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Multiyear versus single-year drought: a comment on Peck and Adams

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The importance of evaluating the effects of droughts that last for prolonged periods is well recognised in a recent paper by Peck and Adams (P&A) (2010, this Journal). However, in my view, the procedure followed in that paper does not yield an adequate measure of the difference between the economic effects of multiyear and single-year droughts. The purpose of this note is to further the debate on how to measure that difference.

There are two major points of concern with P&A's paper. First, P&A assume that farmers are bound to strictly follow a set of prespecified 'agronomic rules'. This assumption is a crucial driver of the intertemporal decisions in the presented optimisation model. Second, the general argument put forward by the paper is sensitive to the choice of comparison points from simulations that are used to establish the difference between the effects of single-year and multiyear droughts. These two concerns are somewhat related, as the simulation runs are subject to the constraining 'agronomic rules'. I will elaborate further on these two issues, which will be followed by suggestions on avenues for further research.

The assumption made in P&A's paper that farmers have to follow a stringent set of 'agronomic rules' is, in my view, problematic. These 'agronomic rules' mainly consist of agronomic recommendations that reflect the susceptibility of certain crops to pests, diseases, nutrient deficiency and weeds. For example, P&A state that onions can only be grown once every 6 years, and maize (corn) cannot be grown in monoculture for more than 2 years. One could expect that the 'agronomic rules' implicitly reflect the superior profitability of rotating crops in the light of the cost of controlling pests, diseases and weeds, compared with growing crops in monoculture. This is the main reason why farmers would ever take-up those rules/recommendations. However, in the case of water shortages, trade-offs have to be considered between the susceptibility to pests, diseases and weeds and the associated costs embodied in the 'agronomic rules', and the profitability – or lack thereof because of inadequate water availability – of planting other crops. For example, despite agronomic rules saying that a certain crop cannot be grown on the same field for more than 2 years, in the light of expected water shortage, it might be optimal to grow it for the third consecutive year and incur the cost of treating pests, diseases and weeds, rather than planting some other crop that is likely

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to perform very poorly if not adequately irrigated. Indeed, farmers are well aware of these trade-offs and take them into account when they make crop choice decisions.

P&A do not explicitly recognise these trade-offs, and impose the 'agronomic rules' as constraints in the optimisation model. These constraints restrict the choice set of farmers in each period, dependent on the crop choice in previous period. Even if a farmer knows that there will not be sufficient water to profitably raise certain crops in the next period, and if they have determined that continuing with the current crop is a best strategy in the face of drought, they are forced by the 'agronomic rules' to switch to another crop. It is quite likely that these restrictions are at least partly responsible for findings reported in the paper that the effects of a multiyear drought are more severe than those of a single-year drought. Consequently, it is questionable whether these findings can credibly be used to measure the difference between economic effects of the two types of drought. Rather, they may be a measure of the effects of the restrictions imposed by the 'agronomic rules'.

These constraining effects of the 'agronomic rules' become further apparent in relation to the second major concern with the P&A's paper, which has to do with the choice of model solutions used to compare single-year and multiyear droughts. To estimate the economic effects of both types of drought P&A run discrete stochastic programs over a 6-year planning horizon, with water availability being in one of two possible states of nature ('full' or 'dry') with fixed probabilities (0.6 and 0.4, respectively). They solve the program for each of the 64 possible combinations for the state-of-nature sequence over the 6-year period. Simulations that involve drought in years 2 and 3 of the planning horizon are then chosen by the authors to compare the economic effects of single-year and multiyear droughts.[1] Three scenarios: 'dry' only in 2nd year, 'dry' only in 3rd year, and 'dry' in both 2nd and 3rd year are then compared with the baseline of no drought over the entire 6-year period. The economic effects of drought are estimated by the difference in the value of the objective function of the baseline and each of the three simulated scenarios. The effects of the two single-year droughts (in 2nd and in 3rd year) are summed together and are compared with the estimated economic effects of a 2-year drought over the same 2 years. The finding that a 2-year drought results in 10 per cent loss, whereas the sum of the two individual year droughts results in 7 per cent loss (4 per cent + 3 per cent), is used to put forward a general argument that the effects of a multiyear drought are more than the sum of its parts.[2]

However, one finds in the same table (F1 in the Appendix) that when the same exercise is performed for years 1 and 2, the sum of the economic effects

[1] Results are not presented for some of the other 2-year drought periods e.g. in years 4–5, and 5–6.

[2] In the P&A paper (p.52), it is stated that the sum of the effects from single year droughts occurring in year 2 and in year 3 is 6 per cent, and not 7 per cent as the sum of 4 per cent and 3 per cent as values given in Table F1 (Appendix) indicates. This may be a typographical error, or may be due to rounding.

of single-year droughts (4 per cent loss for year 1 drought and 4 per cent loss for year 2 drought) is exactly the same as the economic effect of a 2-year drought over those 2 years (8 per cent loss). Also in the same table (F1 in the Appendix), looking at scenarios involving years 3 and 4, one finds that the sum of the effects of single-year droughts (3 per cent loss + 2 per cent loss) is greater than the effect of a 2-year drought over those 2 years (4 per cent loss). This sensitivity of the results to the choice of comparison years indicates that the estimated effects of a multiyear drought are likely due to the effects of additional constraints that are imposed by the 'agronomic rules' in a 2-year period as opposed to the effects of those rules in two adjacent single periods. All this suggests that the reported results are not sufficiently robust and that they cannot be used to draw general conclusions, as a different answer is obtained dependent on the choice of comparison points.

The research question related to the effects of prolonged droughts on individual farmers and farming communities put forward by P&A is topical and relevant, especially in the face of threats of climate change, with predictions that prolonged droughts may become more frequent in many regions throughout the world. However, in my view, further research is required to address the question convincingly. An avenue for further research is to evaluate farm profitability over the entirety of a longer simulated period of time (e.g. over a whole 10-year period) under alternative distributional assumptions for drought years. A good collection of methods for simulating the distribution of drought years is provided by Sen and Boken (2005). Repeated draws from computer-generated random samples of the distribution of drought years over time can be used to identify samples where the whole period is dominated by multiyear droughts and samples where single-year droughts are dominant. Simulated profitability for those samples over the whole period can be used to make comparisons about the economic effects of single-year and multiyear droughts.

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