# QUANTIFYING LONG RUN AGRICULTURAL RISKS AND EVALUATING FARMER RESPONSES TO RISK

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# Potential Uses for the Yield Variability Dataset

by

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We have devoted a large effort to collecting data on yields at the county, crop reporting district, and state levels in order to study variability of yields. This enormous database will provide the opportunity for a lot of "rabbit hunting". However, indiscriminate "rabbit blasting" is not an efficient use of resources. The hunt must be well planned in order to be successful. This short paper outlines some possible trophy rabbits as well as some "wild hares".

Models could be developed to attempt to estimate several variables. Some of the variables which we could attempt to estimate are discussed below.

1. Estimate a general variability measure for all crops and all locations.
   This is a ridiculous possibility since crops have different variabilities, and areas have different variabilities. This variable lacks usefulness from any standpoint.
2. Estimate a general variability measure for each crop.
   This would allow crop variabilities to be different, but the crop would have the same variability across all regions. This is not a good idea because we know crop variability varies across regions. (Crop insurance rates are very localized due to differences in variability across locations).
3. Estimate the impact of detrending method on variability measurement.
   Detrending method has a significant impact on variability measures.

There are several trend adjustment procedures which can be used to remove systematic variability from yield series. These procedures include moving average adjustments, regression estimates of linear and curvalinear form, maximum likelihood estimates and other more sophisticated techniques. All of these techniques have advantages and disadvantages regarding removal of the systematic component of the variance of time series data. Of overriding concern is the fact that the data series are not long by statistical standards and there is substantial variability in some of the series, particularly the less aggregated series. This limits the value of highly sophisticated techniques since the data simply do not support the sophistication of the analysis. Some evidence presented at the meeting suggested that quadratic regression estimation "over fit" the data. With less aggregated and shorter time-series data like farm data, even linear regression estimation will frequently "over fit" the data. Each method has advantages and disadvantages and each method will impact the measure of remaining variability.

4. Estimate variability parameters as inputs for models.

a) Regional models require aggregate variability measures. McCarl and Boisvert's subcommittee is looking into the parameters that are needed to run the aggregate models. b) Farm level models also are in need of input for risk analysis. Providing input on how to convert county variability to farm variability may be quite useful. This could be a subgoal of the following estimation objective.

5. Estimate the impact of size on variability.

Aggregation measured as acres would allow inclusion of different

aggregation units into the same model. A general "aggregation" impact variable would be one step in the direction of recognizing the impact of size on business risk. However, the aggregation impact will likely be different for different regions, and for different crops. Nevertheless, this could be useful as a first step in identifying the impact of size on risk.

6. Estimate the relationship between average yield and yield variability for selected crops.

There are three schools of thought on the possible relationship between average yield and yield variability. One possible relationship is that the variability of yield is higher when the average yield is higher. That is, operating at higher average yield allows greater variability around that average. The second possible relationship is that lower average yields are associated with greater variability. The reasoning being that poor yields both reduce the average yield and increase the variability. Of course a third possibility is that the coefficient of variation could be constant for different average yields. This relationship has significant implications for risk analysis.

In summarizing the possible relationships that could be estimated, it appears that estimating the impact of size (aggregation) on variability could be the most fruitful additional effort that could be made. Exploring relationships between average yield and yield variability could also provide input into understanding risk sources and differences in risk associated with yield level. Of course, supplying parameters for risk models has always been the objective of the data collection effort.

Model Specification

In order to address the reasonable objectives outlined above, one possible model might be:

Variability = f(crop type, location, size of unit, average yield, detrending method, length of series, time period of data series).

Crop type would be represented by dummy variables.

Location would be represented by dummy variables.

Size of unit would be in acres.

Detrending method would be represented by dummy variables.

Length and time period could be dummies representing broad categories such as "short" and "long" and before 1960 and after 1960, for example.

A major issue is what data should be put into this model. One can envision it being used in Kansas with farm level variability, county level variability, crop reporting district variability and state variability. Location might be tough to assign. There may be other farm-level datasets around that we could match with parts of the big dataset we have compiled as a group.

One can also envision this being used with county, state, regional, and national data. In other words, we could attempt to estimate parameters of this model (or a relevant subset of the variables) using the big dataset.

A third thing we want to try would be to estimate parameters of the model using the results of other studies as observations. This approach has been taken by Kerry Smith in his May, 1990 AJAE article on metanalysis of consumer surplus measures from travel cost studies. The objective of such a study in the context of variability measures would be to account for factors

other than the level of aggregation that contribute to differences in yield variability measures so that, if there is some systematic aggregation parameter, it can be recovered. It is likely that any aggregation parameter will not be constant, but depend on the crop, location, etc., but these interactive effects also can be tested with this approach. Since farm level yield information over time is scarce and many studies involving risk are based on farm level decision models, a way to systematically adjust aggregate data to the farm level would prove useful. This approach requires hunting a lot of rabbits, but might be worthwhile. If we can't bag enough rabbits for a "meat" a - analysis, we could, at least, provide a systematic presentation of past study results in tabular form. We envision this to be an expansion of the table presented by Doug Young in his W-149 article on this subject.

We would like to conclude these introductory thoughts with an appeal to the group for help in collecting studies and/or farm level datasets that could be used for our proposed approaches. We hope to have some preliminary results to report at the next meeting. A listing of the studies we've collected to date begins on the following page. For now, we'll hop to it. Wish us good hunting!

## Aggregation and Risk Measures Studies

Anderson, J. R., "Sparse data, climatic variability, and yield uncertainty in response analysis." American Journal of Agricultural Economics, (1973), Vol. 55, No. 1, pp. 77-82.

Anderson, J. R., Dillon, J. L., and Hardaker, J. B., Agricultural Decision Analysis. Iowa State University Press, (1977).

Barber, E. L., "Meeting Weather Risks in Kansas Wheat Farming." Kansas Agricultural Experiment Station Report No. 44, Manhattan, Kansas, (1950), 30 pp.

Barry, P. J., and Barnard, F. L., "Interaction Effects on Rural Financial Intermediaries of Financial Stress and Deregulation." American Journal of Agricultural Economics, (1985), Vol. 67, No. 5, pp. 1191-1195.

Berentsen, W. H., "Spatial variability in Soviet grain productivity 1955-1974." Soviet Geography, (1982), Vol. 23, pp. 630-639.

Brink, L., and McCarl, B., "The Tradeoff Between Expected Return and Risk Among Cornbelt Farmers." American Journal of Agricultural Economics, (1978), Vol. 60, No. 2, pp. 259-263.

Byerlee, D. R., and Anderson, J. R., "Value of Predictors of Uncontrolled Factors in Response Functions." Australian Journal of Agricultural Economics, (1969), Vol. 13, No. 2, pp. 28-37.

Cardwell, V. B., "Fifty years of Minnesota corn production: sources of yield increase." Agronomy Journal, (1982), Vol. 74, pp. 984-990.

Carter. H. O. and Dean, G. W., "Income, Price, and Yield Variability for Principle California Crops and Cropping Systems." Hilgardia, (1960), Vol. 30, No. 6, pp. 175-218.

Carter, T. R., and Parry, M. L., "Climatic change and changes in crop yield variability." in P.B.R. Hazell (ed.), Summary Proceedings of a Workshop on Cereal Yield Variability, (1986), IFPRI, International Food Policy Research Institute and DSE. Washington, D. C., pp. 47-65.

Castleberry, R. M.; Crum, C. W.; and Krull, C. F., "Genetic yield improvement of U.S. maize cultivars under varying fertility and climatic environments." Crop Science, (1984), Vol. 24, pp. 33-36.

Church, B. M., and Austin, R. B., "Variability of wheat yields in England and Wales." Journal of Agricultural Science, (1983), Vol. 100, pp. 201-204.

Day, R. H., "Probability distributions for field crop yields." Journal of Farm Economics, (1965), Vol. 47, No. 3, pp. 713-741.

Dyke, G. V.; George, B. J.; Johnston, A. E.; Poulton, P. R. ; and Todd, A. D., "The Broadbalk Wheat Experiment 1968-1978: Yields and Plant Nutrients in Crops Grown Continuously and in Rotation." Report to Rothamsted Experimental Station for 1982, (1983), No. 2, pp. 5-44.

Eberhart, S. A., and Russell, W. A., "Stability parameters for comparing varieties." Crop Science, (1966), Vol. 6, pp. 36-40.

Eisgruber, L. M. and Schuman, L. S., "The Usefulness of Aggregated Data in the Analysis of Farm Income Variability and Resource Allocation." Journal of Farm Economics, (1963), Vol. 45, No. 3, pp. 587-591.

Evans, L. T., "Yield Variability in cereals: Concluding assessment." in P.B.R. Hazell (ed.), Summary Proceedings of a Workshop on Cereal Yield Variability, (1986), IFPRI and DSE. Washington, D. C.: International Food Policy Research Institute.

Falatoonzadeh, H.; Conner, J. R.; and Pope, R. D., "Risk Management Strategies to Reduce Net Income Variability for Farmers." Southern Journal of Agricultural Economics, (1985), Vol. 17, No. 1 pp. 117-130.

Farnsworth, R. L., and Moffitt, L. J., "Cotton production under risk: An analysis of input effects on yield variability and factor demand." Western Journal of Agricultural Economics, (1981), Vol. 6, No. 2, pp. 155-163.

Feyerherm, A. M.; Paulsen, G. M.; and Sebaugh, J. L., "Contribution of genetic improvement to recent wheat yield increases in the U.S.A." Agronomy Journal, (1984), Vol. 76, pp. 985-990.

Fisher, R. A., "Studies in crop variation I: An examination of the yield of dressed grain from Broadbalk." Journal of Agricultural Science, (1921), Vol. 11, pp. 107-135.

French, J. B.; Schroder, D.; and Headley, J. C., "Role of weather and technology on crop yield risk for corn, soybeans, and winter wheat in selected regions of the United States." Department Paper No. 3, Department of Agricultural Economics, University of Missouri, Columbia, Missouri, (1985), pp. 1-62.

Freund, R. J., "The Introduction of Risk Into a Programming Model." Econometrica, (1956), Vol. 24, pp. 253-263.

Greve, R. W.; Plaxico, J. S.; and Lagrone, W. F., "Production and Income Variability of Alternative Farm Enterprises In Northwest Oklahoma." Bul. B-563, Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, (1960), 38 pp.

Halter, A. N., and Dean, G. W., "Decisions Under Uncertainty: with research applications." South-Western Publishing Co., (1971).

Hazell, P.B.R., "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty." American Journal of Agricultural Economics, (1971), Vol. 53, No. 1,pp. 53-62.

Hazell, P.B.R., "Sources of increased instability in Indian and U.S. cereal production." American Journal of Agricultural Economics, (1984), Vol. 66, No. 3, pp. 302-311.

Heady, E. O.; Kehrberg, E. W.; and Jebe, E. H., "Economic Instability and Choices Involving Income and Risk in Primary or Crop Production." Bul. 404, Agricultural Experiment Station, Iowa State College, Ames, IA, (1954), pp. 619-723.

Held, L. J., and Zink, R. A., "Farm Enterprise Choice: Risk-Return Tradeoffs for Cash-Crop Versus Crop-Livestock Systems." North Central Journal of Agricultural Economics, (1982), Vol. 4, No. 2, pp. 11-19.

Hirshleifer, J., "Investment, Interest, and Capital." Prentice-Hall, Inc., (1970), pp. 277-289.

Houck, J. P., and Gallagher, P. W., "The price responsiveness of U.S. corn yields." American Journal of Agricultural Economics, (1976), Vol. 58, No. 4, pp. 731-734.

Jones, R. B., "Stability in Farm Incomes." Journal of Agricultural Economics, (1969), Vol. 20, pp. 111-124.

Kling, W., "Determination of Relative Risks Involved in Growing Truck Crops." *

Lin, W., "Measuring Aggregate Supply Response under Instability." American Journal of Agricultural Economics, (1977), Vol. 59, No. 5, pp. 903-907.

Love, H. C., "Crop Production Risk in Alberta." Dept. of Agricultural Economics, Agricultural Economics Research Bulletin No. 5 University of Alberta, Edmonton, Alberta, (1968), 54 pp.

Markowitz, H. M., "Mean-Variance Analysis in Portfolio Choice and Capital Markets." Basil Blackwell Ltd., (1989).

Markowitz, H. M., "Portfolio Selection: Efficient Diversification of Investments." Yale University Press, (1959).

Mathia, G. A., "Measurement of price, yield and sales variability indexes for selected North Carolina crops." Economics Research Report No. 36, Dept. of Economics and Business, North Carolina State University, Raleigh, (1975), 32 pp.

Miller, S. E., "Forward Cash Contracting of Cotton." The Journal of Futures Markets, (1986), Vol. 6, No. 2, pp. 249-259.

Mostek, A., and Walsh, J.E., "Corn yield variability and weather patterns in the USA." Agricultural Meteorology, (1981), Vol. 25, pp. 111-124.

Musser, Wesley N., and Kostas G. Stamoulis. "Evaluating the Food and Agriculture Act of 1977 with Firm Quadratic Risk Programming," American Journal of Agricultural Economics, Vol. 63, No. 3 (August 1981), p. 447-456.

Offutt, S., "Aggregating Crop Production Data: A Random Coefficient Approach." The Journal of Agricultural Economics Research, (1989), Vol. 40, No. 2, pp. 11-18.

Pachta, J., and Schurle, B., "A Study of Farm Wheat-Yield Variability." Department Paper, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, pp. 1-11.

Parry, M. L., and Carter, T. R., "The effect of climatic variations on agricultural risk." Climatic Change, (1985), Vol. 7, pp. 95-110.

Quiggin, J. C., and Anderson, J. R., "Stabilization and Risk Reduction in Australian Agriculture." Australian Journal of Agricultural Economics, (1979), Vol. 23, No. 3, pp. 191-206.

Rao, M. R., and Willey, R. W., "Evaluation of yield stability in intercropping: Studies on sorghum/pigeon pea." Experimental Agricultural, (1980), Vol. 16, No. 2, pp. 105-116.

Russell, J. S., "Yield trends of different crops in different areas and reflections on the sources of crop yield improvement in the Australian environment." Journal of the Australian Institute of Agricultural Science, (1973), Vol. 39, pp. 156-166.

Schurle, B. W., "Business Risk Economies of Size: Evidence and Implications." Department Paper, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, pp. 1-12.

Schurle, B., and Tholstrup, M., "Farm Characteristics and Business Risk in Production Agriculture." North Central Journal of Agricultural Economics, (1989), Vol. 11, No. 2, pp. 183-188.

Schurle, B., and Tholstrup, M., "A Statistical and Empirical Investigation of Business Risk in Agricultural Production." Staff Paper No. 87-8, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, pp. 1-14.

Schurle, B., and Pachta, J., "An Evaluation of Farm, County, and Experiment Station Data on Wheat-Yield Variability." Department Paper, Department of Agricultural Economics, Agricultural Experiment Station, Kansas State University, Manhattan, Kansas, pp 1-16.

Siegfried, D. H., and Hall, H. H., "Using Aggregate Data in Agricultural Risk Analyses." Staff Paper 230, Dept. of Agricultural Economics, University of Kentucky, Lexington, KY, (1987), 18 pp.

Siegfried, D. H., and Hall, H. H., "Data Aggregation and Farm Risk Analysis." Agricultural Systems, (1989), Vol. 31, pp. 239-245.

Simmonds, N. W., "Variability in crop plants, its use and conservation." Biological Review, (1962), Vol. 37, pp. 442-465.

Skees, J. R., and Reed, M. R., "Rate Making for Farm-Level Crop Insurance: Implications for Adverse Selection." American Journal of Agricultural Economics, (1986), Vol. 68, No. 3, pp. 653-659.

Smith, A.W., "The Variability of Net Farm Income." Journal of Agricultural Economics, (1972), Vol. 23, pp. 59-63.

Smith, J., and Umail, G., "Production risk and optimal fertilizer rates: a random coefficient model." American Journal of Agricultural Economics, (1985), Vol. 67, No. 3, pp. 654-659.

Smith, V. K., and Kaoru, Y., "Signals or Noise? Explaining the Variation in Recreation Benefit Estimates." American Journal of Agricultural Economics, (1990), Vol. 72, No. 2, pp. 419-433.

Stanhill, G., "Trends and deviations in the yield of the English wheat crop during the last 750 years." Agro-Ecosystems, (1976), Vol. 3, pp. 1-10.

Swanson, E. R., "Crop Intensity and Income Stability." Journal of American Society of Farm Managers & Rural Appraisers, (1962), Vol. 26, No. 2, pp. 45-48.

Swanson, E. R., "Variability of Yields and Income From Major Illinois Crops 1927-1953." Bul. 610, Agricultural Experiment Station, University of Illinois, Urbana, IL, (1957), pp. 3-27.

Talbot, M., "Yield variability of crop varieties in the U.K." Journal of Agricultural Science, (1984), Vol. 102, pp. 315-321.

Thompson, L. M., "Weather variability, climatic change, and grain production." Science, (1975), Vol. 188, pp. 535-541.

Tinker, P. B., and Widdowson, F. B., "Maximizing wheat yields and some causes of yield variation." Proceedings of the Fertilizer Society, (1983), Vol. 211, pp. 149-184.

Tollini, H., and Seagraves, J. A., "Actual and Optimal Use of Fertilizer: The Case of Nitrogen on Corn in Eastern North Carolina." Report No. 14, Dept. of Economics, North Carolina State University, Raleigh, (1970), 52 pp.

Traill, B., "Incorporation of Risk Variables in Econometric Supply Response Analysis." Staff Paper No. 76-27, Dept. of Agricultural Economics, Cornell University, Ithaca, New York, (1976), 14 pp.

Weber, A., and Sievers, M., "Observations on the geography of wheat production instability." Quarterly Journal of International Agriculture, (1985), Vol. 24, No. 3, pp. 201-211.

Webster, J. P. G. and Kennedy, J. O. S., "Measuring Farmers' Trade-Offs Between Expected Income and Focus-Loss Income." American Journal of Agricultural Economics, (1975), Vol. 57, No. 1, pp. 976-105.

Wildermuth, J.; Shane, R.; and Gum, R., "Risk Diversification in Arizona Crop Farm Planning." Progressive Agriculture in Arizona, (Sept.-Oct. 1971), pp. 8-10.

Young, D., "Evaluating Procedures for Computing Objective Risk From Historical Time Series." Proceedings of a seminar sponsored by S-180 Regional Research Project, (1984), 21 pp.

Young, D.; Lin, W.; Pope, R.; Robison, L.; and Selley, R., "Risk Preferences of Agricultural Producers: Their Measurement and Use." Proceedings of a seminar sponsored by W-149 Reg. Research Project, (1982), 28 pp.

Zenger, S., and Schurle, B., "The Impact of Diversification on Farm Risk." Department Paper, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, pp. 1-12.