

Bayesian estimation of natural extreme risk measures

Application to agricultural insurance



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Context

Extreme weather events related to natural disasters and price volatility increased by the deregulation of financial markets are strongly affecting the volume and quality of agricultural production.

Research issues

- Study the insurability of French farm income by modelling the dependence structure between crop yields and prices.
- Select the right statistical model (copulas, extreme value statistics, Bayesian statistics).
- Adapt risk management instruments to provide a better financial hedging of natural hazards.
- Analyze the database extracted from the Farm Accountancy Data Network (FADN).

Copula models

The aim is to model french farm income of two main productions wheat & wine-growing using Copula theory.

- Application of the study to a large database of around 7000 commercial-sized farm holding, focusing on the year 2014 (an extremely hot year).
- Modeling the dependence structure between yields & prices (Fig. 1) according to various parameters (temperatures, fertilizers, pesticides, crop insurance, altitude and regions) by a conditional copula.

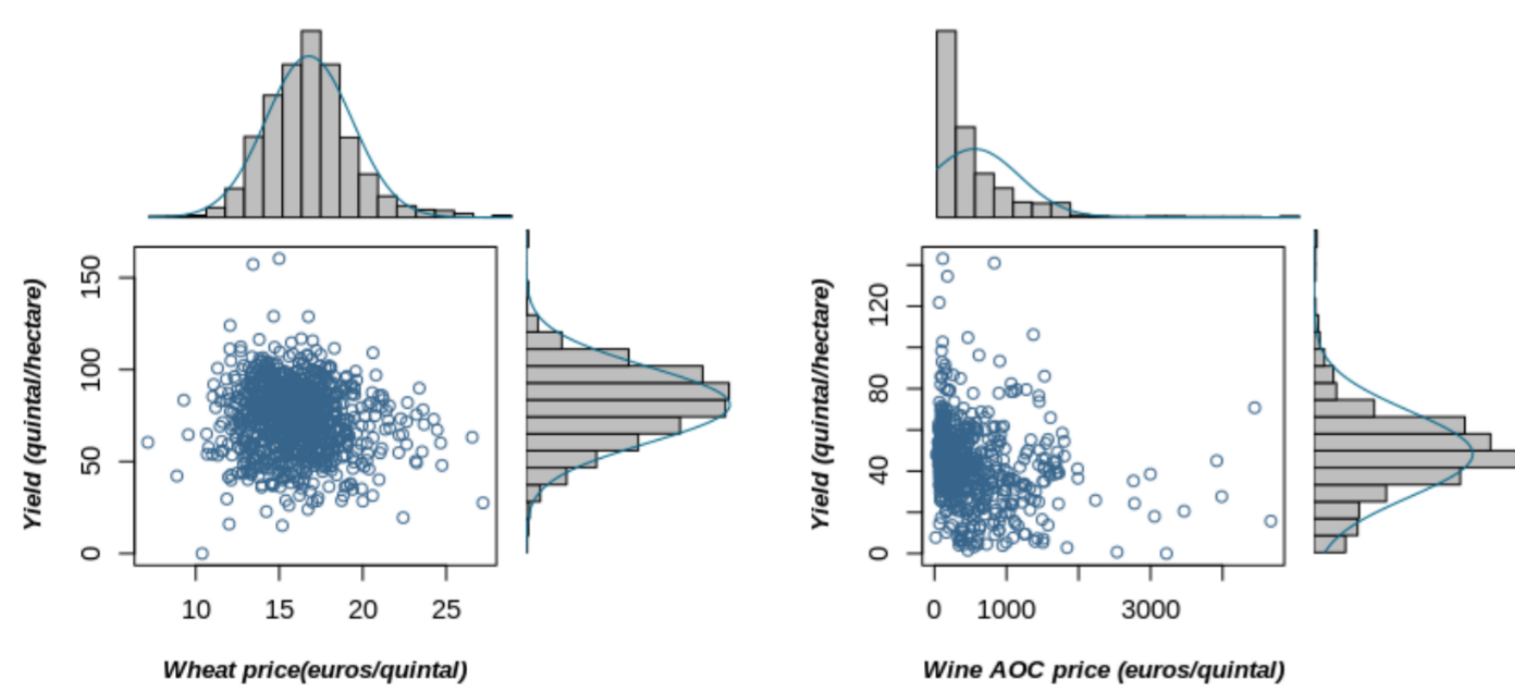


Fig. 1: Price and yield distribution of wheat and wine-growing.

For more information:

- (S1) <http://agreste.agriculture.gouv.fr/publications/graphagri/article/graphagri-regions-edition-2014>
- (S2) <http://www.spiritueuxmagazine.com/2015/10/infographie-les-chiffres-de-la.html>.
- (S3) C. Genest A.C. Favre. Everything you always wanted to know about copula modeling but were afraid to ask. Journal of Hydrologic Engineering, 12(4):347-368, 2007.

Experimental results

- Price volatility and lower yield level of wheat crops are very high and linked to the temperatures record in 2014 (Fig. 2a).
- The downward trend of yield and price correlations of wine-growing (Fig. 2d) is explained by biological requirements for the growth of vines (good sunshine and high temperatures). The upward trend is due to the sensitiveness of vines to very high temperatures accompanied by long periods of drought causing a slowdown in the growth of leaves and grapes.
- Beyond the weather, the decline in wheat and wine-growing yields is due to other factors, such as crop insurance purchase, location in plains (<300m) and regions (Fig. 3a and c). The intensive use of fertilizers and pesticides tempers the correlation (Fig. 2b, c, e and f).

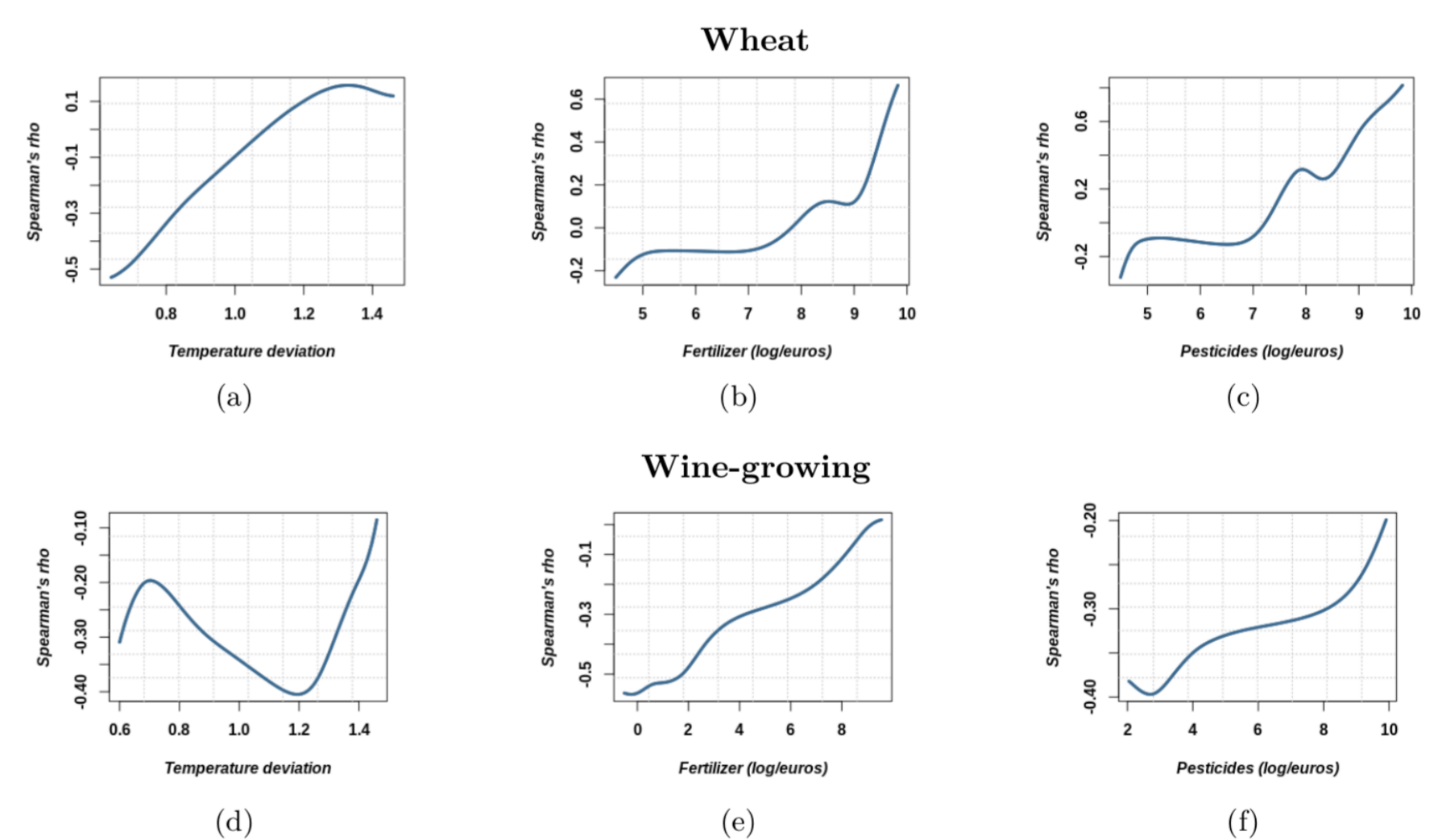


Fig. 2: Price and yield correlations of wheat and wine-growing conditionally to: temperature deviation, fertilizers and pesticides.

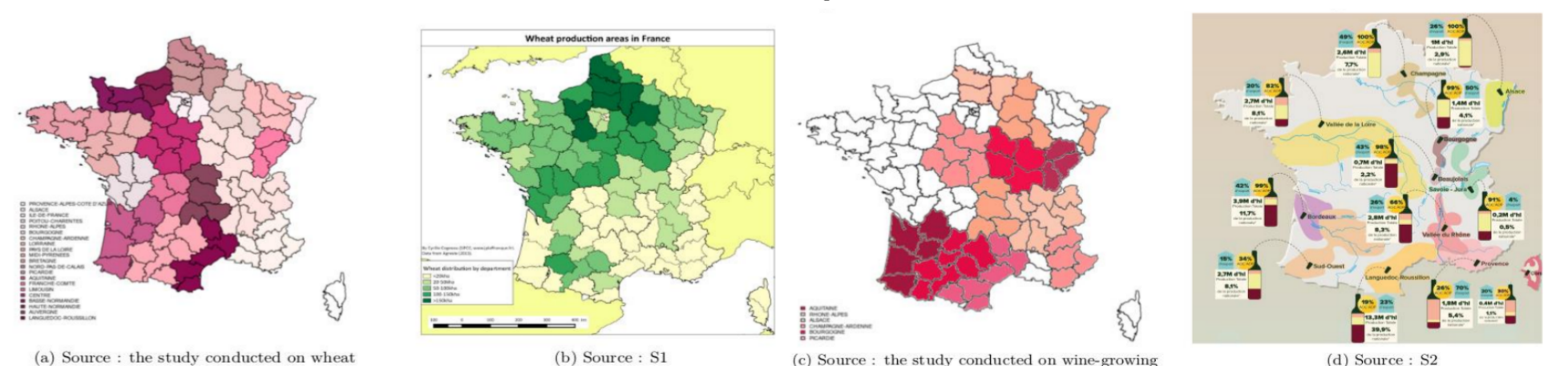


Fig. 3: Price/yield correlations (a,c) and wheat wine-growing productions (b, d) by region - Low (resp. high) correlations are in light (resp. dark) pink.

Prospects

- Develop the Bayesian statistical model.
- Adapt financial instruments (insurance and Cat Bonds) to strengthen proactivity and resilience to natural risks.



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