Detecting regional food systems exposure to climate shocks

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Guardian
Global climate crisis: inevitable, unprecedented and irreversible
CODE RED FOR HUMANITY
DAILY EX
CODE RED
NANCIAL TIMES
PM: WAK TO RED ALERT ON CLIMATE


CLIMATE
Finding Solutions for a Better Tomorrow


latimes.com
California's climate apocalypse
Fires, heat, air pollution: The calamity is no longer in the future — it's here, now
Oregon residents standing ground

Motivations

- The frequency and intensity of natural disasters such as droughts, floods, storms and the diffusion of invasive and unknown pests are year-by-year increasing all over the world (e.g., FAO, 2021)
- The increase of the spread and of the intensity of climate change induced disasters (e.g., Coronese et al, 2019), has started threatening production of the goods which are more exposed to climate change at the global level $\rightarrow$ The provision of food is particularly under threat
- In a world in which production is geographically spread and organized in international value chains, the toolkit provided by input-output analysis is particularly suitable for understanding the resilience of food systems with respect to climate shocks $\rightarrow$ but much more work is needed in terms of data construction and modelling

Aim of the project

Providing an assessment of the ex ante exposure of Italian regional food systems to climate shocks affecting food value chains

1. Estimating food systems stemming from a disaggregated demand for food, both at the regional and the national level
2. Reconstructing and analyzing the international, interregional and intraregional trade networks of intermediate inputs linked to the demand for food, so as to identify the sources of potential bottlenecks in the value chains
3. Performing a stress test analysis to assess the resilience of regional and national food systems to climate shocks

In this presentation

1. We estimate the value chain activated by Italian household expenditures on food
2. We assess the dependence from abroad in terms of value added by distinguishing: imports of final goods; imports of inputs
3. We analyze the interregional network generated by the food demand and identify those regions contributing the most
4. We provide a first assessment of climate indicator dynamics in those regions which have been found to be most relevant in serving the national demand in terms of agricultural products
5. We finally give a sneak preview of the results stemming from more recent works (e.g., regional embeddedness in international value chains, the construction of an interregional food satellite account)

Methodology & Data

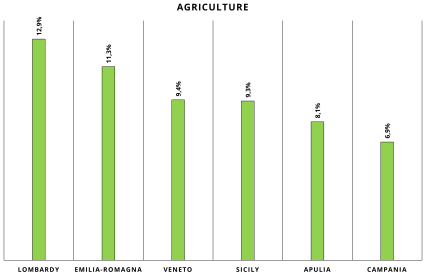
- The Italian interregional input-output database (IRPET-IRIOREG)
- Defining the food value chain
- The intermediate input network
- Climate data

Exposure to international shocks

Considering agricultural and processed food:

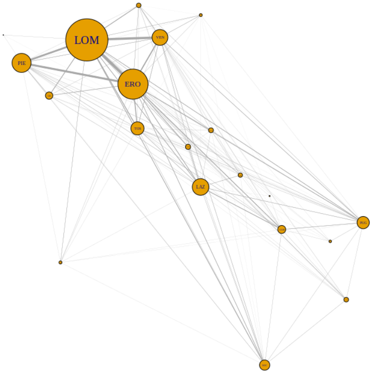
- For those kinds of final goods demanded by the Italian households, 80% is provided by Italian firms. The rest (20%) is imported from abroad
- In terms of value added, and considering the final products produced by Italian firms, the exposure to the rest of the world is 26% (upwardly biased estimation due to the role of leakages)
- Thus: for every euro spent on food by Italian households, 40 cents remunerate production factors localized abroad

Regional contributions: agriculture vs. industry processed

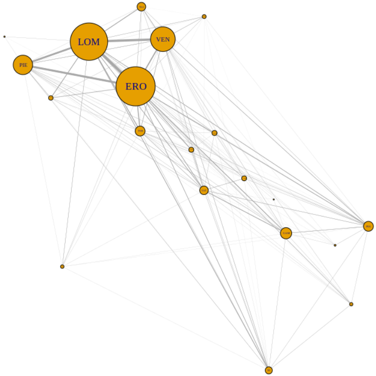


40% of agricultural contribution to meet the Italian household food demand stems from 4 regions in the North (Lombardy, Emilia-Romagna, Veneto, Piedmont)

The interregional network serving national food demand

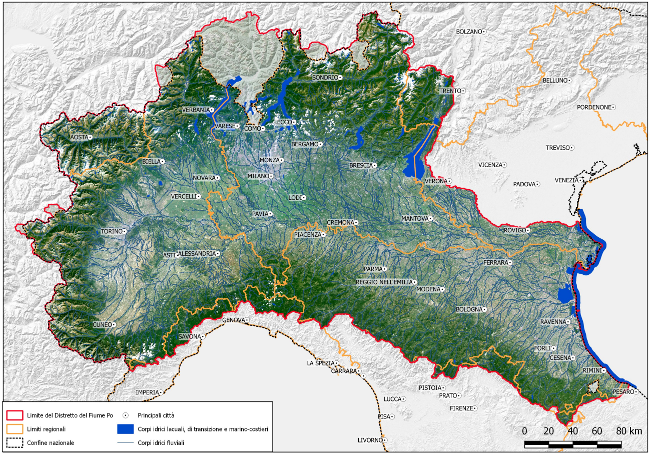


Out-degree

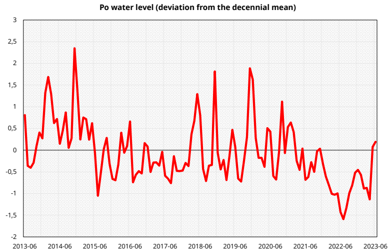


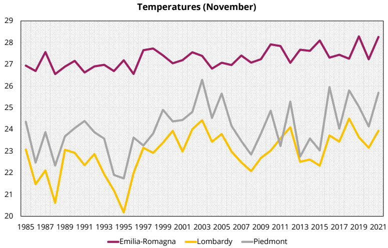
In-degree

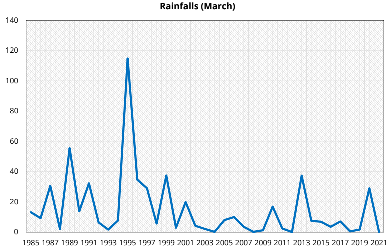
The Po region



Climate shocks (trends?): Drought in 2022

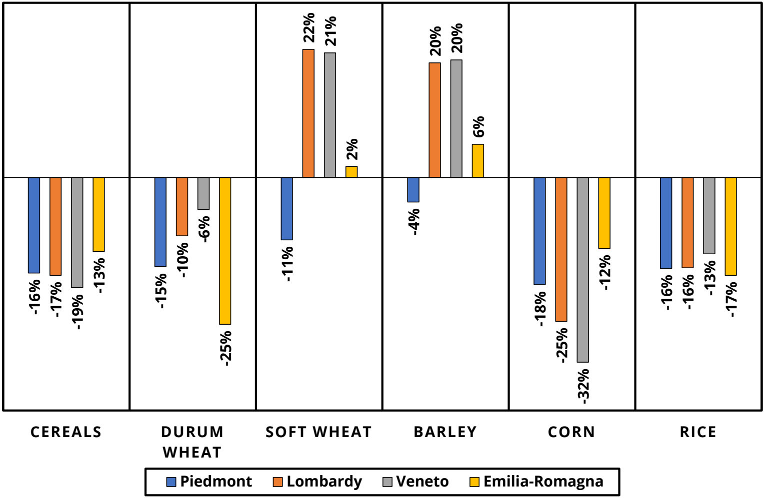




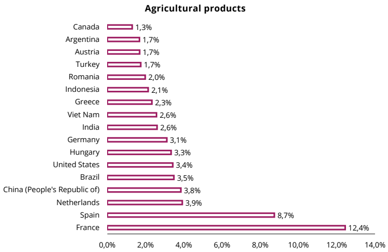


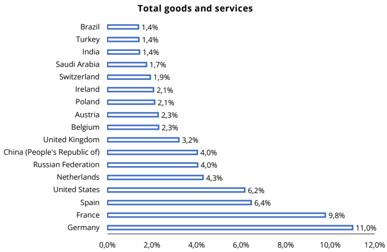
- The water level of Po has decreased over the last years
- The temperatures in the area have been showing increasing patterns
- The rainfalls have been decreasing over time

Climate shocks (trends): Drought in 2022



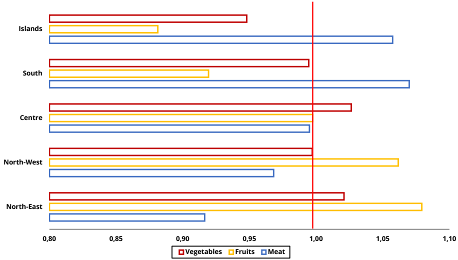
Work in progress (1): the international network (ICIO)

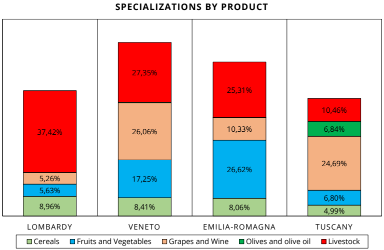




European countries represent the most important suppliers (in terms of value added; notice that value added might not be the best measure to capture dependence from emerging countries; moreover: 23% of agricultural value added stems from RoW production!) → Interregional input-output table integrated in OECD-ICIO tables

Work in progress (2): a food satellite account





(1): Food demand disaggregated in 100 items (left); (2): regional *SUT*s with disaggregated sectors and products (right); (3): international trade (intermediates and final); (4): interregional trade (intermediates and final)

Work in progress (3): from climate shocks to production

- Linking different climate events to production capabilities (different kinds of capital goods) accounting for heterogeneous effects (e.g., irrigated vs. non irrigated agriculture; highlands vs. floodplains; indigenous vs. non-indigenous food)
- Space matters: the importance of going intra-regional in modelling (inter-LMAs input output models with disaggregated food producing sectors) and/or in estimating the extent of the shocks whose effects have to be simulated (spatial models for events, crops, plants)
- Capturing "essential" and "non-substitutable" items (e.g., the case of originally denominated products)
- Sequential models (see, e.g., Reissl et al., forthcoming ESR) and network based techniques (e.g., Inomata & Hanaka, 2023; Liang et al., 2016)

Discussion

- Evaluating the impact of climate change on regional food system is becoming day-by-day more important
- This assessment is naturally “nested” in input-output analysis given the length and the structure of nowadays value chains (indeed, we have been found that dependence from international production of food and intermediate inputs is high)
- However, research is needed:
  - to more satisfactorily capture the dependence on products “essential” and “non-substitutable” products (a food satellite account integrated at the interregional and international level; methods to capture vulnerabilities; sequential modelling)
  - to connect climate patterns to production (sequential modelling)

The interregional input output table

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Defining the food value chain




Value chain as the bundle of production steps ($Y_{z,i}$) stemming from a properly defined final demand shock (z) in region/country (i) and possibly taking place in different regions and countries.

$$Fd_{z,i} + AFd_{z,i} + A(A)Fd_{z,i} + ... + A(A)^n Fd_{z,i} = (I - A)^{-1} Fd_{z,i}$$

In our case, $Fd_{z,i}$ include the final demand of agricultural and industry processed food products stemming from all NUTS2 regions. Notice that you might have: international vs. quasi-interregional vs. quasi-intraregional value chains depending upon the the final good you are considering.

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The intermediate input network

- Given activated production $Y_{z,i}$, we reconstruct the network of intermediate input flows $A \times \hat{Y}_{z,i}$.
- We can then compute standard network analysis centrality indicators so as to identify the key production nodes. E.g., the degree of a node: $s_i = C_D^w(i) = \sum_j^N w_{i,j}$. Where w is the weighted contiguity matrix, w_{ij} is greater than 0 if node i is connected to node j, and the value represents the flow between the two.
- Oriented networks: incoming flows (in-degree) vs. outgoing flows (out-degree).

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Climate data

- Po water level: hydrographic monitoring data retrieved at `www.agenziapo.it`
- Temperature at 2 meters above the surface of the earth: NASA POWER Project retrieved at `power.larc.nasa.gov`
- Rainfalls: NASA POWER Project retrieved at `power.larc.nasa.gov`

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