

Do Water Endowments Shape Trade in Agri-Food Virtual Water? A Heckscher-Ohlin-Vanek Test for Finland

Topic: Development Programme (4) - Discussants: Erik Dietzenbacher and Zhifu Mi

Author: Yue Fu

Co-Authors: Xavier Irz

(1) the research question

Rising virtual water trade (VWT) has sparked interest in how water endowments shape trade patterns, yet empirical evidence remains geographically narrow and theoretically limited.

We aim to study water endowment as a driver of bilateral agrifood Virtual Water Trade (VWT) under the framework of international trade theory, focusing on the trade implications for water abundant regions. Specifically, we examine the Finnish case and address three questions: 1) What are the patterns of Finnish bilateral green and blue VWT embodied in agri-food products? 2) Can relative differences in water endowments between countries explain these patterns? 3) What are the unexploited trade opportunities for Finland from the perspective of water endowments, and what are the implications for global water sustainability?

(2) the method used

We applied the Heckscher-Ohlin-Vanek (HOV) theorem of international trade as the basis to explain the Finnish bilateral agrifood VWT pattern. The theorem connects countries' relative factor (water) abundance with factor content flow embodied in trade (that is, VWT), predicting that relatively water-abundant countries are net exporters of virtual water. We evaluate the empirical fit using a sign test, which captures the percentage of cases where the relative water abundance gap between Finland and its trading partners shares the same sign as their bilateral VWT gap. Furthermore, we calculated correlation coefficients between these two gaps to assess their consistency in magnitude.

Bilateral virtual water flows are calculated following Treffer and Zhu (2010)'s approach, which was HOV theorem-consistent within a multi-regional input-output (MRIO) framework. National water endowments are adjusted for cross-country difference in water use efficiency following Liboreiro (2025)'s method. We distinguish between production and natural-based water endowments, referring to the water a country actually uses versus what can potentially be used for production, respectively. We tested the HOV on with both types of endowments, and interpret the divergence in results as reflecting unexploited agri-food trade opportunities. We also identify the global water stress associated with international trade using information on country-level water scarcity index.

(3) the data used

Bilateral trade data are calculated from the product-by-product monetary MRIO tables in EXIOBASE 3 (version 3.9.6) for the year 2019. The dataset covers 200 products (including 22 agri-food products) across 44 countries and 5 rest-of-the-world regions. For green and blue water endowments, production-based endowment is calculated from the EXIOBASE3 water account as the sum of direct water used for producing all goods within a country. The natural endowment data are sourced from AQUASTAT. Green water endowments are proxied by long-term average annual precipitation, while blue water endowments (considering only the sustainably withdrawable portion) are proxied by available renewable resources multiplied by 0.25 (a low-to-moderate water scarcity benchmark).

(4) the novelty of the research

To our knowledge, this study is the first to apply the HOV framework to water resources using MRIO tables. It provides economically grounded empirical evidence to debates on water endowments and virtual water trade, particularly from the perspective of water-abundant regions. Additionally, we are

pioneer in bringing production-based and natural endowments together to navigate potential agrifood trade opportunities for sustainable resource use.

(5) main findings

We find that Finland is a net importer of both green and blue virtual water, and the production-based endowment explains the direction of both global VWT pattern and Finnish bilateral agriproduct VWT well. Conversely, HOV tests based on natural endowments indicate little alignment between observed and predicted virtual water flows. By reconciling the two sets of results, we further identify unexploited trade potential for Finland to help mitigate global blue water stress. Example strategies include increasing net exports of animal products to water-stressed regions, or shifting staple food imports from high- to low-stress regions (e.g., redirecting rice imports from India to Brazil).