protein wheat. Shipper costs increase for lower protein wheat because more lots are rejected at the mill. Shipper costs for higher protein wheat increase because economic costs of quality giveaways increase.

Alternative buying strategies were then evaluated in comparison to these base case values. First, the buying strategies where wheat is purchased based on protein and location are examined. Then strategies where wheat is purchased on the basis of protein and variety. Finally, strategies where wheat is purchased on protein, location, and variety are evaluated.

Table 6. Change in Payoffs, Probability of Meeting or Exceeding Absorption Specifications and Miller EOQ for Base Case and Protein by Location Purchase Strategies for 14% Protein Wheat

	Base Case	Western ND	Central ND	Eastern ND
Probability of Meeting or Exceeding Specifications for Absorption				
Shipper quality within specs	54%	46%	57%	57%
Shipper quality greater than specs	29%	48%	22%	21%
Miller acceptance	82%	94%	79%	78%
Estimated Miller EOQ by Protein Level (bu)				
13.0%	29,695	22,888	31,078	31,604
13.5%	26,160	21,700	27,396	27,758
14.0%	23,770	20,895	24,825	25,074
14.5%	22,177	20,370	23,032	23,198
15.0%	21,136	20,040	21,787	21,915
Change in Payoffs ($/bu)				
Farmer	$(0.00)	$(0.00)	$(0.00)	$(0.00)
Shipper	$(0.68)	$(0.79)	$(0.61)	$(0.62)
Mill	$(0.08)	$(0.03)	$(0.26)	$(0.26)
Total System	$(0.76)	$(0.82)	$(0.87)	$(0.88)

Location Strategies

Purchase strategies by location (Eastern, Central, and Western North Dakota) were evaluated using estimated relationships between protein and absorption for each location. The change in farmer payoffs was again nil across all locations as no additional costs/revenues are imposed on farmers when purchasing by location. The change in payoffs for shippers and millers was again substantial with the change in shipper payoffs exceeding that for millers.

Changes in payoffs across Eastern and Central North Dakota exhibited similar relationships as for purchase by protein although changes in payoffs indicated higher costs for purchases from Eastern North Dakota than for Central North Dakota. However, changes in payoffs were dramatically different for purchases from Western North Dakota (Figures 7-9). Changes in payoffs in Western North Dakota, for millers, were the lowest of the three locations and were lower than mill costs when purchased by protein only. This low mill quality cost is largely due to a higher probability of purchases from Western North Dakota meeting specifications for absorption, which in turn reduces mill safety stocks and EOQs (Table 6).

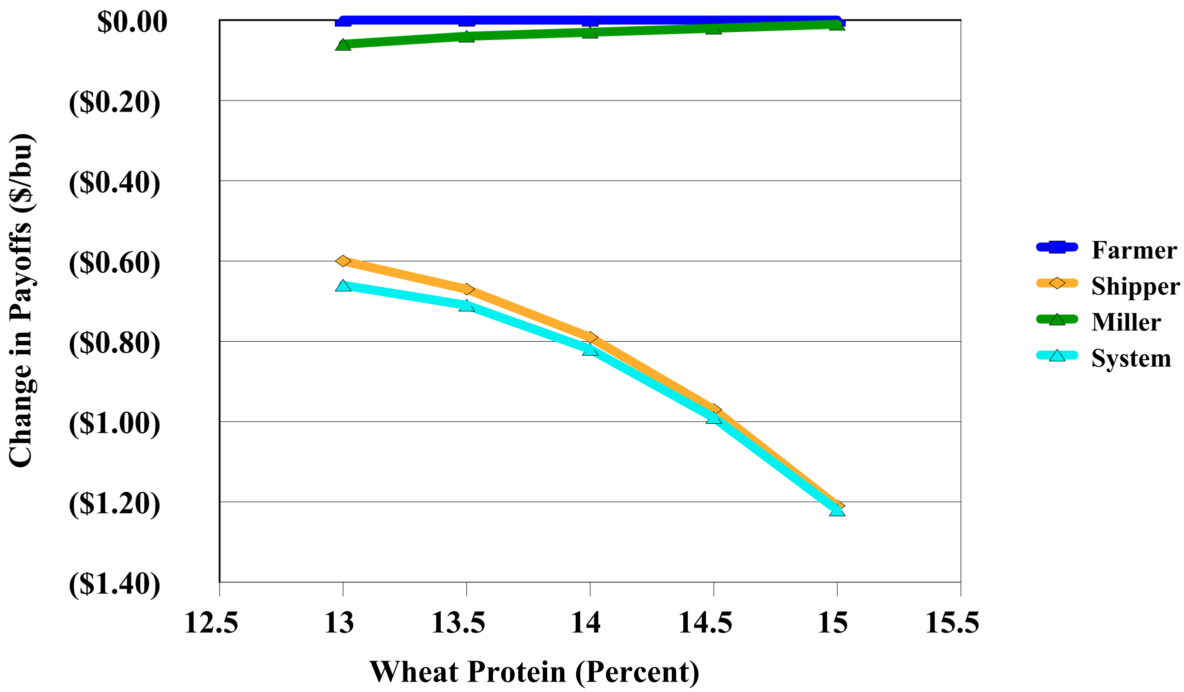

Figure 7. Change in Payoffs by Participant for Purchase by Protein in Western North Dakota

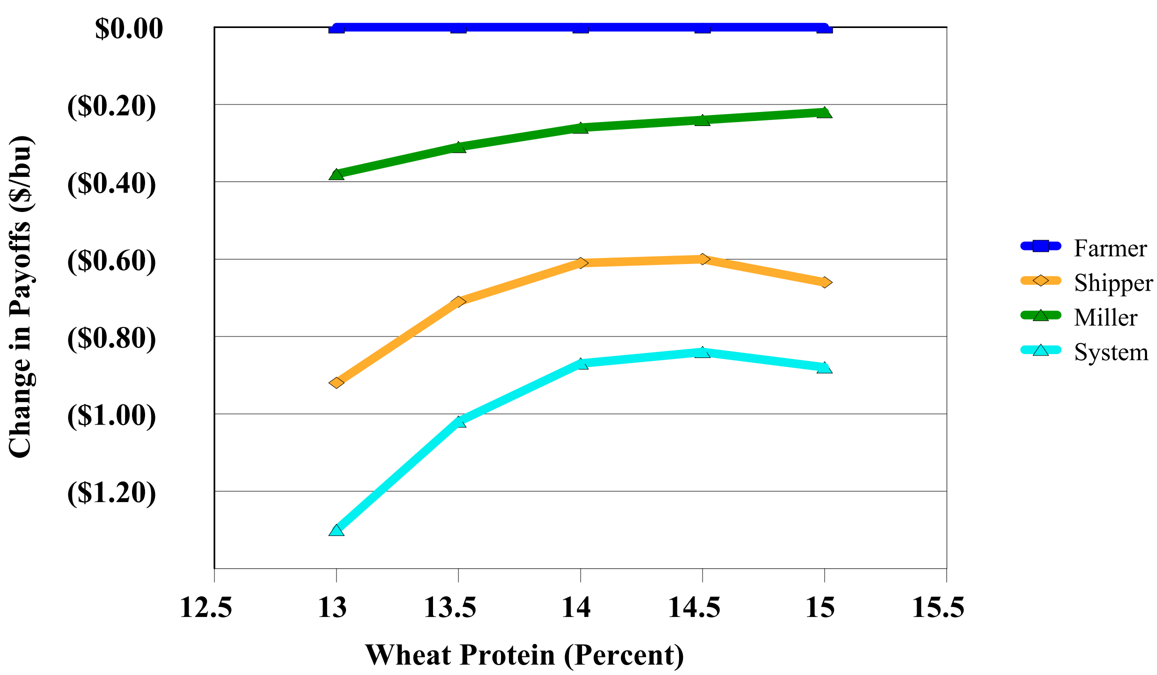

Figure 8. Change in Payoffs by Participant for Purchase by Protein in Central North Dakota

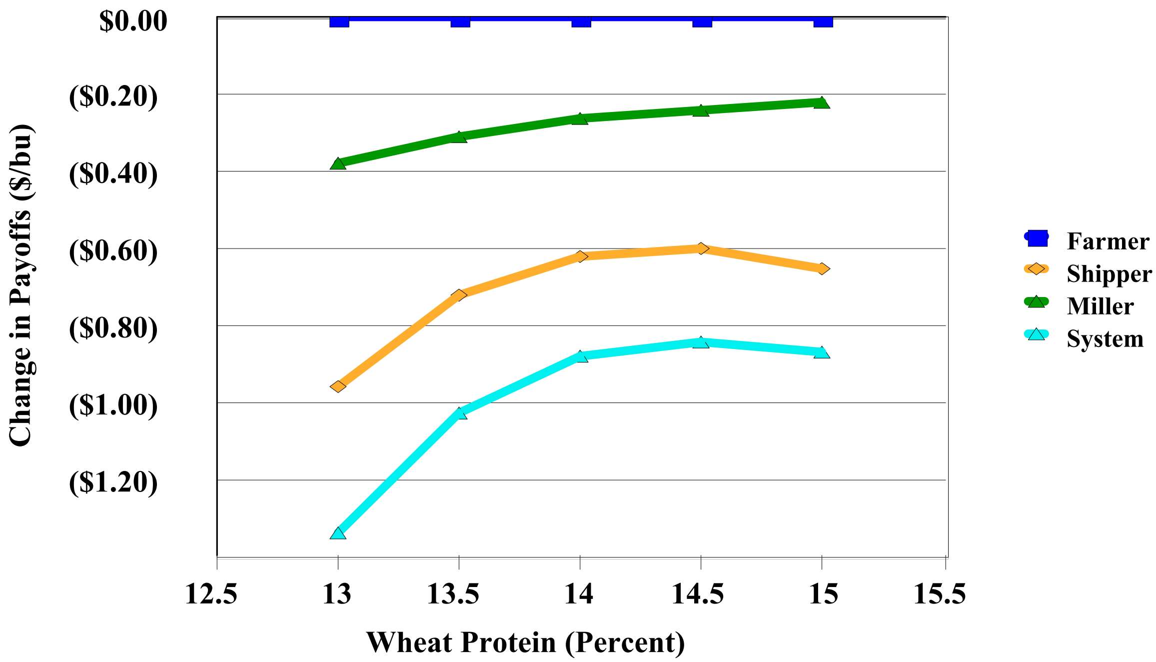

Figure 9. **Change in Payoffs by Participant for Purchase by Protein in Eastern North Dakota**

In contrast, the change in shipper payoffs was highest for higher protein wheat purchased in Western North Dakota than for either of the other locations or the protein only strategy. This occurs because of the high percentage of wheat exceeding specifications for absorption in Western North Dakota resulting in large quality giveaways[7] (economic costs) in comparison to the other locations/strategies. Therefore, the change in payoffs for shippers largely represents higher economic costs of quality giveaways rather than direct cash costs accruing to grain shippers when buying from Western North Dakota (Table 6). In comparison, as the protein level purchased decreases below 14 percent protein, the change in shipper payoffs is lowest for purchase in Western North Dakota (Figure 7). In contrast, changes in shipper costs for the other location strategies increase substantially for purchase of wheat below 14 percent protein as a higher percentage of wheat lots have absorption levels below specifications (Figures 8 and 9).

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[7] Quality giveaways are considered to be when wheat lots have levels for quality characteristics in excess of maximum desired levels. This can occur for a number of reasons. First, shippers may be unable to identify quality levels in a timely manner, thus they do not know they are giving away quality. Second, a market for segregated absorption levels may not exist. Third, a firm may be unwilling or deem it uneconomical to segregate quality. In all cases, the value of this higher level of quality is lost and not captured through either blending or segregation activities.

Variety and Variety by Location Strategies

Strategies that focus on buying based on protein and variety; and protein, variety and location were examined. Strategies that included variety had greater costs to mills and additional revenue for farmers as a premium for varieties of $0.20/bu was assumed. This additional premium shifts some revenue from mills to farmers.

Changes in costs were examined for five individual varieties (Grandin, 2375, Amidon, Len, and Stoa). Changes in payoffs for farmers vary across varieties, which reflects the difference in rejection rates across varieties (varieties with higher rejection rates require more commodity to flow through the system) (Figure 10). However, these changes in payoffs should be viewed with caution because higher rejection rates would tend to decrease the willingness of millers to pay higher premiums. Thus, there would be a tendency for premiums to decline for varieties with higher defect rates.

Changes in shipper payoffs reveal differences across varieties (Figure 11). Stoa and Len have higher rejection rates for lower protein purchases and, as such, incur higher costs. However, for higher protein purchases, Stoa has the lowest cost of any of the varieties. It is interesting that for Grandin, 2375, and Amidon, shipper costs are lowest for purchase of 13.5 percent protein wheat while for Stoa and Len, shipper costs are lowest for 14.5 percent protein purchases (Figure 11).

Changes in mill payoffs reflect differences in acceptance rates across the varieties (Figure 12). However, the change in payoffs converge to similar values as protein levels increase. Similar to other comparisons, the change in system payoffs largely reflect the same relationships that are present for the change in shippers payoffs (Figure 13). The change in payoffs was highest for Len and Stoa for purchase of lower protein wheats and was lowest for Stoa for purchase of higher protein wheats.

Varietal strategies were also compared for the more specific case of purchase by variety, protein, and location. Changes in payoffs for this alternative were examined for the variety Grandin in the three regions of North Dakota and compared to purchase of Grandin by protein only. Changes in shipper payoffs for purchase of Grandin in Western North Dakota are the highest at protein levels exceeding 13.5 percent protein (Figure 14). This occurs because of the higher probability of quality giveaways for absorption when purchasing Grandin in Western North Dakota than in the other regions.

Comparison of changes in mill payoffs for Grandin across strategies were evaluated. The change in mill payoffs for Grandin in Western North Dakota was lowest for all protein levels and differences between the level of change in mill costs across strategies were largest for lower protein levels. For example, changes in payoffs for purchase of 14 percent protein wheat were 5 cents per bushel lower in Western North Dakota than for purchase of Grandin by protein only and were about 7 cents per bushel lower than for purchase of Grandin in either Central or Eastern North Dakota (Figure 15). However, the difference between changes in mill payoffs for 13 percent protein wheat was 25 cents per bushel lower in Western North Dakota than for purchase of Grandin by protein level only and 27 cents per bushel lower than for purchase of Grandin in either Central or Eastern North Dakota.

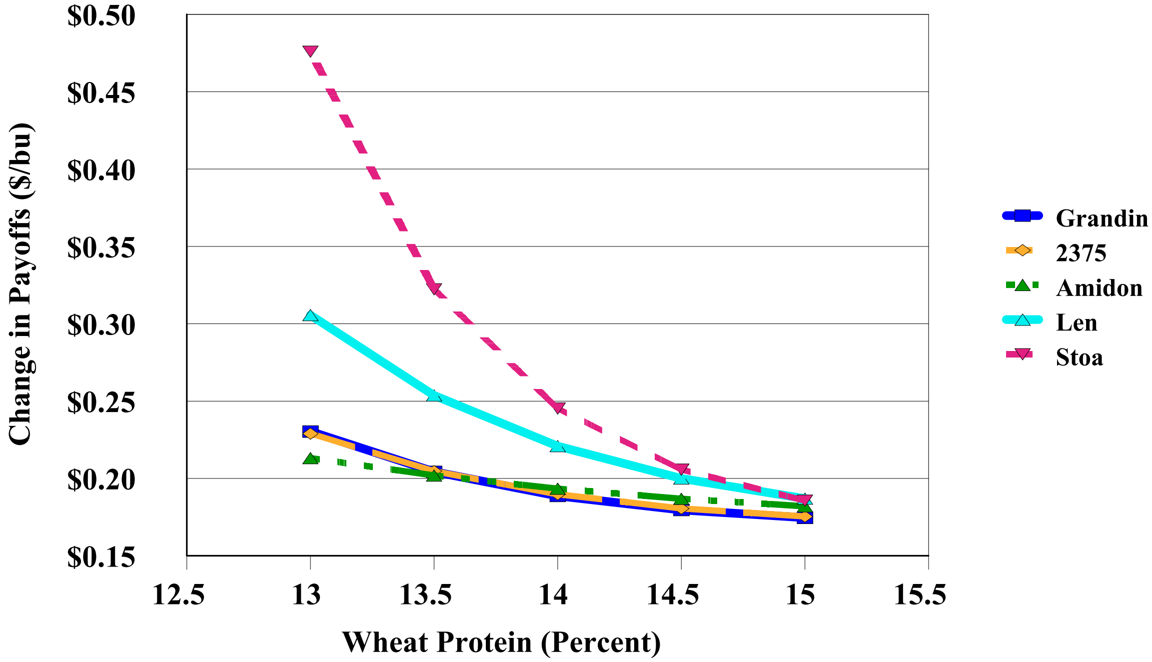

Figure 10. Change in Farmer Payoffs for Purchase by Variety and Protein Strategies

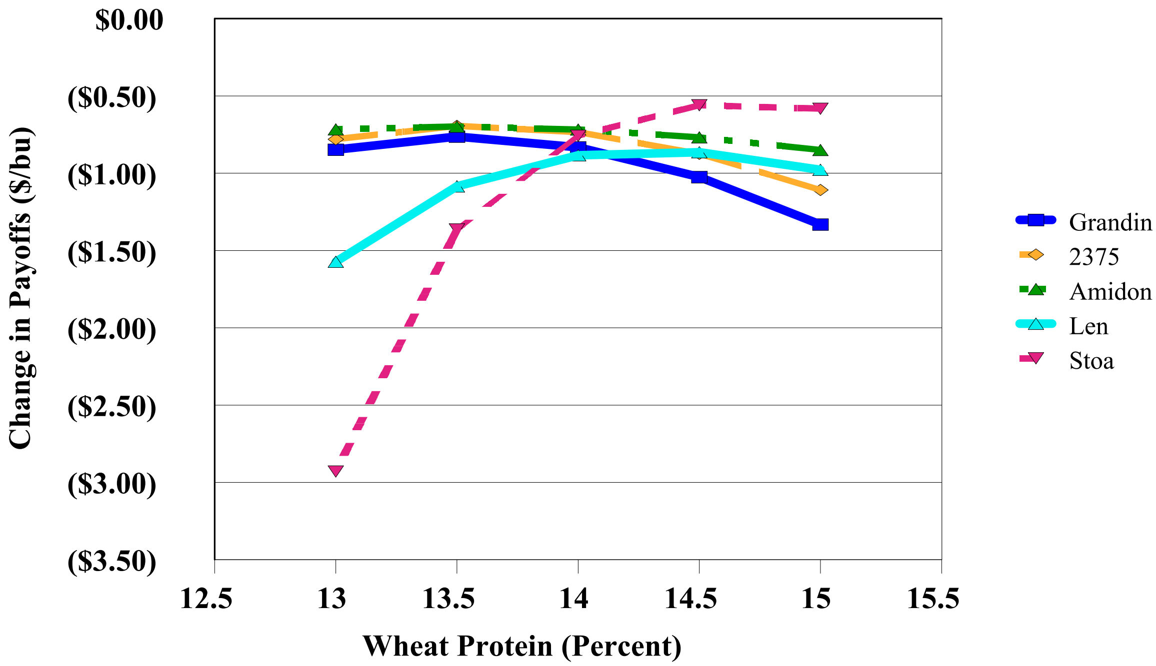

Figure 11. Change in Shipper Payoffs for Purchase by Variety and Protein Strategies

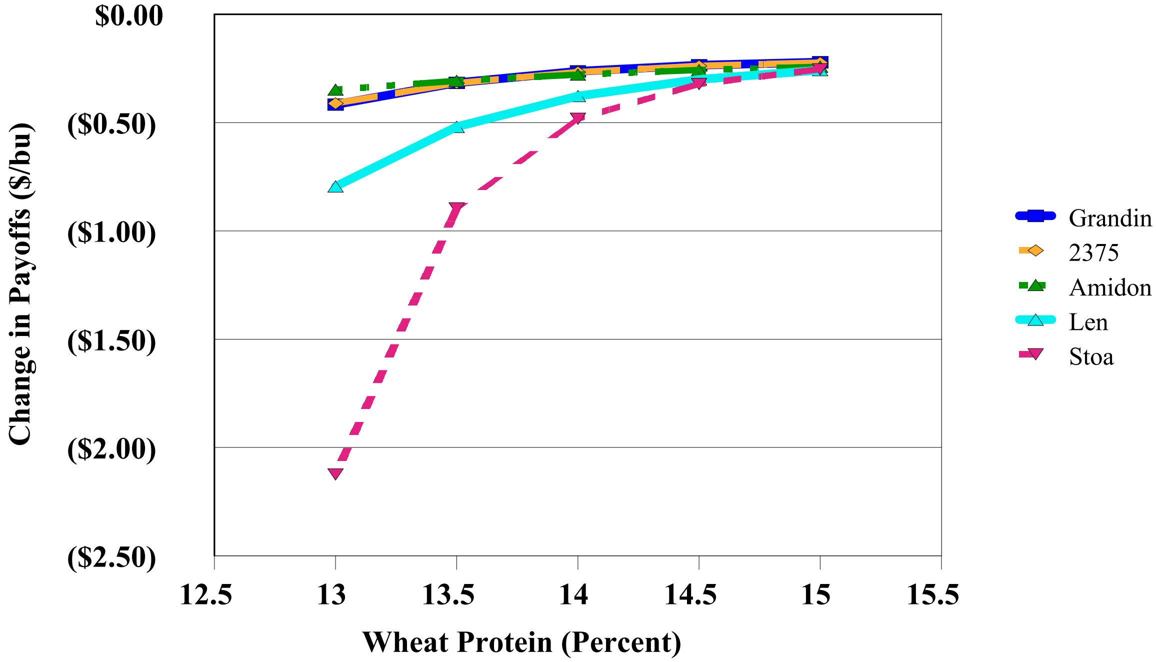

Figure 12. Change in Miller Payoffs for Purchase by Variety and Protein Strategies

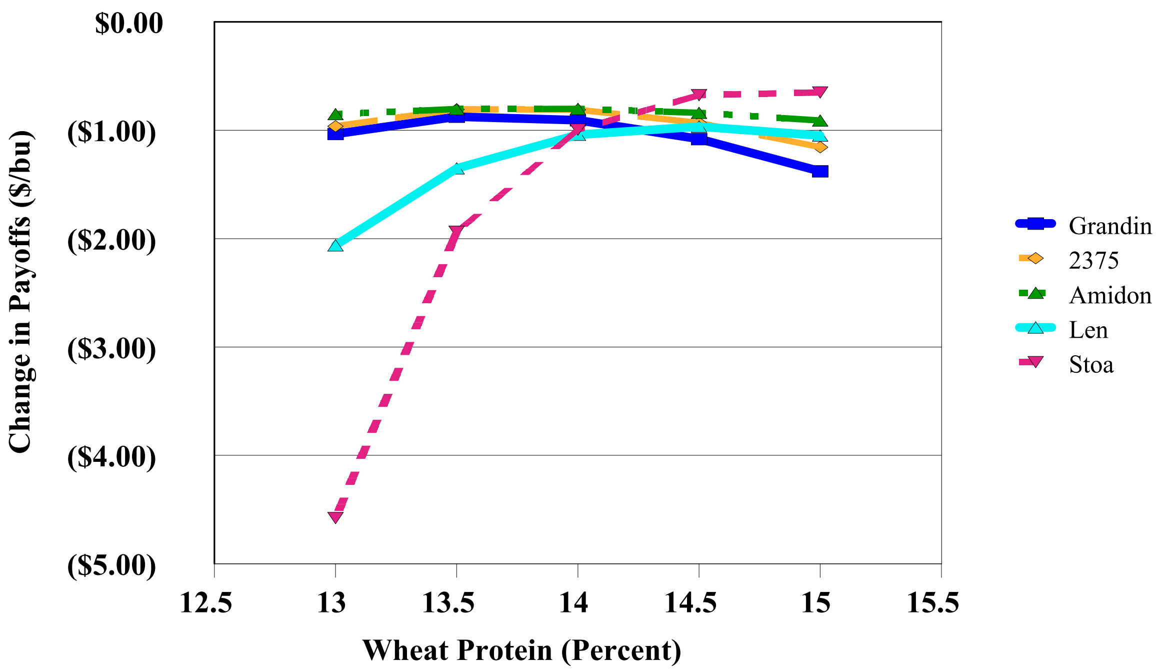

Figure 13. Change in System Payoffs for Purchase by Variety and Protein Strategies

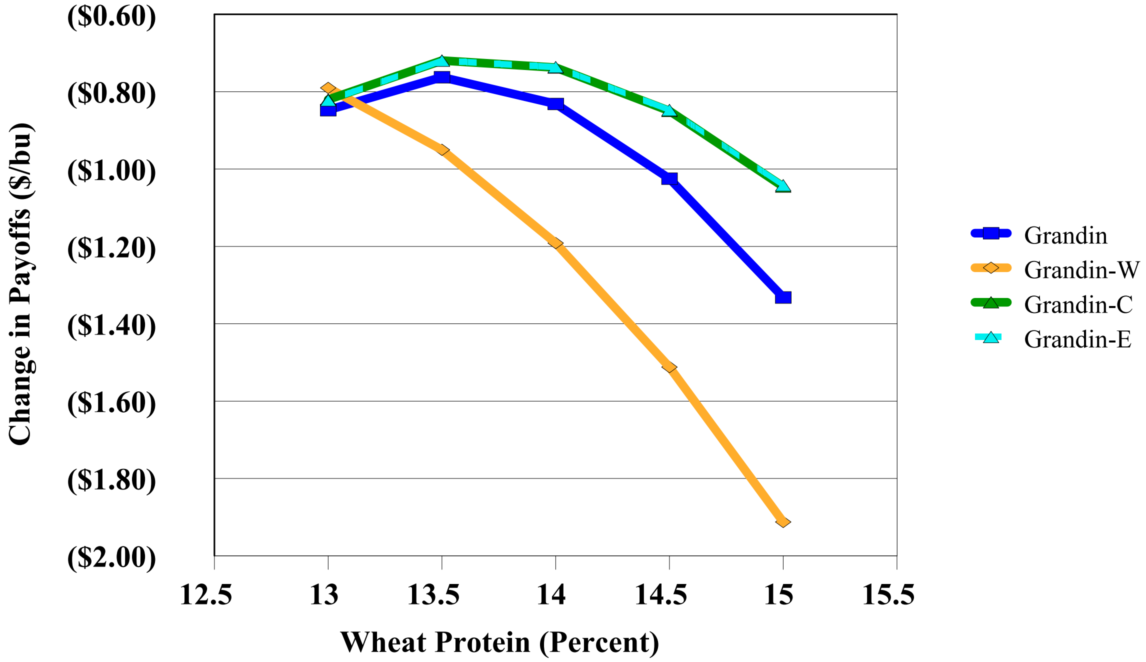

Figure 14. Change in Shipper Payoffs for Variety and Variety by Location Purchase Strategies

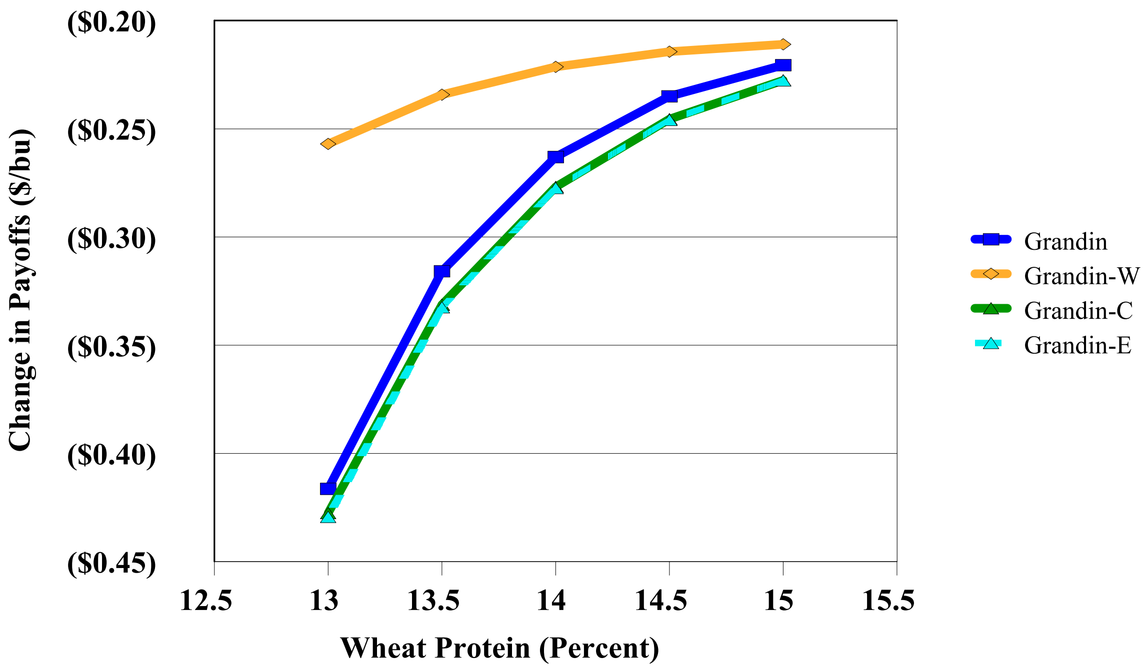

Figure 15. Change in Mill Payoffs for Variety and Variety by Location Purchase Strategies

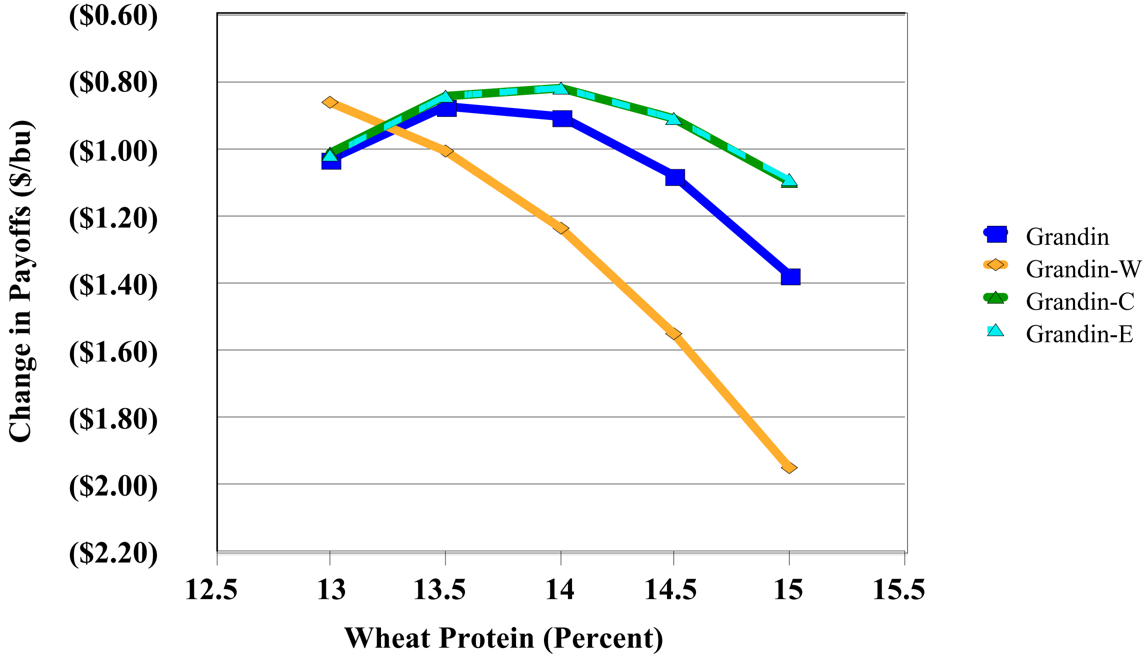

Figure 16. **Change in System Payoffs for Variety and Variety by Location Purchase Strategies**

Comparison of the change in system payoffs across variety strategies exhibit the same relationship as for the change in shipper payoffs (Figure 16). Again, purchase of Grandin in Western North Dakota has the highest change in system payoffs due to the higher proportion of quality giveaways that occur for shippers than in any of the other strategies.

Comparison Across Strategies

The results indicate that the change in shipper payoffs increases dramatically for higher levels of protein purchased as strategies become more specific to location and variety (Table 7, Figure 17). At lower protein levels, the change in shipper payoffs are lowest for the most specific buying strategies. Again, this is due to the high proportion of lots having quality greater than specifications (Table 8, Figure 18) which implies that the change in shipper payoffs are largely opportunity costs. For example, for the purchase of 14 percent protein wheat, 62.1 percent of lots exceeds quality requirements for purchase of Grandin in Western North Dakota. This compares to 28.6 percent for purchase by protein only, 39.8 percent for purchase of Grandin, and 47.9 percent for purchase of wheat in Western North Dakota. Comparison of the change in total system payoffs reveals similar results as the change in shipper payoffs dominates the change in system payoffs for all strategies (Figure 19).

Table 7. Comparison of Change in Payoffs for Alternative Purchase Strategies

	Protein	Western ND	Grandin	Grandin-West ND
Farmer				
13	$(0.00)	$(0.00)	$0.230	$0.187
13.5	$(0.00)	$(0.00)	$0.204	$0.179
14	$(0.00)	$(0.00)	$0.189	$0.175
14.5	$(0.00)	$(0.00)	$0.179	$0.172
15	$(0.00)	$(0.00)	$0.175	$0.171
Shipper				
13	$(0.909)	$(0.602)	$(0.847)	$(0.790)
13.5	$(0.724)	$(0.667)	$(0.762)	$(0.950)
14	$(0.676)	$(0.792)	$(0.832)	$(1.191)
14.5	$(0.730)	$(0.974)	$(1.025)	$(1.512)
15	$(0.868)	$(1.210)	$(1.332)	$(1.912)
Mill				
13	$(0.236)	$(0.062)	$(0.416)	$(0.257)
13.5	$(0.136)	$(0.040)	$(0.316)	$(0.234)
14	$(0.080)	$(0.027)	$(0.263)	$(0.221)
14.5	$(0.049)	$(0.019)	$(0.235)	$(0.214)
15	$(0.031)	$(0.014)	$(0.221)	$(0.211)
System				
13	$(1.145)	$(0.664)	$(1.033)	$(0.860)
13.5	$(0.860)	$(0.708)	$(0.874)	$(1.005)
14	$(0.756)	$(0.819)	$(0.906)	$(1.238)
14.5	$(0.778)	$(0.992)	$(1.080)	$(1.554)
15	$(0.898)	$(1.224)	$(1.378)	$(1.952)

Table 8. Comparison of Probability of Quality Meeting or Exceeding Shipper and Mill Specifications and Miller EOQs for Alternative Purchase Strategies

	Protein	Western ND	Grandin	Grandin-West ND
Shipper Quality Within Specifications (Absorption=63% +-2%)				
13	.52	.56	.56	.51
13.5	.54	.52	.55	.44
14	.54	.46	.50	.35
14.5	.50	.39	.42	.26
15	.44	.32	.32	.18
Shipper Quality Greater than Specifications (Absorption >65%)				
13	.14	.30	.18	.40
13.5	.21	.39	.28	.50
14	.29	.48	.40	.62
14.5	.38	.57	.53	.72
15	.48	.66	.65	.81
Mill Quality Above Minimum Specifications (Absorption >61%)				
13	.66	.86	.74	.91
13.5	.75	.90	.83	.95
14	.82	.94	.90	.97
14.5	.88	.96	.95	.99
15	.93	.98	.97	.99
Estimated Mill EOQ by Protein Level (bu)				
13	29,695	22,888	25,959	21,053
13.5	26,160	21,700	23,029	20,214
14	23,770	20,895	21,269	19,715
14.5	22,170	20,370	20,244	19,431
15	21,136	20,040	19,683	19,291

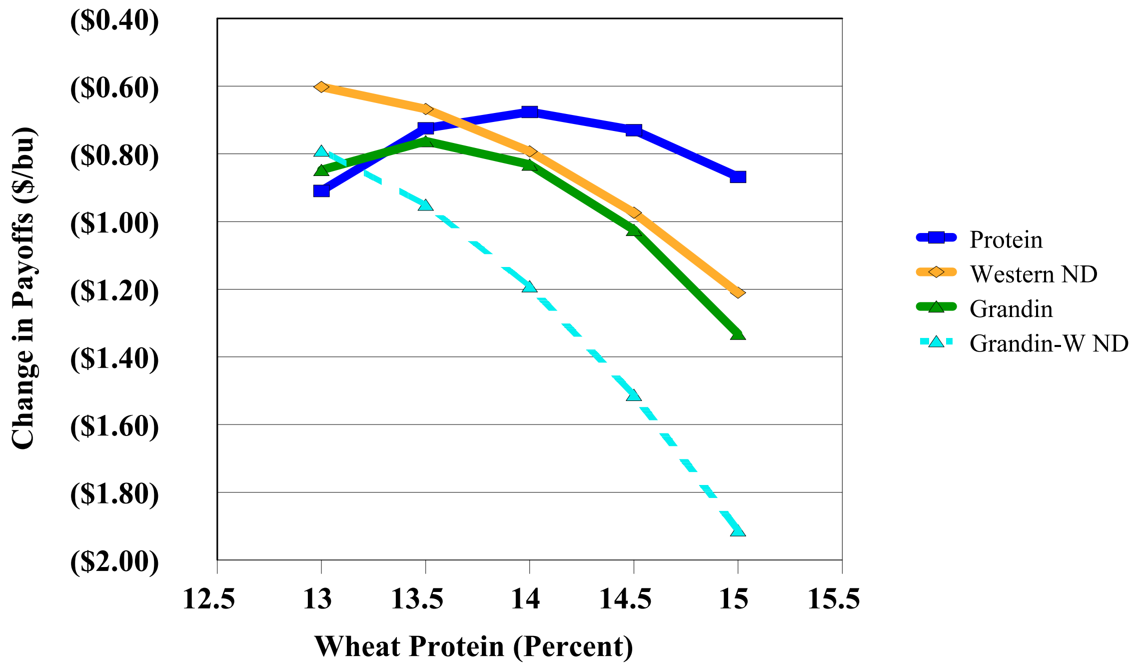

Figure 17. Comparison of Change in Shipper Payoffs for Alternative Purchase Strategies

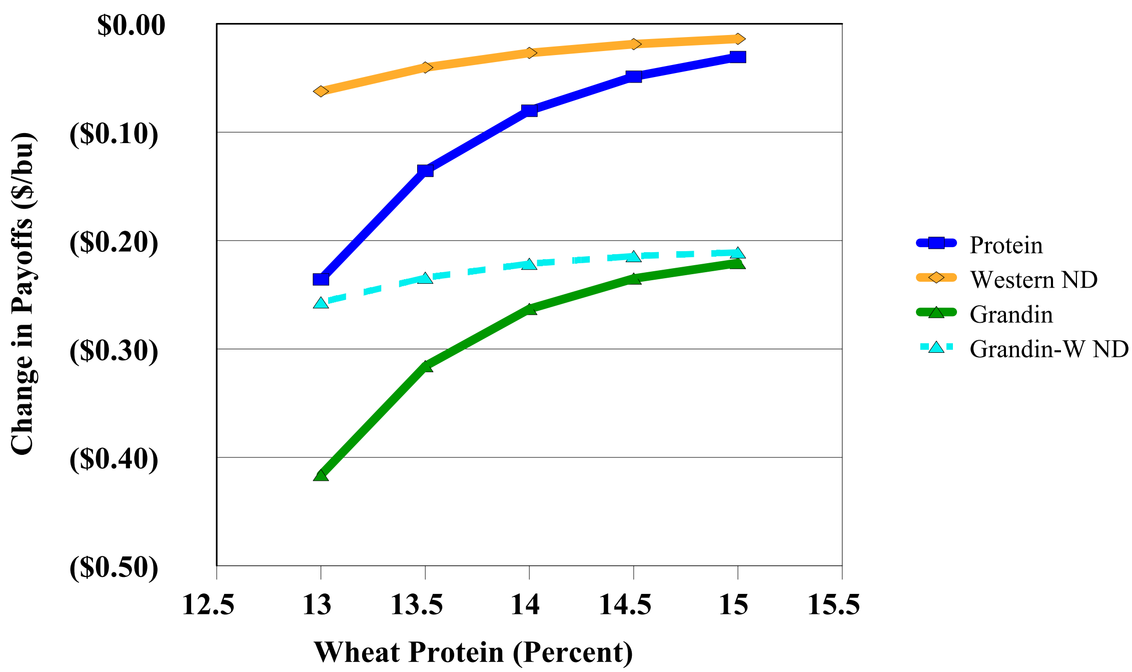

Figure 18. Comparison of Change in Mill Payoffs for Alternative Purchase Strategies

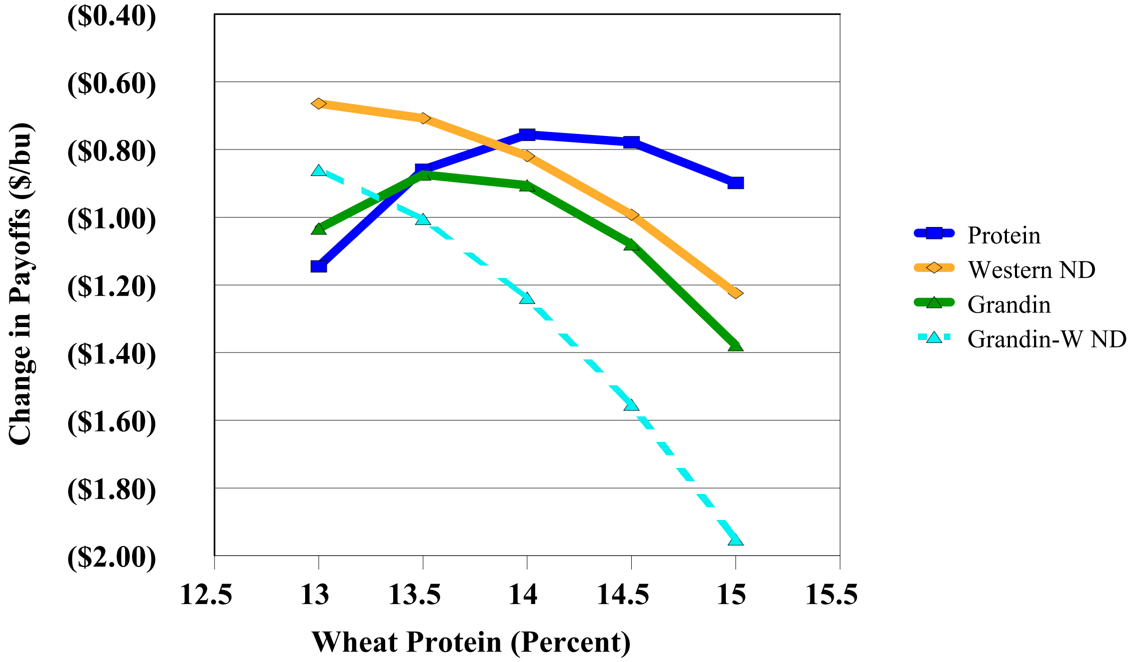

Figure 19. Comparison of Change in System Payoffs for Alternative Purchase Strategies

The results also illustrate the transfer of payoff from mills to farmers for variety specific strategies. In the case of absorption, movement to more specific strategies that focus on protein and variety or protein, variety, and location have limited impact on reducing the size and variability of mill quality costs. Movement to the most specific strategies that focus on protein, variety, and location did decrease the change in payoffs and variability of the change in payoffs across protein levels. Note that the millers EOQ's for purchase of wheat in Western North Dakota and for purchase of Grandin in Western North Dakota displayed the lowest range of EOQs across protein levels (Table 8).

We examined the variety specific strategies (Purchase of Grandin and Purchase of Grandin in Western North Dakota) in comparison to the base protein only strategy. If there is no premium for variety specific purchase, the decrease in quality costs is the difference in mill payoffs. However, these have to be adjusted to reflect the difference in probability of acceptance. When this is done, the value of reduced procurement costs for the variety specific strategies by protein level range from 1.6 cents per bushel to 18.1 cents per bushel (Table 9 and Figure 20). These values (1.6 cents per bushel to 18.1 cents per bushel) represent the most a miller could pay for the strategy. However, the size of the premium paid by millers (assessed at 20 cents per bushel) more than offsets any benefit in procurement costs. It is important that this value represents potential savings from procurement and does not represent operational efficiencies from improved quality/consistency in milling which is beyond the scope of this study.

The major effect on participants in the wheat marketing chain of movement to more specific purchase strategies is the increased costs imposed on shippers. As strategies become more specific, changes in payoffs are largely due to increased economic costs of quality being shipped in excess of quality demanded (quality giveaways), especially for higher quality varieties. These higher economic costs could provide incentives to shippers to implement strategies and/or purchase equipment that allows them to identify and segregate lots based on end-use qualities to capture any premiums that could be obtained by selling higher quality lots to buyers willing to pay for that higher quality.

Table 9. Estimated Value of Variety Specific Strategies

	Mill Quality Payoffs with No Premiums for Variety Strategies			Difference in Mill Payoffs Between Protein and Variety Strategies		Value Adjusted for Defect Rates	
Protein Level	Protein	Grandin	Grandin W-ND	Grandin	Grandin W-ND	Grandin	Grandin W-ND
	cents/bu						
13	-23.6	-14.5	-3.7	9.1	19.9	6.7	18.1
13.5	-13.6	-7.5	-2.3	6.1	11.3	5.1	10.7
14	-8.0	-4.1	-1.5	3.9	6.5	3.5	6.3
14.5	-4.9	-2.3	-1.1	2.6	3.8	2.5	3.7
15	-3.1	-1.5	-0.9	1.6	2.2	1.6	2.2

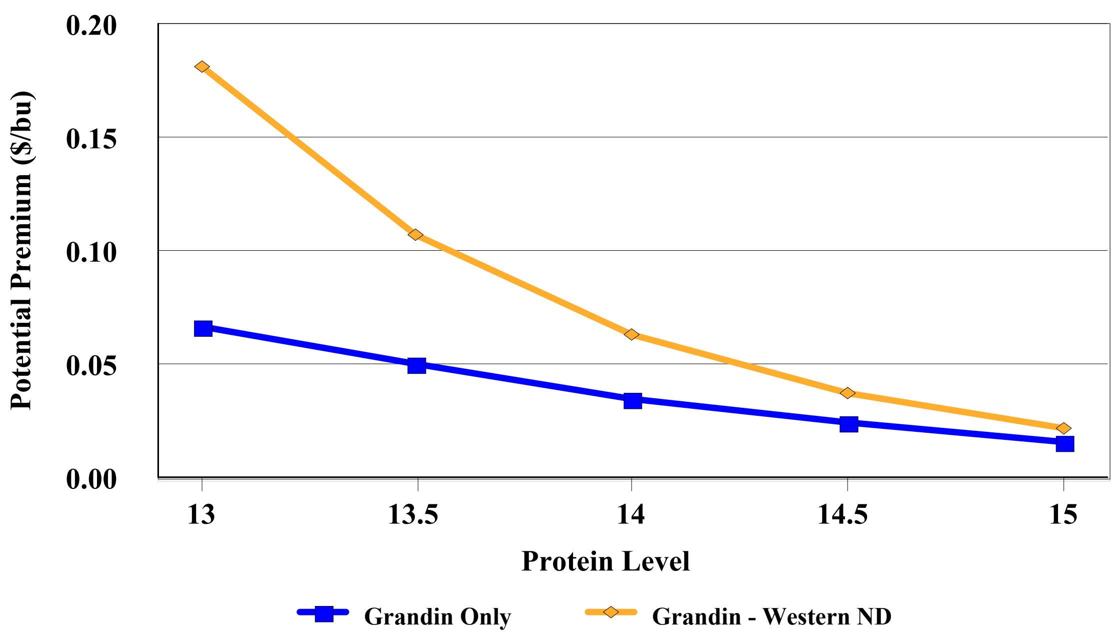

Figure 20. Estimated Potential Value of Purchase by Variety and Variety by Location Strategies for Grandin

SUMMARY AND IMPLICATIONS

Changes in payoffs were compared and contrasted across participants in the wheat marketing chain for a range of purchase strategies that could be considered within the continuum of "Identity Preserved" or IP sales. As strategies became more specific (movement toward purchase by either location, variety, or variety and location), the probability of lots meeting quality specifications for absorption generally increased. The lowest levels of rejection were for wheat purchased by protein level in Western North Dakota and by protein and variety in Western North Dakota. Changes in payoffs for mills generally followed this relationship. As strategies became more specific, quality improved, and changes in payoffs declined. However, strategies that included purchase by variety had higher mill costs due to the increased premiums paid. Strategies that included location or location and variety generally had lower variability in the change in mill payoffs across the range of protein levels examined than did strategies that focused only on protein or protein and variety.

The increase in specificity in strategies had the greatest impact on the change in shipper payoffs. As strategies become more specific, higher economic costs are incurred by shippers. This occurred due to a higher probability of exceeding specifications for absorption when purchasing with more specific strategies. These economic costs, in many cases, are substantial and would provide incentives for shippers to segregate lots based on quality.

The other change in payoffs among participants was the shifting of revenue to farmers from mills for variety specific strategies. This analysis indicates that when the desired quality characteristic is absorption, premiums paid for specific varieties quickly offset any reduction in procurement costs achieved by mills. Variety specific strategies reduced costs of procurement for mills in the area of 2 to 18 cents per bushel. However, in our case, these are offset by the assumed variety premium of 20 cents per bushel.

This analysis focused on absorption as the end-use quality characteristics desired by millers. Other end-use quality factors (such as loaf volumes, wet gluten, farinograph measures including mix tolerance, peak time, etc.) could also be end-use quality factors that determine whether lots are accepted or rejected. For example, one of the complaints from some buyers about the variety '2375' is its low dough strength. Results for this analysis show that when Grandin, a higher dough strength variety, is compared with 2375, there is little difference in quality acceptance/rejection and costs to shippers, mills, and the system. However, if a measure of dough strength was utilized, these results could change dramatically.

Another question that should be examined is the applicability of the size of costs for quality differences being the same for both quality shortages (where product is rejected) and quality giveaways (product exceeds desired specifications but can be blended with lower quality to increase profitability). Shippers who may be able to segregate based on end-use quality may/may not be able to capture significant premiums. If asymmetry in quality costs exists between quality shortages and quality excesses, then these results may not hold.

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APPENDIX TABLES

Appendix Table 1. Estimated Relationships Between Absorption and Wheat Protein, by Year

	1989	1990	1991	1992	1993	1994	1995
Constant	39.26	49.77	28.18	47.17	55.99	56.38	44.89
Protein	1.78*	0.90*	2.34*	1.26*	0.73*	0.43*	1.29*
RMSE	2.08	2.11	2.63	2.48	1.93	1.56	1.87
R-Square	.60	.17	.41	.18	.07	.06	.36

Appendix Table 2. Estimated Relationships Between Absorption and Wheat Protein, by Location, Year

	1989	1990	1991	1992	1993	1994	1995
Constant	45.24	41.51	36.35	45.48	54.51	57.35	39.92
Protein	1.37*	1.44*	1.76*	1.34*	0.77*	0.30	1.52*
D1	1.70	-1.16	2.48*	1.97*	1.72*	1.83*	2.87*
D2	0.84	0.88	-0.92	-1.17	0.25	0.89	0.06
RMSE	2.06	2.04	2.28	2.11	1.78	1.40	1.25
R-Square	.60	.23	.56	.41	.21	.25	.72

D1 is a binary variable representing Western North Dakota,
D2 is a binary variable representing Central North Dakota.
* Significant at $p > 0.05$.
Observations include varieties with > 0 shares of planted acres for that year.

Appendix Table 3. Estimated Probability of Not Meeting Milling Specifications (Defect Rates), by Protein Level and Purchase Specification

	Protein Level				
	13.0%	13.5%	14.0%	14.5%	15.0%
Base Case	34.1%	25.2%	17.6%	11.7%	7.4%
Western ND	14.5%	9.8%	6.3%	3.9%	2.3%
Central ND	37.0%	28.5%	21.1%	15.0%	10.1%
Eastern ND	38.1%	29.5%	21.9%	15.6%	10.7%
2375	25.8%	17.0%	10.4%	5.9%	3.1%
Amidon	20.2%	15.8%	12.1%	9.0%	6.6%
Grandin	26.2%	16.8%	9.9%	5.4%	2.7%
Len	44.4%	33.0%	23.0%	15.0%	9.0%
Stoa	64.3%	47.2%	30.7%	17.4%	8.4%
Grandin Western ND	9.0%	5.2%	2.8%	1.4%	0.7%
Grandin Central ND	27.0%	18.5%	11.9%	7.2%	4.0%
Grandin Eastern ND	27.2%	18.6%	12.0%	7.2%	4.0%