



## Virtual water trade and country vulnerability: A network perspective

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This work investigates the relationship between countries' participation in virtual water trade and their vulnerability to external shocks from a network perspective. In particular, we investigate whether (i) possible sources of local national crises may interact with the system, propagating through the network and affecting the other countries involved; (ii) the topological characteristics of the international agricultural trade network, translated into virtual water-equivalent flows, may favor countries' vulnerability to external crises.

Our work contributes to the debate on the potential merits and risks associated with openness to trade in agricultural and food products. On the one hand, trade helps to ensure that even countries with limited water (and other relevant) resources have access to sufficient food and contribute to the global saving of water. On the other hand, there are fears that openness may increase the vulnerability to external shocks and thus make countries worse off. Here we abstract from political considerations about food sovereignty and independence from imports and focus instead on investigating whether the increased participation in global trade that the world has witnessed in the last 30 years has made the system more susceptible to large shocks.

Our analysis reveals that: (i) the probability of larger supply shocks has not increased over time; (ii) the topological characteristics of the VW network are not such as to favor the systemic risk associated with shock propagation; and (iii) higher-order interconnections may reveal further important information about the structure of a network. Regarding the first result, fluctuations in output volumes, among the sources of shock analyzed here, are more likely to generate some instability. The first implication is that, on one side, past national or regional economic crises were not necessarily brought about or strengthened by global trade. The second, more remarkable, implication is that, on the other side, supporting a national policy of self-sufficiency in food production while progressively reducing the participation in international agricultural trade does not necessarily protect a country from economic instability. Moreover, it is well established in the literature that, over time, international food trade has favored more efficient use of water resources, at the global level. This fact, together with our conclusions, highlights the important role of international trade in driving the efficient allocation of water resources.

To sum up, our evidence reveals that the increased globalization witnessed in the last 30 years is not associated with an increased frequency of adverse shocks (in either precipitation or food production). Furthermore, building on recent advances in network analysis that connect the stability of a complex system to the interaction between the distribution of shocks and the network topology, we find that the world is more interconnected, but not necessarily less stable.