Crop yields and prices as affected by drought

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INTRODUCTION

Droughts are known to cause major losses on crop yields throughout the world and previous research made for Portugal also confirmed significant effects of precipitation anomalies (as measured by the Standardized Precipitation Index, SPI) in the production of annual crops. On the other hand, the effects of reduced yield on the prices have been thoroughly investigated in the Po Basin, confirming, for some crops, a negative correlation between yields and prices. However interaction among prices, yields and droughts needs further research.

Objectives

- Investigate the contribution of meteorological drought to crop yield anomaly and the subsequent price reaction, using Portugal mainland and the Po Basin for three annual crops: wheat, maize and rice (Fig.1).
- Develop a coherent conceptual model to integrate the relationships between drought, yields, and prices applicable across regions and crops (Fig. 2).

DATA

- EUROSTAT data of crop yields and prices for three cereals that are important in both countries: wheat, as a winter crop common to all regions, and maize and rice as summer crops more regionally distributed.
- SPIs (calculated for 1,2 and 3 months accumulation periods using 1979-1999 as the reference period) computed with the Watch Forcing Data ERA-Interim (WFDEI) for the duration of the crop yield series

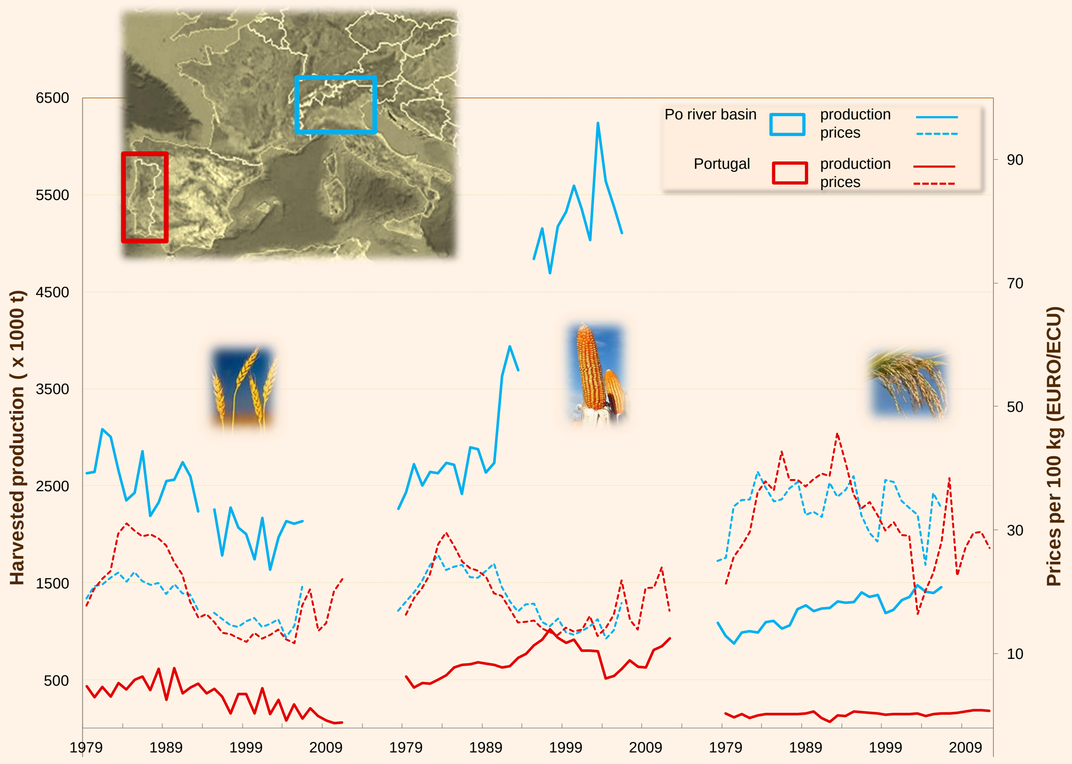


Fig. 1 - Wheat, Maize and Rice productions and corresponding absolute selling prices (EUROSTAT data: Po river Basin, Italy -1979-2007; mainland Portugal 1980-2013)

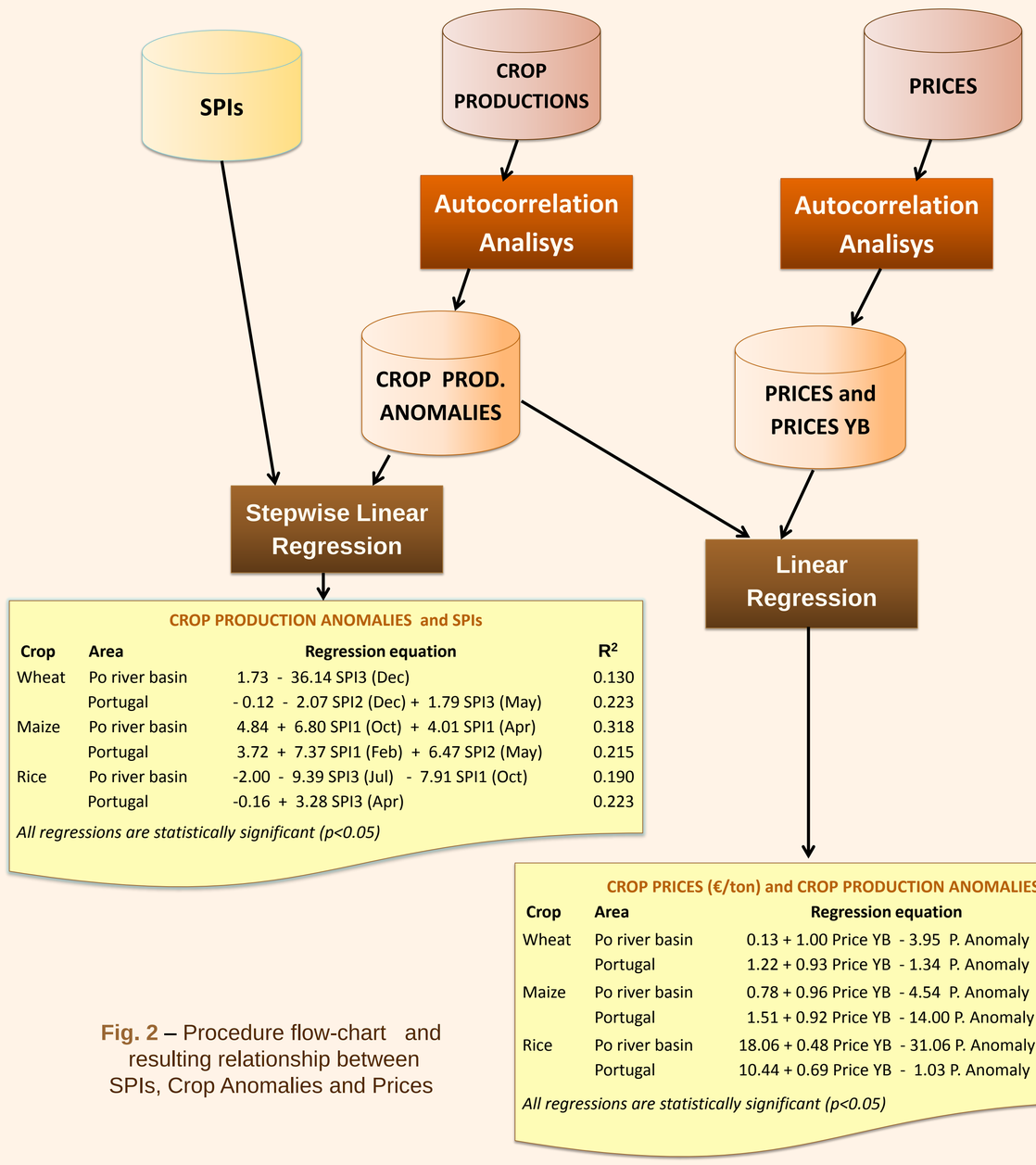
TAKE HOME MESSAGES

- It is possible to isolate and to detect significant correlations between SPIs and crop production after removal of the noise by de-trending the data using adequate reference periods.
- The effects of the various SPIs differ according to the crop and the study area. Both positive and negative effects of the SPIs were detected.
- For the correlation of prices with production anomalies it is clear that the effect is always negative, as predicted from economic theory. However, the magnitude of the effects varies and it seems associated with the dependency on global markets, namely for wheat in both areas and for rice in Portugal. For maize in both countries and especially for rice in the Po Basin, the significance of the production anomalies is very important determining prices, thus indicating that these productions are more dependent on local specialist markets.
- The developed general approach works for both study areas and crops tested, indicating that it might be appropriate to use across region and crops in Europe

OUTCOMES OF THE APPROACH

1) Detecting the anomalies in crop production

- The anomalies in production were computed as the difference (in absolute values and in proportion) between observed values and average values for different reference periods.
- The different reference periods tested were all the combinations of one or two years before and one or two years after the current year. Partial autocorrelation analyses (PACF) confirmed this window.
- The selection of the "best" crop production anomaly was done for each crop by the interpretability of the results of R^2 comparison between the different SPIs and the different crop yield anomalies computed.



CROP PRODUCTION ANOMALIES and SPIs

Crop	Area	Regression equation	R^2
Wheat	Po river basin	1.73 - 36.14 SPI3 (Dec)	0.130
	Portugal	- 0.12 - 2.07 SPI2 (Dec) + 1.79 SPI3 (May)	0.223
Maize	Po river basin	4.84 + 6.80 SPI1 (Oct) + 4.01 SPI1 (Apr)	0.318
	Portugal	3.72 + 7.37 SPI1 (Feb) + 6.47 SPI2 (May)	0.215
Rice	Po river basin	-2.00 - 9.39 SPI3 (Jul) - 7.91 SPI1 (Oct)	0.190
	Portugal	-0.16 + 3.28 SPI3 (Apr)	0.223

All regressions are statistically significant (p<0.05)

CROP PRICES (€/ton) and CROP PRODUCTION ANOMALIES

Crop	Area	Regression equation	R^2
Wheat	Po river basin	0.13 + 1.00 Price YB - 3.95 P. Anomaly	0.865
	Portugal	1.22 + 0.93 Price YB - 1.34 P. Anomaly	0.857
Maize	Po river basin	0.78 + 0.96 Price YB - 4.54 P. Anomaly	0.870
	Portugal	1.51 + 0.92 Price YB - 14.00 P. Anomaly	0.798
Rice	Po river basin	18.06 + 0.48 Price YB - 31.06 P. Anomaly	0.410
	Portugal	10.44 + 0.69 Price YB - 1.03 P. Anomaly	0.510

All regressions are statistically significant (p<0.05)

Fig. 2 – Procedure flow-chart and resulting relationship between SPIs, Crop Anomalies and Prices

2) Relationship between crop yield anomaly and SPIs

For each crop and each study area, models were developed using SPIs with significant correlation with crop anomaly. The linear regression model was then obtained by a stepwise (forward) procedure using the SPIs significantly correlated as explaining variables (report 1, Fig.2).

Anomalies in wheat production were found to be negatively affected by winter rains for both areas with a positive effect of more spring rains only for Portugal. For maize the models indicate always negative effects of drought (or positive effects of excess rain) from October to May in the two areas. For rice the two areas show very different effects: whereas for the Po Basin the excess rain has negative effects in summer and in the harvesting period (October), in drier Portugal the model detected a negative effect of drought (or a positive effect of extra rain) in early spring.

3) Links between prices and anomalies

After detecting a strong relationship between the prices of the current year and the prices of the year before (confirmed by PACF), linear regressions models were used to predict the crop price for a given year based on the price of the previous year (Price YB) and the corresponding production anomaly (P. Anomaly) (report 2, Fig.2).

For all crops and areas, prices of the current year depend mainly on the price of the previous year and, to a lesser extent, on the crop production anomaly. However the relationships between production anomalies and prices differ between crops and areas.

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