Robust Facility Location for United Nations High Commissioner for Refugees

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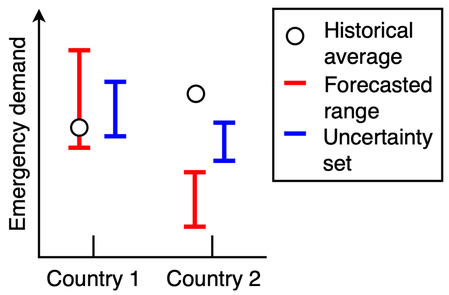
Problem

- **Background:** UNHCR deploys a USD 7.8B budget to aid 69M forcibly displaced people [1].
- **Previous work:** Jahre *et al.* locate facilities under merged emergency response and ongoing operations supply chains, reducing costs and lead times [2].
- **Approach:** We extend Jahre's model using robust optimization and emergency demand forecasts.
- **Justification:** We divorce UNHCR pre-planning from sole reliance on historical demand by flexibly incorporating uncertainty and demand projections.
- **Benefit:** Forward-looking, robust facility location enhances UNHCR humanitarian aid capabilities.

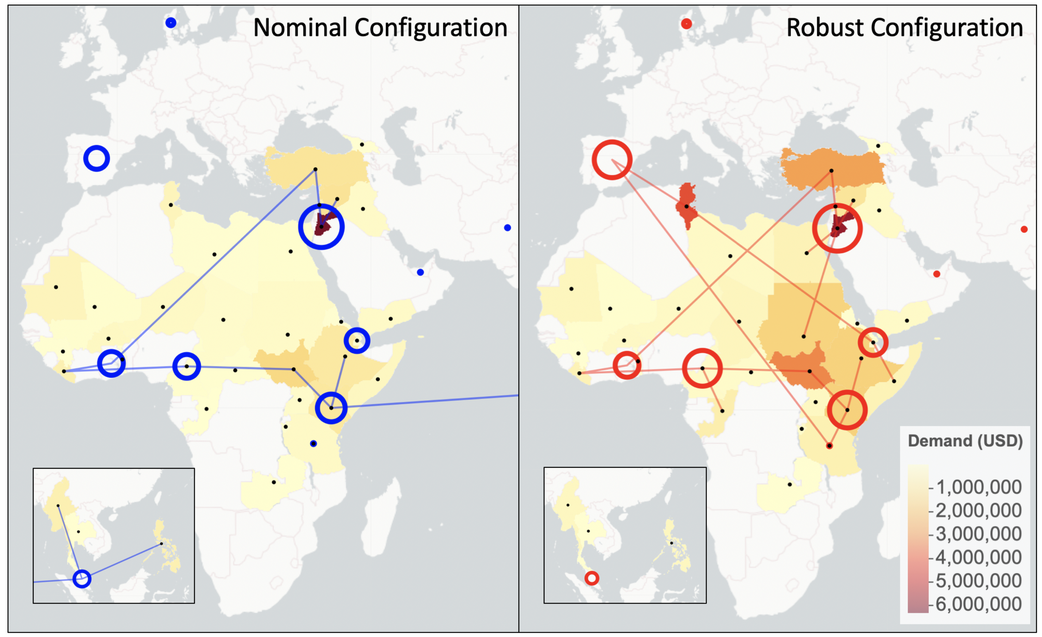
Data & Model

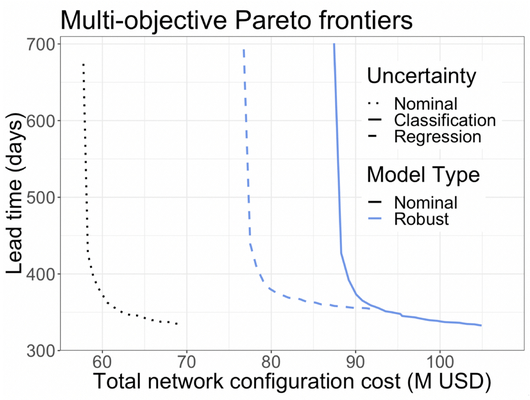
- **Data [2].** Emergency response and ongoing demand in USD for 16 world regions (2011-2013). Lead times and transportation costs among 69 countries, 11 potential warehouses, and 14 suppliers. Warehouse opening costs and inventory storage costs.
- **Model.** Facilities and inventory levels are based on projected flows over a pre-planning horizon.
- **Forecasts.** Political turmoil indices predict regional emergency demand. Classification estimates assign probabilities to discretized demand classes. Regression estimates yield confidence intervals.
- **Uncertainty sets.**

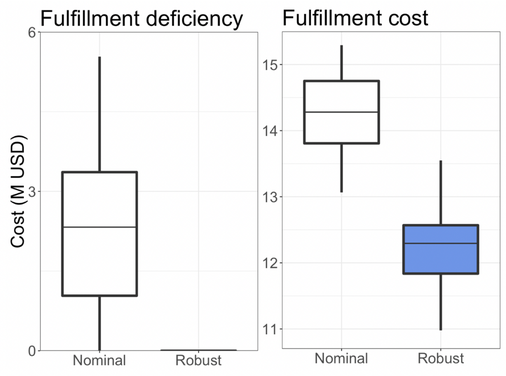


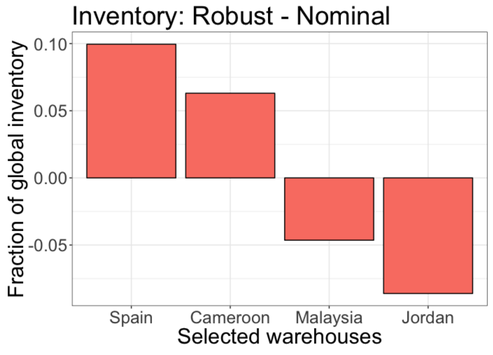
To avoid extreme conservatism, convert from regional to country-level bounds with weights based on each country's historical share of regional demand. Take a weighted average of bounds and historical demand based on parameterized trust in forecast.

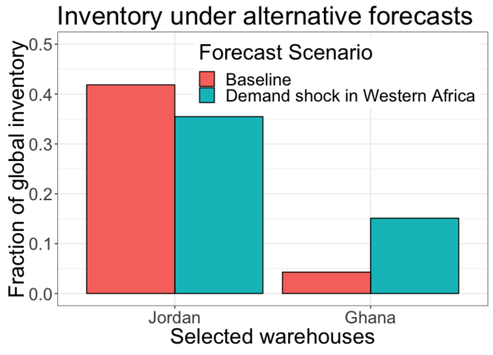
Results











Conclusions

- **General conclusion.** The robust model cuts fulfillment costs and eliminates fulfillment deficiency over all considered demand scenarios, with little to no sacrifice on lead time. We pay for this with 50% higher upfront network configuration costs.
- **Facility locations are insensitive** to a robust approach. This conclusion holds even after an ablation study on demand forecasts, in which we spiked demand throughout the world.
- **Network resilience improves** with robust inventory allocation based on demand forecasts. Average simulated fulfillment costs decrease by 15%, and the standard deviation by 28%.
- **Initial inventory volumes meaningfully increase** in the robust regime. The map shows the network's increased preparedness for highly uncertain emergency demand in Northern Africa. However, paranoid inventory stocking is solely responsible for increasing upfront network configuration costs.
- **Next steps.**
  - Perform more sensitivity analysis to quantify added value of robustness and demand forecasting.
  - Refine demand forecasts with more historical demand data and additional covariates, such as natural disaster indicators.
  - Develop a multi-period pre-planning formulation with adaptive flow policies, based on demand forecasts that match the usable life of global warehouses.

Acknowledgements

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References

[1] UNHCR.org, (2019). UNHCR - The UN Refugee Agency. [online] Available at: https://www.unhcr.org/ [Accessed 7 May 2019].

[2] Jahre, M., J. Kembro., T. Rezvanian, O. Ergun, S.J. Hpnes, and P. Berling, 2016. Integrating supply chains for emergencies and ongoing operations in UNHCR. Journal of Operations Management, No. 45 (57-72).