

ESTIMATING THE ECONOMIC IMPACT OF A CROP DISEASE: THE CASE OF FUSARIUM HEAD BLIGHT IN U.S. WHEAT AND BARLEY

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ABSTRACT

Plant diseases, particularly those affecting major agricultural crops, can have serious economic consequences, both for agricultural producers and for the regional economy. Since 1993, the spring grain producing area in the upper Midwest region of the United States has experienced a prolonged outbreak of Fusarium head blight (FHB), commonly known as scab, a fungus disease that affects wheat, barley, and other small grains. The purpose of this paper is to estimate the direct and secondary economic impacts of FHB infestations of wheat and barley during the period 1998-2000. The findings indicate that scab continues to be a major problem for U.S. wheat and barley producers. The cumulative direct economic losses from FHB in hard red spring (HRS) wheat, soft red winter (SRW) wheat, durum wheat, and barley is estimated at \$870 million from 1998 through 2000. The combined direct and secondary economic losses for all the crops were estimated at \$2.7 billion. Two states, North Dakota and Minnesota, account for about 55 percent of the total dollar losses.

INTRODUCTION

Plant diseases, particularly those affecting major agricultural crops, can have serious economic consequences, both for agricultural producers and for the regional economy. Fusarium head blight (FHB), commonly known as scab, is a fungus disease that affects wheat, barley, and other small grains (McMullen and Stack 1999). FHB results in yield losses, and infected grain is also subject to price discounts. FHB is recognized as a factor limiting grain production in many parts of the world. Since 1993, the spring grain producing area in the upper Midwest region of the United States has experienced a prolonged outbreak of FHB (Stack 1999). Centered on the Red River Valley of North Dakota and Minnesota, the FHB outbreak led to serious losses for farmers (McMullen *et al.* 1997).

The impact on the U.S. wheat and barley industries has been sufficient to stimulate a national response; a consortium of scientists and agribusiness leaders has developed a "U.S. Wheat and Barley Scab Initiative" to target research and outreach to solving this disease problem. Because the Scab Initiative must compete with other agricultural and natural resource problems to secure funding, the consortium sought estimates of the economic impact of the scab outbreak. Estimates of economic impact of scab are equally important for crop quality insurance (USDA, 2000). Traditional estimates focused on lost producer income solely due to reduced yields and abandoned acres, may lead to ineffective design of quality crop insurance instruments. In the very least, economic impact estimates of a disease must incorporate price impacts in a manner that captures the interaction between yield reduction and price increases

or decreases. The purpose of this paper is to estimate the direct and secondary economic impacts of FHB infestations of wheat and barley during the period 1998-2000.

METHODS AND DATA

Study design required choosing which crops and states should be included. The study focused on three wheat classes (hard red spring, soft red winter, and durum) and barley. For hard red spring (HRS) wheat, durum wheat, and barley, the affected states were Minnesota, North Dakota, and South Dakota. For soft red winter (SRW) wheat, the affected states were Illinois, Indiana, Kentucky, Michigan, Missouri, and Ohio.

Estimating the direct impacts (first round effects) of FHB for each type of grain entailed separately estimating (1) the effect on production and (2) the effect on prices received by producers in each year. These estimates were made for multi-county Crop Reporting Districts (CRDs) in each state. The product of the production and price effects was the estimate of the direct impact of FHB infestation.

To estimate the economic losses due to FHB in a given CRD, the value of production under 'normal' conditions was estimated (i.e., if there had been no outbreak). Normal crop value is the product of two variables: p_n , the price that farmers would have received, and q_n , their expected production in absence of scab. For years of scab outbreak, both variables are unobserved and must be estimated. The lost crop value is then calculated as the difference between actual and normal crop value (Johnson *et al.* 1998, Nganje *et al.* 2001). Nganje *et al.* (2001) provide detail methodology of estimating production loss, price impacts, and secondary economic impacts.

DATA SOURCES

Data on temperature and precipitation by region were obtained from the National Climatic Data Center (U.S. Department of Commerce). Data on planted and harvested acres, harvested yield, production, and average prices received by producers were obtained from the National Agricultural Statistics Service (U.S. Department of Agriculture). Average CBT and MGE futures prices were derived from a database of weekly quotes collected from *Grain Market News* (U.S. Department of Agriculture) and the *Wall Street Journal*. Basis was calculated as the difference between average price received in a region and the average futures price. For North Dakota, prices received were available by crop reporting district; in other states, prices are based on state averages. Prices for the 2000 marketing year were based on data available through February, 2001. Data on national wheat and barley supplies were from the *Wheat Yearbook* published by the Economic Research Service of the U.S. Department of Agriculture.

RESULTS

Production losses over the three-year period were estimated to total 47.8 million bushels of wheat (all classes) and 42.8 million bushels of barley. Hard red spring wheat dominated the wheat losses (27.6 out of 47.8 million bushels). Losses for both wheat and barley were most severe in 2000, followed by 1998 (data not shown).

Price effects were substantial in all three years, but generally were greatest in 1998. For hard red spring wheat, the futures price effect ranged from about 1 cent to 7 cents per bushel, while the basis effect varied among CRDs and between years from less than 10 cents to 71 cents. For other wheat classes, the futures price effect was always less than 3 cents per bushel, while the basis effect exceeded \$1 per bushel in some cases. The total price effect for barley varied from 13 to 80 cents per bushel (data not shown).

The direct economic impact from FHB was greatest in 1998 (\$457 million) and least in 2000 (\$160 million) (Table 1). Both SRW and HRS wheat producers sustained substantial losses in 1998 (\$235 million and \$144 million, respectively). In both 1999 and 2000, HRS wheat growers had the largest losses. The total loss for the three-year period was estimated at \$871 million, or an average of \$290 million annually. Overall, the price effect accounted for 77 percent of the direct impacts of FHB (Table 1).

Table 1. Direct Economic Effects from Fusarium head blight in the United States, by Crop and State, 1998 through 2000.

| Crop | Economic Effect | 1998 | 1999 | 2000 | Total, 1998-2000 |
|-----------|-----------------|------------------------|-------|-------|------------------|
| | | ----- \$ million ----- | | | |
| HRS | Production Loss | 25.6 | 19.5 | 36.9 | 82.0 |
| | Price Effect | 118.5 | 97.2 | 32.7 | 248.4 |
| | Total | 144.1 | 116.7 | 69.6 | 330.5 |
| Durum | Production Loss | 2.0 | 10.1 | 12.5 | 24.6 |
| | Price Effect | 18.5 | 18.8 | 8.4 | 45.7 |
| | Total | 20.5 | 28.9 | 20.9 | 70.4 |
| SRW | Production Loss | 16.0 | 3.2 | 5.5 | 24.8 |
| | Price Effect | 219.0 | 77.7 | 11.9 | 308.6 |
| | Total | 235.0 | 80.9 | 17.5 | 333.4 |
| Barley | Production Loss | 28.7 | 17.1 | 27.1 | 72.9 |
| | Price Effect | 28.8 | 9.8 | 24.8 | 63.4 |
| | Total | 57.5 | 26.9 | 51.9 | 136.4 |
| All Crops | Total | 457.2 | 253.5 | 159.9 | 870.6 |

Among the affected states, North Dakota had substantially the greatest impacts in each of the three years (Table 2). Overall, North Dakota accounted for 41 percent of all direct impacts from FHB, followed by Minnesota and Ohio. The losses sustained by North Dakota's wheat producers averaged 10.5 percent of the total cash receipts from wheat sales over the period 1998-2000. For barley growers, the losses were even more severe, averaging 25.7 percent of the value of barley production over the three-year period. In 2000, the losses associated with FHB represented 35.9 percent of total barley sales (USDA, National Agricultural Statistics Service).

Table 2. Direct Economic Effects from Fusarium head blight in the United States, by State and Crop, 1998 through 2000.

| State | Crop | 1998 | 1999 | 2000 | Total, 1998 - 2000 |
|-----------------|--------|------------------------|-------|-------|-----------------------|
| | | ----- \$ million ----- | | | |
| North Dakota | HRS | 80.8 | 53.3 | 48.8 | 182.9 |
| | Durum | 20.4 | 28.7 | 20.9 | 70.0 |
| | Barley | 37.0 | 21.7 | 44.2 | 103.0 |
| | Total | 138.2 | 103.8 | 113.9 | 355.8 |
| Minnesota | HRS | 38.6 | 38.5 | 11.7 | 88.8 |
| | Durum | 0.1 | 0.2 | a | 0.3 |
| | Barley | 19.9 | 5.1 | 7.6 | 32.7 |
| | Total | 58.7 | 43.7 | 19.3 | 121.8 |
| Ohio | SRW | 70.0 | 27.4 | 5.1 | 102.5 |
| Illinois | SRW | 48.6 | 17.5 | 0.3 | 66.4 |
| South Dakota | HRS | 24.8 | 24.9 | 9.1 | 58.9 |
| | Barley | 0.6 | 0.1 | a | 0.7 |
| | Total | 25.3 | 25.1 | 9.2 | 59.6 |
| Missouri | SRW | 38.8 | 8.7 | 4.0 | 51.5 |
| Michigan | SRW | 33.1 | 13.8 | 4.2 | 51.0 |
| Indiana | SRW | 23.8 | 8.0 | 2.6 | 34.3 |
| Kentucky | SRW | 20.7 | 5.6 | 1.3 | 27.6 |

a Less than 0.1

To estimate the secondary impacts of FHB infestations, the direct effects were assumed to primarily represent a reduction of producer net revenues (i.e., the activities and expenditures associated with crop production occur with or without scab infestation). The direct economic effects were therefore allocated to the *Households* sector of the input-output model. Over the three-year study period, the \$870.6 million of direct impacts resulted in an additional \$1,809.3 million of secondary impacts, for a total economic impact of almost \$2.7 billion (Table 3). Impacts were greatest in 1998 (\$1.4 billion).

Table 3. Total (Direct and Secondary) Economic Impacts for Fusarium head blight in All Crops, by Economic Sector and Year, Northern Great Plains and Central United States, 1998 through 2000.

| Economic Sector | 1998 | 1999 | 2000 | Total, 1998-2000 |
|--------------------------------------|------------------------|--------------|--------------|---------------------|
| | ----- \$ million ----- | | | |
| Agriculture | 43.0 | 23.8 | 15.0 | 81.8 |
| Construction | 41.2 | 22.9 | 14.4 | 78.5 |
| Communication & Public Utilities | 48.2 | 26.7 | 16.9 | 91.8 |
| Retail Trade | 340.5 | 188.8 | 119.1 | 648.3 |
| Finance, Insurance, & Real Estate | 76.9 | 42.6 | 26.9 | 146.3 |
| Households | 709.8 | 393.5 | 248.2 | 1351.5 |
| Government | 49.4 | 27.4 | 17.3 | 94.0 |
| Other Sectors ¹ | 98.5 | 54.6 | 34.4 | 187.5 |
| Total Direct Impacts | 457.2 | 253.5 | 159.9 | 870.6 |
| Total Secondary Impacts | 950.2 | 526.8 | 332.3 | 1809.3 |
| Total | 1407.4 | 780.3 | 492.2 | 2679.9 |

¹Includes sectors such as business, professional, personal, and social services, transportation, and manufa

The distribution by state of the total economic impacts of FHB infestations was similar to that of the direct effects (Table 4). North Dakota experienced the largest effects, both on average and for each year. The total economic impact for North Dakota averaged more than \$365 million annually over the study period, almost 41 percent of the total impacts of FHB.

DISCUSSION

The purpose of this study was to estimate the economic losses from FHB infestations suffered by U.S. wheat and barley producers during the period 1998 to 2000. The study was intended to provide an update to earlier work by Johnson *et al.* (1998), which estimated losses to wheat producers from 1993 through 1997. The present study was designed to estimate the price and yield effects of FHB, accounting for reduced yields, higher abandoned acres, and price impacts on wheat futures and basis, as well as malting and feed barley prices. The goal was to provide policy makers with estimates of the magnitude, distribution, and trend over time of FHB-related losses, as well as the secondary economic impacts resulting from these direct effects. These estimates were of special interest in the context of obtaining continuing support for the U.S. Wheat and Barley Scab Initiative, which provides funding for

Table 4. Total (Direct and Secondary) Economic Impacts from Fusarium head blight, All Crops, by State, in the Northern Great Plains and Central United States, 1998 through 2000.

| State | 1998 | 1999 | 2000 | Total | By State |
|-------|------------------------|-------|-------|--------|-----------|
| | ----- \$ million ----- | | | | --- % --- |
| ND | 425.4 | 319.4 | 350.5 | 1095.4 | 40.9 |
| MN | 180.6 | 134.6 | 59.5 | 374.8 | 14.0 |
| OH | 215.6 | 84.3 | 15.6 | 315.5 | 11.8 |
| IL | 149.7 | 53.7 | 0.9 | 204.3 | 7.6 |
| SD | 78.0 | 77.2 | 28.3 | 183.4 | 6.8 |
| MO | 119.5 | 26.9 | 12.3 | 158.7 | 6.8 |
| MI | 101.8 | 42.3 | 12.9 | 157.1 | 5.9 |
| IN | 73.2 | 24.6 | 8.0 | 105.7 | 3.9 |
| KY | 63.7 | 17.3 | 4.1 | 85.0 | 3.2 |
| Total | 1407.4 | 780.3 | 492.2 | 2679.9 | - - - |

research to develop scab resistant varieties, as well as other research and educational efforts to solve this disease problem.

The findings indicate that scab continues to be a major problem for U.S. wheat producers. Scab-related losses for wheat growers were estimated to average \$245 million annually from 1998 through 2000, compared to \$261 million annually during 1993-1997 (Johnson *et al.* 1998). The scab effects on wheat were substantially less in 2000 than in previous years, which may reflect the introduction of FHB resistant varieties in North Dakota and Minnesota. However, it also may reflect weather conditions that were less conducive to scab development.

Although North Dakota had substantially the greatest impacts, scab losses affect producers over a wide geographic area. Eight of the states included in the study had estimated direct impacts of at least \$10 million per year over the period 1998-2000. The disease also poses major problems for producers of several classes of wheat, as well as barley.

The scab losses were substantial not only in absolute magnitude but also relative to the value of affected crops. In North Dakota, scab losses in wheat from 1998 through 2000 averaged more than 10 percent of the value of the wheat crop while barley losses averaged almost 26 percent of the total crop value over the same period.

Impacts from scab affect not only grain producers but also other sectors of the economy. Income reductions for farmers lead to reduced revenues for a variety of agricultural supply and

service businesses, and economic linkages result in subsequent effects on many sectors of local and state economies. For every dollar in direct scab losses to producers, more than two dollars in secondary economic effects are incurred.

Overall, the direct and secondary economic impacts of FHB infestations have been found to be substantial and widely distributed, both geographically and among economic sectors. Further, these losses dwarf the resources presently committed in combating the problem (funding for the U.S. Wheat and Barley Scab Initiative was \$4.3 million in FY 2000). Continued support for research in this area should be relatively easy to justify.

Estimates of the economic impact of scab also have important implications in developing third party quality risk management strategies, using insurance instruments. The USDA Loss Adjustment Manual (LAM) Standards Handbook for 2001 and Succeeding Crop Years emphasize the importance of estimating the reduction in value due to scab.

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