DEMYSTIFYING COPULAS: AN INTERACTIVE LESSON   [Intermediate level]

Title: *Demystifying copulas and implications for diversification benefit*

Format: To do this exercise, follow the guidance in Copula_Diversify_1.3_participant.docx and use the structured EXCEL sheet Copula_Diversify_1.1_participant.xlsx. For answers please see Copula_Diversify_inc_answers_1.3.docx, with a completed version of the Tasks in Copula_Diversify_1.1_T1T2_complete.xlsx.

Summary of activity: An EXCEL-based exploration, creating your first copula in a step-by-step exercise. Then, using this to understand how correlation affects joint risk in multi-hazard / compound risk scenarios through simulation.

Why is the training important: In short, because diversification is the basis of all (re)insurance, and correlation (a.k.a. dependency) destroys diversification. So, it's fundamental. If we get dependency wrong, we mis-estimate risk, mis-price risk etc …. And, most people feel that copulas are scary, yet they really matter for tail-end risk (i.e. rare yet severe impacts).

Scenario: A firm has assumed complete independence between risks (e.g. lines of business). You're sceptical. Before talking to them, you would like to:

- remind yourself of correlation coefficients (i.e. Pearson, Spearman)
- get your head around these things called 'copulas'
- estimate how much of an effect pairwise dependency *could* have upon a firm's risk (e.g. at 1-in-200 level)

Level & Audience: Intermediate level. No equations! For those with of some experience the field of catastrophe risk management, or PhD students studying compound or multi-hazard risk. It can also serve as a reminder to those experienced in modelling dependency.

Duration: ~2-3h of effort.

Take home messages: Also see Briefest_Guide_1.3.pdf – A 2-pager summarising the key things to know!

Copulas:
- A way of describing how ranks of two (or more) observed quantities (e.g. A and B) relate to each other, called their 'dependency structure'
- Not conceptually scary
- Readily possible to do useful tests (e.g. if correlation were higher, what effect would this have?)

Diversification benefit (i.e. reduction from being completely linked) increases with
- number of types of loss (e.g. lines of business)
- if two types of loss are roughly equal is size
- loss distributions have 'heavy' tails (e.g. log-Normal)
- dependency stronger, particularly in the tail (e.g. Gumbel)

Additional Reading: This work is based upon the idea that flooding and wind in the UK are linked rather than dependent (Bloomfield et al., 2023; De Luca et al., 2017; Hillier et al., 2023).

Bloomfield, H., Hillier, J. K., Griffin, A., Kay, A. L., Shaffrey, L., Pianosi, F., James, R., Kumar, D., Champion, A. J., and Bates, P. D.: Co-occurring wintertime flooding and extreme wind over Europe, from daily to seasonal timescales, Weather Clim. Extremes, 39, 100550, https://doi.org/10.1016/j.wace.2023.100550, 2023.

De Luca, P., Hillier, J. K., Wilby, R. L., Quinn, N. W., and Harrigan, S.: Extreme multi-basin flooding linked with extra-tropical cyclones, Env. Res. Lett., 12, 114009, https://doi.org/10.3390/atmos10100577, 2017.

Hillier, J. K., Perkins, T., Li, R., Bloomfield, H., Lau, J., Claus, S., Harrington, P., Latchman, S., and Humphry, D.: What if it's a perfect storm? Stronger evidence that insurers should account for co-occurring weather hazards, Bank Underground, 2023.