WEATHER VARIABILITY

Important Factor in the Food Crisis

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Abstract

World grain reserves are now roughly equivalent to, or smaller than, the difference between production in a favorable weather year worldwide and an unfavorable year. Thus there is a strong justification for the consideration of meteorological variability in assessing the potential for crisis in the world food production.

Some of man's important activities have become more (rather than less) sensitive to large-scale meteorological variability. A prime example can be found in the world's food system, with grain reserves at levels about equal in magnitude to meteorologically induced year-to-year yield variability.

There is a great need to extend or complement our increasingly effective ability in the area of general circulation modeling into the complex interface between the atmosphere and important aspects of the world economy.

Since World War II, grain yields have tended to increase through time. This upward trend has been attributed to "technology," a term that includes increased fertilizer usage, improved farm machinery, better seed, increased use of insecticides and herbicides.

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Figure 1 illustrates this tendency toward increased yields with data for corn yields of the five major corn-producing states (Iowa, Illinois, Indiana, Ohio, and Missouri) for 1945-1973. Also shown are simulated yields that result from holding technology constant at 1945 levels, with the year-to-year variability in the simulated yield series resulting from year-to-year weather variability. (The simulation was based on regression coefficients obtained from a sample of weather/yield data prior to 1945.)

If

Y = observed yield

Y^* = the yield that would have been observed had technology been held constant at 1945 levels

$\hat{Y}^*$ = a simulated yield at 1945 technology

ΔY = the contribution of technology

then

$$\Delta Y = Y - Y^*.$$

Because the exact value of Y^* is not known we use

$$\hat{Y}^* = Y^* + e,$$

where e is a stochastic error term. Then $\Delta Y = Y - \hat{Y}^*$.

Figure 1 Weighted Average of Corn Yields of Five States (Ohio, Indiana, Illinois, Iowa, and Missouri), 1945-1973.

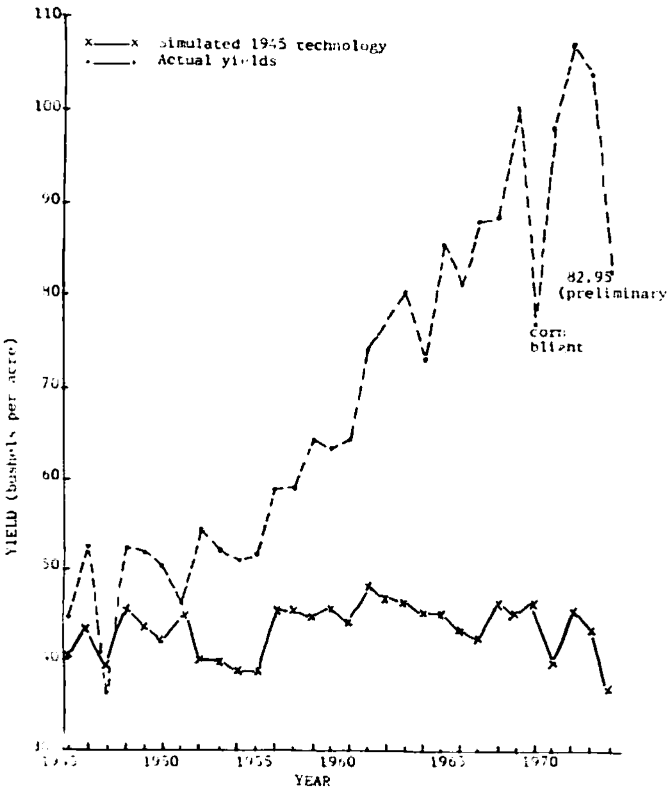


Figure 2 Trend in Midwest Corn Yields, 1945-1973.

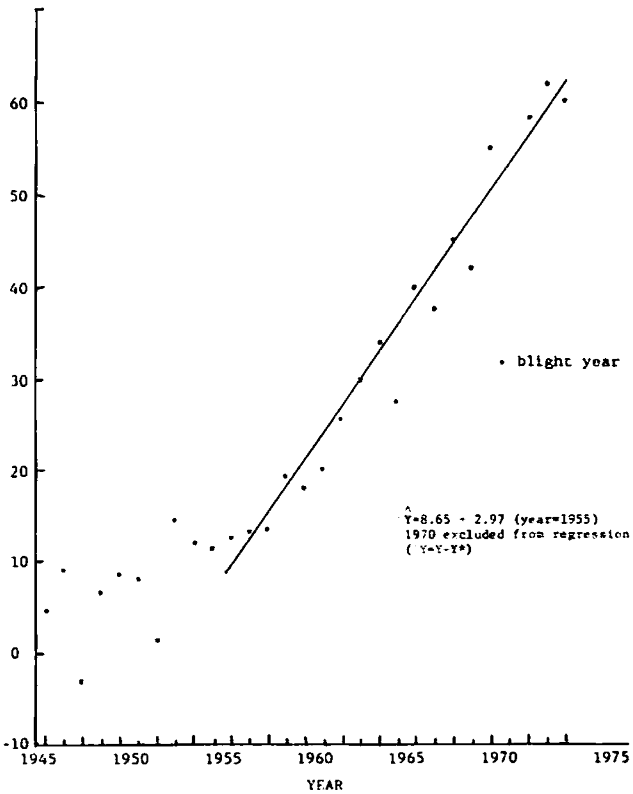
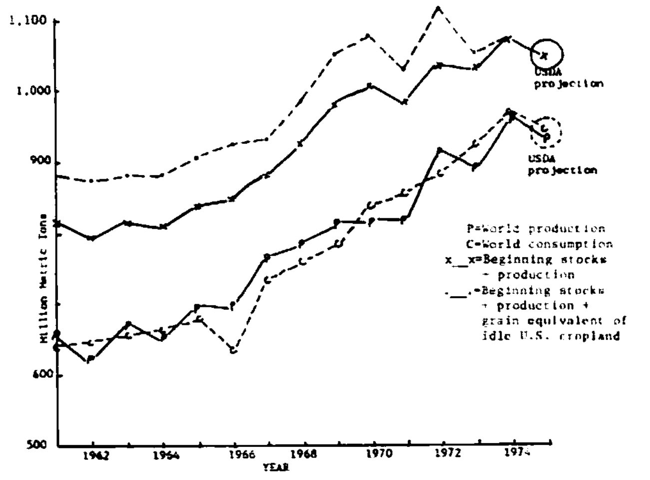


Figure 3 Total Grain Situation Worldwide, 1960-1973, and Projected to 1975.



Given a sample series of Y and $\hat{Y}^*$ such as that shown in Figure 2, we can fit a trend line to the sample. The result of doing this for a sample of 1955-1973 is

$$\hat{Y} = 8.65 + 2.97 \text{ (year - 1955)}.$$

The method just described provides a rational basis for monitoring the future trend of the nonmeteorological influences on yields, which we lump together under the term "technology." This is a fundamentally important question.

Another fundamentally important question concerns the future values of grain production and consumption. Even though global yields of grain have shown a trend toward higher values over the last 20 to 25 years, the trend toward increased consumption of grain has been rising even faster.

A series of these values is shown in Figure 3 (totals for wheat, rye, barley, oats, corn, and sorghum). One feature of these data is especially important: If a simple linear trend is fitted to the production series, and another is fitted to the consumption series for 1961-1973, then (in million metric tons of grain),

$$\hat{P} = 606.88 + 24.62 \text{ (year = 1961)}$$
$$\hat{C} = 594.75 + 25.95 \text{ (year = 1961)}$$

where P is total production for a particular crop year, and C is total consumption for the same year. The difference in the slope terms is 1.33 million metric tons. (This is very close to the annual average shortfall presented by the U.S. Department of Agriculture Service in publication FG 21-74, 23, August 1974.) If the two equations are plotted in graphic form, they intersect in 1973. form, they intersect in 1973.

Another fundamentally important question is concerned with production, consumption, and grain reserves. Prior to 1973, the United States had a substantial acreage of land that was withheld from production. In Figure 3, this unused land is expressed in terms of its potential for grain reserve values. If P and C are defined as previously described, and if R is the grain reserve (sometimes called "beginning stocks") as of 1 July in a particular year, i, then

$$R_{i+1} = R_i + P_i - C_i.$$

Early in the decade of the sixties, grain reserves plus the equivalent of idle U.S. cropland were about 30 to 35 percent of annual world consumption of grain. As shown graphically in Figure 3, the idle U.S. cropland was close to zero in the 1973-74 crop year. By that time, grain reserves were down to about 11 percent of consumption. These figures do not include Russia or Mainland China. If Russia and China are included, grain reserves, expressed in terms of percentage of annual consumption, were closer to 6 or 7 percent, as shown in Figure 4. With several major grain producing areas of the world having substantial decreases in production during the current crop year (1 July 1974 to 30 June 1975), world grain reserves as of 1975 are likely to be even lower.

The fundamental significance of this situation is: **World grain reserves are now roughly equivalent to (or smaller than) the difference between production in a favorable weather year worldwide and an unfavorable year.** This implies a strong need to consider the impact of large-scale meteorological variability. This need was not as pressing prior to the crop year ending in June 1972.

Conclusion

The debate between meteorologists who adhere to the theory that we are in the midst of a systematic climate change and those who do not is not merely a polite academic exercise. The point we all can agree upon is perhaps the most crucial—that is, we can expect to see a continuation of large-scale meteorological variability. In a world that is just barely producing enough grain in favorable years to meet the increase in population, any deviation in weather toward less than ideal conditions will have an increasingly serious economic impact.

Figure 4 World Reserves of Grain as Percentage of Total Consumption, 1961-1973.