# Potential Economic Consequences of the Entry of an Exotic Fungal Pest: The Case of Soybean Rust

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## ABSTRACT

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This report presents an analysis of the economic consequences if a virulent race of the soybean rust pathogen, *Phakopsora pachyrhizi*, were to become established in the United States. The analysis uses an econometric-simulation model to estimate the consequences of soybean rust under two alternative environmental and grower response assumptions. Although profits to some soybean farmers and producers of other feed grains would rise, total losses to consumers and other sectors of the U.S. economy are forecasted to exceed $7.2 billion per year even with a conservative estimate of potential damage. The extent and nature of these losses depend on the assumed severity and spread of the disease.

*Additional key words*: crop losses, modeling.

This paper addresses the question of the economic consequences of the establishment in the United States of a virulent and aggressive race of the soybean rust pathogen (*Phakopsora pachyrhizi* Sydow). The outcome is interesting not only because the rust can significantly reduce yield for some domestic soybean producers, but also because other growers might unexpectedly profit from higher prices due to the decreased supply. Examination of the industry suggests that associated users and beyond-the-farm-gate industries would suffer the greatest losses. In recent years, the U.S. has produced over 60% of the world soybean crop (21). Any significant reduction of U.S. production would not be quickly replaced by international competitors. By even the most conservative of the scenarios presented the introduction of the pathogen would cause a significant increase in food prices and reduce the availability of final consumption goods.

Soybean rust was chosen for examination because it has been identified as a major disease of soybeans (R. C. McGregor, *unpublished*). U.S. commercial germplasm lacks resistance (K. R. Bromfield, *personal communication*), and *P. pachyrhizi* has recently been reported on soybeans in nearby Puerto Rico (22). The McGregor report (R. C. McGregor, *unpublished*) listed the soybean rust pathogen in the top 25 of the 100 most dangerous exotic pests. The available data on losses from the disease have been summarized by Bromfield et al (2), and the McGregor evaluation seems not to be extreme. Regional losses ranging from 10 to 30% are reported throughout the Orient (12,17,24). Losses reported in individual fields have ranged from 70 to 90% in Taiwan (7, and A. Tschanz, *personal communication*) and 15 to 40% in Japan (10). Results from field research plots specifically established to evaluate the impact of soybean rust have shown yield reductions ranging from 23 to 95% among the popular commercial cultivars (16,23).

One method of plant protection is quarantine to prevent entry of a pest into an area where it does not currently exist. It is extremely difficult to project the benefits of a quarantine program because, among other things, one always lacks data on the damage the exotic pest could cause in a new area. A pest may be of little or no economic importance in its native land due to a natural system of checks and balances; when introduced into an area with a favorable climate, susceptible host, and without natural enemies, the pest population may dramatically increase, causing significant losses (R. C. McGregor, *unpublished*). Likewise, what is an apparently suitable environment in a new area may unexpectedly not support pest or pathogen development for unknown reasons. Soybean rust is not known to be present in the continental U.S. (outside of containment greenhouses). A measure of the value of entry prevention for *P. pachyrhizi* is derived by estimating the economic repercussions from establishment of the pathogen.

Since data on the behavior of soybean rust in the field in the U.S. do not exist, its behavior in the U.S. must be conjectured from field observations in areas where it is endemic and from controlled-condition greenhouse and growth chamber experiments designed to evaluate that potential (2,3,13–15). In essence then, the basis for the assumptions used to derive estimates of the economic consequences is not field experience where the forecast is to be applied, but rather data collected elsewhere applied to and interpreted for climates in U.S. soybean growing regions. Increases in intensity notwithstanding, predicting the spread of the pathogen within and between seasons is problematical. *P. pachyrhizi* is known to infect and spread from various nonsoybean wild and cultivated hosts, including various garden legumes (22). Whether soybean rust can survive our winter climes on such hosts can only be speculated at this point. There is currently no biological or climatological evidence to indicate that this pathogen could not survive on such widespread hosts, in at least the southern part of the U.S. soybean growing area. Rust quickly became epidemic on soybeans in the Philippines even where the crop had not previously been grown (11), presumably because of survival on nonsoybean hosts (K. R. Bromfield, *personal communication*). In most Oriental countries the pathogen is pandemic due to year round cropping and/or survival on wild hosts (9,11,24, and A. Tschanz, *personal communication*).

A factor to keep in mind throughout this analysis is that when working with macroeconomics and pandemics, even small changes in the underlying assumptions of the model can have major impacts on the resulting analyses. However, as shocking as the results are, we believe them to be conservative interpretations of the available data. For example, Scenario 1 uses 1% and 3% yield losses in the south and southeast, and Scenario 2 uses 4% and 13%.

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This paper does not perform a cost/benefit analysis of quarantine programs per se. Questions of costs and effectiveness of quarantines or other programs to prevent the introduction or assuage the impact of *P. pachyrhizi* are not considered. Instead, estimates of the cost of quarantine breakdown are produced. The benefits that would accrue from an unbreached quarantine could be extrapolated as being opposite the economic impact of establishing the pathogen in the U.S. The impact of a region-wide fungicide application program, publicly financed, to lessen the damage of soybean rust could be simulated; however, when there is already uncertainty in disease losses, speculating on potential governmental responses would cloud the other important issues that need to be addressed.

Simulating the impact of disease losses that would occur in the absence of any governmental control programs, (quarantines, inspections, or area-wide programs) should provide a means for rationally setting a value on such programs. Such simulation can yield a set of opportunity cost measures: estimates of what might be sacrificed without such action. This provides a means of comparing the cost of an effective program to the losses that could be prevented by its implementation (benefits); also, we can examine estimates of both costs and benefits of such programs to see if funds are efficiently used or if they could better be utilized in other projects.

## MATERIALS AND METHODS

**Loss simulation.** To analyze the possible economic consequences of the introduction of the soybean rust pathogen into the U.S., TECHSIM, a regionalized econometric-simulation model for the production and consumption of major U.S. field crops, was utilized (6). The field crop commodities included in the model are soybeans, corn, grain sorghum, wheat, barley, oats, cotton lint, and cottonseed. Also included are the forward industry meal and oil products of cottonseed and soybeans. The model was specifically designed for use in regulatory analyses that may be categorized as types of technological change. Regulatory restrictions can be considered as negative technological progress. Regulations that restrict options in farm input choices or developments in new farm production technology that expand options can be thought of as changes in the efficiency with which agricultural production is undertaken. Governmental regulations may reduce farm efficiency while a technological development (for example, development of a new and more effective pesticide) may increase agricultural production efficiency. These types of technological changes (both positive and negative) can operate as inputs to TECHSIM. Physical productivity and/or costs of production of any subset of modeled commodities can be exogenously altered as a representation of a technological development. The introduction and establishment of soybean rust would be a kind of technological change which, like regulation, promises to have negative impact.

The model was designed to use the data on technological change as input to produce a detailed list of changes in economic welfare (profits and losses) to specific segments of the agricultural economy. This type of information is useful in public policy analysis so that potential impacts on specific regions or interest groups can be addressed. The model forecasts changes in profits per hectare for each of the modeled commodities in 13 regions over any number of years (Table 1). Additionally, more highly aggregated welfare changes are forecasted. These include profit changes for all producers of each crop, totals for producers of all crops, producers of meals and oils, and the sum of welfare changes for consumers and all producers involved in transforming raw agricultural commodities into final consumable products.

In TECHSIM, estimated supply and demand functions for the commodities and some processed products are linked in a recursive adjustment model. On the supply side, annual production of each commodity is based on relative expected profitability of each commodity. Thus, farm level decision-making with the goal of maximizing profits drives the operation of the model. When cost of production or per hectare productivity of a crop is altered, the expected profitability of that crop relative to all others is altered, thereby inducing shifts in hectares planted and production. The model is recursive in that the farm-level profits earned in one simulated year are used to determine planting decisions in the following year.

The operation of the model can be described through classes of equations. Cropland acreage response functions are based on net returns, estimated for each commodity in each region where the crop is grown. Multiplying these functions by the associated per-hectare production functions, summing across regions, and adding inventories determines annual quantities supplied. Demands for each of the commodities consist of several components: feed, food, seed, inventory, and export. Each component, estimated at the national level, is a function of its own and substitute prices. Equating supply and demand responses and solving the equations simultaneously determines market prices and utilization patterns for the commodities. Prices, quantities, and costs of production allow calculation of crop-specific profit levels by region. Profits, or net returns, provide the links between simulated marketing years. Actual net returns are used as a base for farmer expectations for net returns during the following year. This drives the cropland response function by altering the hectares planted the following year. A base and policy run of the model produces changes in these variables, and shows changes in farm income, its distribution, the welfare of some direct purchasers of agricultural commodities, and the welfare of consumers and food processors.

In the version of TECHSIM employed here, the estimated regression equations all produced coefficients with signs that are anticipated by economic theory. Statistical significance of the estimates is uniformly high with most $R^2$ values exceeding 0.90. Of more importance, however, the estimated coefficients make commodity demands behave as expected: slightly price inelastic (19). Commodity demands all have the characteristic that a change in price causes a proportionately smaller change in the quantity demanded.

The TECHSIM model has been evaluated before by both USDA and EPA in regulatory analyses. Also, it has been used in analyses of technological change directly related to pest management. The model was chosen by a USDA evaluation team to estimate adjustments to the boll weevil management or eradication program (18,20). It has also been used to investigate the economics of technological change in agriculture for areas beyond pest management: specifically, analysis of the development of alternative fuels from agricultural products (5).

For the present application of the model, introduction of the pathogen and establishment of the disease was used to change the opportunities farmers face. This would reduce productivity and, hence, the relative profitability of growing soybeans. This change can be represented by manipulatable variables in the model. Changes in these variables (per hectare production and per hectare cost of production for a given commodity [soybeans]) represent the farm level changes that would occur as regulatory or technological changes are made. In TECHSIM, these measures can be altered in

TABLE 1. Regional demarcation for TECHSIM, a regionalized econometric-simulation model for production and consumption of major U.S. field crops

| Region | States |
|---|---|
| 1 | Washington and Oregon |
| 2 | California |
| 3 | Montana, Idaho, Wyoming, Colorado, Utah, and Nevada |
| 4 | New Mexico and Arizona |
| 5 | Nebraska and Kansas |
| 6 | North Dakota and South Dakota |
| 7 | Oklahoma and Texas |
| 8 | Minnesota, Wisconsin, and Michigan |
| 9 | Ohio, Indiana, Illinois, Iowa, and Missouri |
| 10 | Arkansas, Louisiana, and Mississippi |
| 11 | Alabama, Georgia, South Carolina, and Florida |
| 12 | Kentucky, West Virginia, North Carolina, Tennessee, and Virginia |
| 13 | Pennsylvania, Maryland, New York, and New England |

any or all crop production areas on any or all commodities, and the model allows changes for one commodity group to have a ripple effect on the desirability of growing other commodities within, and even across, production areas.

Table 2 presents forecasts from the model in the absence of any unexpected technological changes (ie, no soybean rust pathogen present). These baseline data are presented for purposes of comparison, and forecasts for five consecutive years are presented. When soybean rust disease losses were simulated beyond five years, adjustments in any of the important forecasted variables were minor, at most. Fifth-year data represent a good approximation of new equilibrium values.

**Scenarios for disease development.** This analysis of the economics of soybean rust was initiated by deciding how many hectares of soybeans *P. pachyrhizi* might infect, and by how much it would reduce per hectare yield. This is difficult because there is uncertainty regarding where the pathogen might enter the country, the speed at which it might spread, the soybean production areas that might support disease development, the severity of infection and its impact on yield in each of these areas, the ability of the pathogen to overwinter, and whether sufficient chemical controls are available. With this degree of uncertainty, the range of outcomes that could be postulated is enormous. The endpoints of this range are so far apart and so speculative that an analysis based on extremes would not be informative. However, based on data collected under controlled conditions at the USDA's Plant Disease Research Laboratory, Frederick, MD, in conjunction with field studies in countries where the disease occurs naturally, there is a wide range of possible scenarios suggested for U.S. epidemics. The scenarios chosen for analysis were not designed as an exhaustive list of possibilities of disease behavior, but rather each represents a different class of potential behavior. No scenario can be assumed to be most (or least) likely until some of the unknowns listed above (where it enters, whether it overwinters, etc.) can be resolved. (The conflicting goals of brevity and the demand for detail led to the following presentation of only two scenarios. A complete list of the full range of scenarios and results is available from the authors on request).

The scenarios can be categorized in terms of the ultimate extent and severity of the infection. It is assumed that environmental conditions that encourage the spread of disease would also lead to increased intensity and thus would exacerbate losses in any given area. It is further assumed in each case that the disease would first appear in the southern Mississippi Valley. The climate in that area is analogous to portions of the Orient where the pathogen survives and the disease becomes severe. Also, the Mississippi Valley supports an array of cultivated and wild legumes that apparently serve as hosts (K. R. Bromfield, *personal communication*), possibly allowing the pathogen to survive the winter. In the first scenario, the disease is assumed to be confined to the Mississippi Valley (Region 10). In the second scenario, the disease is assumed to breach that region and spread from the Mississippi Valley to the Corn Belt. With this more extensive distribution presumably due to more favorable environment for disease increase, per-hectare disease losses in each region are assumed to be greater.

With each of these environmental scenarios, two patterns of soybean grower response were assumed possible: case 1, no response; and case 2, aerial spraying of the crop with a fungicide. The first case was felt to be plausible since the performance of fungicides against this pathogen is relatively unknown, especially under environmental conditions for the U.S., and because fungicides and appropriate spray equipment may not be in sufficient supply to allow immediate response. Again, uncertainty is a major problem in this analysis. Case two also must be considered possible since chemical control recommendations exist where soybean rust exists (1). Assuming that fungicides could be applied, we assumed aerial spraying costs to be $25 per hectare and used only one spray in the most conservative disease loss scenario. Spray efficacy was assumed to depend on the disease severity.

A detailed analysis of two scenarios follows:

*Scenario 1.* Per hectare soybean yields diminish 1% in the lower Mississippi Valley (Region 10) in 1982. In subsequent years per hectare yields diminish 4% across the south (Regions 7, 10, and 11). In each year, growers in infected areas incur additional production costs (fungicide sprays) of $25 per hectare per year.

*Scenario 2.* Per hectare soybean yields diminish 3% in the lower Mississippi Valley in 1982. In subsequent years per hectare losses reach 13% in the south, as the disease spreads from the south (Regions 7, 10, 11, and 12) into the Corn Belt (Region 9). Equipment and materials for spraying are assumed to be in insufficient supply for the expanded demand so fungicide sprays are not applied.

Tables 3–8 provide the five yearly forecasted changes for scenarios 1 and 2, respectively. Table 2 provides a base to which Tables 3 and 6 can be compared. These data represent forecasted changes in economic variables. Tables 4 and 7 include profits to soybean producers, by region. Impacts on producers of other commodities, processors, forward industries, and consumers in general are presented in Tables 5 and 8.

TABLE 2. Base forecast: U.S. soybean supply and demand

| Year | Planted hectares, (× 1,000) | Metric tonnes (× 1,000) Production | Supply | Export | Price per metric tonne |
|---|---|---|---|---|---|
| 1982 | 23,335 | 57.319 | 63.732 | 21.658 | $250.00 |
| 1983 | 23,349 | 57.362 | 63.781 | 21.674 | 249.26 |
| 1984 | 23,359 | 57.398 | 63.826 | 21.691 | 248.16 |
| 1985 | 23,369 | 57.431 | 63.869 | 21.710 | 247.06 |
| 1986 | 23,377 | 57.462 | 63.909 | 21.729 | 249.95 |

TABLE 3. Scenario 1 (with grower response). Changes in U.S. soybean supply and demand caused by soybean rust. Spread of rust is confined to nine southern states (Regions 7, 10, and 11)

| Year | Hectares planted (× 1,000) | Metric tonnes (× 1,000) Production | Supply | Export | Price per metric tonne |
|---|---|---|---|---|---|
| 1982 | 0 | −0.085 | −0.085 | −0.015 | 0.74 |
| 1983 | 1 | −0.479 | −0.486 | −0.096 | 5.51 |
| 1984 | 27 | −0.376 | −0.420 | −0.133 | 7.72 |
| 1985 | 87 | −0.223 | −0.292 | −0.138 | 7.72 |
| 1986 | 106 | −0.170 | −0.244 | −0.136 | 7.72 |

TABLE 4. Scenario 1 (with grower response). Changes in soybean profits ($/hectare) caused by soybean rust. Notice that infected areas (regions 7, 10, and 11) show losses

| Year | Region 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1.47 | 1.22 | 1.39 | 1.56 | 1.77 | −27.15 | 1.26 | 1.37 | 1.59 |
| 1983 | 9.20 | 7.68 | −32.34 | 9.80 | 11.12 | −31.75 | −31.60 | 8.58 | 9.96 |
| 1984 | 12.77 | 10.65 | −29.03 | 13.58 | 15.42 | −28.70 | −28.62 | 11.89 | 13.81 |
| 1985 | 13.21 | 11.02 | −28.56 | 14.06 | 15.96 | −28.27 | −28.19 | 12.31 | 14.29 |
| 1986 | 13.04 | 10.88 | −28.65 | 13.88 | 15.75 | −28.34 | −28.27 | 12.15 | 14.11 |

TABLE 5. Scenario 1 (with grower response). Aggregate U.S. economic impacts predicted ($ million profit and loss) as a result of soybean rust infections spreading to regions 7, 10, and 11

| Year | Profit: Corn | Soybean | Total crop | Soybean meal and oil | Losses to consumers, processors, and livestock producers | Net |
|---|---|---|---|---|---|---|
| 1982 | 0 | −84.38 | −84.38 | 11.41 | −48.13 | −121.10 |
| 1983 | 10.64 | −10.13 | −2.09 | 70.75 | −308.67 | −238.74 |
| 1984 | 62.25 | 99.17 | 157.89 | 90.60 | −480.24 | −237.79 |
| 1985 | 117.63 | 131.20 | 250.34 | 88.56 | −562.93 | −236.06 |
| 1986 | 133.38 | 324.89 | 280.40 | 86.73 | −592.13 | −235.20 |

As a final caveat before interpreting the model results, it must be noted that the assumed behavior of the disease is somewhat simplistic. Per hectare losses are assumed to begin in the first year at low levels and then increase in the second year to equilibrium values where they remain unchanging throughout the modeled time period. Certainly no disease is likely to behave in such an unvarying manner from season to season. Changing weather and environmental conditions would, in some years, induce the pathogen to spread and cause substantial losses, whereas in other years farmers may find the disease to be trivial. As a result, the economic situation is probably even more unstable than these scenarios portray. Distribution of favorable or unfavorable years for the disease is a function of environmental conditions and therefore unavailable. Thus, a somewhat conservative, but constant, average value was employed.

## RESULTS

In scenario 1 (limiting the disease to the southeastern states and assuming a grower response of aerial spraying of fungicides) the maximum annual production loss (United States total, 1982) amounts to less than 1%. In 1982, 1985, and 1986, this represents aggregate production losses of less than 0.5% (Table 3) in the United States. Movements in soybean prices reflect that such a loss is not of macroeconomic consequence. There are, however, distributional consequences for soybean growers in the United States. Growers in the infected areas suffer reduced profits since production is reduced and costs are increased. The small increase in the price of soybeans cannot offset the production diminution for these growers. All other soybean growers enjoy slightly higher prices; their profits increase. The corn belt producers fare best, eventually receiving almost $16 extra per hectare (Table 4). Changes in aggregate corn, soybean, and total crop profits (Table 5) show that, in general, profits to feed grain growers increase. This is a result of generally higher feed grain prices. Consumers eventually feel the impact of these changes in higher prices of beef, pork, and poultry. Livestock producers and meat producers all pay slightly higher prices for their inputs. Total losses to consumers and producers beyond field crop production would eventually rise from $48.1 to $592.13 million per year over the five-year simulation period (Table 5).

It has been shown that in vertically related industries, welfare effects can be estimated for some markets not explicitly modeled (4,8). This is incorporated in TECHSIM under the heading "Losses to consumers, processors, and livestock producers." This refers to the sum of losses to consumers (higher prices for livestock products and processed foods) and to all industries beyond the farm gate that depend on soybeans and their processed products (feedlot operators, slaughterhouses, and retail grocery stores). While this represents a highly aggregated group, it does serve to indicate distinctions in the distribution of gains and losses resulting from the production losses. Those growers still able to grow soybeans find their operations more profitable, while everyone else from buyers of raw soybeans to consumers of final food products finds they are substantially worse off when soybean production falls.

In scenario 2, production of soybeans was forecasted to fall 11% in 1983 and by 1986 prices would rise 42% (Table 6). Exports are shown to fall 8% (Table 6). Per hectare profits rise in each region, even in the regions with the heaviest losses. This is a consequence of the characteristic that price rises proportionately faster than quantities marketed fall. Obviously, some growers would suffer extensive dollar losses in these regions while others will have enough production to benefit from the higher prices. Averaging losses across all growers shows the losses to be relatively smaller than the overall price change (increase). Each ton of soybeans is much more valuable and, overall, total farm revenues would increase. Obviously the farmer who would have incurred heavy losses would have benefited by spraying, but this scenario is one of no spray response (at least for the region in general) and thus the cost of spraying incurred in scenario 1 is not deducted from profits here. In this scenario, the unaffected areas will receive ~$180 per hectare additional revenues (Table 7). Total profits for producers increase nearly $5 billion, but consumer losses and losses to industries beyond the farm gate increase by over $7 billion (Table 8). The $2 billion difference is not just the direct loss of beans due to the disease but also the disruption losses and the ripple effect to feed and food industries beyond the farm gate. Net losses, losses in excess of gains, amount to $1.4 billion in most years (Table 8). This situation entails more than a direct transfer from one group to another; it is a direct loss to the U.S. economy as a whole.

## DISCUSSION

In examining the results of this paper it must be noted that the chosen per hectare losses are quite small compared to the observed losses listed by Bromfield (2, and K. R. Bromfield, *personal communication*) and others (7,10,12,16,17,23,24 and A. Tschanz, *personal communication*). If the U.S. proves to have the suitable environment for *P. pachyrhizi* anticipated (2,3,13–15) and per hectare losses were as high as forecasted by McGregor (R. C. McGregor, *unpublished*), all of the economic impacts listed here would be many times larger than shown. The actual behavior of economic variables could be significantly different from those shown. With soybean prices rising, alternative high protein feed sources could become profitable enough to produce and market. Synthetic feed sources could become more economically viable and at least partially substitute for lost soybeans. That is, these price increases may induce development of new technologies and shifts in beyond-the-farm-gate industries to the point that forecasted price rises would be truncated.

TABLE 6. Scenario 2 (without grower response). Changes in U.S. soybean supply and demand caused by soybean rust. This scenario assumes that the rust spreads to 14 southern states and five midwestern states (regions 7, 9, 10, 11, and 12)

| Year | Hectares planted (× 1,000) | Metric tonnes, (× 1,000) Production | Supply | Export | Price per metric tonne |
|---|---|---|---|---|---|
| 1982 | 0 | −0.256 | −0.256 | −0.046 | 2.57 |
| 1983 | 48 | −6.353 | −6.374 | −1.169 | 66.18 |
| 1984 | 790 | −4.685 | −5.214 | −1.647 | 92.65 |
| 1985 | 1,426 | −3.265 | −4.072 | −1.784 | 101.10 |
| 1986 | 1,730 | −2.559 | −3.514 | −1.822 | 103.31 |

TABLE 7. Scenario 2 (without grower response). Changes in soybean profits ($/hectare) caused by soybean rust spreading to regions 7, 9, 10, 11, and 12

| Year | Region 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|
| 1982 | 4.40 | 3.67 | 4.17 | 4.68 | 5.32 | −7.39 | 3.77 | 4.10 | 4.76 |
| 1983 | 112.10 | 93.51 | 40.49 | 119.29 | 51.55 | 37.39 | 36.58 | 39.76 | 121.27 |
| 1984 | 156.97 | 130.95 | 77.73 | 167.03 | 98.96 | 71.77 | 70.22 | 76.33 | 169.82 |
| 1985 | 171.12 | 142.74 | 89.62 | 182.09 | 114.11 | 82.76 | 80.96 | 88.01 | 185.12 |
| 1986 | 174.72 | 145.75 | 92.82 | 185.92 | 118.18 | 85.71 | 83.86 | 91.16 | 189.02 |

TABLE 8. Scenario 2 (without grower response). Aggregate U.S. economic impacts predicted ($ million profit and loss) as a result of soybean rust infections spreading to regions 7, 9, 10, 11, and 12

| Year | Profit Corn | Soybean | Total crop | Soybean meal and oil | Losses to consumers, processors, and livestock producers | Net |
|---|---|---|---|---|---|---|
| 1982 | 0 | 62.29 | 62.29 | 34.08 | −144.02 | −47.66 |
| 1983 | 31.82 | 1,320.28 | 1,355.11 | 741.83 | −3,442.08 | −1,346.48 |
| 1984 | 384.59 | 2,644.21 | 3,029.82 | 1,003.32 | −5,354.28 | −1,364.61 |
| 1985 | 907.82 | 3,255.83 | 4,259.18 | 1,096.41 | −6,653.32 | −1,355.12 |
| 1986 | 1,167.86 | 3,479.26 | 4,840.76 | 1,136.86 | −7,281.52 | −1,356.50 |

However, an antithetical scenario is also possible. If synthetic substitutes could not become economically viable fast enough or if the costs of beyond-the-farm-gate industry shifts are too great, then the forecasted increases in soybean prices would be underestimates of the impact of soybean rust in the U.S. Economic models are developed from observed movements of economic variables. Losses as large as 50% have no historical precedent and using such information in any model would be extrapolating far beyond the limits the model could reasonably be expected to forecast. Large reductions in production or unanticipated bottlenecks in distribution of soybeans could make all successive processing or redistribution impossible.

The results presented here not only point out the potential magnitude but also illustrate the complex nature of evaluating the impact of a new crop pest. Whether or not everyone can agree upon the fine details of disease development, which for exotic pests are necessarily more speculative than for endemics, or upon the subsequent impacts to the economy, the approach taken was intentionally conservative, and the results are still dramatic. With soybean rust there would be significant distributional effects as well as losses in production efficiency. Some farmers might be driven out of business while others would profit from higher prices. In spite of higher profits for some, larger dollar losses would be incurred by all consumers. The economy in general would be less well off. The numbers presented here must be interpreted as averages. As such, they mask some important considerations. For example, in recent years, equipment capital for poultry and pork production has gone almost exclusively into construction of equipment for use of low-cost high-protein feeds. Soybeans are the dominant part of these feeds. If soybeans become expensive (due to short supply) these producers will either pay the increased price, suffer the additional expense of adjusting their production practices, or go out of business. In this sector, business failures would be common and consumers would encounter increased poultry and pork prices along with less supply. Of course these effects would have further ripple effects. Because soybeans are basic to so many industries, the ripples would come from many directions and overall market disruptions would be widespread and probably too complex to fully anticipate.

We have attempted to expand the concept of crop loss to include more than the specific loss of a product due to a disease. Obviously, significant crop losses, due to whatever reason, cause serious repercussions throughout the economy. These repercussions are magnified when a major crop such as soybeans is involved. This paper illustrates some of the benefits and advantages of simulation models for studying an abstract problem with potentially serious consequences. In the case of a new disease, simulation models can help determine consequences of allowing the disease to enter or spread; and, as importantly, provide a rational estimate of the value of stopping that disease.

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