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Report to Congressional Requesters

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WHEAT PRICING

Information on Transition to New Tests for Protein

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Congressional Requesters

Protein levels in wheat are an important factor in determining hard red spring (HRS) wheat prices, particularly for HRS wheat grown in Minnesota, Montana, North Dakota, and South Dakota. Higher protein commands higher prices in the market. Therefore, the accuracy and reliability of protein testing is of primary importance to these areas and to those who buy and sell high-protein wheat. In 1993, concerns were raised that a new technology for estimating the protein levels of wheat—the Near Infrared Transmittance (NIRT) technology—was producing estimates that were lower than those provided by an older technology. This new technology was introduced by the Federal Grain Inspection Service (FGIS)—an agency in the U.S. Department of Agriculture (USDA) that provides official inspections of grain. Inspections by laboratories other than those supervised by FGIS are known as unofficial inspections. While official inspections must meet FGIS' standards and are used for both domestic and export sales, they are generally required for export sales. In contrast, unofficial inspections are not subject to FGIS' standards. Unofficial inspectors can range from "in-house" graders at grain elevators and processing plants to third-party inspection agencies.

Because of the above concerns, you asked us to (1) describe the pricing situation for wheat in 1993, (2) evaluate FGIS' introduction of the NIRT technology, (3) analyze the economic impact of the NIRT technology on segments of the industry, and (4) describe recent efforts to standardize unofficial protein testing of wheat.

Results in Brief

Prices for wheat with high amounts of protein were at record levels in 1993. During the previous 5 years, these prices ranged from $3.04 per bushel to $5.18 per bushel in the Minneapolis market—a major market for HRS wheat. In comparison, in 1993, prices ranged from $4.58 to $7.19 per bushel for similar wheat in the same market. High-protein wheat received record prices in 1993 largely because supplies were low at the beginning of the year and unusually severe weather conditions during the 1993 growing season further decreased supplies.

FGIS took reasonable steps in introducing the NIRT technology for official protein testing. However, difficulties commonly associated with the transition to a new technology, as well as the unusual 1993 crop conditions that were not reflected in the initial calibration for protein levels, led to concerns about FGIS' actions and eroded confidence in the NIRT technology.

Our analysis showed that because the NIRT technology generally provided lower protein readings on some damaged high-protein wheat, the market reacted by raising the premiums for high-protein wheat. The resulting higher premiums generally offset any losses that would have occurred from the lower NIRT readings. We estimate that because of the NIRT technology, price premiums rose 50 cents per bushel more, on average, than they would have risen if the NIRT technology had not been used. However, this overall conclusion does not discount the possibility that some individual farmers and grain elevator operators incurred losses.

The National Conference on Weights and Measures, in conjunction with FGIS, has proposed standards for unofficial protein testing. These standards would help promote greater uniformity in commercial grain inspection. Even though the standards are not yet enforceable, they can be used by manufacturers as guidelines in the design of protein-testing equipment. The adoption of these standards would help to make unofficial protein readings more consistent.

Background

Components of wheat quality include damage, protein levels, and the test weight of wheat. HRS wheat, one of the six basic classes of wheat, maintains the highest protein content—usually 13 percent or above. This wheat, planted in the spring, grows primarily in the North Central states of Minnesota, Montana, North Dakota, and South Dakota. In 1993, USDA estimated that HRS wheat production in these states represented approximately 90 percent of the HRS wheat grown in the United States.

Federal or official protein testing is managed by FGIS, which (1) approves equipment for the official inspection of grain, (2) operates testing laboratories, (3) authorizes qualified state agencies and private laboratories to inspect grain, and (4) provides federal oversight of official grain inspection. In fiscal year 1993, FGIS and other entities authorized to perform official protein inspections conducted over 660,000 wheat protein inspections. FGIS performed approximately 10 percent of these inspections.

For official protein testing, FGIS uses near-infrared spectroscopy, which provides results more quickly than other technologies. FGIS has two types of this technology: the Near Infrared Reflectance (NIRR) technology and the NIRT technology. The NIRR technology estimates protein by measuring the amount of infrared light that is reflected from a portion of ground grain, while the NIRT technology estimates protein by measuring the amount of infrared light that passes through whole kernels of grain. Since NIRT instruments analyze whole grain samples, they reduce operator errors, decrease analysis time, and provide more consistent results. After using the NIRR technology since 1978, FGIS began using the NIRT technology for official protein testing in May 1993.

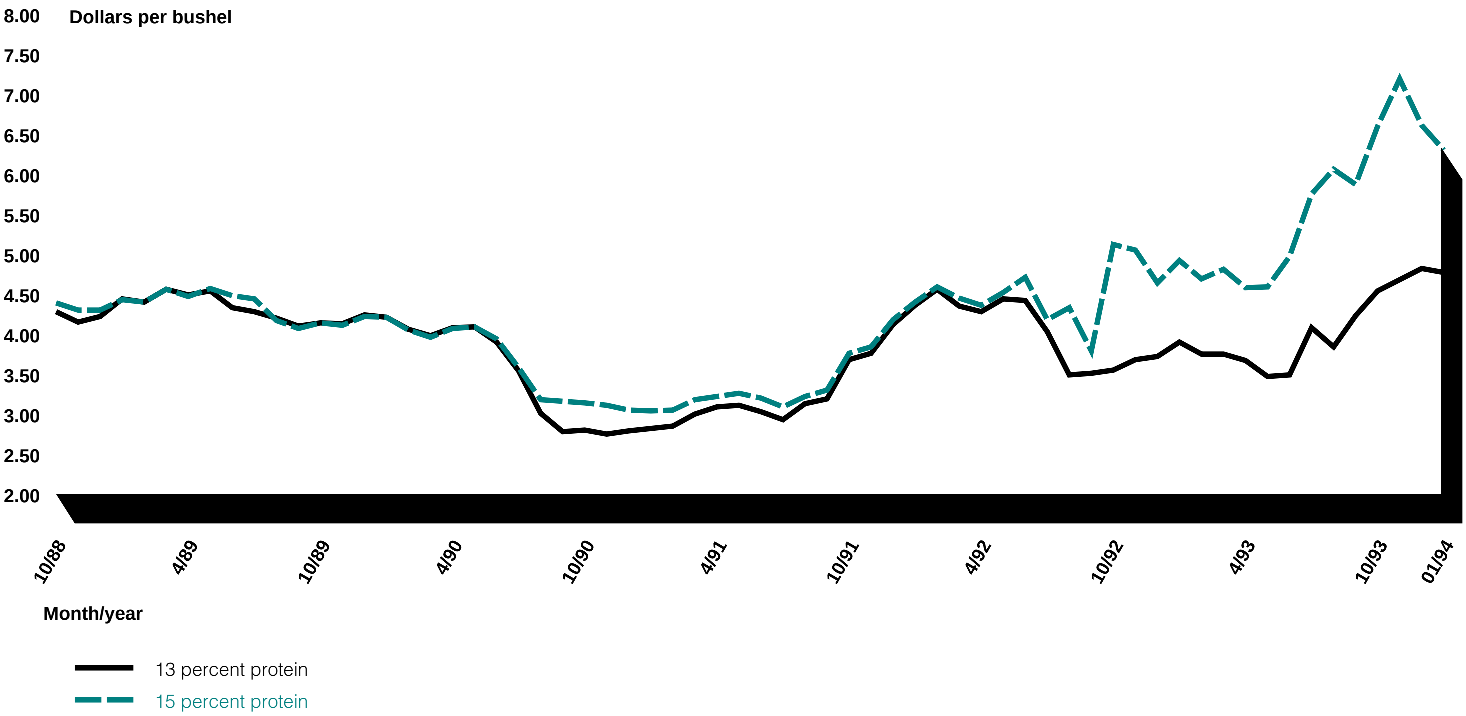
To calibrate the NIRR and NIRT technologies, FGIS uses a chemical process, referred to as the reference technology, that measures, rather than estimates, protein levels in wheat samples. This process is costly and time-consuming, making it too impractical for routine testing.

Prices for High-Protein Wheat Were at Record Levels in 1993

The unusual protein-pricing situation in 1993 occurred in two phases and was the result of short supplies of high-quality, high-protein wheat. Initially, the short supply was due to quality problems resulting from high moisture levels in the 1992 crop, which reduced stocks of high-quality, high-protein wheat at the end of 1992. The prices for this wheat, which had averaged $3.36 per bushel in calendar year 1991, increased to an average of $4.63 per bushel in 1992. These short supplies continued into 1993, helping to keep premium prices at a high level. The 1993 winter wheat harvest had low levels of protein and/or other quality problems that further decreased supplies. In addition, the 1993 HRS wheat harvest did not replenish the stocks of high-quality wheat. Heavy moisture, combined with cold temperatures, delayed the harvest and produced lower yields and uneven quality. The overall quality of the crop varied in the four North Central states, depending on rainfall levels. Farmers, grain elevator operators, millers, and other representatives of the grain industry told us that the 1993 crop was one of the worst they had seen for quality.

Moreover, the shortage of high-protein wheat was perceived to be even greater than was actually the case because the NIRT technology underestimated the protein levels in some damaged high-protein wheat, according to FGIS. Consequently, the price premium for high-protein wheat increased further. For example, as figure 1 shows, the price for 15-percent HRS wheat went from $4.58 per bushel in April 1993 to $6.60 in October and to $7.19 by November.

Figure 1: Variations in Protein Prices for HRS Wheat for the Minneapolis Market, October 1988-January 1994



Source: USDA's Economic Research Service.

FGIS' Procedures Were Generally Reasonable, but Certain Conditions Eroded Confidence in Test Results

FGIS took a systematic approach to evaluating the NIRT technology and followed established procedures for implementing it. However, several conditions during implementation, such as weather-related damage to the grain, made the transition more difficult than anticipated and led to concerns about FGIS' thoroughness in deciding to implement the NIRT technology. (See app. I for the chronology of the evaluation and implementation of the NIRT technology.)

FGIS Took a Systematic Approach to Introducing the NIRT Technology

FGIS followed reasonable procedures in evaluating and introducing the NIRT technology into the official protein testing system in 1993. For its initial assessment of the technology, FGIS followed the broad criteria cited in its Type Evaluation Handbook to determine whether further evaluation was warranted. According to FGIS' documentation, the NIRT technology met these broad criteria. This handbook also provides performance standards for any testing technology and prescribes procedures for evaluating and approving the technology. After this phase, FGIS conducted more rigorous evaluations.

First, FGIS weighed the advantages and disadvantages of switching to the NIRT technology for the agency's testing. In doing so, FGIS determined that the NIRT technology's advantages outweighed the benefits of continuing to use the NIRR technology. The NIRT technology lowers labor costs because it requires fewer operating steps and reduces the potential for errors by operators. As a result, the NIRT technology's results on the same sample are more consistent from instrument to instrument and, except in certain cases when grain quality problems are unusual, should be more representative of the actual protein levels than the NIRR technology's results.

However, agency officials recognized that upgrading the equipment at all of FGIS' official testing stations would be costly and would cause some market disruptions. The disruptions would occur principally because, for a period of time, official testing stations could be using either the NIRR or the NIRT equipment, thus producing different estimates.

Second, FGIS evaluated different approaches to introducing the new technology into the market. After considering various implementation alternatives, FGIS decided to replace NIRR equipment with NIRT equipment at FGIS-operated official testing stations when the implementation of the NIRT technology began. FGIS' goal was to minimize the time during which both types of instruments were used for official testing. In turn, this would minimize the exposure of the wheat market system to different official testing results at different locations. However, FGIS did not require other official inspection sites to replace NIRR equipment with the NIRT equipment but strongly encouraged them to do so as soon as funds became available. By August 1994, all of the official locations that were testing HRS wheat had switched to the NIRT technology.

Third, FGIS completed a pilot study at 16 official inspection stations in 1992 to compare the results of testing conducted with NIRR and NIRT instruments. For the 5-week study, both instruments at each location analyzed HRS wheat market samples for protein levels. The pilot study showed that in the field, the NIRT technology's results were more consistent and, on average, closer to the reference technology results than were the NIRR technology's.

FGIS planned to recalibrate the NIRT equipment periodically, as it had done for the NIRR equipment. FGIS periodically recalibrates the testing equipment with new wheat samples because different wheat characteristics may be present in each new crop year (June 1 to May 1 of the following year). These characteristics need to be reflected in the calibration data for continued accurate protein readings.

FGIS periodically discussed the development of the NIRT technology with the agency's Advisory Committee. Members of the Committee include farmers, university faculty, grain elevator managers, representatives of mills and grain companies, and others involved in the grain industry. FGIS kept the Committee apprised of the pilot testing results. At its June 1992 meeting, the Committee recommended that FGIS "continue moving toward NIRT technology as the standard protein testing method, and continue to explore means of phasing in the technology to minimize the impact on the industry."

FGIS also sought the advice of grain industry representatives in determining the best time to implement the switch to the NIRT technology. To do this, FGIS held a telephone conference with industry officials from major grain companies and milling and trade associations in February 1993. These officials generally agreed that in order to minimize any impacts on the market, FGIS should introduce the NIRT technology in the beginning of May, as it did, when there is generally a low amount of wheat in the marketing system.

Several Circumstances Impeded a Smooth Transition to the NIRT Technology

As FGIS had expected, not all official non-FGIS inspection sites began using the NIRT technology on the official implementation date. Consequently, official results were provided on the basis of testing conducted using two different technologies that did not necessarily produce equivalent results. Those in the wheat market that purchased wheat on the basis of one technology's test results and sold it on the basis of another's saw, in some cases, differences in protein results. These differences created disparities between expected and actual prices.

However, these anticipated difficulties were made much worse by the unanticipated damage to the HRS wheat crop in 1993. When FGIS originally calibrated the NIRT equipment in 1991, it used market samples from 1991 and prior years that did not represent some of the unusual quality problems found in the 1993 crop. As a result, the NIRT equipment was not producing accurate readings on some samples of 1993 HRS wheat. In

January 1994, FGIS updated the original calibration. This new calibration is based on samples from 1988-93 crop years representing a range of growing conditions and protein levels. These samples also reflected the quality of the 1993 crop.

Concerns Eroded Confidence in FGIS and the NIRT Technology

Many local farm and grain elevator organizations and others in the industry we spoke to raised concerns about FGIS' decision-making process and the procedures the agency used to introduce the NIRT technology. Although FGIS informed its Advisory Committee and other grain industry representatives about its progress toward implementing the NIRT technology, many farmers and grain elevator managers we spoke with were not fully aware of FGIS' decisions. For these individuals, an FGIS notice announcing the effective dates of the changes may have been the only information they received on the NIRT testing technology. Knowing little about FGIS' testing and calibration efforts, many of these individuals had little confidence in the validity of the NIRT technology or in FGIS' decision to use the technology for protein testing. Table 1 shows the market's concerns about FGIS' actions and GAO's findings related to those actions.

Table 1: Wheat Market's Concerns About the Introduction of the NIRT Technology

Market's concern	GAO's findings
The NIRT technology could not predict protein well on damaged wheat because FGIS calibrated the NIRT technology by using only selected samples of premium quality wheat rather than by using wheat representing actual quality conditions.	When FGIS initially calibrated the NIRT technology in 1991, FGIS used samples from the wheat that the industry sent to official laboratories in 1991 and previous years. While representative of that 5-year period, the samples did not represent the high damage that occurred after 1991.
FGIS required official laboratories to remove NIRR instruments from their premises as soon as they switched to the NIRT technology. This was probably done to prohibit comparative testing.	To avoid confusion over test results at the same site, FGIS asked only that official laboratories not use both instruments for testing.
FGIS' pilot study results were based only on premium quality samples that were not representative of the quality of the wheat traded in the market.	The pilot study evaluated the performance of the NIRT technology on 1992 samples of wheat traded in the market.
The results of the NIRT technology might be more consistent than the NIRR technology's results, but the results of the NIRT technology are not as accurate as the NIRR technology's results.	FGIS' testing results indicate that the NIRT technology's results in the field are more consistent and more accurate than the NIRR technology's results. This is because of the NIRT technology's operational advantages.
The NIRT technology always underestimates protein levels.	In 1993, the NIRT technology underestimated protein in high-damage, high-protein wheat—the kind that was primarily harvested in North Dakota that year. The 1994 recalibration of the NIRT technology has taken this condition into account.
FGIS made an implementation mistake by not running the NIRT and NIRR technologies in tandem for a period of time before proceeding with full implementation of the NIRT technology.	FGIS determined that it was not cost-effective to operate the two technologies at all official points. FGIS ran the two technologies side by side in its pilot study at 16 official locations and found that the NIRT technology's results were closer to the reference technology's results.
FGIS made an implementation mistake by not requiring all official inspection points to switch at the same time.	FGIS switched its locations to the NIRT technology at the same time. The agency strongly recommended that all other official inspection locations switch to the NIRT technology, but taking into account budget constraints at these sites, it did not require the switch. As of August 1994, all official inspection locations testing HRS wheat were using the NIRT technology.
FGIS' 1994 recalibration of the NIRT technology was an attempt to correct the agency's original faulty calibration.	According to FGIS officials, FGIS had planned the NIRT recalibration as an update of the 1991 calibration rather than as a correction. The recalibration would have taken place in the absence of a particular problem. However, because of the unusual characteristics of the 1993 crop, FGIS expedited its NIRT recalibration.

Economic Losses in 1993 Were Offset by High Premiums

Although farmers and operators of grain elevators in the wheat market were concerned about losses resulting from lower protein readings by the NIRT technology, our economic analysis suggests that such losses were offset, overall, by the increase in price premiums that resulted from the lower NIRT readings. By underestimating protein levels in heavily damaged HRS wheat, the NIRT technology indicated an apparent additional shortage of high-protein wheat. Farmers and grain elevator operators generally benefited from this perception. The artificial shortage resulting from the lower readings created price premiums that were higher than they would have been if the protein levels had been measured accurately. (See app. II for a more detailed discussion of our economic analysis.)

For example, our analysis shows that wheat exported through the Pacific Northwest had price premiums that were, on average, 53 cents higher per bushel because of the NIRT technology's original calibration. In addition, the NIRT technology's readings did not generally drop farmers and others out of the high-protein categories altogether. While our economic analysis shows that losses from lower protein readings were offset by higher premiums in the aggregate, some farmers we spoke with believed that they had incurred severe financial losses.

Efforts to Standardize Unofficial Protein Testing Are Under Way

Unofficial protein testing is generally more common than official protein testing for U.S. wheat traded in the domestic market. For example, it is common practice for elevator managers to use in-house NIRR or NIRT equipment to measure protein levels in wheat before they offer farmers a price for their wheat. However, without federal standards, this unofficial protein testing varies from site to site in terms of equipment operation, maintenance, and calibration. As a result, determinations of protein levels can vary extensively within the commercial sector and between this sector and the official protein testing.

To promote greater uniformity in commercial grain inspections, in 1990, the Congress amended the United States Grain Standards Act, authorizing FGIS to work with the Department of Commerce's National Institute of Standards and Technology and the National Conference on Weights and Measures to standardize unofficial grain inspections.[1] The Institute sponsors the Conference, a standards-writing organization whose members include weights and measures officials from states and local communities, federal government officials, manufacturers, trade representatives, and consumer organizations. The 1990 act authorized FGIS, along with the Conference and the Institute, to develop a program to evaluate equipment for the unofficial testing system. This program is to include identifying inspection instruments that require standardization, establishing performance criteria, developing a national testing program

[1]Grain Quality Incentives Act of 1990, P.L. 101-624, title XX, section 2009, Nov. 28, 1990. Prior to this legislation, FGIS' activities were restricted to the official inspection system. FGIS' authority to work cooperatively on standardized commercial grain inspections was subsequently expanded to include "other appropriate governmental, scientific, or technical organizations." United States Grain Standards Act Amendments of 1993, P.L. 103-56, section 11, Nov. 24, 1993.

for instruments used on commercial inspections, and developing standard reference materials or other means necessary for the calibration or testing of approved instruments.

In January 1994, the Conference introduced its proposal to standardize measurement practices for wheat protein in the commercial sector and its proposal to have the unofficial system use only equipment that meets the Conference's standards by 2005. If enforced by states, these standards could ensure consistent operation of the unofficial equipment and minimize operator error.

In July 1994, members of the Conference voted to approve the proposed standards. However, they deferred a decision on when these standards could be enforced by the states. Manufacturers can start using these standards as guidelines for designing protein-testing instruments. In addition, FGIS planned to start testing instruments for adherence to the standards in the fall of 1994.

Agency and Industry Comments and Our Response

We discussed a draft of this report with FGIS' Acting Director, Quality Assurance and Research Division and with the Chief of the Quality Control and Testing Branch, Quality Assurance and Research Division. These officials agreed with our results. However, they suggested minor technical revisions to our draft. Where appropriate, we incorporated these revisions into the report.

We also discussed the draft with the Vice President and Director of Planning and Evaluation, U.S. Wheat Associates. He also agreed with our results and did not suggest any changes.

Scope and Methodology

To address our objectives, we interviewed officials at FGIS and the Agricultural Stabilization and Conservation Service in USDA and the Congressional Research Service. We spoke with representatives of national farm, milling, and trade organizations as well as local organizations in Minnesota, Montana, North Dakota, and South Dakota. We also talked to representatives from FGIS-authorized laboratories, state departments of agriculture, and academia. In addition, we spoke to officials of the Canadian Grain Commission. We also obtained and analyzed documentation and data from these agencies and organizations. (See app. III for a list of organizations contacted.) Finally, we spoke to a number of individual farmers and elevator operators.

To evaluate the economic impacts of the new technology on industry, we used an economic model that describes spring wheat prices as a function of the various wheat characteristics such as protein, test weight, total damage, and moisture content. Our economic analysis encompassed the states of Minnesota, Montana, North Dakota, and South Dakota.

We conducted our review between November 1993 and July 1994.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of this letter. At that time, we will send copies to the Secretary of Agriculture. We will also make copies available to others on request.

Please contact me at (202) 512-5138 if you or your staff have any questions about this report. Major contributors to this report are listed in appendix IV.

John W. Harman
Director, Food
and Agriculture Issues

List of Requesters

The Honorable Conrad Burns
The Honorable Kent Conrad
The Honorable Byron L. Dorgan
The Honorable Larry Pressler
United States Senate

The Honorable Tim Johnson
The Honorable David Minge
The Honorable Collin C. Peterson
The Honorable Earl Pomeroy
House of Representatives

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Abbreviations

EGIS	Export Grain Inspection System
FGIS	Federal Grain Inspection Service
GAO	General Accounting Office
HRS	hard red spring
HRW	hard red winter
NIRR	Near Infrared Reflectance
NIRT	Near Infrared Transmittance
USDA	U.S. Department of Agriculture

Chronology of the Evaluation and Implementation of the NIRT Technology

Late 1980s	The U.S. Department of Agriculture's (USDA) Federal Grain Inspection Service (FGIS) began to use the Near Infrared Transmittance (NIRT) technology for determining protein levels in soybeans. Because it found the technology successful, FGIS decided to investigate the NIRT technology's usefulness for determining wheat protein levels.
June 1990	FGIS' testing showed that the NIRT technology met established requirements for estimating wheat protein levels.
July 1991	FGIS completed the NIRT calibration for hard red spring (HRS) wheat, which was necessary to begin implementing the NIRT technology.
September 1991	FGIS presented four alternatives for implementing the NIRT technology to the agency's Advisory Committee: (1) not implementing the NIRT technology for wheat protein, (2) using the NIRT technology concurrently with the NIRR technology, (3) phasing out the NIRR technology as part of the NIRT technology's implementation, and (4) converting all official inspection sites from the NIRR technology to the NIRT technology at the same time. FGIS discussed with the Advisory Committee (whose members included farmers) the inevitable differences between the two technologies.
October 1991	Between June of 1990 and October of 1991, FGIS assessed the impact of including the NIRT technology in the official system. It determined that there was little difference in accuracy between the NIRT technology and the reference technology but determined that there were differences in results between the NIRR and NIRT technologies.
November 1991	FGIS decided to implement the NIRT technology for official protein testing. It planned to verify the performance of the first several units before allowing their official use. FGIS would proceed to purchase and phase in units as soon as possible by January 1, 1994.
March 1992	FGIS announced a pilot study to compare the NIRT technology's performance with that of the NIRR technology using market samples at 16 FGIS-operated locations. The pilot study started in the week ending

March 14, 1992, and included 5 weeks of data for each location in the study.

June 1992

Pilot study results showed that the expected accuracy was better for the NIRT technology than for the NIRR technology when used under field conditions as opposed to controlled laboratory conditions.

FGIS reported on the status of the NIRT technology to the FGIS Advisory Committee. FGIS officials reported that they found the NIRT technology to be closer to the reference technology than the NIRR technology and that the use of the NIRT technology would improve the accuracy of the entire system. In addition, FGIS found that field NIRR technologies, on average, estimated higher protein levels than did the NIRT technology, implying that in some instances, using the NIRT technology would yield lower protein measurements. The Advisory Committee recommended that FGIS continue moving toward the NIRT technology as the standard protein-testing method and continue to explore means of phasing in the technology to minimize the impact on the industry.

FGIS constructed an NIRT technology implementation schedule.

July 1992

FGIS announced in the Federal Register that the agency would introduce the NIRT technology as an “additional” type of technology in the agency’s national program to inspect wheat protein levels.

Because FGIS found that the calibration for hard red winter (HRW) wheat did not accurately estimate protein levels, FGIS suspended its announced implementation of the NIRT technology for official protein testing for HRS wheat, soft white wheat, and HRW wheat, pending additional verification testing.

August 1992

FGIS planned to develop updated NIRT calibrations for HRS wheat in the fall and winter of 1993.

January 1993

FGIS announced that it had completed testing for soft white wheat and HRS wheat and was prepared to begin using the NIRT instruments for these classes on February 22, 1993.

February 1993

FGIS participated in a conference call with industry representatives. The discussion centered around (1) the best time for implementing the NIRT technology and (2) industry's concerns about introducing two different official methods for determining wheat protein that do not provide identical results. FGIS said it would address any measurement discrepancies on a case-by-case basis.

After reviewing industry's comments, FGIS decided not to implement the NIRT program for soft white and HRS wheat on February 22, 1993. FGIS rescheduled its implementation of the NIRT program for all classes of wheat to May 2, 1993. As suggested during the call, this date coincides with the start of the marketing year for wheat. Although spring wheat is typically harvested later, several participants indicated that stocks should be sufficiently low by May 2 so the market impact of the new testing program would be reduced. Furthermore, establishing one implementation date for all classes of wheat would minimize the time needed to check and maintain two separate instruments.

FGIS started the first of two training programs for Protein Coordinators (FGIS employees located around the country who are responsible for direct technical oversight of official wheat protein testing) so that they would be prepared to train NIRT operators in the field.

March 1993

FGIS announced the use of the NIRT technology for official wheat protein testing, effective May 2, 1993. All FGIS locations providing wheat protein testing were being equipped with the NIRT technology. FGIS planned to use the NIRT technology for official testing at export locations and for federal appeals—the highest level of official retests. Non-FGIS official sites without NIRT instruments could continue to provide wheat protein testing with their NIRR equipment.

May 1993

FGIS began using the NIRT technology for official wheat protein inspections. All FGIS-operated stations began to use the NIRT technology only.

Within 1 to 2 weeks after the switch to the NIRT technology, FGIS learned of differences between the NIRR technology's and NIRT technology's results for wheat protein in HRS wheat. These differences were found in both previous stocks and Canadian wheat imports. For example, the Montana Department of Agriculture started receiving calls from export elevator operators in Portland, Oregon, expressing concern that the NIRT technology was predicting lower protein levels than the NIRR technology did.

FGIS started a series of studies to identify why the differences occurred and whether corrective measures were needed. Those tests, according to FGIS, showed that the NIRT technology was performing within the expectations of protein levels for normal HRS wheat. The differences between the NIRR technology and the NIRT technology were, in many cases, equally due to the error in the NIRR technology as well as the NIRT technology. Canadian feed wheat, which was not covered in the NIRT calibration, consistently fell outside the expected statistical tolerances for accuracy.

On May 21, FGIS scheduled NIRT recalibrations for HRS wheat, soft white wheat, and soybeans. Resources were scheduled from May 1993 through September 1993 to work on the development of a new HRS wheat protein calibration.

On May 27, FGIS conducted a teleconference with 37 grain industry representatives—from Minnesota, North and South Dakota, Montana, Idaho, Oregon, and Washington State—to address industry concerns about the NIRT technology's results. At this meeting, FGIS agreed to monitor the situation in order to identify any problems with the NIRT technology's results.

October 1993

According to FGIS, one of the first indications of problems with the readings from the NIRT technology on the 1993 HRS wheat crop came from the Grand Forks Grain Inspection Department, Inc. To address this concern, FGIS obtained 10 HRS wheat samples from that company for laboratory analysis.

November 1993

FGIS developed a preliminary new HRS wheat recalibration that included a small number of 1993 crop samples that were obtained early in the harvest and represented typical production for the areas in which they were harvested. Had there been no quality problem with the 1993 crop of HRS wheat, FGIS would probably have implemented this recalibration in May 1994 as a routine update.

According to FGIS' analysis of samples from several locations chosen to reasonably represent the HRS wheat market, the current calibration for HRS wheat showed lower protein levels than it should have on a significant portion of 1993 crop samples, particularly those samples with quality problems that affected their appearance.

November-December 1993

Between November 16 and December 7, 1993, FGIS developed and evaluated a new NIRT calibration for HRS wheat that incorporated 1993 crop samples.

December 1993

FGIS determined that the new calibration would significantly improve the accuracy of protein estimates for the 1993 HRS wheat. A final evaluation using a group of samples with a protein range chosen from samples coming from all major HRS wheat-marketing areas indicated that the new NIRT calibration should transfer well to field instruments, maintain accuracy on normal HRS wheat, and improve the accuracy of protein determinations for samples that were damaged and therefore difficult for NIRT technology to predict. The calibration was based on samples from the 1988-93 crop years. FGIS believed that the revised calibration would particularly improve official protein results for the 1993 crop that was getting lower estimates from the NIRT technology. The updated calibration was expected to increase the protein levels of affected samples by 0.1 to 0.5 percent, with the larger increases occurring above the 13.5-percent protein level. These changes can make a significant difference in prices for farmers selling wheat during a shortage of high-protein, high-quality wheat. While the recalibration would not completely eliminate the tendency to give lower protein readings in lower-quality samples, it would improve the overall accuracy of the calibrations.

FGIS sent instructions for the upcoming new calibration for HRS wheat and its implementation to all locations testing HRS wheat using the NIRT technology. FGIS would begin implementation of the new calibration for HRS wheat on January 10, 1994, but because of expected market impacts, the new calibration would not be used until January 24, 1994.

FGIS expected that there would be differences between the new and old calibrations on some types of samples. Therefore, FGIS delayed the implementation of the new calibration following the agency's announcement to have all instruments set with the new calibration before the date set for implementation. This was intended to minimize the possibility that some entities would gain an unfair market advantage from prior knowledge or earlier use of the calibration.

January 1994

FGIS held a teleconference on January 5 with all official protein-testing locations to review the processes that FGIS would use to convert to the new calibration to make the change as smooth as possible.

FGIS announced that on January 24, it would update the official NIRT protein calibration for HRS wheat.

On January 24, all NIRT instruments began to use the new calibration for HRS wheat.

August 1994

All official locations testing HRS wheat had switched to the NIRT technology.

Economic Impact of Wheat Protein Testing

This appendix discusses our estimation of the economic impact of low protein readings by FGIS' NIRT technology during the 1993 crop year. Overall, we found that the economic impact of lower protein readings from the NIRT technology was generally balanced by increased protein premiums[1] that resulted from these lower readings. The lower protein readings exacerbated the market's response to a scarcity of high-protein wheat during a year in which high-protein wheat was already in short domestic and international supply because of weather- and disease-related problems. We estimate that initial low readings by the NIRT technology inflated protein premiums by approximately 53 cents per bushel for HRS wheat sold between the 13- and 15-percent protein levels in the Pacific Northwest export market. For the Great Lakes export market, although data are limited, we estimate that premiums were approximately 82 cents higher.

First, we provide an explanation of our choice of the hedonic regression framework for this analysis. We then furnish some intuition on the theoretical framework for the hedonic model. Next, we discuss the empirical model and estimation techniques that we used to obtain the effects of low protein readings. A description of our data and data sources follows. For both the Pacific Northwest and the Great Lakes markets, we then provide and examine the regression results. Last, using these regression results, we calculate the economic impact of low protein readings on both of these markets.

Analysis Used

We used a hedonic regression model, incorporating monthly price and quality data, to estimate the effect of artificially low protein measurements on protein premiums for HRS wheat. Protein premiums were estimated to be a function of different wheat characteristics—protein, damage, moisture—as well as a variable representing the supply of protein and a variable representing low NIRT readings in that period of time during which the NIRT technology was in effect but before the machines were recalibrated in January of 1994.

The hedonic approach was valuable in this analysis, since it is a "characteristics" regression approach, and characteristics such as protein and damage can be of vital importance in determining the price that

[1]We define protein premiums in this appendix as the difference between an average protein percentage price and a base price. Using 13 percent as the base price, the premium for 14-percent protein would be the average 14-percent market price over the average 13-percent market price. The additional premium at the 15- percent level would be the difference between the average market price for 15-percent protein and 14-percent protein wheat.

particular wheat shipments/crops can command in the market. It also helped us to incorporate the fact that wheat with different levels of protein, while similar, is a quite different product. For example, a characteristic of one wheat protein level, such as the moisture in 13 percent-protein wheat, may have an effect on the demand and price of 14-percent protein wheat. In addition, the fact that blending is so prevalent in this industry makes the characteristics of one type of wheat an important part of another's demand. By controlling for these important wheat characteristics, the coefficient on the NIRT calibration variable helped us to isolate the separate effect on protein premiums of the low protein readings.

We used monthly price and quality data at export markets from 1985 to 1993. Since they are official testing sites, export markets were the only points where all observations were definitely tested using the NIRT technology from May to December 1993. In addition, we only estimated effects on wheat protein premiums from the Pacific Northwest and the Great Lakes export markets because these were the only markets that had a complete record of prices by average protein level.

Hedonic Theoretical Model

In a hedonic model, the individual coefficients of the regression variables represent the implicit, or nonmarket, price of each characteristic found in that product. Following the hedonic work in the economics literature (Ladd and Martin[2], Wilson[3], Espinosa and Goodwin[4], and others), processors demand a differentiated agricultural product such as wheat because of the particular characteristics it possesses. These characteristics can be stated as input arguments into the processor's production function. For example, the amount of flour demanded for making bread dough and rolls is highly influenced by a characteristic such as protein content. Maximization of the processor's profit function, which includes this production function, yields a first-order condition that can be interpreted as the hedonic price function:

$$1)\ r_i = p_h \sum_j (\partial f_h / \partial x_{j \cdot h})(\partial x_{j \cdot h} / \partial v_{i_h})$$

[2]George W. Ladd and Marvin B. Martin, "Prices and Demands for Input Characteristics," American Journal of Agricultural Economics, Vol. 58 (1976), pp. 21-30.

[3]William W. Wison, "Differentiation and Implicit Prices in Export Wheat Markets," Western Journal of Agricultural Economics, Vol. 14, No. 1 (1989), pp. 67-77.

[4]Juan A. Espinosa and Barry K. Goodwin, "Hedonic Price Estimation for Kansas Wheat Characteristics," Western Journal of Agricultural Economics, Vol. 16, No. 1 (1991), pp. 72-85.

where,

r_i = the price of input i

$x_{j.h}$ = the total quantity of characteristic j that enters into the production of product h

v_{ih} = the quantity of the i^{th} input used in the production of the h^{th} product

$\delta x_{j.h}/\delta v_{ih}$ = the marginal yield of characteristic j in production of output h from input i

$\delta f_h/\delta x_{j.h}$ = the marginal physical product from one unit of characteristic j used in the production of the h^{th} product

$p_h(\delta f_h/\delta x_{j.h})$ = the value of the marginal product of the j^{th} characteristic used in the production of h

The last term, therefore, can be interpreted as a marginal implicit price (or imputed price) paid for the j^{th} product characteristic used in the production of output h. The last equation can be simplified by assuming that $\beta_j = p_h\ (\delta f_h/\delta x_{j.h})$ and $x_{jih} = \delta x_{j.h}/\delta v_{ih}$ are both constant[5] and is therefore:

$$2)\ r_i = \sum_j \beta_j x_{jih}$$

where β_j is the marginal implicit value of the characteristic j and x_{jih} is the quantity of characteristic j contained in each unit of input i that goes into the production of h. Thus, by regressing input prices on input characteristics, as measured by x_{jih}, we can determine the effect that physical characteristics have on the prices paid for inputs and measure the marginal implicit values (or hedonic prices) of these characteristics.

In our model, we assume that r_i, the price variable, is a protein premium. Protein premiums are prices that millers and others must pay in the marketplace to obtain wheat of desired quality. We use protein premiums instead of the total market price of wheat because we want to estimate the effects of the low protein readings on premiums directly. Variations in protein premiums, or price differentials, are more likely to be captured by

[5]This assumption means that each additional unit of input contributes the same amount of a given characteristic and that the marginal implicit price for the characteristic is constant.

variations in characteristics than are variations in the base price, which fluctuate in response to broader market conditions. Similarly, we did not want variations in the base wheat price to overwhelm the variations in premiums. As with total price, premiums are affected by the levels of characteristics of the different protein percentages.

Empirical Model and Estimation Procedure

We specified the empirical relationship between protein premiums and implicit prices of HRS wheat characteristics by the following linear sum:

$$3)\ PR_{it} = C + \sum_{j} \beta_j X_{itj} + \varepsilon$$

where, PR_{it} is the average protein premium for HRS wheat (dollars per bushel) from the i^{th} protein percentage in time t, c is the constant term, the β_j's represent marginal implicit prices for the j = 1, ..., m hard red wheat characteristics, as measured by the x_{itj}'s, and ε is the error term.

We used conventional measures of wheat quality from the agricultural economics literature in our estimation of wheat price premiums. These measures included the percentage of protein, test weight, percentage of moisture, and percentage of total defects. With hard wheat, processors use protein to predict the quantity of wheat gluten, which makes protein a desirable quality for bread-making. Producers are paid for protein content based on quarters or fifths of a percentage point. Therefore, higher protein levels should have a positive influence on protein premiums. We also used test weight, which measures the density of wheat kernels and is an important indicator of flour yield. Therefore, we expect a positive relationship between test weight and premiums. We expect to see a negative relationship between moisture content and premiums, since a high moisture content means a possibility of moisture damage in the storage and handling of the wheat. Total defects are the sum of three factors: damaged kernels, shrunken and broken kernels, and foreign material. We expect total defects to have a negative effect on premiums. Damage was an especially important variable to include, since the NIRT technology initially displayed low protein readings in wheat with high damage.

Because of blending and other demand considerations, we also realized the impact that a certain protein level's characteristics may have on another category's premium. In order to capture these effects, we included in some specifications the influence of characteristics outside of that particular protein premium category. For example, in the 15-percent protein specification for the Pacific Northwest market, we include the moisture level for both 13- and 14-percent protein wheat. Here, we assume that as the moisture level increases for the 13- and 14-percent protein categories, there will be a greater demand for higher quality 15- percent protein wheat for blending purposes. Similarly, we assume that as the moisture level increases for 13-percent protein wheat, there will be an economic incentive to blend with 14-percent protein wheat. We do not, however, include moisture in 15-percent protein wheat in the 14-percent premium specification. This is because we assume that a lower-protein wheat will not be blended with a higher-protein wheat with too much moisture.

We also had to deal with the complication of the importance of the supply effects for the 1992 and 1993 crop years because of the natural shortage of high-protein wheat on the market. In general, economists have found that the relative supplies of higher-protein wheat to lower-protein wheat or the dispersion of protein in wheat is an important factor in determining premiums. For instance, during times in which higher-protein wheat is in relatively short supply, premiums for higher-protein wheat are likely to be high. We incorporated these supply effects within the hedonic framework, starting with the following expression where the marginal implicit value for an additional unit of wheat protein is a function of the supply of protein of that level:

$$4)\ \beta_{prot} = \alpha_0 + \alpha_1 Q_{prot}$$

where β_{prot} is the marginal implicit value of an additional unit of wheat protein and Q_{prot} is the ratio of the quantity of wheat at a certain protein level to the total domestic supply of wheat. We expect there to be a negative relationship between this implicit value for protein, β_{prot}, and Q_{prot}, the ratio of that particular supply of protein to total domestic supply. That is, the sign on α_1 is expected to be negative because as the supply of a particular protein category increases (decreases) relative to the total supply of protein, the relative value placed on that category of protein decreases (increases). Therefore, substituting expression 4 into expression 3 gives us:

$$5)\ PR_{it} = C + (\alpha_0 + \alpha_1 Q_{prot}) x_{it1} + \Sigma\beta_{(j-1)} x_{it(j-1)} + \varepsilon$$

$$6)\ PR_{it} = C + \alpha_0 x_{it1} + \alpha_1 Q_{prot} x_{it1} + \Sigma\beta_{(j-1)} x_{it(j-1)} + \varepsilon$$

The explanatory variable of interest in this analysis, however, is not a wheat characteristic per se, but is a dummy variable that represents the separate effect of low protein readings on premiums, holding constant the observed wheat characteristics and conditions of protein supply. This dummy variable represents that time period between the introduction of the NIRT technology and the recalibration of the NIRT technology. The NIRT machines with the initial, lower calibration were installed in early May of 1993 and were recalibrated upward in January of 1994. Specifically, to incorporate the price effect of the lower protein readings, we included a dummy variable which takes on a value of 1 for May to December 1993, and zero otherwise. During this time period, the market was reacting to the effects of these lower protein readings. Since this is a highly competitive market, wheat premiums are very sensitive to the distribution of high-protein wheat. Thus, by switching this variable on, we could obtain a value for a protein premium differential representing the effects of low protein readings, holding constant other factors. We expect this variable to be positively related to protein premiums. First, the market could have been reacting to information about low protein readings by the NIRT technology. Additionally, this variable could be positively related to premiums, since our supply ratio variable, Q_{prot}, was based on yearly data and may not be sensitive to the monthly variation introduced by the calibration problem. Consequently, the effect of reduced supply shows up in this dummy variable. (See discussion in "Data and Data Sources" section.)

In addition to these other supply factors, spring wheat premiums are also affected by the supply of HRW wheat, since this class substitutes for spring wheat in certain categories. In particular, higher-protein, 13-percent HRW wheat substitutes on the margin for lower-protein, 14-percent spring wheat. Therefore, in order to capture this competitive supply effect, we included the monthly percentage of HRW wheat to total spring and winter wheat at the 13-percent protein level.

Finally, in order to account for seasonality, we also included a dummy variable, which we labelled 1 during preharvest months, when supplies are smaller, and zero during postharvest months, when supplies and stocks are larger.

Pacific Northwest Market Estimation

Using this hedonic empirical model, we estimated protein premiums at the 14- and 15-percent protein levels for the Pacific Northwest export market. First, we corrected for autocorrelation using a single equation autoregressive procedure—the Yule-Walker method.[6] First-order autocorrelation is often prevalent in time-series analysis such as this. Using the transformed variables from this procedure, we estimated the equations jointly by the Seemingly Unrelated Regression model.[7] This estimation technique provides a gain in efficiency by using information on explanatory variables that are included in the system but excluded from the ith equation. Using 78 observations, we jointly estimated equations 7 and 8:

$$7)\ PR_{14}=C+\alpha_0 PROT_{14}+\alpha_1 WTPR_{14}+\beta_1 PROT_{13}+\beta_2 TD_{13}+\beta_3 TD_{14}+\beta_4 TW_{13}+\beta_5 TW_{14}+\beta_6 MST_{13} +\beta_7 MST_{14}+\beta_8 CAL+\beta_9 HRW_{13}+\beta_{10} SEAS+\varepsilon$$

$$8)\ PR_{15}=C+\alpha_0 PROT_{15}+\alpha_1 WTPR_{15}+\beta_1 PROT_{14}+\beta_2 TD_{14}+\beta_3 TD_{15}+\beta_4 TW_{14}+\beta_5 TW_{15}+\beta_6 MST_{13} +\beta_7 MST_{14}+\beta_8 MST_{15}+\beta_9 CAL+\beta_{10} SEAS+\varepsilon$$

where:

PR_{14} = Protein premium for 14-percent protein wheat calculated as the difference between the average monthly price for 14-percent protein and 13-percent protein for HRS wheat.

PR_{15} = Protein premium for 15-percent protein calculated as the difference between the average monthly price for 15-percent protein and 14-percent protein for HRS wheat.

C = Constant

$PROT_{13}$ = Average monthly protein percent at the 13-percent level (between 13.0 percent and 13.99 percent) for the Portland market.

[6]This is described in A.R. Gallant and J.J. Goebel, "Nonlinear Regression With Autoregressive Errors," Journal of the American Statistical Association, Vol. 71 (1976).

[7]A. Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," Journal of the American Statistical Association, Vol. 57 (1962), pp. 348-368.

$PROT_{14}$ = Average monthly protein percent at the 14-percent level (between 14.0 and 14.99) for the Portland market.

$PROT_{15}$ = Average monthly protein percent at the 15-percent level (between 15.0 percent and 15.99 percent) for the Portland market.

$WTPR_{14}$ = Ratio of 14-percent protein HRS wheat on the domestic market to the total quantity of 13-, 14-, and 15-percent HRS wheat times the average 14-percent protein level ($PROT_{14}$).

$WTPR_{15}$ = Ratio of 15-percent protein HRS wheat on the domestic market to the total quantity of 13-, 14-, and 15-percent HRS wheat times the average 15-percent protein level ($PROT_{15}$).

TD_{13} = Average monthly total defects at the 13-percent protein level; total damage includes total damaged kernels, shrunken and broken kernels, and foreign material.

TD_{14} = Average monthly total defects at the 14-percent protein level.

TD_{15} = Average monthly total defects at the 15-percent protein level.

MST_{13} = Average monthly moisture content at the 13-percent protein level.

MST_{14} = Average monthly moisture content at the 14-percent protein level.

MST_{15} = Average monthly moisture content at the 15-percent protein level.

CAL = Dichotomous variable to represent low protein reading; 1 for May 1993 to December 1993 and zero otherwise.

SEAS = Dichotomous variable representing seasonality; 1 during the preharvest months and zero for postharvest months.

TW_{13} = Average monthly test weight in pounds of grain per bushel at the 13-percent protein level.

TW_{14} = Average monthly test weight in pounds of grain per bushel at the 14-percent protein level.

TW_{15} = Average monthly test weight in pounds of grain per bushel at the 15-percent protein level.

HRW_{13}= Monthly proportion of 13-percent HRW wheat of the total amount of 13-percent protein wheat.

Great Lakes Market Estimation Procedure

For the Great Lakes export market, there was an insufficient number of observations at the 15-percent protein level to warrant using the SUR method. Therefore, we estimated premiums for the 14- and 15-percent protein levels by the single equation autoregressive method above. Using this procedure, we were able to use 47 observations at the 14-percent protein level and 39 observations at the 15-percent protein level. However, since these numbers were still quite small, we reduced the total number of explanatory variables in both equations. The Great Lakes equations we estimated for 14- and 15-percent protein premiums were:

$$9)\ PR_{14}=C+\alpha_0 PROT_{14}+\alpha_1 WTPR_{14}+\beta_1 TD_{14}+\beta_2 TW_{14}+\beta_3 MST_{14}+\beta_4 CAL+\beta_5 SEAS+\varepsilon$$

$$10)\ PR_{15}=C+\alpha_0 PROT_{15}+\alpha_1 WTPR_{15}+\beta_1 TD_{15}+\beta_2 TW_{15}+\beta_3 MST_{15}+\beta_4 CAL+\beta_5 SEAS+\varepsilon$$

Data and Data Sources

We obtained all quality data from the FGIS Export Grain Inspection System (EGIS) data files for each month and each protein percentage. These data files keep records of each shipment or shipload sent to each export market in the United States for all of the grains. Using this database for 1985 through 1993, we calculated monthly average quality characteristics—such as average defects and moisture levels for our explanatory variables—for 13- to 13.9-percent, 14- to 14.9-percent, and 15- to 15.9-percent protein levels. For some months, we had missing observations for certain percentage categories of HRS wheat. Because of this, for the Pacific Northwest market, our number of observations were reduced from 99 to 78 including 2 missing observations in the key May to December 1993 period.

We then weighted these quality characteristics by the size of shipload or shipload bushels to obtain a more representative estimate of the average monthly quality characteristics. In addition, we included HRW wheat in the 13-percent category, since quality characteristics (such as sprout damage) of HRW wheat in this category have an effect on the demand for HRS wheat at the 13- and 14-percent levels. Including HRW wheat at the 13-percent level also gave us a greater number of observations.

We obtained quantity data on the production of HRS wheat from USDA's February 1994 Situation and Outlook Report as well as from the U.S. Wheat Associates' U.S. Wheat: 1993 Crop Quality Report. We obtained the percentage of U.S. production of different protein categories such as 13-percent, 14-percent, or 15-percent protein wheat from various issues of North Dakota State University's Regional Quality Report for HRS wheat for the years 1985 to 1993. In order to calculate our supply ratio variable, Q_{prot}, we used yearly quantity data. We then divided this yearly data into months and applied a monthly smoothing process. To these monthly total quantity figures, we multiplied the percentage of the different protein categories such as 13, 14, and 15 percent that we obtained from North Dakota State University. Although this was somewhat of a limited measure in that it may not capture month-to-month fluctuations, it does represent broader supply conditions related to HRS wheat.

To calculate price premium data, we used monthly price data for 13-, 14-, and 15-percent HRS wheat obtained from USDA's Livestock and Grain Market News from the Pacific Northwest arket and the Minneapolis market from 1985 until 1993. To find premiums, we subtracted the average 14-percent price from the 15-percent price to obtain the average monthly 15-percent price premium. Similarly, we calculated the average 14-percent differential by subtracting the average 13-percent price from the average 14-percent price. In order to express these price data in constant dollars, we adjusted the price series using the Bureau of Labor Statistics' Producer Price Index for crude materials.

Data used in order to calculate economic loss included the quantities sold into the export market. This was taken again from the EGIS database and organized at each protein level. Protein premium data used for these calculations were taken from Livestock and Grain Market News as well as other USDA publications.

Results of Regression Models

For both the Pacific Northwest and the Great Lakes market, the variable used to reflect low protein readings, CAL, had a positive effect on protein premiums and was highly statistically significant. This result was unaffected by the type of model used or the inclusion of different variables. However, greater confidence should be placed on the results for the Pacific Northwest market because of the larger number of observations at both the 14- and 15-percent protein levels.

Pacific Northwest Regression Results

Regression results for the Pacific Northwest market revealed that CAL, the variable used to approximate the effect of low protein readings, was significant and positively related to both 14- and 15-percent protein premiums. For the price difference between 14 percent and 13 percent or the 14-percent premium, PRE14, the CAL variable indicated that low readings increased premiums by approximately 31 cents. This result was consistent throughout the trial of many model specifications and inclusion of various combinations of explanatory variables.

Other significant variables included 14-percent protein percentage; total defects, 14 percent; moisture, 13 percent; test weight, 13 percent; and percentage of HRW wheat, 13 percent. Interestingly, 14-percent protein was significantly and negatively related to premiums. This result may represent the distribution of protein across protein levels at the export market. We expect that higher-protein wheat should command higher premiums than lower- protein wheat in a relative sense. However, if the entire wheat protein distribution was skewed because of a supply shortage of high-protein wheat, then a lower average percentage of a certain protein level would be associated with a higher premium.[8] Thus, we interpret the negative relationship between average protein percent and protein premiums as the result of this variable capturing this supply effect. Nevertheless, inclusion or exclusion of the protein percentage variable, PROT, did not affect the robustness of the estimated coefficient of CAL, our variable of interest.

Total defects at the 14-percent level had the expected negative sign and decreased premiums by 16 cents for every 1 percentage point increase in damage. Moisture at the 13-percent protein level was significant and positively related to 14-percent premiums. We interpret this relationship to mean that the greater the moisture for 13-percent wheat, the greater the demand for 14-percent wheat. As expected, the 13-percent HRW wheat revealed a competitive effect and was negatively related to 14-percent HRS wheat premiums.

For the 15-percent premium percentage equation, statistically significant variables include protein percentage, PRO14; average moisture at the

[8]Although we attempted to control for supply effects at each protein level with the variable WTPR, our control did not perform well.

13-percent and 14-percent level, MST13 and MST14; test weight at the 14-percent level, TW14; and the seasonality variable, SEAS; and CAL. The CAL variable indicated that premiums were increased by 22 cents during those months in which there were low test readings.

Table II.1: Regression Results From the Pacific Northwest Export Market

PRE14		PRE15	
Independent variable	Coefficient/ significance	Independent variable	Coefficient/ significance
CONSTANT	–1.623	CONSTANT	–1.792
WTPR14	–0.011	WTPR15	–0.011
PROT13	–0.196	PROT14	–0.442***
PROT14	–0.289*	PROT15	–0.003
TD13	0.045	TD14	–0.008
TD14	–0.155**	TD15	0.067
MST13	0.094**	MST13	0.091**
MST14	0.045	MST14	0.108**
N/A	N/A	MST15	–0.053
TW13	0.118***	TW14	0.104*
TW14	0.006	TW15	0.004
CAL	0.313***	CAL	0.216**
HRW13	–0.314***	N/A	N/A
SEAS	0.012	SEAS	0.081*
System Weighted $R^2 = 0.82$ 130 degrees of freedom			

Note: PRE14 = 14-percent protein premium. PRE15 = 15-percent protein premium. N/A = not applicable.

***Denotes significance at the 1-percent level or greater.

**Denotes significance at the 5-percent level.

*Denotes significance at the 10-percent level.

Great Lakes Regression Results

Regression results for the Great Lakes market also showed the CAL variable to be highly statistically significant and positive at both the 14-percent and 15-percent protein premium levels. Interestingly, for the 14-percent protein premium level, the effect of low protein readings was to increase premiums by approximately 26 cents, which was less than that for the Pacific Northwest market. However, at the 15-percent protein level, the CAL variable indicated that protein premiums would be approximately

56 cents higher because of low protein readings. Overall, adding the 14- and 15-percent effects of this variable together, premiums increased by 82 cents per bushel. The only other significant variable was the supply variable at the 15-percent level, WTPR15. However, less confidence should be placed in these results than in the Pacific Northwest results because of the lower number of observations in each model, the lower R^2s, and the fact that there were few significant explanatory variables.

Table II.2: Regression Results From the Great Lakes Export Market

PRE14		PRE15	
Independent variable	Coefficient/ significance	Independent variable	Coefficient/ significance
CONSTANT	3.051	Constant	–6.686
WTPR14	0.019	WTPR15	–0.068***
PROT14	–0.200	PROT15	0.359
TD14	–0.027	TD15	0.098
TW14	–0.024	TW15	–0.022
MST14	0.110	MST15	0.248
SEAS	–0.001	SEAS	0.002
CAL	0.256***	CAL	0.560*
R^2 = 0.39 Degrees of freedom = 38		R^2 = 0.54 Degrees of freedom = 30	

Note: PRE14 = 14-percent protein premium. PRE15 = 15-percent protein premium. This table has no coefficients at the 5-percent significance level (**).

***Denotes significance at the 1-percent level or greater.

*Denotes significance at the 10-percent level.

Economic Impact Determination

To determine the economic impact of low protein readings on the producer, we compared the effect of premium increases due to the market's reaction to these lower readings with the effect of losses from lower protein levels of wheat. Overall, we found that a loss in premium income from lower protein readings was offset by gains from increases in protein premiums owing to a perceived decrease in wheat protein in the marketplace.

Our estimates of economic impacts from gains and losses are based on "average" price impacts over the affected period. Given the data available to us, we were able to estimate the increase in premiums in this period, holding everything else constant. We obtained the gains or the price effects from the low protein readings from the CAL variable in the regression results (see tables II.1 and II.2). For example, in the 14-percent premium equation of the Pacific Northwest market, the coefficient on the CAL variable translated into an increase in premiums of approximately 31 cents. In the 15-percent premium category, this gain was approximately 22 cents. We then compared these gains from the market with losses from being forced into the next lower protein category.

To calculate loss, we assumed that producers were forced into the next lower protein category. This was based on a study by USDA's Economic Research Service that reported, on average, that all readings for HRS wheat were 0.16 percentage points lower under the new testing devise.[9] For the Pacific Northwest market, to obtain premiums at each percentage, we calculated average price differences at each protein percentage from Grain and Livestock Market News and divided the price difference into quarters. Since protein scales for premiums are graduated into quarters or fifths of a percentage point, an adjustment downward does not necessarily mean a move into the next whole protein percentage. In the Pacific Northwest market, premiums are based on quarters of a percentage, while the Great Lakes market follows the Minneapolis market, which is based on fifths of a percentage. For the Great Lakes market, we obtained average monthly premiums at 13-, 14-, and 15-percent protein levels from the Economic Research Service's study mentioned above. The assumption that all producers were bumped down into the next protein category was conservative, since some experts noted that only high-damaged, high-protein wheat was affected by the new protein-testing technology.

Holding everything else constant, the net effect of these two estimates—gain from the market and loss from lower protein readings—provides an estimate of net economic impact for the two export markets—the Pacific Northwest and the Great Lakes. Using data from the EGIS data file, we were able to calculate how much 13-, 14-, and 15-percent HRS wheat was exported from the Pacific Northwest and the Great Lakes markets. From these calculations, we found that there was a modest gain in the Pacific Northwest export market and a small loss in the Great Lakes export market. However, these net gain or loss estimates for each market are minor compared with the total value of wheat traded in these export markets. Therefore, on balance, losses from the lower protein readings were generally offset by gains in the marketplace from a perceived short supply of high-protein wheat. While individual farmers and others may

[9]William Lin, Economic Effects of Updating Protein Calibration for Hard Red Spring Wheat, USDA, Economic Research Service, Commodity Economics Division, Staff Report No. AGES9417 (June 1994).

have experienced significant losses or gains, the aggregate economic effects seemed to be minimal.

Table II.3: Economic Impact of Low Protein Readings on the Pacific Northwest Market

Total gain or loss	Quantities (bushels in thousands)	Premium change (cents)	Totals (dollars)
Gain			
13	N/A	No gain	N/A
14	75,845[a]	0.31[b]	$23,511,950
15	1,520[a]	0.22[b]	334,400
Total gain			**23,846,350**
Loss			
13	16,377[a]	0.20[c]	3,275,400
14	75,845[a]	0.20[c]	15,169,000
15	1,520[a]	0.14[c]	212,800
Total loss			**18,657,200**
Net gain or (loss)			$5,189,150

Note: N/A = not applicable.

[a]These figures are compiled at different protein percentages for the Pacific Northwest market and are taken from the EGIS data files.

[b]These figures are estimates of gains in premium (CAL variable) from the market in cents taken from the above model of the Pacific Northwest Market.

[c]These figures represent average Pacific Northwest premium categories calculated by taking price differences between protein levels and dividing these into quarters; they are taken from Livestock and Grain Market News.

Table II.4: Economic Impact of Low Protein Readings on the Great Lakes Market

Total gain or loss	Quantity (bushels in thousands)	Premium change (cents)	Totals (dollars)
Gain			
13	N/A	No gain	N/A
14	14,915[a]	0.26[b]	$3,877,900
15	581[a]	0.56[b]	325,360
Total gain			4,203,260
Loss			
13	13,900[a]	0.17[c]	2,363,000
14	14,915[a]	0.15[c]	2,237,250
15	581[a]	0.23[c]	133,630
Total loss			4,733,880
Net gain or (loss)			$(530,620)

Note: N/A = not applicable.

[a]These figures are compiled at different protein percentages for the Great Lakes Market and are taken from the EGIS data files.

[b]These figures are estimates of gains in premiums (CAL variable) from the market in cents taken from the above model of the Great Lakes Market.

[c]These figures represent average monthly Minneapolis protein premium categories divided into fifths; they are taken from Economic Effects of Updating Protein Calibration for Hard Red Spring Wheat, USDA, Economic Research Service, Staff Report No. AGES9417, p. 11.

Organizations Contacted

Minnesota

Minnesota Association of Wheat Growers
Minnesota Department of Agriculture
Minnesota Farmers Elevator Association

Montana

Montana Department of Agriculture
Montana Farmers Union
Montana Grain Growers Association
Montana Wheat and Barley Committee

North Dakota

North Dakota Farm Bureau Federation
North Dakota Farmers Union
North Dakota Grain Dealers Association
North Dakota Grain Growers Association
North Dakota State University
North Dakota Wheat Commission

South Dakota

South Dakota Farm Bureau Federation
South Dakota Farmers Union
South Dakota Grain and Feed Association
South Dakota Grain Growers Association
South Dakota Wheat Commission

National Associations

Millers National Federation
National Grain and Feed Association
National Grain Trade Council
U.S. Wheat Associates

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