Shape Persistence in Elicited Subjective Crop Yield Probability Density Functions

Clop-Gallart M.M.[1] and Juárez-Rubio F.[1]

[1] Universitat de Lleida/Department of Business Administration and Economic Management of Natural Resources, Lleida, Catalonia, Spain

Abstract— **The shape persistence of a crop yield probability density function (PDF) was studied by using two variants of the Visual Impact Method (VIM) to elicit subjective estimations by farmers. In one variant ten weights were used to describe the PDF and in the other variant the farmer chose the number of weights. Results were compared directly and by means of Weibull distributions fitting, with evidence being obtained in favor of methodological persistence and the equivalence of the two estimation methods.**

Keywords— **Subjective crop yield PDF elicitation, Visual impact method, Methodological persistence.**

I. INTRODUCTION

In recent years, the debate over the shape of crop yield probability density functions (PDFs) ([1], [2], [3], [4], [5], [6], [7], [8], [9]), as well as the economic impact of crop production distributions used in risk management models, has moved forward. A significant contribution, and a summary of the state of the art, can be found in [10]. Nevertheless, the objections raised by [11] cannot be considered to have been resolved. The necessary advances in the subjective estimation of variables in the area of risk programming have been defended by authors such as [12], [13], [14] or [15]. From a DSS development perspective, it is important to continue moving forward in determining the best PDF estimation techniques for farmers.

Previous works by the authors ([16], [17]) have shown the methodological and time persistence of subjective point parameter estimations (mean, median, mode, etc.) when farmers estimate crop yield PDFs. The question examined in this work is whether the functional form elicited from farmers is also maintained when variants are introduced to the method used to express the form (methodological persistence). Concretely, the farmers' crop yield PDF estimates were examined using two variants of the Visual Impact Method (VIM) with data from rainfed and irrigated crops. In one case ten weights were used to describe the PDF and in the other case the farmer could freely select the number of weights. The results were compared to determine if the two variants offered similar results.

II. MATERIALS AND METHODS

In the year 2000, a group of 44 farmers expressed their opinion on the form of a crop yield PDF with which they were familiar (34 responses for rainfed crops and 15 for irrigated crops). Two variants of the VIM ([18], [19]) were used to this end.

Each farmer stated range (between maximum and minimum) yield values for the crops they were familiar with. The interviewers (university students) divided the range into five equal intervals and invited the farmers to assign a frequency to each of the intervals. This assignment was done with the help of (a) ten weights that the farmer distributed amongst the five intervals, and (b) a number of weights chosen freely by the farmer. In the latter case all the farmers assigned an equal or greater number of weights than the original ten units.

Histograms estimated using the ten-weight VIM were compared with histograms estimated using a number other than ten, to determine the methodological persistence of the estimation. This comparison was done in three ways:

- Comparing graphic representations of the skewness and kurtosis moment-ratio diagrams of both distributions.
- Comparing the PDFs obtained for both modalities of the VIM, using the Kolmogorov-Smirnov test.

• Fitting to Weibull distributions and comparing the parameters (shape and scale) estimated with each method[1].

III. RESULTS

The results of the methodological persistence evaluation of the VIM, for the density functions estimated using ten weights or a distinct number of weights, are described here below.

A. Skewness-kurtosis moment-ratio diagrams

The estimations obtained using the ten-weight or ten-plus-weight VIM are available. Graphic representation makes it possible to obtain moment-ratio diagrams in which skewness and kurtosis are shown. The results can be seen in Figures 1 and 2 (for the rainfed crops) and 3 and 4 (for the irrigated crops).

In the case of rainfed crops, farmers elicited largely asymmetric functions, with positive and negative skewness in similar proportions for both cases. With respect to kurtosis, a greater number of cases with negative values are seen, especially with the ten-weight VIM.

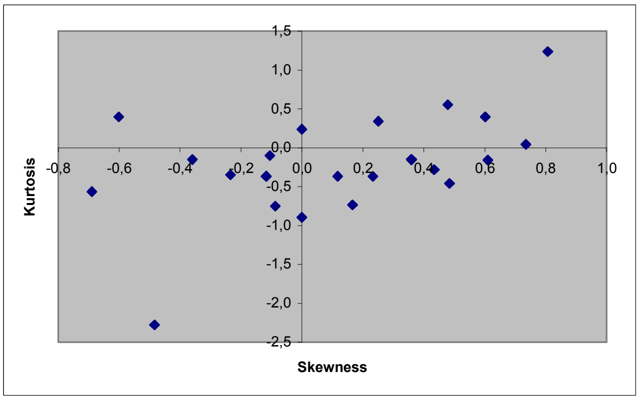

Fig. 1 Skewness-Kurtosis diagram (ten-weight VIM, rainfed crops)

In the case of irrigated crops, a greater quantity of cases with negative skewness are seen, both with the ten-weight and the ten-plus-weight VIM. With respect to kurtosis, negative values also predominate.

[1] To avoid the bias mentioned by [20] and [21], if d1 and d2 are the values to be compared, relative differences are expressed as: (d1 – d2) / [(d1 + d2) / 2]

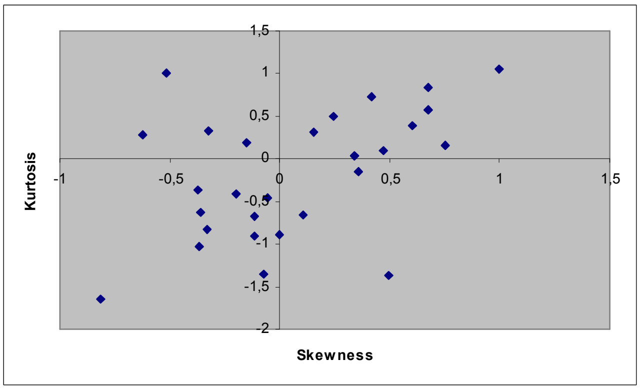

Fig. 2 Skewness-Kurtosis diagram (ten-plus-weight VIM, rainfed crops)

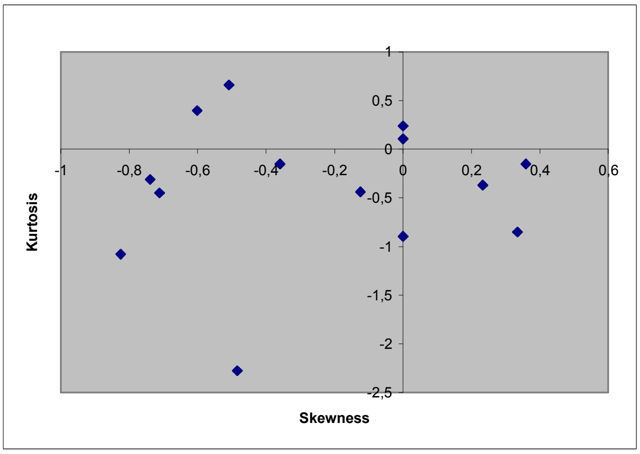

Fig. 3 Skewness-Kurtosis diagram (ten-weight VIM, irrigated crops)

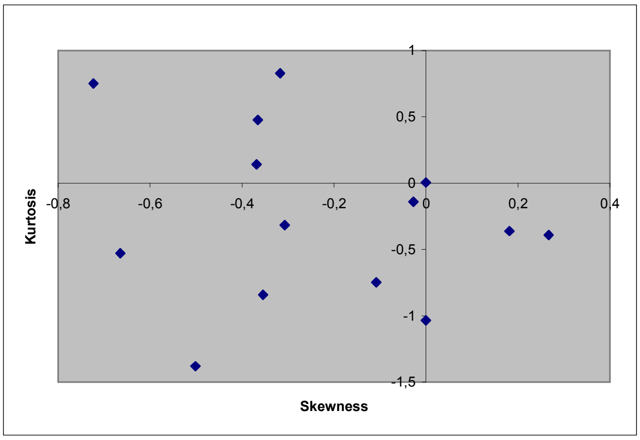

Fig. 4 Skewness-Kurtosis diagram (ten-plus-weight VIM, irrigated crops)

Which is to say, farmers tend to estimate platykurtic distributions for both for rainfed (ten-weight VIM) and irrigated crops using both variants of the VIM.

B. Comparison of probability density functions

The ten-weight and ten-plus-weight VIM estimated histograms were compared for each farmer. The proximity of the two distributions was estimated using the Kolmogorov-Smirnov test (0.05 significance).

The results obtained indicate that the hypothesis of similarity between the two functions cannot be rejected for any of the rainfed and irrigated cases studied (for n=10, Massey 0.410), reinforcing the idea of persistence between the distinct estimations elicited from farmers. In the case of n=number of weights used by the farmer in the ten-plus-weight VIM, the result indicates that the hypothesis of similarity between functions cannot be rejected in 31 of 32 (97%) cases of rainfed crops and in all irrigated crops.

C. Fitting to the Weibull distribution

Weibull distributions were fitted, and were evaluated using the Kolmogorov-Smirnov test (0.05), with the result that, for rainfed crops, the hypothesis of similarity between the two functions studied could not be rejected, in all the ten-weight cases and 29 of the 32 ten-plus-weight cases.

In irrigated crops, it is not possible to reject the similarity hypothesis of the functions studied in all the ten-weight cases and in 10 of the 14 ten-plus-weight cases.

The shape and scale parameters for the Weibull distribution and the various PDFs elicited (using the ten-weight and ten-plus weight VIM variations) are available. Table 1 shows the relative differences obtained for these parameters.

Table 1 Relative differences between shape and scale parameters of the Weibull distribution (%)
Sh: Shape, Sc: Scale

Crop	n	Mean		SD		Median		Max		Min	
		Sh	Sc	Sh	Sc	Sh	Sc	Sh	Sc	Sh	Sc
Rainfed	32	10	3	7	2	9	3	29	11	0	0
Irrigated	14	14	2	21	3	6	1	75	8	0	0

Given that the scale parameter has a much smaller variability than that of the shape parameter, Table 2 shows detailed results obtained for the shape parameter, classified into three groups of cases: those that have a shape coefficient less than seven, those between seven and ten, and those greater than ten.

Table 2 Observed cases for the Weibull distribution's shape parameter (%)
10W: ten-weight VIM, >10W: ten-plus-weight VIM

Crop	Shape <7		Shape 7-10		Shape >10	
	10W	>10W	10W	>10W	10W	>10W
Rainfed	72	72	9	9	19	19
Irrigated	36	36	14	28	50	36

For the ten-weight VIM (10W), the majority of observed cases presented a shape parameter inferior to seven for rainfed crops. In the case of irrigated crops, half the observed cases presented a shape coefficient greater than ten.

In the case of using ten-plus-weight VIM (>10W), the values were identical to the results seen when ten weights were used, in the case of rainfed crops. In irrigated crops, the cases in which the shape coefficient is less than seven are equal to those which have a shape coefficient greater than ten, with the cases having shape coefficients between seven and ten remaining in the minority.

The shape parameter indicates the level of kurtosis, with primarily platykurtic estimations being obtained in rainfed crops and a less evident tendency in irrigated crops, where the functions were flattened in 14% of cases when the number of weights was other than ten.

The Wilcoxon test (with a 0.05 level of significance) for related samples was used for the shape and scale parameters, for the ten-weight and ten-plus-weight VIM variants, indicating that the similarity hypothesis between the values studied could not be rejected in any of the cases, for both rainfed and irrigated crops.

IV. CONCLUSIONS

When using the VIM for PDF crop yield estimation, similar results are obtained using ten weights or a number of weights freely chosen by the farmer. As a consequence, the ten-weight VIM is recommended, since it is the simplest variant to use.

The similarity of responses indicates methodological persistence, one of the logical conditions needed to have confidence in the estimates.

REFERENCES

1. Day RH (1965) Probability Distributions of Field Crop Yields. J Farm Econ 47(3):713-741
2. Gallagher P (1986) U.S. Corn Yield Capacity and Probability: Estimation and Forecasting with Nonsymmetric Disturbances. N Cent J Agr Econ 8(1):109-122
3. Gallagher P (1987) U.S. Soybean Yields: Estimation and Forecasting with Nonsymmetric Distributions. Amer J Agr Econ 69(4):796-803
4. Nelson CH, Preckel PV (1989) The Conditional Beta Distribution as a Stochastic Production Function. Amer J Agr Econ 71(2):370-378
5. Nelson CH (1990) The Influence of Distributional Assumptions of the Calculation of Crop Insurance Premia. N Cent J Agr Econ 12:71-78
6. Taylor CR (1990) Two Practical Procedures for Estimating Multivariate Nonnormal Probability Density Functions. Amer J Agr Econ 72(1):210-218
7. Ramírez OA (1997) Estimation and Use of a Multivariate Parametric Model for Simulating Heteroskedastic, Correlated, Nonnormal Random Variables: The Case of Corn Belt Corn, Soybean, and Wheat Yields. Amer J Agr Econ 79(1):191-205
8. Goodwin BK, Ker AP (1998) Nonparametric Estimation of Crop Yield Distributions: Implications for Rating Group-Risk Crop Insurance Contracts. Amer J Agr Econ 80(1):139-153
9. Just RE, Weninger Q (1999) Are Crop Yields Normally Distributed?. Amer J Agr Econ 81(2):287-304
10. Sherrick BJ, Zanini FC, Schnitkey GD, Irwin SH (2004) Crop Insurance Valuation Under Alternative Yield Distributions. Amer J Agr Econ 86(2):406-419
11. Pease JW (1992) A Comparison of Subjective and Historical Crop Yield Probability Distributions. Southern Journal of Agricultural Economics 24(2):23-32
12. Anderson JR (1997) An 'ABC' of risk management in agriculture: overview of procedures and perspectives. In: Risk Management Strategies in Agriculture: State of the Art and Future Perspectives (Huirne RBM, Hardaker JB, Dijkhuizen AA, eds). Wageningen Agricultural University, Wageningen, The Netherlands, pp. 1-13
13. Miranda MJ (1991) Area-Yield Crop Insurance Reconsidered. Amer J Agr Econ 73(2):233-242
14. Hardaker JB, Huirne RBM, Barry PJ, King RP (1997) Risk Management Strategies in Agriculture: the State of the Art and Future Perspectives. In: Risk Management Strategies in Agriculture. State of the Art and Future Perspectives (Huirne RBM, Hardaker JB, Dijkhuizen AA, eds). Wageningen Agricultural University, Wageningen, The Netherlands, pp. ix-xiv
15. Van Der Fels-Klerx IHJ, Goossens LHJ, Saatkamp HW, Horst SHS (2002) Elicitation of quantitative data from a heterogeneous expert panel: formal process and application in animal health. Risk Analysis 22(1):67-81
16. Clop-Gallart MM, Juárez-Rubio F (2006) Persistence of point crop yield subjective estimates. Spanish Journal of Agricultural Research 4(3):202-206
17. Clop-Gallart MM, Juárez-Rubio F (2007) Elicitation of subjective crop yield PDF. Spanish Journal of Agricultural Research 5(1):16-24
18. Francisco EM, Anderson JR (1972) Chance and choice West of the Darling. Australian Journal of Agricultural Economics 16:82-93
19. Anderson JR, Dillon JL, Hardaker JB (1977) Agricultural decision analysis. The Iowa State University Press, Ames, Iowa, USA
20. Bland JM, Altman DG (1995) Comparing methods of measurement: why plotting difference against standard method is misleading. Lancet 346:1085-1087
21. Bland JM, Altman DG (1999) Measuring agreement in method comparison studies. Stat Methods Med Res 8: 135-160

Use macro [author address] to enter the address of the corresponding author:

- Author: Clop-Gallart M.M.
- Institute: Universitat de Lleida
- Street: Av. Rovira Roure, 191
- City: Lleida (25198), Catalonia
- Country: Spain
- Email: mclop@aegern.udl.cat