

A novel, scenario-based approach to comparing non-pharmaceutical intervention strategies across nations

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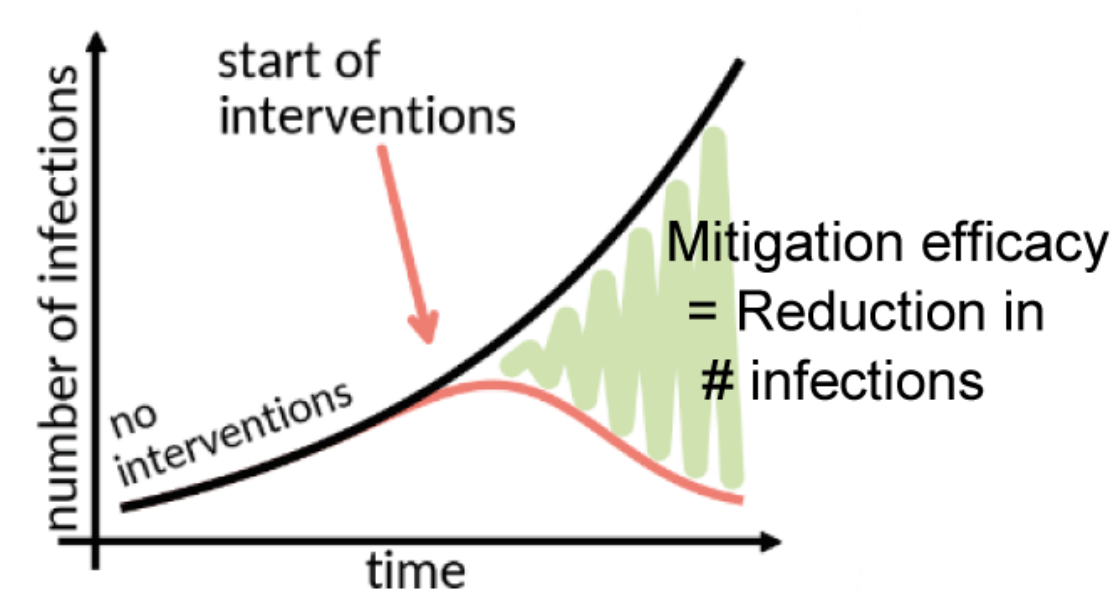
The impact of interventions on epidemiological, social, economic dimensions

The SARS-CoV-2 pandemic is a systemic global crisis characterized by huge ecological, social, and economic impacts posing a global threat to humanity (Hsiang et al, 2020).

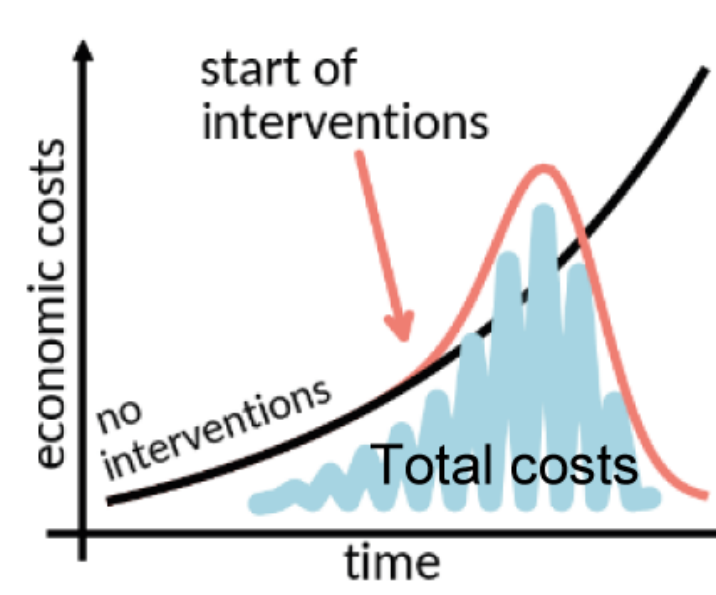
This study focuses on a deeper understanding of how to increase the coping capacity of nations facing such a systemic crisis. The coping capacity shows the nation's performance in the mitigation of infections, societal compliance, and reduction of economic costs.

To understand the effectiveness of non-pharmaceutical interventions (NPIs) in different nations, we transfer NPI strategies from a reference nation to a focal nation while preserving the packaged nature of NPIs and controlling for national framework conditions.

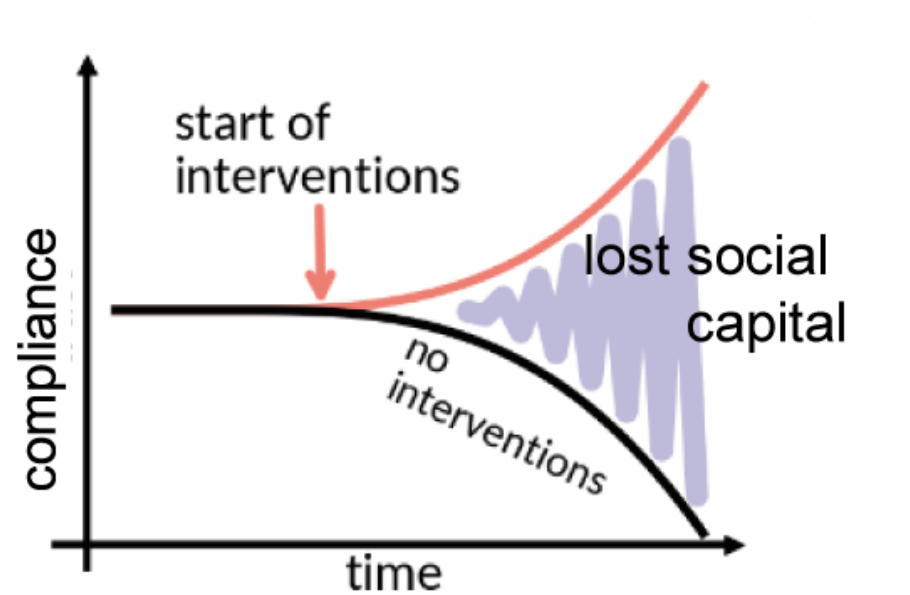
Health Dimension Dynamics of the pandemic



Economic Dimension Costs of Interventions



Social Dimension Development of Compliance



Hsiang, S., Allen, D., Annan-Phan, S. et al. The effect of large-scale anti-contagion policies on the COVID-19 pandemic. *Nature* **584**, 262-267 (2020).

A coupled epidemiological-behavioral model

A coupled epidemiological-behavioral model accounting for the impact of NPIs reads

Epidemiological model

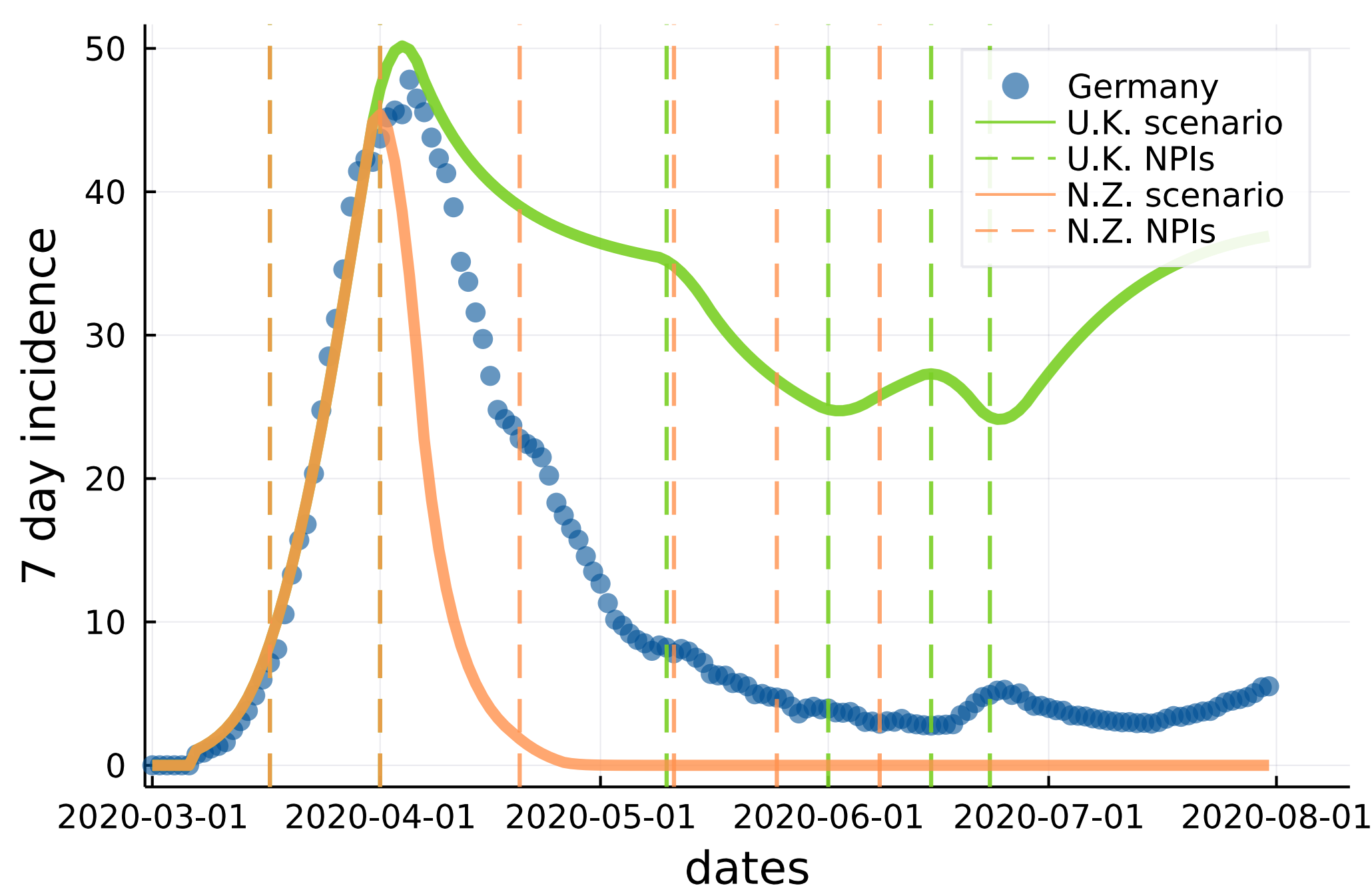
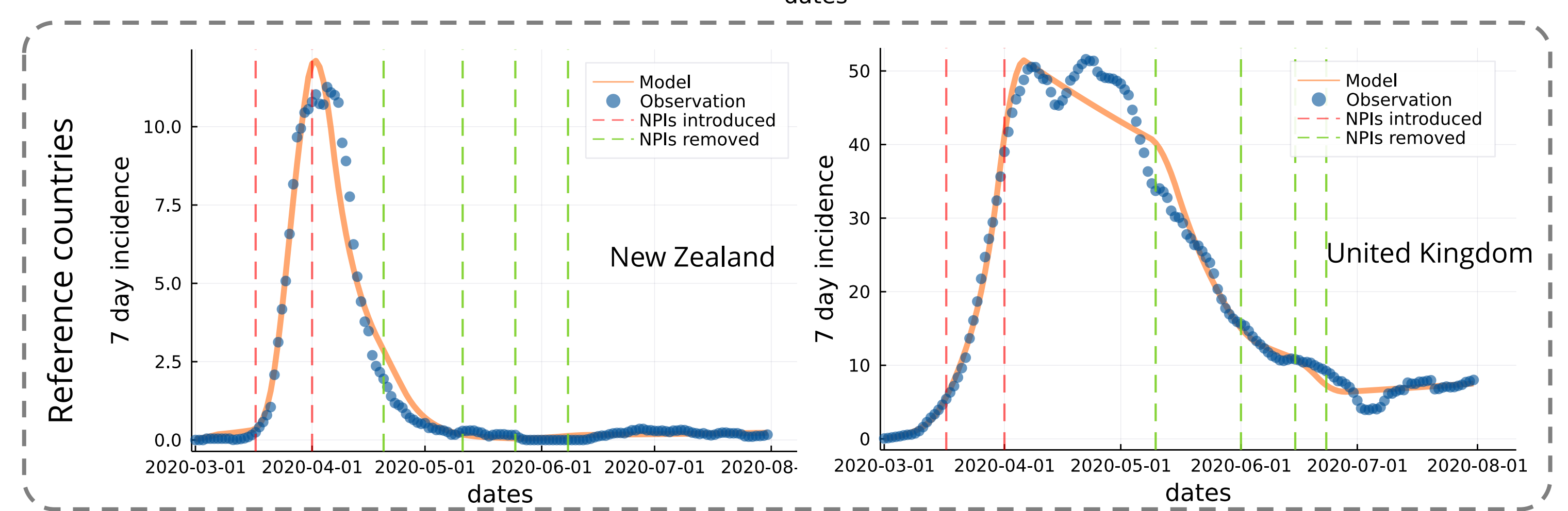
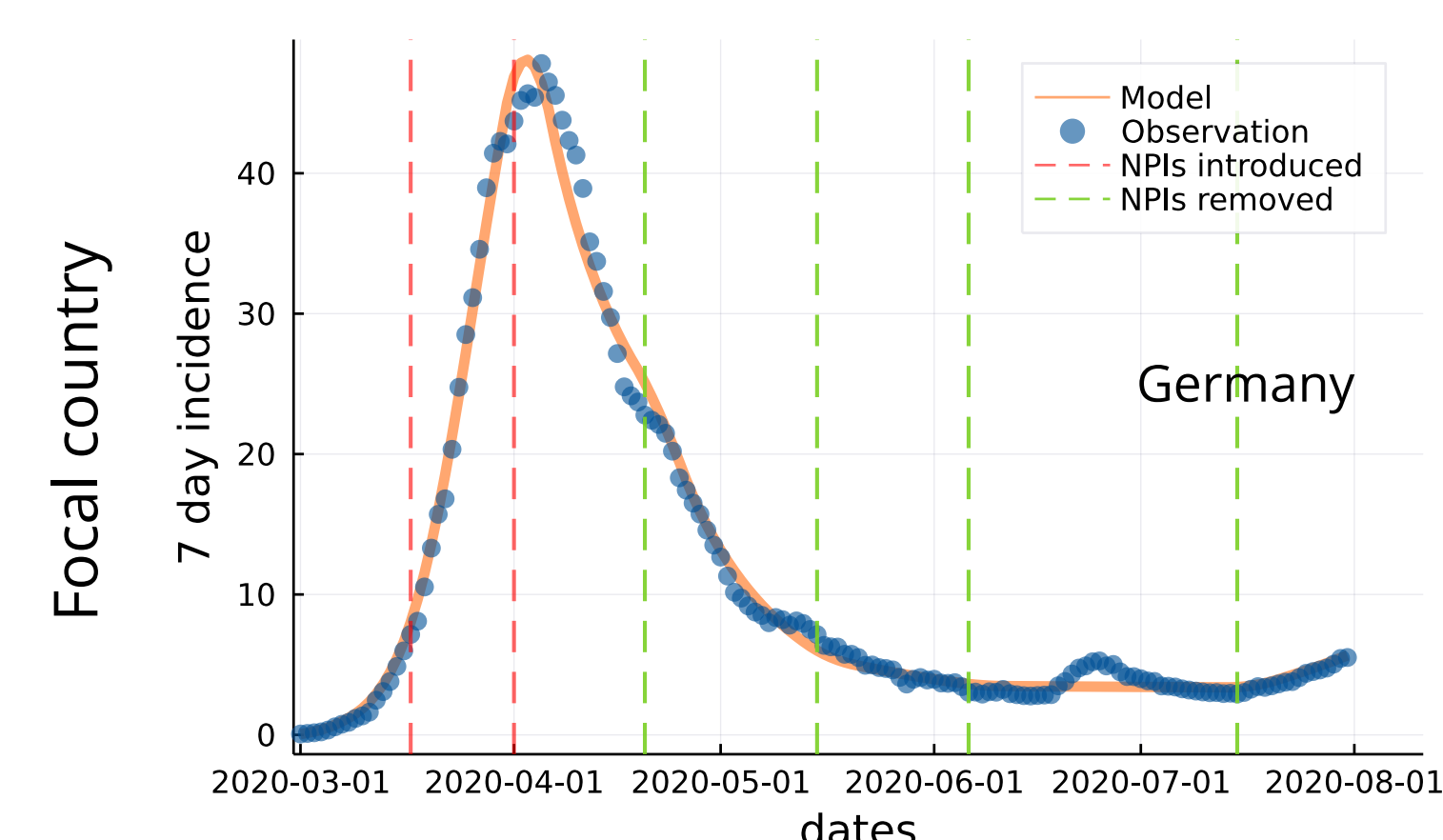
$$\begin{aligned} \frac{dS}{dt} &= -\frac{\beta_j}{N} IS \\ \frac{dI}{dt} &= \frac{\beta_j}{N} IS - \gamma I \\ \frac{dR}{dt} &= \gamma I \end{aligned}$$

Behavioral model

$$u(\beta) = \frac{1}{1-\epsilon} (\tau^{1-\epsilon} \beta^\epsilon - \epsilon\beta)$$

$$\max_{\beta} \{u(\beta) - \beta I \Delta v\}$$

where β_j is the contact rate which changes when national NPIs are introduced or removed, γ is the recovery rate. The SIR compartment model is coupled with the behavioral model where $u(\beta)$ is the utility, ϵ captures the importance to have social contacts. τ is the stringency index of the current NPIs, Δv depends on the individual risk assessment of being infected.



Scenario transfer

To transfer the NPI strategy of a reference country to the focal country, we first identify the dates of NPI changes in both countries. We use the first NPI dates and associated disease transmission rates of the focal country, until the epidemic wave has fully evolved.

The subsequent NPI dates and disease transmission rates are then transferred from the reference country to simulate how the wave would have further developed in the focal country under the reference country's NPI strategy.

Impact on relative economic cost

Implementing the N.Z. and U.K. scenarios in Germany results in different outcomes, with the N.Z. strategy having the potential to end the first wave earlier and the U.K. strategy leading to a sustained outbreak.

Despite these divergent epidemiological outcomes, the economic model suggests that both strategies, when viewed in the context of Germany, are suboptimal and would have a substantial relative cost increase.

By considering the interplay of the epidemiological, social and economic impacts, this work sheds light on the comparisons of the NPIs in different nations and its potential to strengthen the coping capacity of nations facing a future epidemics.

