Georgios Karakatsanis [(1), (2) *] and **Sandra Bierbach** [(2)]
(1) Department of Water Resources and Environmental Engineering, School of Civil Engineering, "ITIA" Research Team, National Technical University of Athens (NTUA), Heroon Polytechneiou 5, GR-157 80, Zographou, Greece
(2) Chair of Hydraulic and Water Resources Engineering Faculty of Civil, Geo and Environmental Engineering, Arcisstrasse 21, 80333 Munich, Germany

CC BY

ENTROPY OF EGYPT'S VIRTUAL WATER TRADE GRAVITY FIELD

MOTIVATION and STUDY SCOPE

One of the world's major challenges is the achievement of adequate water and food supply. Water scarcity and freshwater withdrawals can be approached with awareness and knowledge of water consumption and global water dynamics. Virtual water trade globalization via the trade of agricultural commodities, has an effect on the economy, water and food supply as well as on energy use. The water footprints of traded food commodities provide with important information on transfers of water volumes as well as on consumed and polluted water volumes. Good water management practices require detailed surveys of green, blue and grey water footprints embedded in the traded goods, in order to adress global water issues. This study investigates the fragmentation of the gravity field of virtual water trade for green, blue and grey water footprints between Egypt and its top 27 trade partners for the top 14 agricultural commodities produced in the country.

METHODOLOGY

We use a standard Gravity equation to investigate the effect of distance on VWT flows between Egypt and its selected trade partners, as well as the gravity factor G.

$$VWT_{ij} = G \cdot \frac{M_i^{\,a} \cdot M_j^{\,b}}{D_{ij}^{\,c}} \quad \Longleftrightarrow \quad G = \frac{VWT_{ij} \cdot D_{ij}^{\,c}}{M_i^{\,a} \cdot M_j^{\,b}}$$

VWT_{ij} = Volume of Virtual Water Trade flows between countries I and j, per water footprint type.
G = Gravity factor (A factor expressing technological level for overcoming distance limitations).
M_i, M_j = Total water volume used at each country I and j for total agricultural output.
D_{ij} = Geographical (flying) distance between countries I and j.
a, b, c = Parameters expressing elasticity towards per unit of variable change.

Selected Trade Commodities and Partners for the Variables

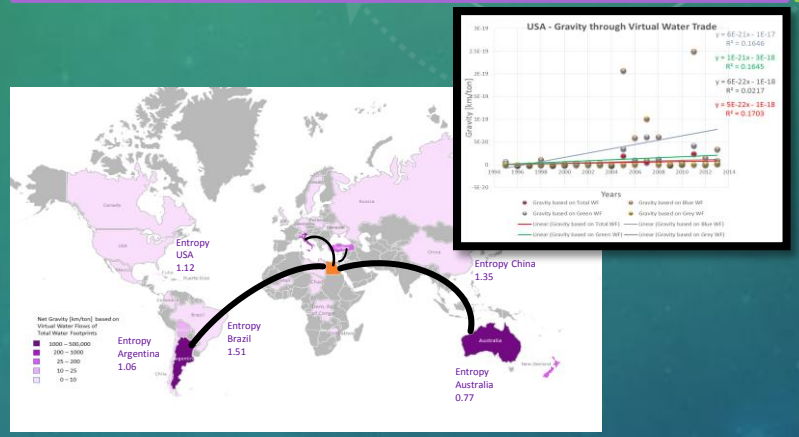
Selected Food Commodities

Wheat	Maize	Rice	Potatoes	Tomatoes	Mangos	Mandarines
Grapes	Cottonseed	Dates	Sugar Beet	Oranges	Onions	Bananas

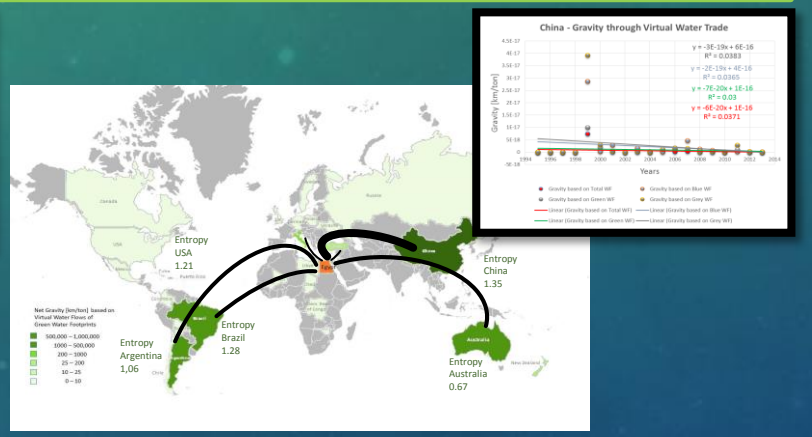
Selected Trade Partners

North America	South America	Europe	Asia	Africa	Oceania
Canada	Colombia	Sweden	Russia	Chad	Australia
USA	Brazil	United Kingdom	Ukraine	Libya	New Zealand
Mexico	Bolivia	Germany	China	Dem.Rep.of Congo	
Cuba	Argentina	Poland	Jordan	Mali	
Puerto Rico	Chile	Italy	Turkey	Zimbabwe	

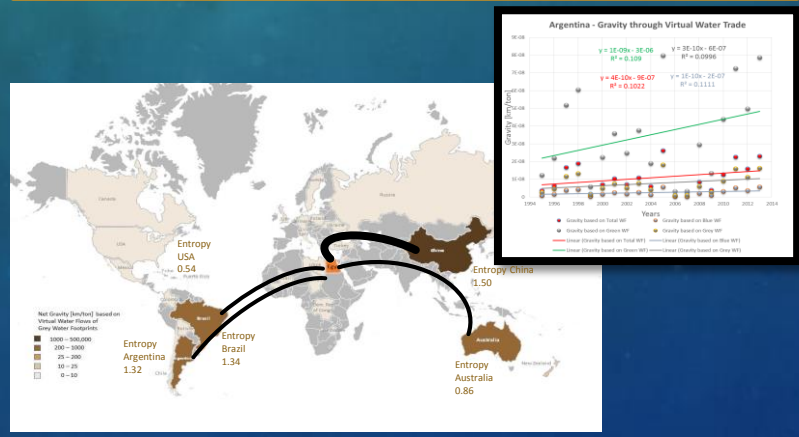
Gravity Distribution of VWT Net Through Virtual Water Trade of Food Commodities for Total Water Footprints



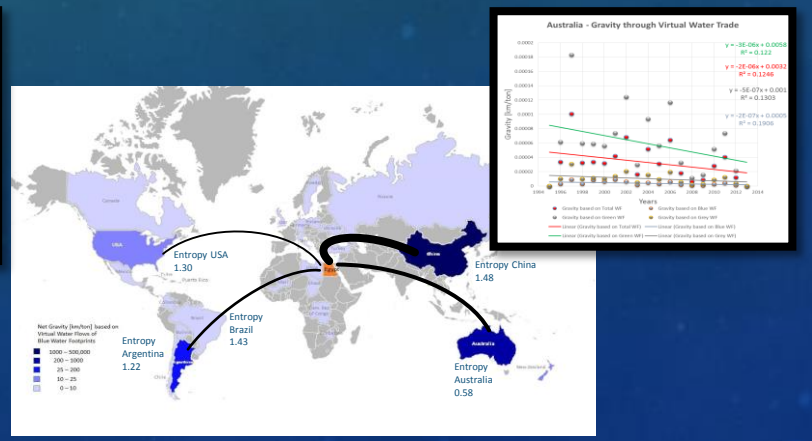
Gravity Distribution of VWT Net Through Virtual Water Trade of Food Commodities for Green Water Footprints



Gravity Distribution of VWT Net Through Virtual Water Trade of Food Commodities for Grey Water Footprints



Gravity Distribution of VWT Net Through Virtual Water Trade of Food Commodities for Blue Water Footprints



References

Antonelli, Marta and Martina Sartori (2014), **Unfolding the potential of the Virtual Water concept. What is still under debate?**, MPRA Paper No. 60501, http://mpra.ub.uni-muenchen.de/60501/
Fracasso, Andrea (2014), **A gravity model of virtual water trade**, Ecological Economics, Vol. 108, p. 215–228
Fracasso, Andrea; Martina Sartori and Stefano Schiavo (2014), **Determinants of virtual water flows in the Mediterranean**, MPRA Paper No. 60500, https://mpra.ub.uni-muenchen.de/60500/
Yang, H. et al. (2006), **Virtual water trade: An assessment of water use efficiency in the international food trade**, Hydrology and Earth System Sciences 10, p. 443-454

Conclusions

- The Gravity Model is a useful tool for analyzing virtual water trade flows.
- Economy and water issues have complex interelations that require further variables for the gravity equation to predict virtual water trade more accurately.
- Results confirm the findings of other authors who used different methods.

Conclusions for Further Work

- Results on the effect of Dij are counterintuitive.
- More variables influencing trade, water footprints and economy for more reliable results.
- The gravity model is generally a usefull tool for improving spatiotemporal management in food and water issues.