



Designing policies towards economic resilience and food security during turbulent times

An application to the Kenyan economy

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Kenya's exposure to recent global shocks

COVID-19 pandemic

- Impacts (multiple channels), public spending and fiscal stimulus

Ukraine war

- Exposure to trade – limited as only a fraction of wheat and fertilizers imported from belligerent countries
- Increase of world commodity prices

Debt sustainability

- Debt to GDP at 60% (decreasing trend)
- Debt servicing to GDP at 5.3% (increasing trend)

Food security

- Drought in 2022
- +0.9M people facing high levels of acute food insecurity (IPC projection for 2022)

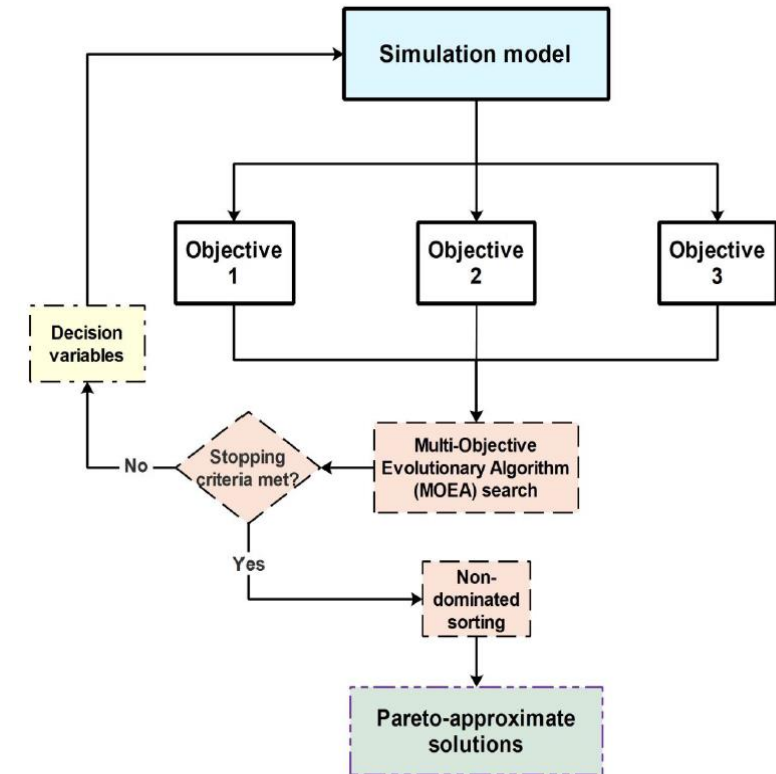
New government programme with a focus on a more equitable distribution of income and social security & an expansion of the tax revenue base

Gap in designing policy responses through modelling

- Policy options need to respond to multiple and often competing objectives
- From an ex-ante evaluation perspective, options are usually pre-determined and explored via sensitivity and scenario analyses – ‘outside the box thinking’ solutions could be ignored
- Multi-objective evolutionary algorithms (MOEA) could fill this gap by starting with a relatively agnostic view on what the policy responses should be
 - They start from well defined policy objectives and classes of instruments that could be used to reduce trade-offs
 - The MOEAs assess which combinations of instruments best reduce objectives trade-offs

MOEA principles

- **Multi-objective** – rely on meta-heuristics to construct an approximation of a Pareto front across a number of conflicting objectives
- A sorting process filters out the sub-optimal “dominated solutions”
- **Evolutionary** – use the evolutionary operations of “crossover” and “mutation” in the search process to generate populations with new characteristics for the next iteration (“generation”)
- Each generation (e.g. a batch of policy options) improves the Pareto front until a stopping criteria is reached



optCGE modelling framework setup (1/2)

- MOEA embedding a single-country CGE model (JRC DEMETRA for Kenya)
- Six policy objectives defined: GDP (+), Welfare (EV-based) (+), GINI welfare (inequality) (-), Government income (+), CPI (-) and Food CPI (-)
- All simulation include shocks on world prices – fuels (+35%), fertilizers (+75%), wheat (+43%), maize (+30%), veg oils (+30%)
- Using government response as a reference for how much the MOEA can improve trade-offs between policy objectives. Gov response: fuel subsidies (12.6% ave), fertilizer subsidies (11% ave)
- Post simulation, two metrics were added: Score (taking different weights of the policy objective improvements) and #Objectives improved (of the six MOEA objectives)
- A Random Forest ML algorithm was applied on the ensemble of policy evaluations (15 000) to assess the relative importance of specific instruments on policy objectives

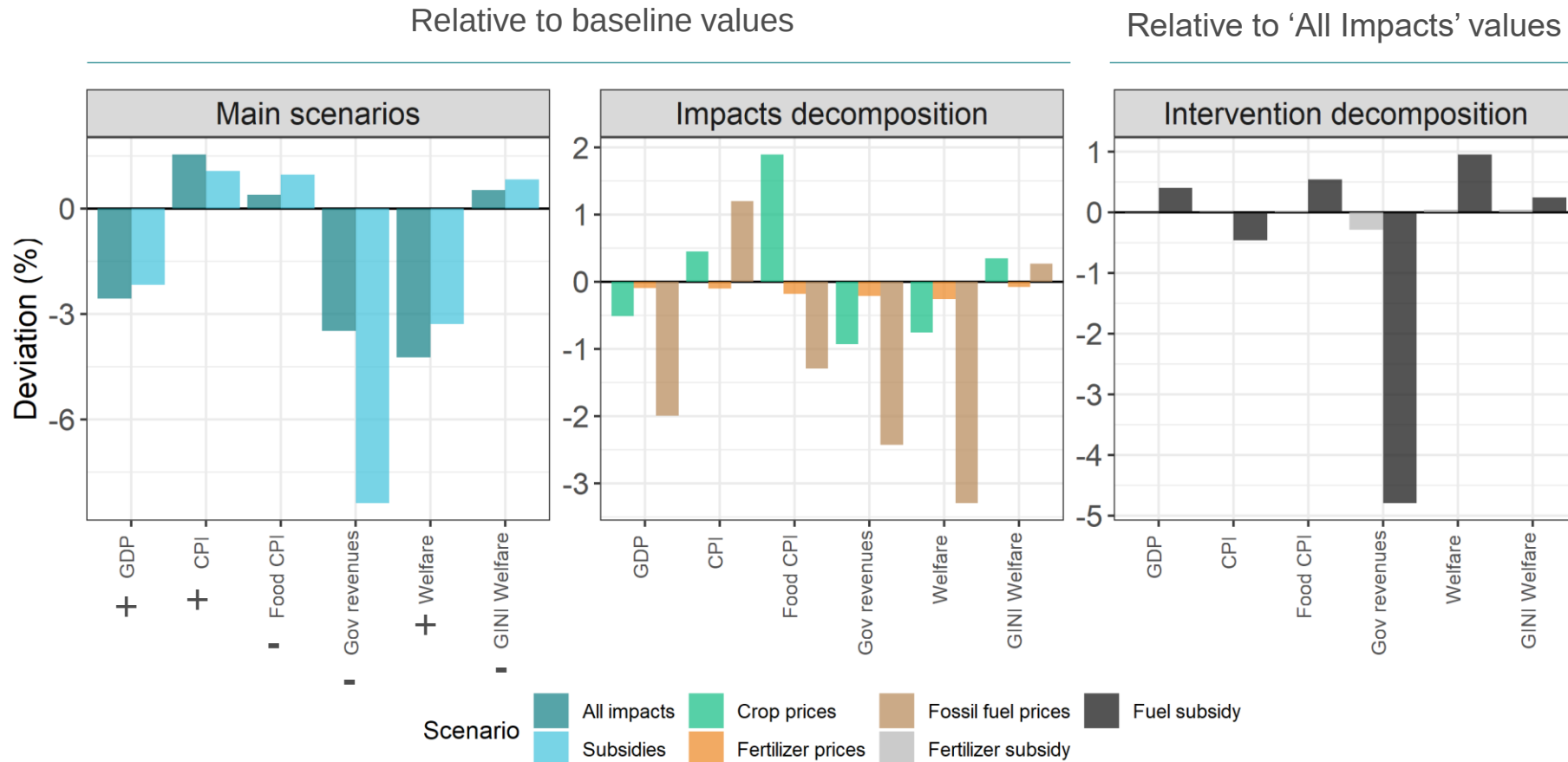
optCGE modelling framework setup (2/2)

Three types of instruments in the MOEA runs → 115 model parameters as MOEA 'decision variables'

- sales taxes changes of base rates for the 53 marketed commodities within the ranges:
 - -12.6% to 0% change for petroleum products and -11% to 0% change for fertilizers
 - -4% to +1% for trade services and transportation
 - -1% to +1% increase for all other commodities
- output taxes for the 40 activities within -1% and +1% range
- government transfers to households (lump-sum cash transfers) for the 22 household groups: max increase of 33% initial transfers, but not more than 5bn KSh per household group (~50m USD)

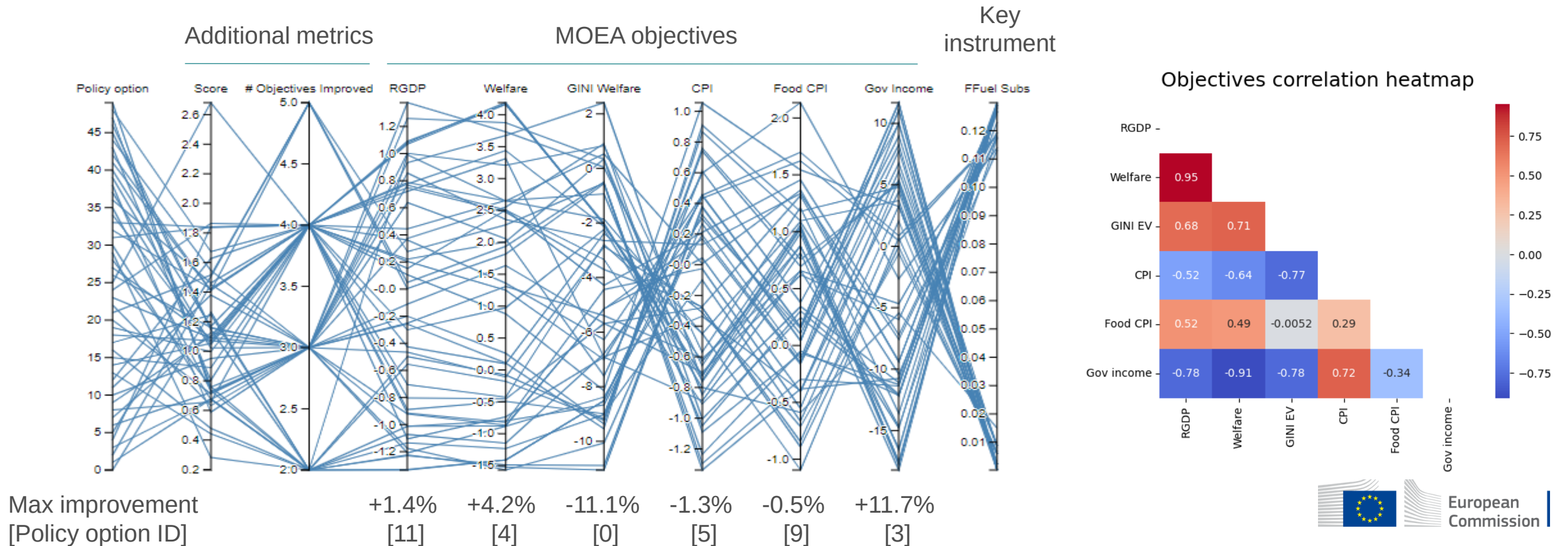
Pre-MOEA results – impacts and responses

Government response (Subsidies): 3 of 6 policy objectives are improved (GDP, CPI and Welfare) at the expense of government revenue, food CPI and welfare inequality



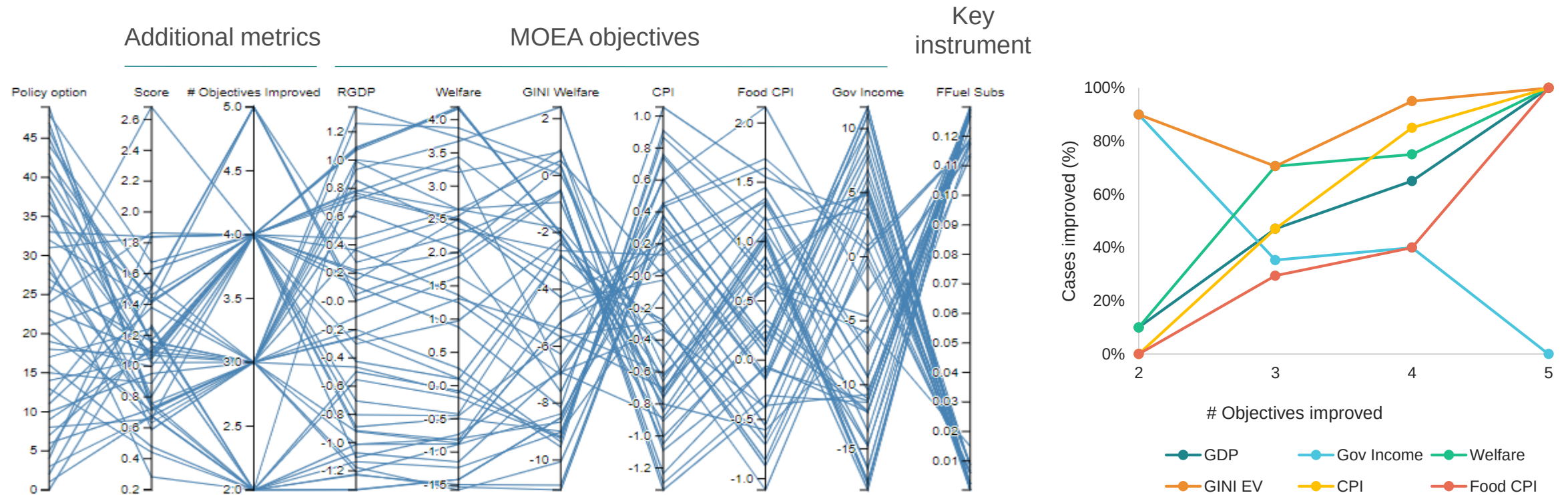
MOEA results – Pareto surface approximation

50 policy options generated, all of which produce a better Score than the base government response
3 options with 5 objectives improved, 20 options with 4 objectives improved



MOEA results – Pareto surface approximation

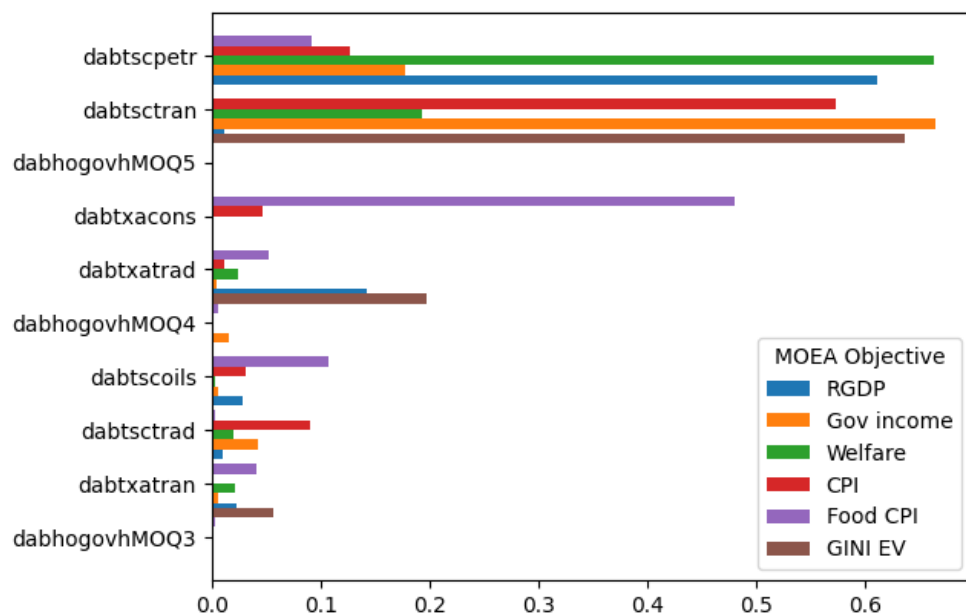
Government income is traded off to improve the other objectives
GINI Welfare the most likely to be improved across policy options followed by Welfare
Food CPI the least likely to be improved



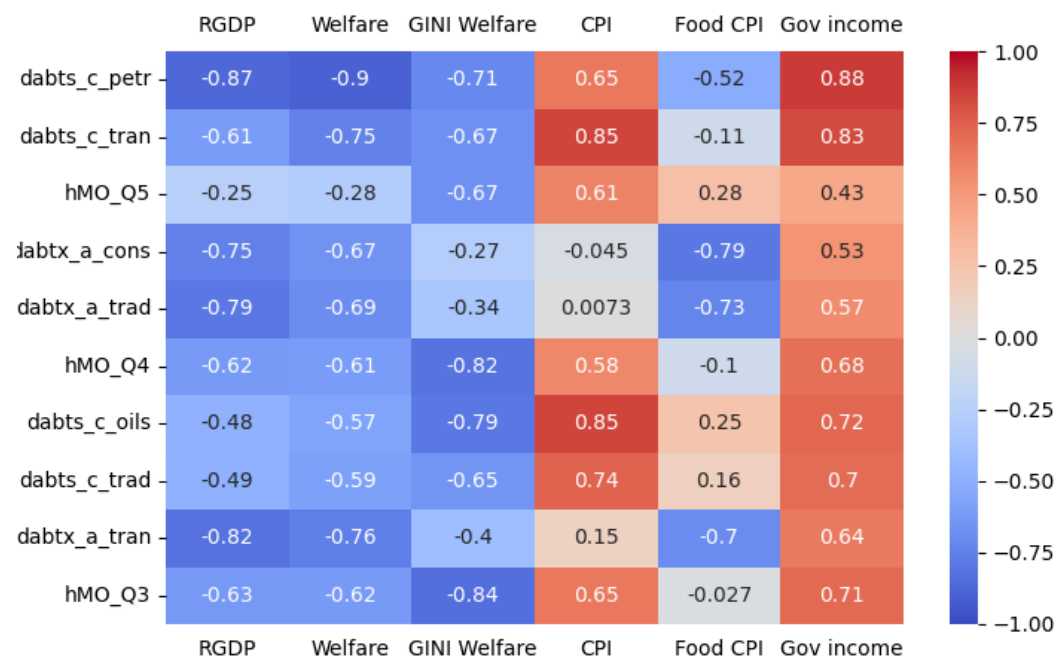
MOEA results – most impactful parameters

Fuel and transportation sales tax/subsidy the most impactful for 5 of the 6 objectives
 Sales taxes have a negative effect on GDP, welfare and inequality
 Transfers to lower quintiles in Mombasa (MO) are the most important for inequality reduction

Random Forest feature importance

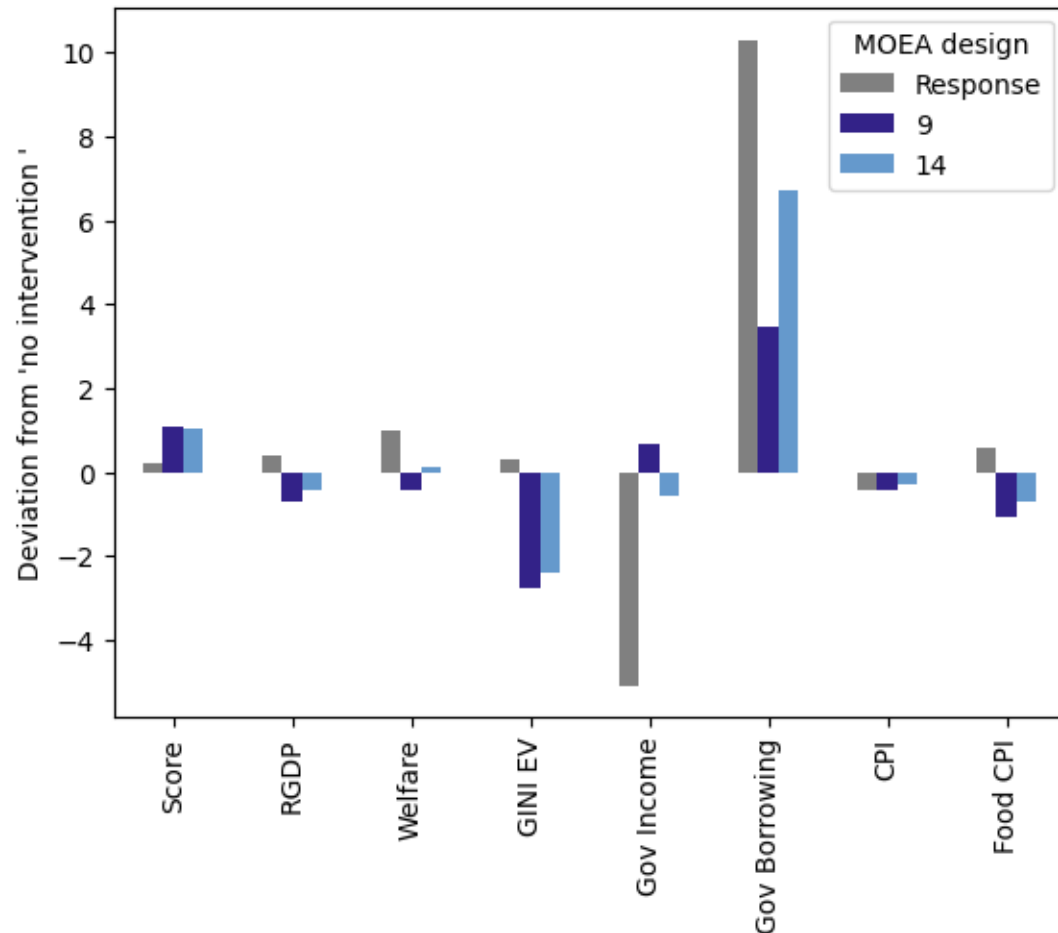


Correlation with MOEA objectives



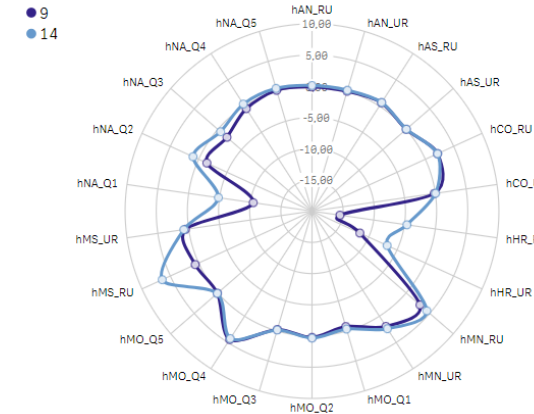
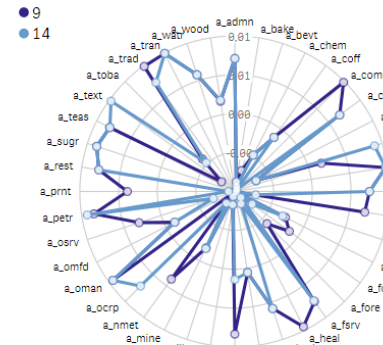
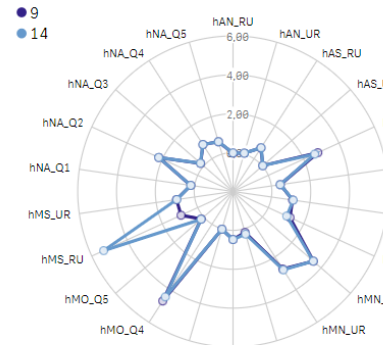
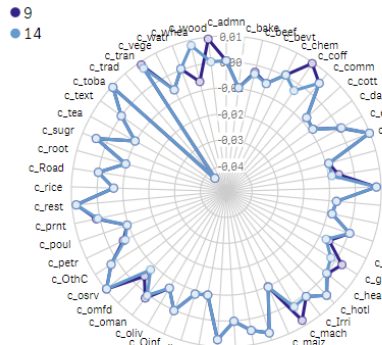
Note: dabts = sales tax ; dabtx = output tax; dabhogov = transfers

Policy options for food security and welfare



- Two designs with slightly different specifications (based on Euclidean distance of policy shocks) – options 9 and 14
- Both designs improve 4 out of 6 objectives relative to the base case, while the ‘Response’ only 3.
- Option 9 specifies lower household transfers for some hh groups
- Better outcomes on inequality reduction, gov borrowing, CPIs
- Lower GDP and negative aggregate welfare impacts.
- Design 14 offers a compromise at the expense of gov borrowing but still below the ‘Response’ levels

Dashboard of policy options



MOEA for policy design - conclusions

- The initial Kenyan government response to the 2022 commodity price increases has been evaluated against policy options defined by an MOEA with 6 policy objectives and 3 classes of instruments
- The response with fossil fuel and fertilizer subsidies was close to the MOEA Pareto surface as many MOEA policy options include these subsidies at the 2022 levels
- With the subsidies needing to be phased out due to spending and debt sustainability issues, the MOEA offers alternative policy designs with better outcomes on public spending and borrowing, however with trade-offs on GDP
- The use of dashboards can help showcase objectives and identify policy options that fit stakeholders' priorities (e.g. reduce negative impacts on gov income, improve food prices).
- An iterative process involving the MOEA narrowing down key policy instruments could further facilitate the identification of favourable policy designs

Thank you

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