The impact of agri-food trade in a changing climate: Mitigation, Adaptation, and Food Security

Charlotte Janssens (KU Leuven)

5th Global Food Security Conference

April 10, 2024

Quiz

Trade and Mitigation

Question

What is the effect of international agri-food trade on the GHG emissions from global food systems?

1. Trade is an important driver of food systems' GHG emissions
2. Trade plays a minor role in food systems' GHG emissions
3. The effect is heterogeneous and varies across trade patterns
4. The effect depends on the presence of mitigation policies

Quiz

Trade and Adaptation

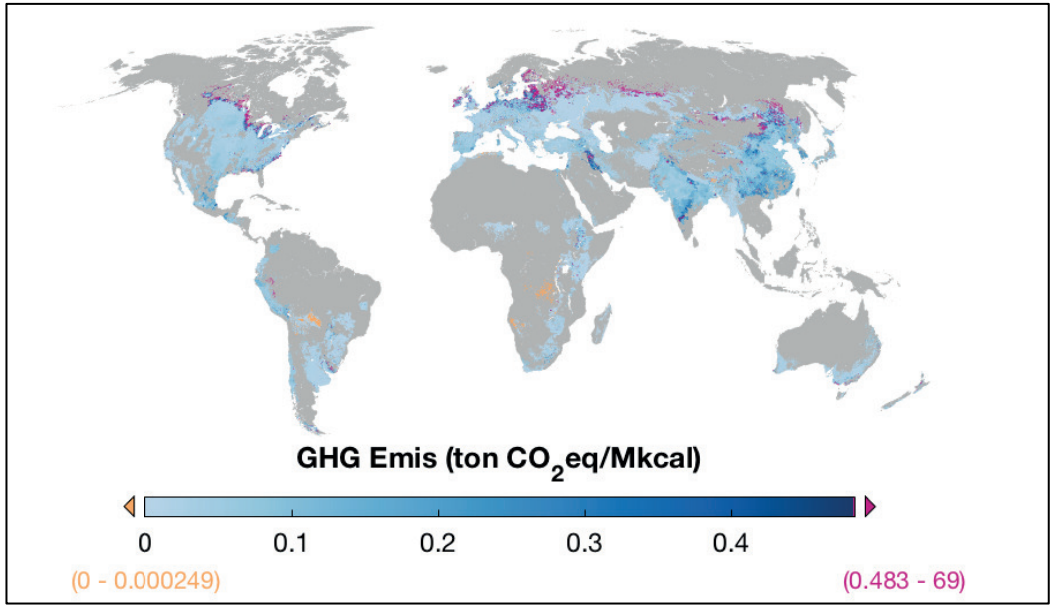
Question

What is the average effect of international agri-food trade on the impact of climate-induced food supply shocks?

1. Trade buffers climate shocks on average
2. Trade aggravates climate shocks on average
3. Trade has on average no effect on the impact of climate shocks

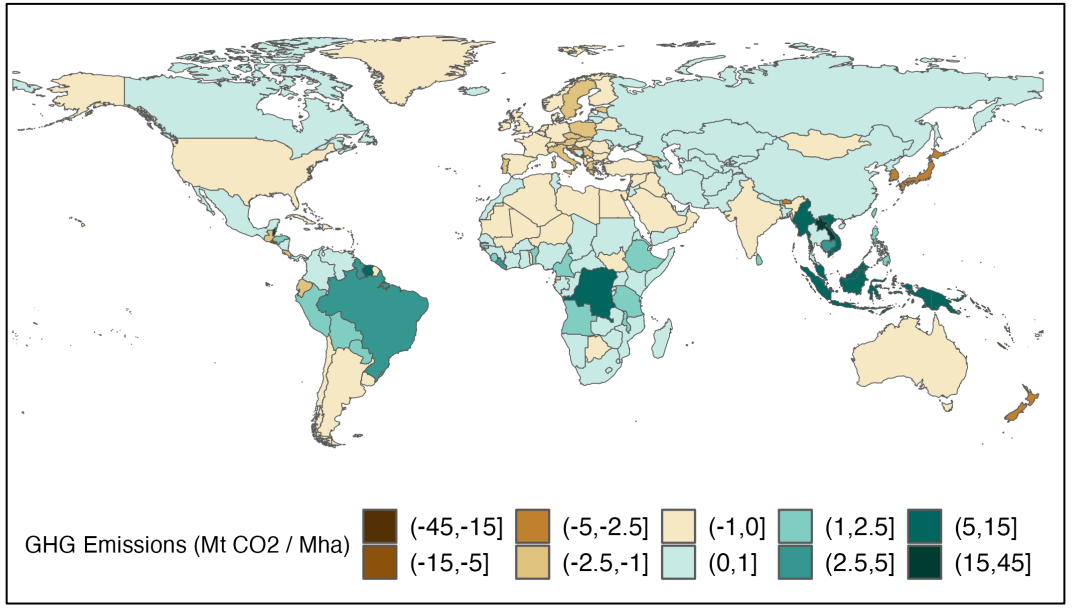
Climate change mitigation

Agricultural emissions



Agricultural production emissions of wheat in 2000
(Dalin et al. 2024; Carlson et al. 2017)

Land use change emissions



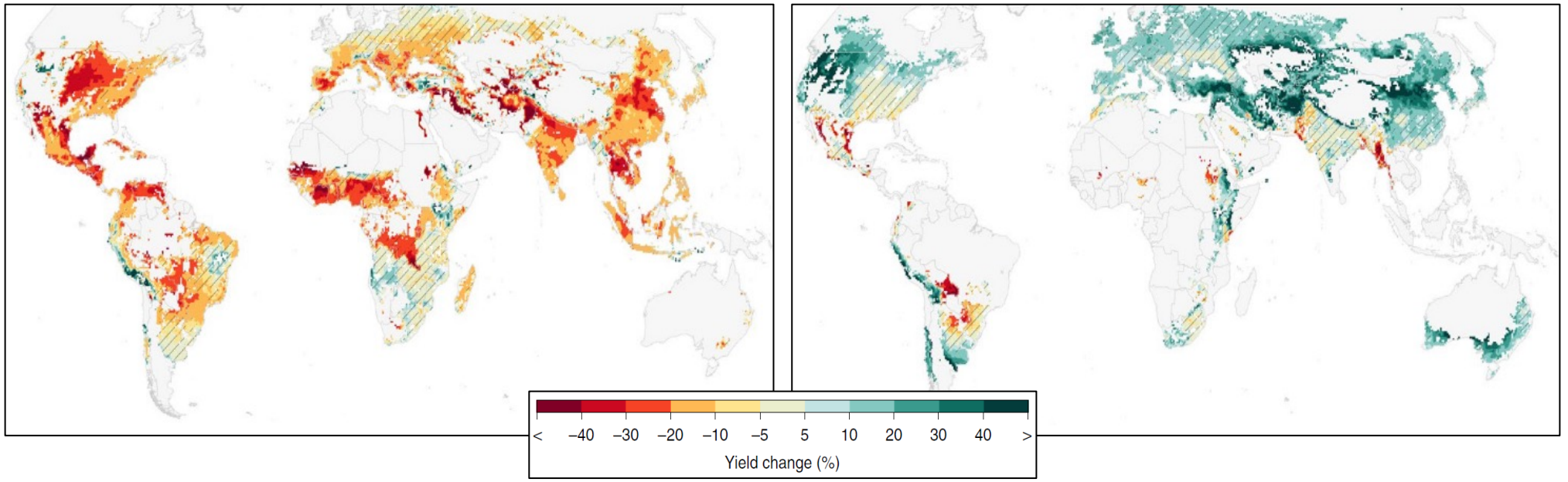
LULUC emissions linked to agriculture in 2020
(OSCAR v3.3; Gasser et al. 2020)

Rationale

Climate change adaptation

Maize (average -24%)

Wheat (average +17.5%)



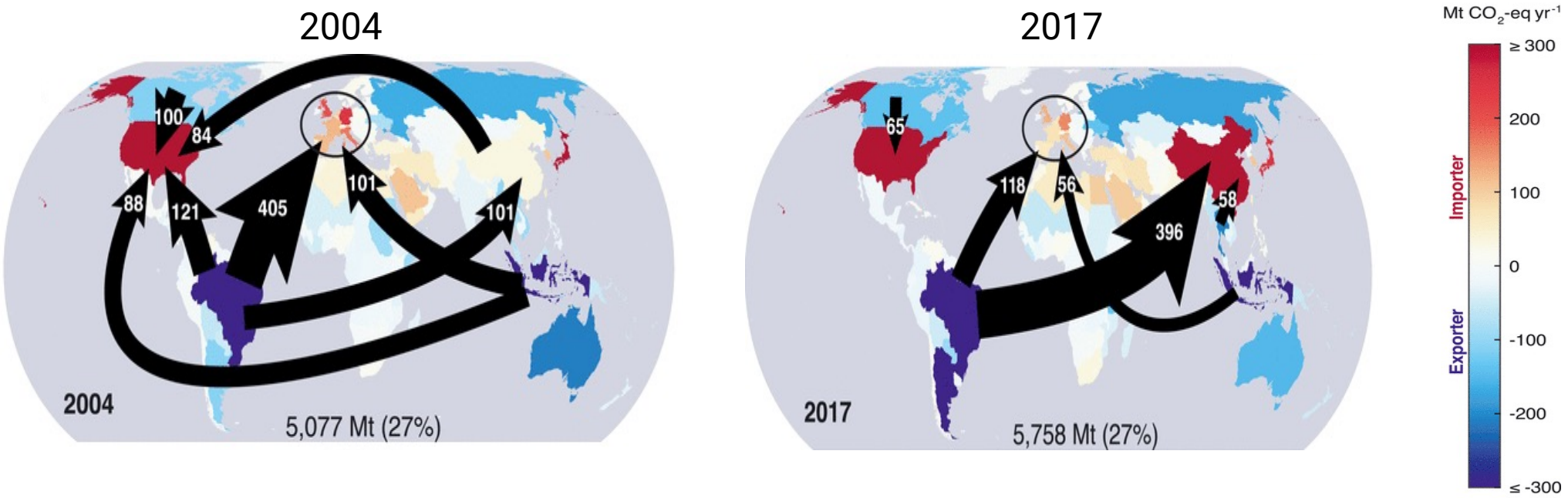
Median crop yield changes (2069–2099) under RCP8.5 (Jaegermeyr et al. 2021)

Trade x mitigation

Trade and Mitigation

Trade x mitigation

How much GHG emissions linked to trade?



AFOLU GHG emissions embodied in international trade (Hong et al. 2022)

Trade x mitigation

How much GHG emissions from transport?

- 4.8% of global food systems emissions (Crippa et al. 2021)
- 67% of global agri-food trade volume is transported by sea, 32% over land (rail or road) and only 1% via air (Verschuur et al. 2022)
- Emission intensity of freight (Ecoinvent v3.10)



0.83 > 0.14 > 0.04 > 0.01 kg CO2 / ton-km

Are trade patterns GHG emissions efficient?

Emission intensity of bilateral trade flow ($\Delta\ e_{ijg}$):

$\forall$ exporter i, importer j, good g : $\Delta\ e_{ijg} = \left(e_{ig}^{Y} + e_{ijg}^{T} - e_{jg}^{Y}\right)$ $\left[\frac{kg\ CO_2eq}{kg}\right]$

with e_{ig}^{Y} and e_{jg}^{Y} production emission intensities, and e_{ijg}^{T} transport emission intensity.

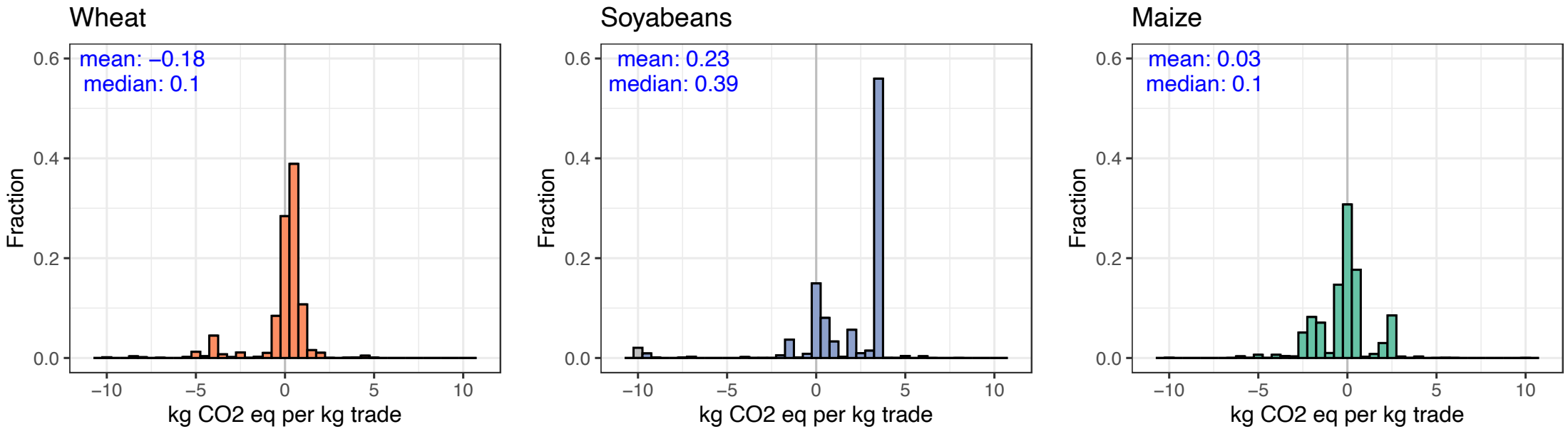
$\Delta\ e_{ijg} < 0$	$\Delta\ e_{ijg} > 0$
em. intensity exporter + em. intensity transport **<** em. intensity importer	em. intensity exporter + em. intensity transport **>** em. intensity importer
Trade flow **efficient** in terms of GHG emissions	Trade flow **inefficient** in terms of GHG emissions

Source: Janssens et al. (2024)

Trade x mitigation

Are trade patterns GHG emissions efficient?

Emission intensity of trade flows ($\Delta\ e_{ijg}$) weighted by trade quantity



(bilateral trade flows of 2018 at HS6 level)

Source: Janssens et al. (2024)

Trade x mitigation

Trade and future mitigation pathways

Study	Trade scenario	Mitigation scenario	Trade + Mitigation scenario
Verburg et al. (2009)	**Open trade** (*int. trade barriers* ↘): LUC CO_2 ⇧ +15%		
Schmitz et al. (2012)	**Open trade** (*int. trade barriers* ↘): LUC CO_2 ⇧ +42% Agri non-CO_2 ⇧ +1%		
Himics et al. (2018)	**Open trade** (*EU FTA agenda*): Agri non-CO_2 ⇧ +0.1%	**EU carbon tax:** Agri non-CO_2 ⇩ -0.5%	**Open trade + EU carbon tax:** Agri non-CO_2 ⇩ -0.3%
Thom et al. (2023)	**Restricted trade** (*EU import stop*): Agri non-CO_2 ⇧ +0.2%	/	/

Hypothesis

GHG emission abatement

Open trade + Global mitigation

>

GHG emission abatement

Global mitigation

Trade x adaptation

Trade and Adaptation

Trade x adaptation

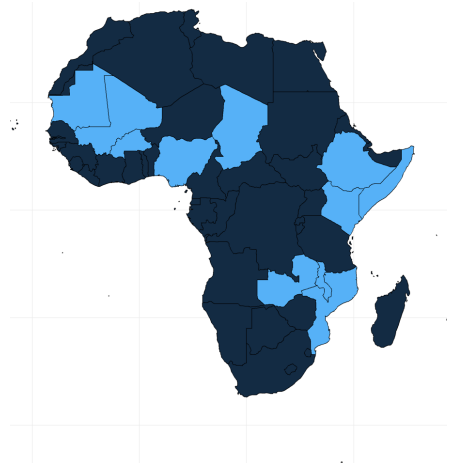
Trade and the impact of local climate shocks

Theory

- Isolated from markets: local harvest ↑ ↓, food price ↓ ↑, consumption ↑ ↓
- Connected to markets: local harvest ↑ ↓, food price = =, consumption = =

Empirical evidence from Sub-Saharan Africa

- Quarterly subnational data for 2009 – 2016 and 12 countries
- Food insecurity impacts of climate extremes buffered by:
  - A region's local and international market access
  - A country's international cereal imports and stocks



Source: Janssens (2024)

Trade x adaptation

Trade and the impact of remote climate shocks

Theory

- Isolated from markets: remote harvest ↑ ↓, food price = =, consumption = =
- Connected to markets: remote harvest ↑ ↓, food price ↓ ↑, consumption ↑ ↓

Besides market acces, impact of remote shocks depends on:

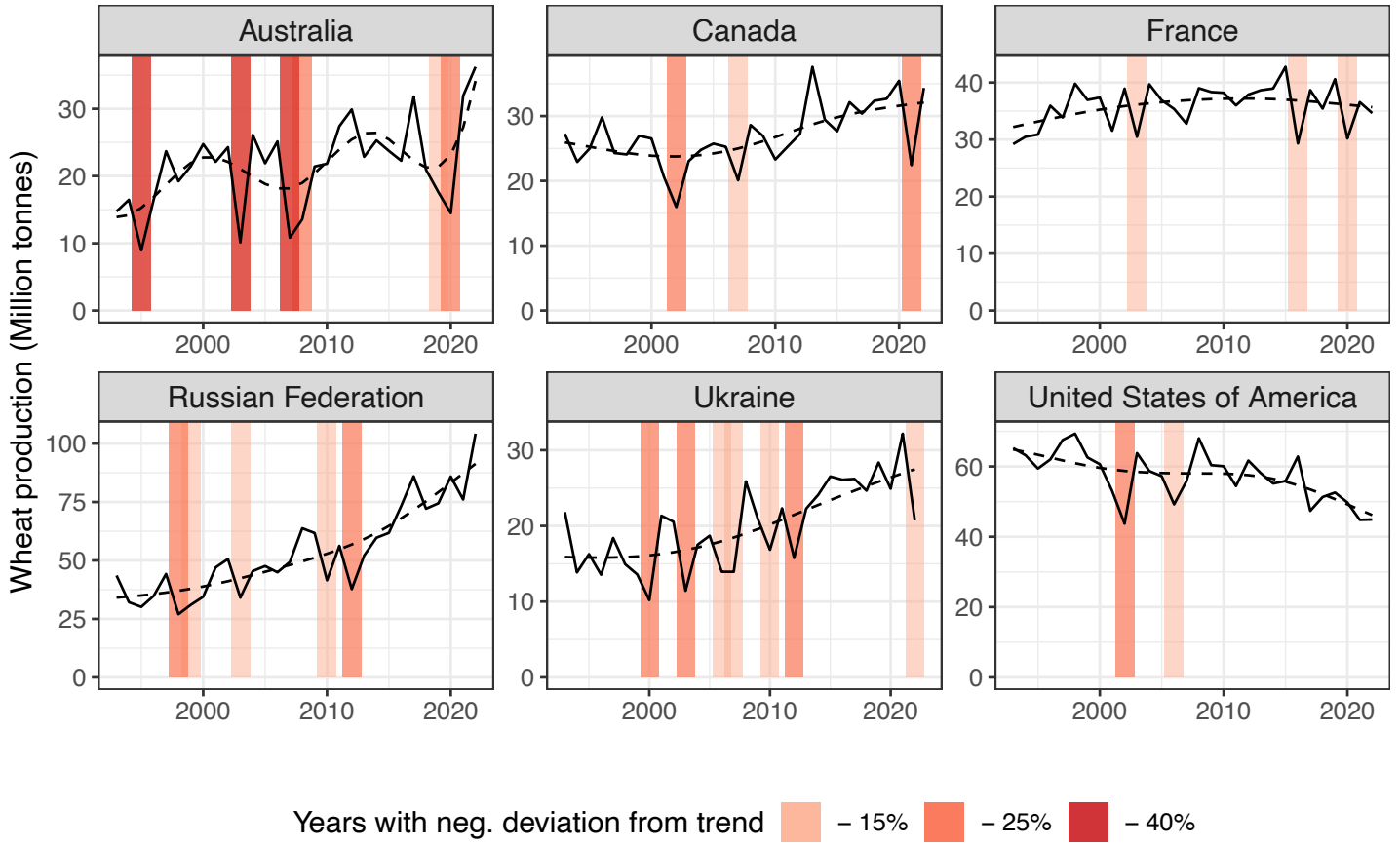
1. Size and concurrency of production shocks at exporter side
2. Price insulation policies
3. Vulnerability at importer side

→ **Empirical example**: wheat

Trade and the impact of remote climate shocks

Trade x adaptation

1. Exporter: size and concurrency of shocks



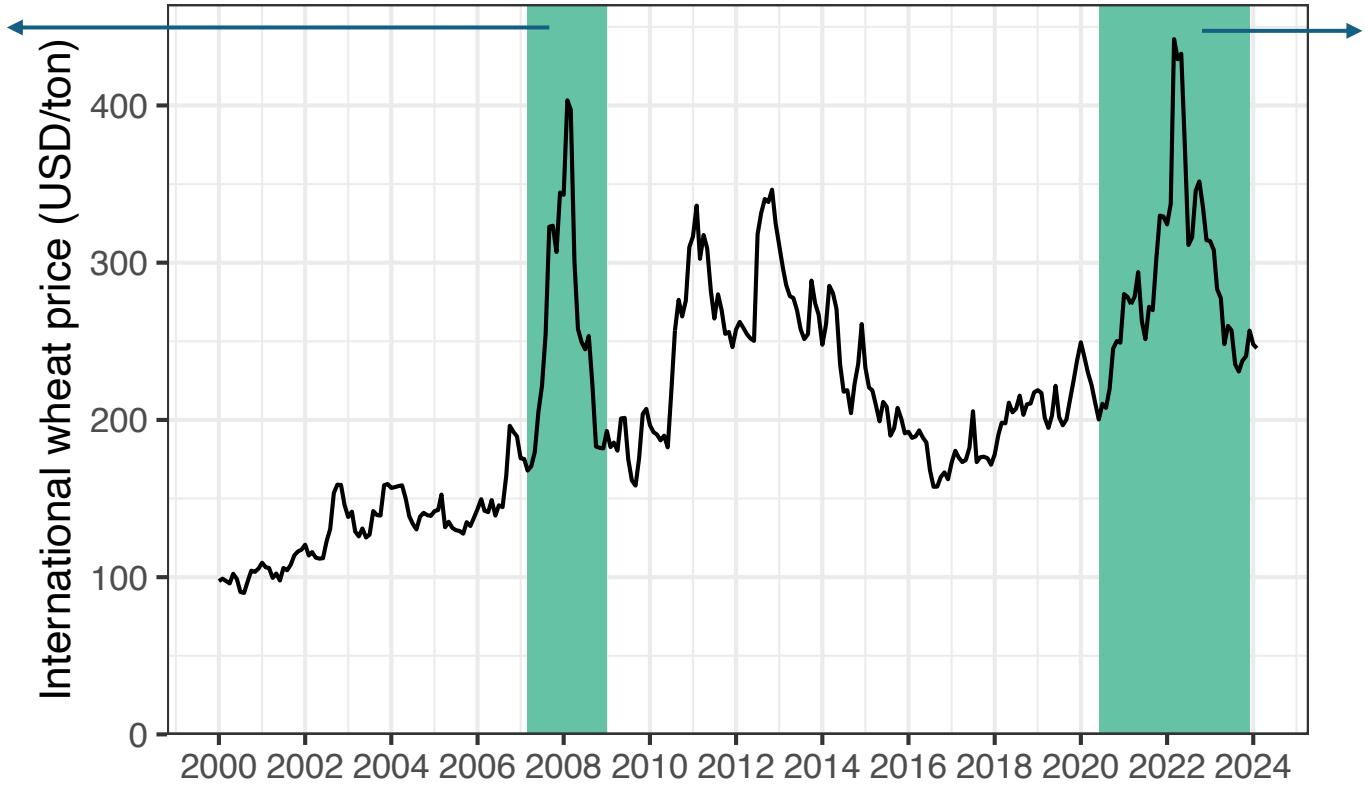
Source: FAOSTAT (2024)

Trade and the impact of remote climate shocks

Trade x adaptation

2. Price insulation policies

Price insulation policies contributed to global price increase (Giordani et al., 2016)



Price insulation policies double global price increase (Martin & Minot, 2023)

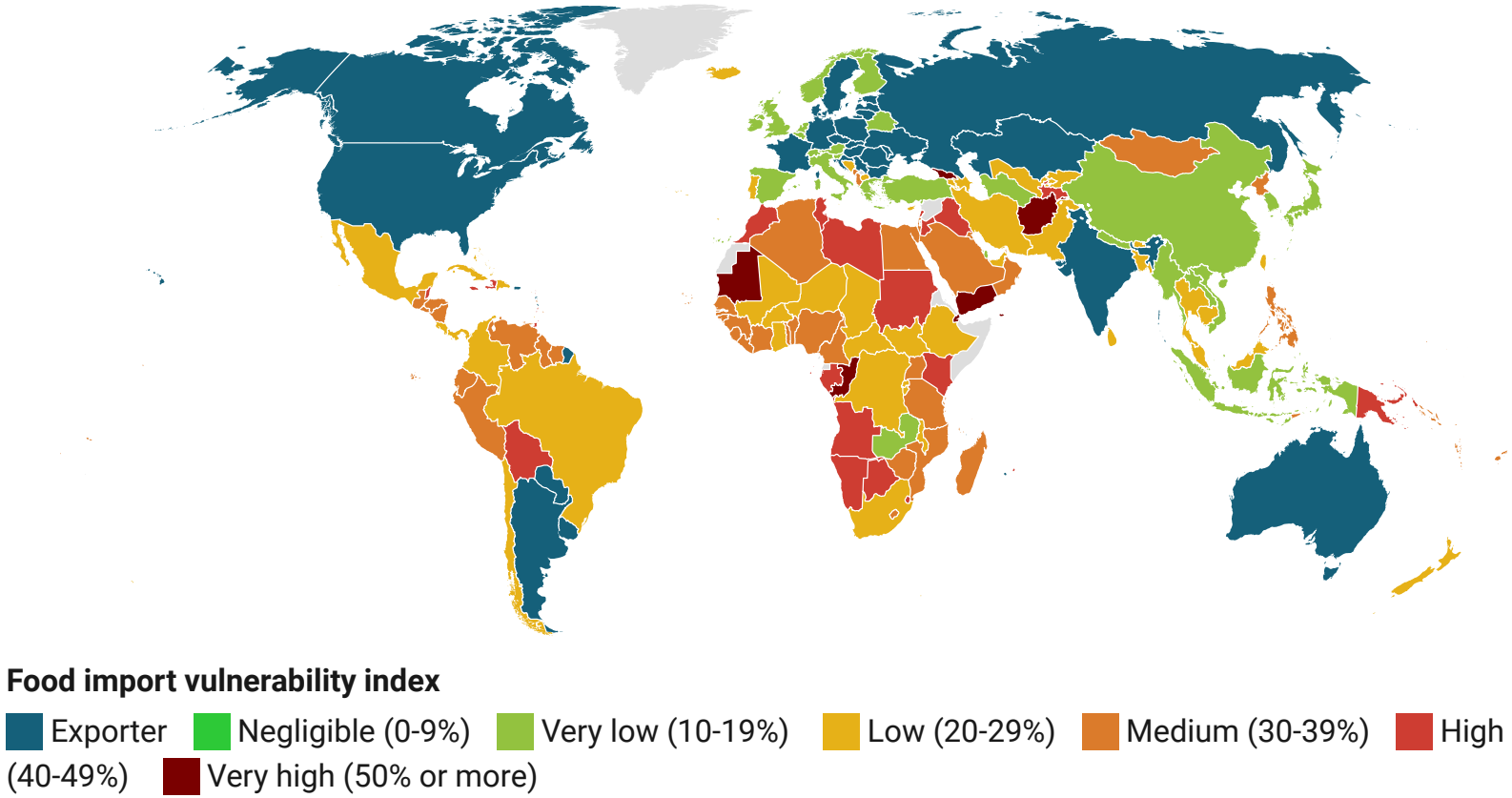
Between March and July '22, 15 countries imposed wheat export restrictions (Laborde & Mamun, 2022)

Source: FPMA (2024)

Trade and the impact of remote climate shocks

Trade x adaptation

3. Importer: Food Import Vulnerability

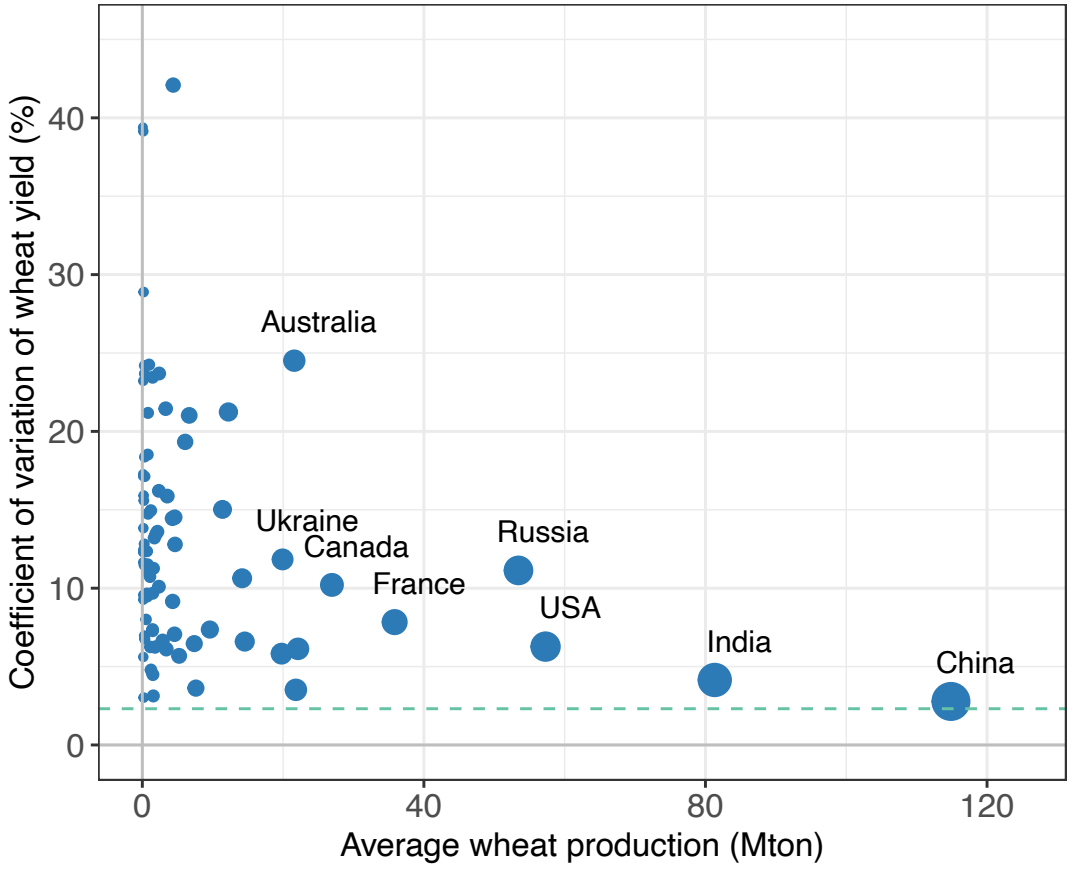


Source: Food Security Portal – Food Price Monitor (2023) Wheat

Trade and the impact of climate shocks

Trade x adaptation

Variability of wheat yield by country (1993 – 2022)

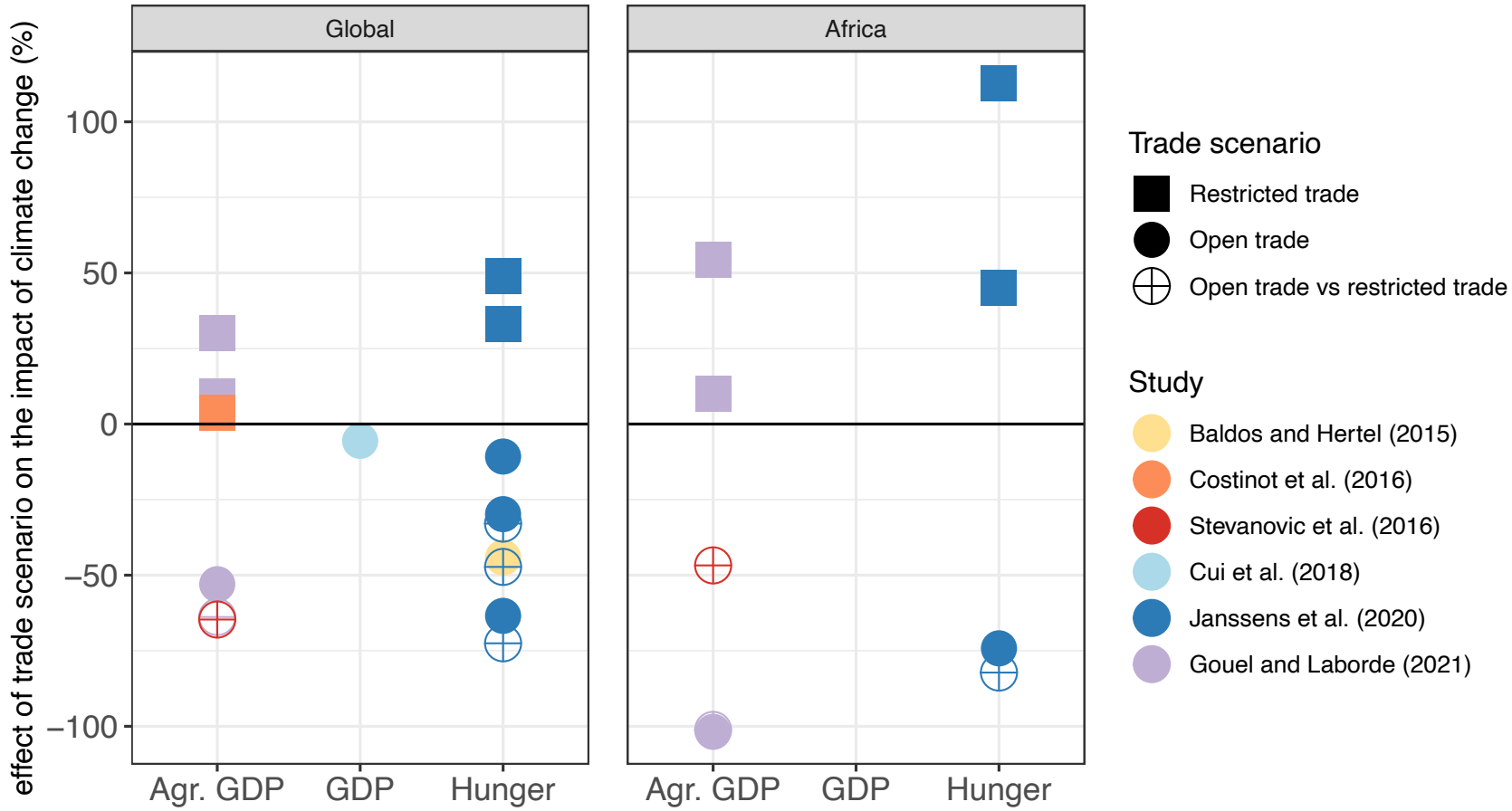


Variability of global wheat yield = 2.3%

Source: FAOSTAT (2024)

Trade x adaptation

Trade and future climate change impacts



Source: adapted from Fig. S5 in Janssens et al. (2020)

Future research

- **Empirical studies**: data & insight on mechanisms
  - Granular data on GHG emissions throughout food systems
  - Barriers to well-functioning regional or global trade systems
  - Compensation for distributive impacts of trade, shocks, mitigation
- **Forwardlooking analyses**: simulation of radical changes
  - More intense, frequent, and widespread climate extremes
  - Complete appearance or disappearance of agricultural suitability
  - Large-scale afforestation under 1.5°C and 2°C mitigation pathways
  - Fundamentally different trade systems (e.g., autarky)
- **Trade-offs & synergies** !

Conclusion

1) The link between trade and mitigation / adaptation is heterogeneous

2) If we steer it in the good direction, international trade may offer overall wins

Acknowledgements

Carole Dalin (ENS)
Thomas Gasser (IIASA)
Christophe Gouel (INRAE)
Jasper Verschuur (Oxford University)

Research Foundation Flanders
Opening new horizons

Thank you !

charlotte.janssens@kuleuven.be

References

- Baldos, U. L. C., & Hertel, T. W. (2015). The role of international trade in managing food security risks from climate change. Food Security, 7(2), 275–290. https://doi.org/10.1007/s12571-015-0435-z
- Carlson, K. M., Gerber, J. S., Mueller, N. D., Herrero, M., MacDonald, G. K., Brauman, K. A., Havlik, P., O'Connell, C. S., Johnson, J. A., Saatchi, S., & West, P. C. (2017). Greenhouse gas emissions intensity of global croplands. Nature Climate Change, 7(1), 63–68. https://doi.org/10.1038/nclimate3158
- Costinot, A., Donaldson, D., & Smith, C. (2016). Evolving comparative advantage and the impact of climate change in agricultural markets: Evidence from 1.7 million fields around the world. Journal of Political Economy, 124(1), 205–248. https://doi.org/10.1086/684719
- Crippa, M., et al. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food, 2(3), 198–209. https://doi.org/10.1038/s43016-021-00225-9
- Cui, H. D., Kuiper, M., van Meijl, H., & Tabeau, A. (2018). Climate change and global market integration - Implications for global economic activities, agricultural commodities, and food security. FAO.
- Gasser, T., Crepin, L., Quilcaille, Y., Houghton, R. A., Ciais, P., & Obersteiner, M. (2020). Historical CO2 emissions from land use and land cover change and their uncertainty. Biogeosciences, 17, 4075–4101. https://doi.org/10.5194/bg-17-4075-2020
- Dalin et al. (2024) Variability, interactions and drivers of key environmental stressors from food production worldwide, in prep
- Giordani, P. E., Rocha, N., & Ruta, M. (2016). Food prices and the multiplier effect of trade policy. Journal of International Economics, 101, 102–122. https://doi.org/10.1016/j.jinteco.2016.04.001
- Gouel, C., & Laborde, D. (2021). The crucial role of domestic and international market-mediated adaptation to climate change. Journal of Environmental Economics and Management, 106, 102408. https://doi.org/10.1016/j.jeem.2020.102408
- Himics, M., et al. (2018). Does the current trade liberalization agenda contribute to greenhouse gas emission mitigation in agriculture? Food Policy, July 2017, 1–10. https://doi.org/10.1016/j.foodpol.2018.01.011
- Hong, C., et al. (2022). Land-use emissions embodied in international trade. Science, 376, 597–603. https://www.science.org

References

- Jägermeyr, J., et al. (2021). Climate impacts on global agriculture emerge earlier in new generation of climate and crop models. Nature Food. https://doi.org/10.1038/s43016-021-00400-y
- Janssens, C., et al. (2020). Global hunger and climate change adaptation through international trade. Nature Climate Change, 10(9). https://doi.org/10.1038/s41558-020-0847-4
- Janssens et al. (2024) GHG emission efficiency of international agri-food trade flows, in prep
- Janssens (2024) Trade, Storage, and Climate Extremes: Theory and Evidence from Sub-Saharan Africa, https://doi.org/10.13140/RG.2.2.34897.13920, preprint (blogpost)
- Laborde D. & Mamun A. (2022). Food Export restrictions during the Ukraine-Russia crisis
- Martin, W., & Minot, N. (2023). The Impact of Price Insulation on World Wheat Markets during Covid-19 and the Ukraine Crisis.
- Schmitz, C., et al. (2012). Trading more food: Implications for land use, greenhouse gas emissions, and the food system. Global Environmental Change, 22(1), 189–209. https://doi.org/10.1016/j.gloenvcha.2011.09.013
- Stevanović, M., et al. (2016). The impact of high-end climate change on agricultural welfare. Science Advances, August, 1–10.
- Thom, F., Gocht, A., & Grethe, H. (2023). EU agriculture under an import stop for food and feed. World Economy. https://doi.org/10.1111/twec.13537
- Verburg, R., Stehfest, E., Woltjer, G., & Eickhout, B. (2009). The effect of agricultural trade liberalisation on land-use related greenhouse gas emissions. Global Environmental Change, 19, 434–446. https://doi.org/10.1016/j.gloenvcha.2009.06.004
- Verschuur, J., Koks, E. E., & Hall, J. W. (2022). Ports' criticality in international trade and global supply-chains. Nature Communications, 13(1), 1–13. https://doi.org/10.1038/s41467-022-32070-0