Economics Bulletin

Volume 39, Issue 3

Comment on "A Monte Carlo filtering application for systematic sensitivity analysis of computable general equilibrium results"

Davit Stepanyan
Humboldt University of Berlin

Harald Grethe
Humboldt University of Berlin

Khalid Siddig
Humboldt University of Berlin

Abstract

In a recent article published in the Journal of Economic Systems Research, Mary et al. (2018) introduced an interesting approach to systematic sensitivity analysis applied in a Computable General Equilibrium (CGE) modelling framework. This approach offers a systematic method of identifying the model parameters that have the greatest impact on the uncertainty of model output. According to the authors, moreover, it increases the quality of the approximated results by decreasing the dimensionality of the problem. This article contributes to a recent set of studies discussing the accuracy and appropriateness of different uncertainty analysis methods in economic simulation models. While the focus of the article is on a more efficient way of sensitivity analysis, we see a problem in using an arbitrary rotation of Stroud`s octahedron as a benchmark for assessing Monte Carlo simulations.

No potential conflict of interest was reported by the authors.
Citation: Davit Stepanyan and Harald Grethe and Khalid Siddig, (2019) "Comment on "A Monte Carlo filtering application for systematic sensitivity analysis of computable general equilibrium results"", *Economics Bulletin*, Volume 39, Issue 3, pages 1925-1929
Contact: Davit Stepanyan - davit.stepanyan@hu-berlin.de, Harald Grethe - grethe@hu-berlin.de, Khalid Siddig - khalid.siddig@hu-berlin.de.
Submitted: July 05, 2019. **Published:** August 22, 2019.

Economics Bulletin

Submission Number: EB-19-00610

Comment on 'A Monte Carlo filtering application for systematic sensitivity analysis of computable general equilibrium results'

Davit Stepanyan
Humboldt-Universität zu Berlin

Harald Grethe
Humboldt-Universität zu Berlin

Khalid Siddig
Humboldt-Universität zu Berlin

Abstract

In a recent article published in the Journal of Economic Systems Research, Mary et al. (2018) introduced an interesting approach to systematic sensitivity analysis applied in a CGE modelling framework. This approach offers a systematic method of identifying the model parameters that have the greatest impact on the uncertainty of model output. Moreover, according to the authors, it increases the quality of the approximated results by decreasing the dimensionality of the problem. The article contributes to a recent set of studies discussing the accuracy and appropriateness of different uncertainty analysis methods in economic simulation models. While the focus of the article on a more efficient way of sensitivity analysis is appreciated, we see a problem in using an arbitrary rotation of Stroud's octahedron as a benchmark for assessing Monte Carlo simulations.

No potential conflict of interest was reported by the authors.
Submitted: July 05, 2019.

1. Introduction

Mary et al. (2018) evaluate the quality of simulation model results approximated using Monte Carlo (MC) and Monte Carlo Filtering (MCF) against model results obtained via Stroud's (1957) order 3 Gaussian quadratures (GQ). Stroud's theorem of degree 3 quadrature formulae states the following:

> *A necessary and sufficient condition that 2n points $v_1, \ldots, v_n, -v_1, \ldots, -v_n$ form an equally weighted numerical integration formula of degree 3 for a symmetrical region is that these points form the vertices of a Q_n whose centroid coincides with the centroid of the region and lie on an n-sphere of radius $r = \sqrt{nI_2 / I_0}$ (Stroud 1957, p. 259).*

Where, Q_n is the regular n-dimensional generalized octahedron that is being integrated into the n-sphere; I_0 is the volume of the symmetrical region; I_2 is the integral of the square of any of the variables of the region over the entire region. Stroud was, however, faced with the problem that whenever the dimensionality is greater than 3, the vertices of the octahedron were falling outside the n-sphere producing unusable formulae. In order to counteract this problem, Stroud (1957) proposed his degree 3 integration formulae to rotate the octahedron and bring the vertices back into the n-sphere.

Later, Artavia et al. (2015) found that, depending on the rotation of Stroud's octahedron, the quality of the approximation of the true distribution of model results may differ strongly. This was confirmed and analysed in more detail by Stepanyan (2018). Villoria and Preckel (2017), moreover, found inaccuracies in the approximation of distributions of model results using GQs when comparing them with the results obtained by the MC method in the Global Trade Analysis Project (GTAP) model. In conclusion, assessing the results based on MCF with results based on GQs generated by an arbitrary rotation of Stroud's octahedron as a benchmark (Mary et al., 2018, p. 16) may lead to wrong results.

2. Demonstration

We demonstrate the aforementioned statement using an economy-wide recursive-dynamic CGE model (Diao and Thurlow 2012).[1] The model is calibrated to the most recent social accounting matrix for the Sudan (Siddig et al. 2016), with multiple sectors, 26 of which are crop-producing. As model closures, reflecting a specific economic environment, we assume flexible government savings and fixed direct tax rates within the government balance. For the external balance, we assume a flexible exchange rate and fixed foreign savings. For the saving-investment identity, we assume a fixed share of investment in total absorption, while household saving rates can adjust uniformly in order to generate the necessary funds for investment. The model runs over the period from 2018 to 2025. Since extreme weather shocks in the Sudan occur in a cyclical manner (MEPD 2013), on average every five years, we apply the stochastic yield shocks in every fifth year, namely, in 2018 and 2023 (for more details, see Stepanyan et al. 2019).

The effects of yield uncertainty of seven model crops have been analyzed. In order to replicate the finding by Artavia at al. (2015), we have generated 20 different families of GQ points by

[1] The selected model is comparable with the one used by Mary et al. (2018).

applying 20 random rotations of Stroud's octahedron. The rotations are operationalized by permuting the coordinates prior to applying the Stroud matrix.

Figure 1 presents the coefficients of variation of average growth rates of production quantities and prices of traditional rain-fed millet over the model solution period.[2] These results clearly demonstrate that, depending on the selected rotation of GQs, the approximated results differ strongly. Therefore, using the results produced by any arbitrary rotation of GQs as a benchmark in order to evaluate the quality of approximations by other methods may lead to incorrect conclusions.

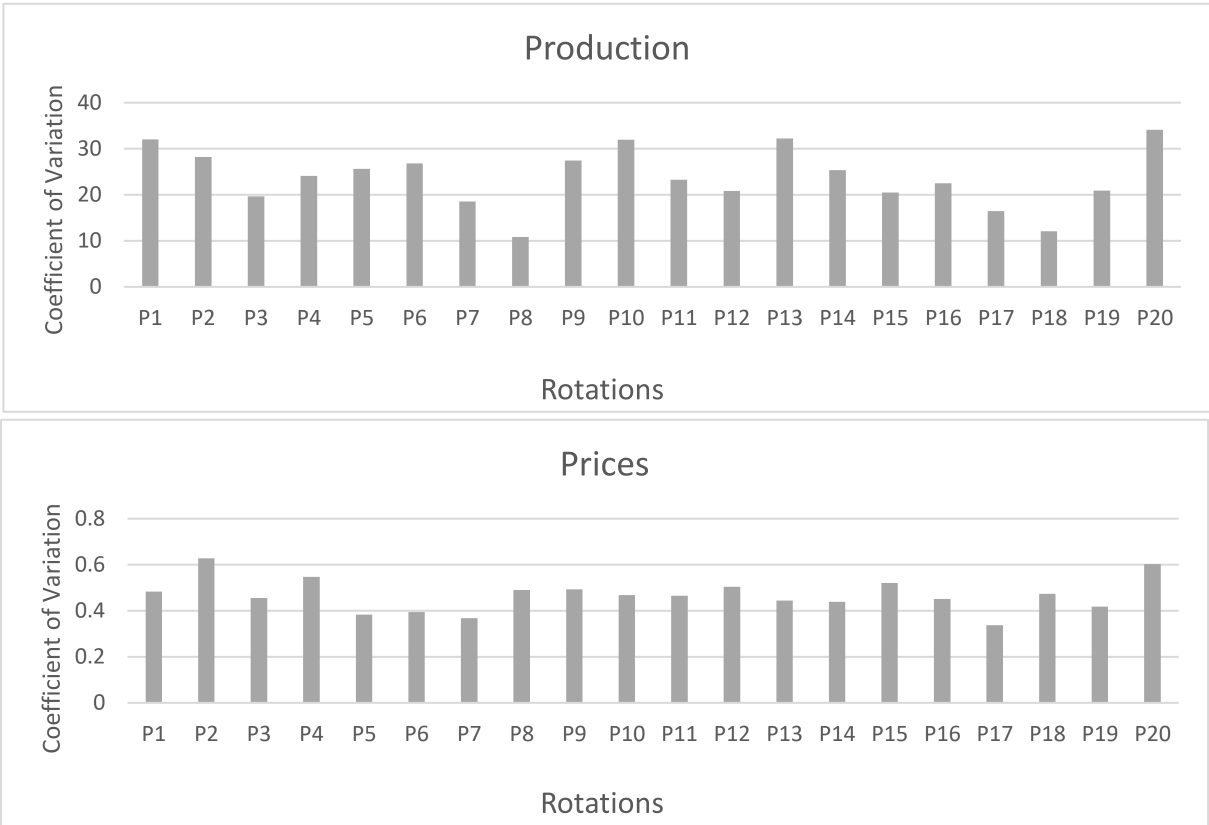

Figure 1. Coefficients of variation of the average growth rates of production and prices of traditional rain-fed millet in the Sudan for the period of 2018 to 2025. P1-P20 are the results approximated by 20 GQ families generated by 20 random rotations.

[2] The results of the rain-fed millet sector are presented for demonstrational purposes. The results of other stochastically modelled sectors are similar. We will be glad to share them upon request.

3. Conclusion

Using the results approximated by GQs generated from an arbitrary rotation of Stroud's octahedron as a benchmark to evaluate the quality of approximations obtained by MC or MCF can be misleading. To demonstrate this, we apply an economy-wide recursive-dynamic CGE model with seven stochastic crop-producing sectors. We solve the model using 20 families of randomly generated GQ points and analyse the coefficients of variation of production quantities and prices of these seven sectors. The results strongly differ among families of GQs. Therefore, we claim that the benchmark selected by Mary et al. (2018) to demonstrate the quality of their proposed method for systematic sensitivity analysis is not convincing. Instead, as a benchmark one may use a large enough MC sample that leads to convergence in model results or use points from several GQ families generated by random rotations of Stroud's octahedron, as demonstrated by Stepanyan et al. (2019).

References

Artavia, M., H. Grethe, and G. Zimmermann (2015) "Stochastic Market Modeling with Gaussian Quadratures: Do Rotations of Stroud's Octahedron Matter?" *Economic Modelling* **45**, 155–168. https://doi.org/10.1016/j.econmod.2014.10.017.

Diao, X., and J. Thurlow (2012) "A Recursive Dynamic Computable General Equilibrium Model" In Strategies and Priorities for African Agriculture: Economywide Perspectives from Country Studies. Edited by X. Diao, J. Thurlow, S. Benin, and S Fan. Washington D.C., *International Food Policy Research Institute (IFPRI).*

Mary, S., E. Phimister, D. Roberts, and F. Santini (2018) "A Monte Carlo Filtering Application for Systematic Sensitivity Analysis of Computable General Equilibrium Results" *Economic Systems Research* **29 (4)**. https://doi.org/10.1080/09535314.2018.1543182.

MEPD (Ministry of Environment, Natural Resources and Physical Development) (2013) "Sudan's Second National Communication under the United Nations Framework Convention on Climate Change". Khartoum. https://unfccc.int/resource/docs/natc/sudnc2.pdf.

Siddig, K., S. Elagra, H. Grethe, and A. Mubarak (2018) "A post-separation Social Accounting Matrix for the Sudan" MENA RP Working Paper 8. Washington, DC and Cairo, Egypt, *International Food Policy Research Institute (IFPRI).* http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132312

Stepanyan, D. (2018) "Application of Gaussian Quadratures in the Global Biosphere Management Model (GLOBIOM) as an Efficient Approach to Uncertainty Analysis" Laxenburg, Austria, *International Institute for Applied Systems Analysis (IIASA).* http://www.iiasa.ac.at/web/home/education/yssp/YSSP_report_Davit_Stepanyan.pdf

Stepanyan, D., H. Grethe, G. Zimmermann, K. Siddig, A. Deppermann, A. Feuerbacher, J. Luckmann, H. Valin, T. Nishizawa, T. Ermolieva, and P. Havlik (2019) "Multiple Rotations of Gaussian Quadratures: An Efficient Method for Uncertainty Analyses in Large-Scale Simulation Models" *Presented at the 22nd Annual Conference on Global Economic Analysis, Warsaw, Poland*. https://www.gtap.agecon.purdue.edu/resources/download/9432.pdf.

Stroud, A. H. (1957) "Remarks on the Disposition of Points in Numerical Integration Formulas" *Mathematical Tables and Other Aids to Computation* **11 (60)**, 257–61.

Villoria, N. B., and P. V. Preckel. (2017) "Gaussian Quadratures vs. Monte Carlo Experiments for Systematic Sensitivity Analysis of Computable General Equilibrium Model Results" *Economics Bulletin* **37 (1)**, 480–487.