Assessing drought exposure in European agriculture using PICCOLO-FABIO, an interregional food trade model

Topic: Input-Output Modelling: Disaster analyses (2)
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Climate change is expected to intensify the frequency and severity of droughts across Europe, posing significant risks to agricultural production and the food systems that depend on it. As drought severity can range widely within one country, estimates of supply chains with higher spatial resolution are needed to characterize drought risk exposure. This study develops an inter-regional (NUTS-2) version of the Food and Agriculture Biomass Inputâ€“Output (FABIO)[1] model to quantify the exposure of European food trade to drought risk under current and future climate conditions. Drought exposure is quantified by linking regional agricultural trade flows to Copernicus satellite-based soil moisture anomaly data.

Inputâ€“output (IO) analysis has been widely used to study supply-chain dependencies, resource use, and environmental pressures embedded in production and trade. The development of multi-regional inputâ€“output (MRIO) databases, which combine national IO tables into a single balanced global framework, has enabled such analyses at the global scale. Prominent examples include EXIOBASE[2], Eora[3], and FIGARO[4], which have been applied to assess environmental impacts embodied in trade. However, while these databases provide global coverage, their national-level resolution limits their ability to capture spatially heterogeneous climate risks such as droughts, which often vary substantially within countries. Subnational or interregional IO tables are rarely published due to data and resource constraints, creating a critical gap for climate risk assessments that require finer spatial detail.

This study extends FABIO[1], an established physical MRIO framework for food, feed, and biomass flows, into an interregional European model. The interregional FABIO disaggregates national food trade into NUTS2-level trade using regional crop and livestock production, regional demand, and reported trade flows. The FABIO database is regionalized following two main steps, similarly to Ouyang et al[5]. First, international trade is estimated using reported subnational trade data where available, subject to the constraints that regional exports and imports do not exceed supply and demand, and that national totals remain consistent with the original FABIO data. Second, domestic interregional flows are estimated using the CHARM approach in combination with a gravity model[6]. The model distinguishes 67 sectors and 332 NUTS 2 regions.

Using this framework, drought exposure is assessed by linking regional agricultural trade with satellite-based drought intensity metrics, considering both historical events and projected future conditions. The results show that accounting for trade significantly increases estimated drought exposure of food consumption in Northern Europe compared with production-based assessments. Exposure varies strongly across food categories; non-essential commodities are generally more exposed than staple foods. Trade can both amplify and buffer drought impacts, depending on the geographic extent of the drought and the availability of alternative sourcing regions.

Overall, this study demonstrates the value of combining interregional inputâ€“output modeling with satellite-based climate indicators to assess the vulnerability of European food trade to droughts. The results reveal the exposure to drought risk in regions and support the design of diversification and resilience strategies in agricultural supply chains. The annual resolution of the model, consistent with inputâ€“output tables and available trade data, cannot capture dynamics such as monthly stock variations that can be critical for drought impacts, and merits further research. Beyond drought risk assessment, the interregional FABIO framework can be applied to other spatially explicit environmental questions, including consumption-based analyses of nitrogen emissions, land use, and other local pressures.

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