Post-Kyoto Climate Negotiations: A Dynamic Game Approach

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Outline

- Global target on cumulative GHG emissions
- Collectively committed to reach the global target
- But non-cooperative behavior on the burden sharing
- Non-cooperative game approach
- GEMINI-E3

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Game model

Players are collectively committed (forced ?) to reach a target on total cumulative emissions by the year 2050.
We denote $\bar{e}_j(t)$ the cap decided by player j for period t, and $\bar{E}$ is the global constraint. The following equality must be satisfied

$$\sum_{j \in M} \sum_{t=0}^{1} \bar{e}_j(t) \leq \bar{E} \tag{1}$$

Game model

- The result of a global economic *m*-country equilibrium defines a welfare gain for each player at t and denoted $W_{j,t}(\bar{e}(t))$.
- Given a choice of moves $\bar{e} = \{\bar{e}(t)| : t = 0, 1\}$ also called an *emission program* the total payoff to player j is given by

$$J_j(\bar{e}) = \sum_{t=0}^{1} W_{j,t}(\bar{e}(t)) \quad j \in M. \tag{2}$$

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- We assume that the players behave in a noncooperative way but are bound to satisfy the global cumulative emissions constraints.
- The solution concept that we propose to use is the one studied by Rosen (1965) under the name of *normalized equilibrium* under a *coupled constraint*.

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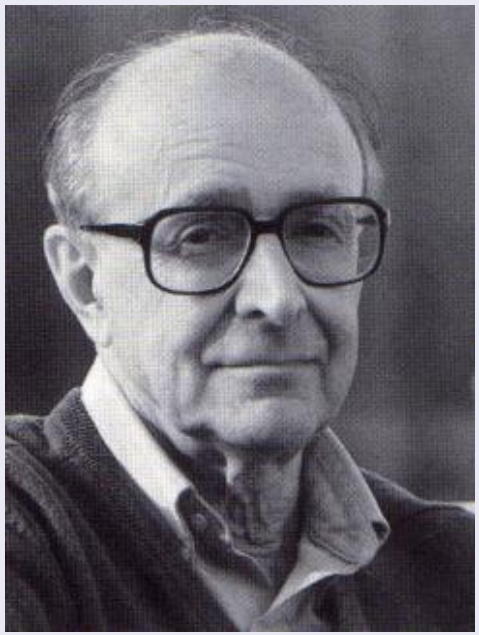
Normalized equilibrium

J.B. Rosen



Equilibrium under coupled constraints

- Each player has a positive weight r_i. The weights sum to one.
- Weights can be interpreted as the "power" of negotiation.
- The equilibrium exists and is unique under monotony assumptions.
- The equilibrium is the solution of a variational inequality problem.

Coupled equilibrium

Definition

Let us call $\mathcal{E}$ the set of emissions $\bar{e}$ that satisfy the constraints (1). Denote also $[\bar{e}^{*-j}, \bar{e}_j]$ the emission program obtained from $\bar{e}^*$ by replacing only the emission program $\bar{e}^*_j$ of player j by $\bar{e}_j$.
The emission program $\bar{e}^*$ is an equilibrium under the coupled constraints (1) if the following holds for each player $j \in M$

$$\bar{e}^* \in \mathcal{E} \tag{3}$$

$$J_j(\bar{e}^*) \geq J_j([\bar{e}^{*-j}, \bar{e}_j]) \quad \forall \bar{e}_j \text{ s.t. } [\bar{e}^{*-j}, \bar{e}_j] \in \mathcal{E}. \tag{4}$$

In this equilibrium, each player replies optimally to the emission program chosen by the other players, under the constraint that the global cumulative emission limits must be respected.

Outline

Payoffs from a CGE model

Aggregated version of GEMINI-E3 :

- CGE model in 3 regions and 14 sectors
- based on GTAP-5 database
- Non-CO2 gases (EMF21 data)

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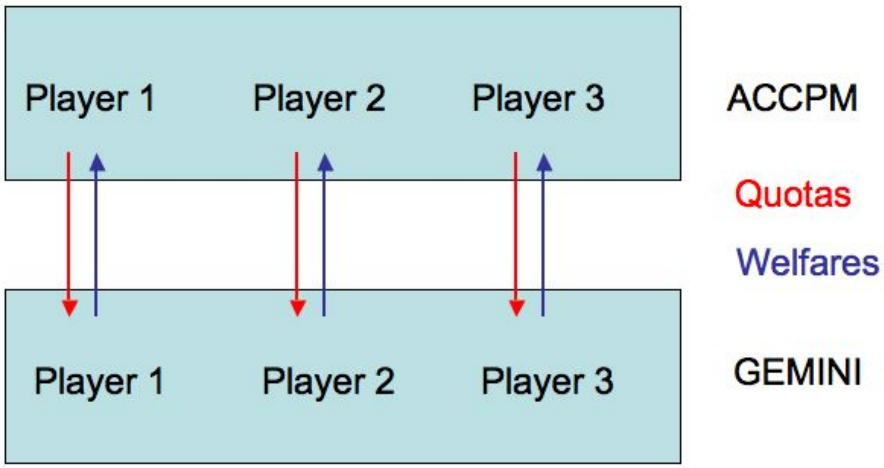
Coupling ACCPM with GEMINI



- ACCPM proposes a quotas allocation to GEMINI-E3.
- GEMINI-E3 returns welfares.
- With this new information, ACCPM proposes new quotas.
- The procedure continues until we are close enough to the equilibrium.

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Stabilization scenario

- Stabilization toward 550 ppmv
- A target on total cumulative emissions by 2050
- 3 players : USA, other-OECD (IND), and developing countries (SUD)
- 2 periods of 25 years each
- Global emission trading

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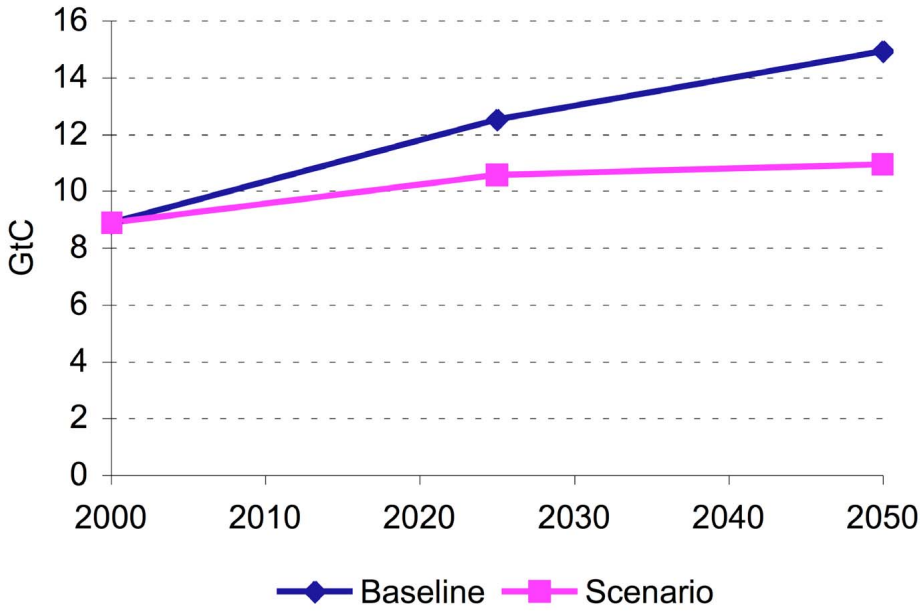

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1. 11 GtC-eq in 2050,
2. -30% of global GHG emissions by 2050,
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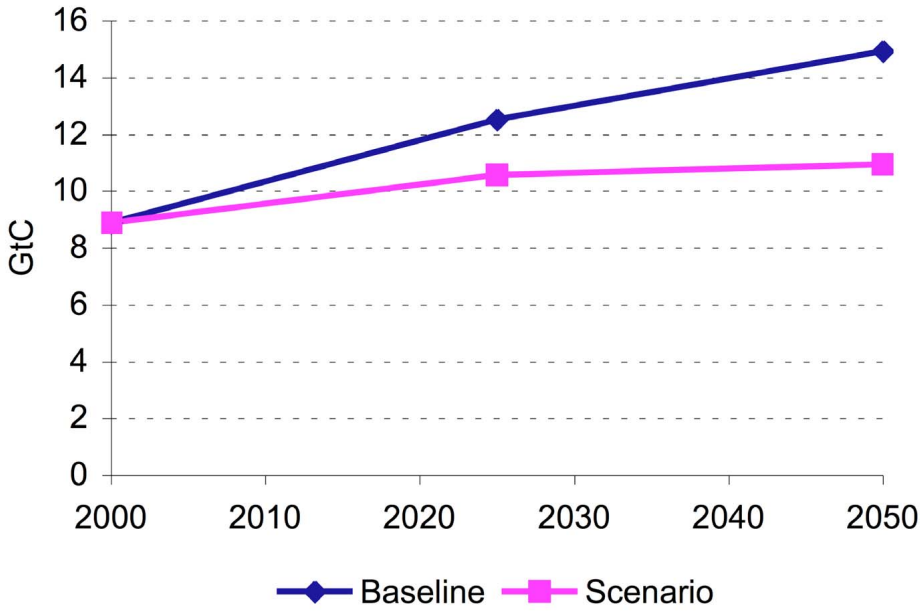

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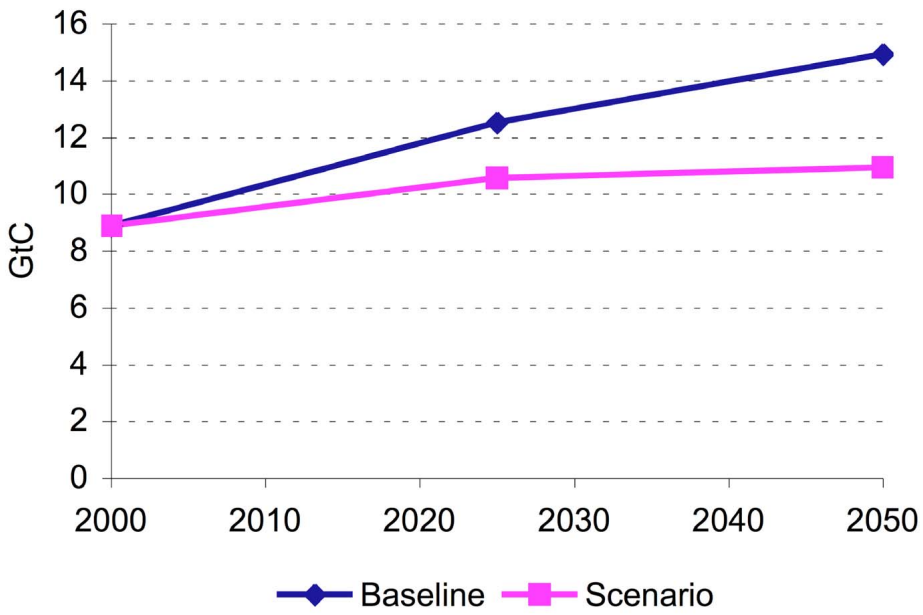

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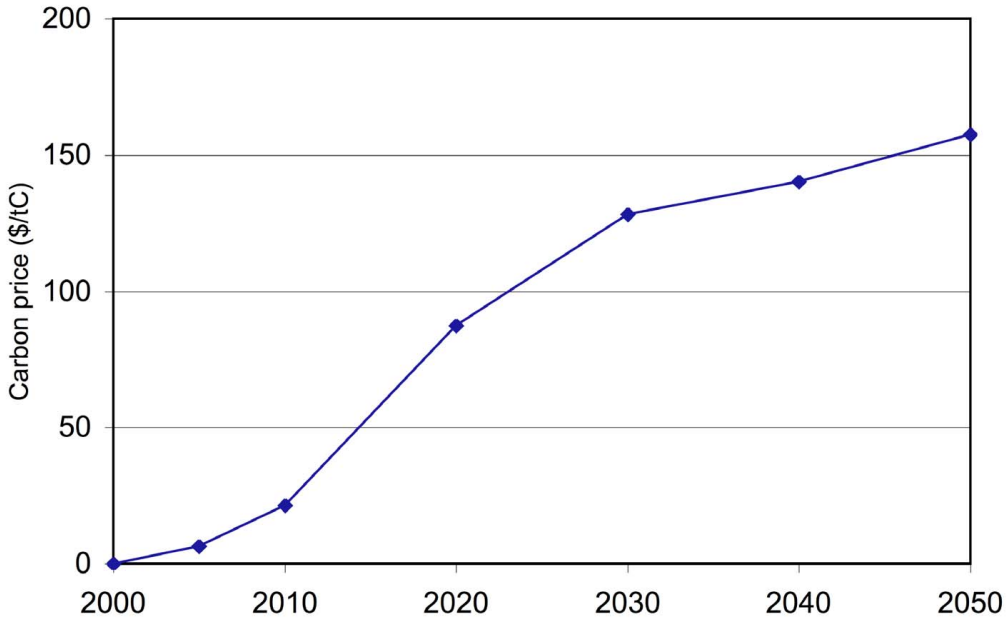

- $\simeq$ 108 $/tC in 2025,
- $\simeq$ 160 $/tC in 2050.

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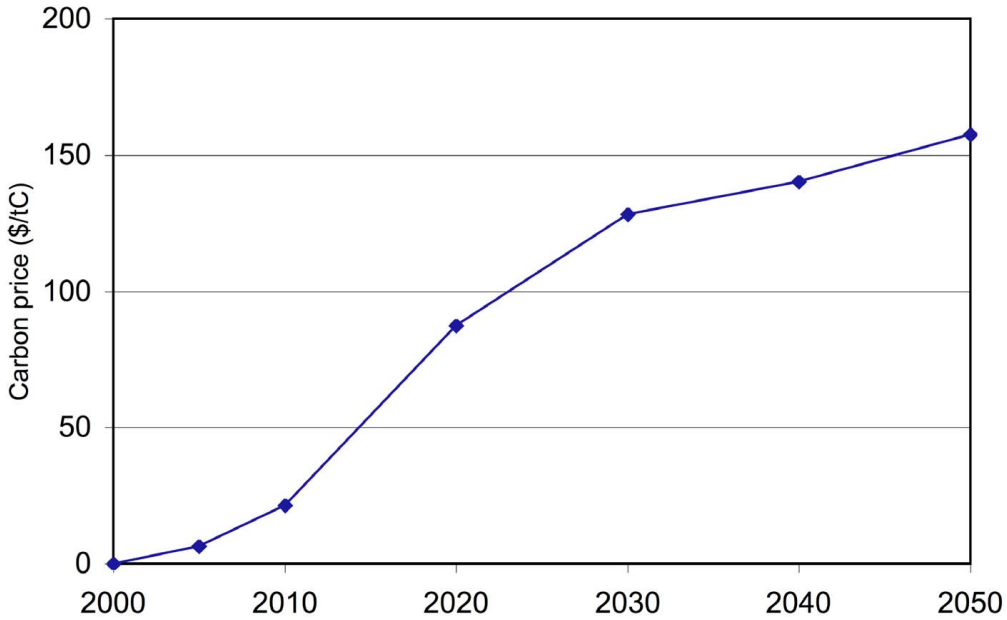

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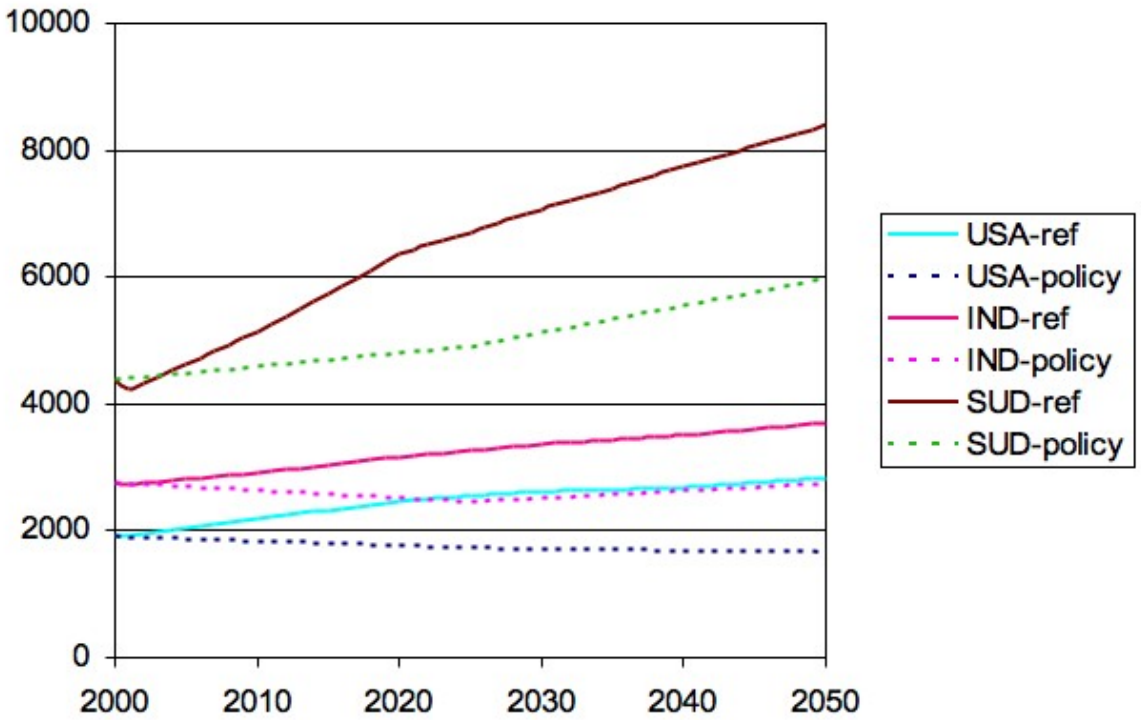

- Same weight for everybody,
- USA=-33%, IND=-26%, SUD=-47%,
- Progressive reduction,
- Costly to delay.

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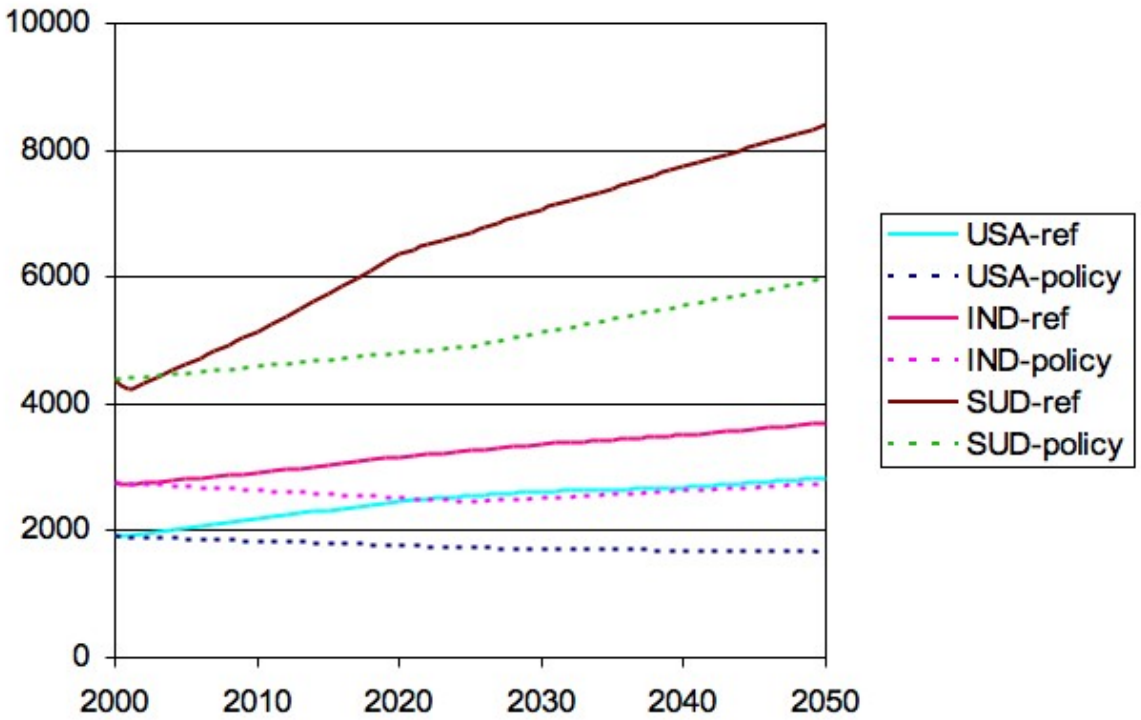

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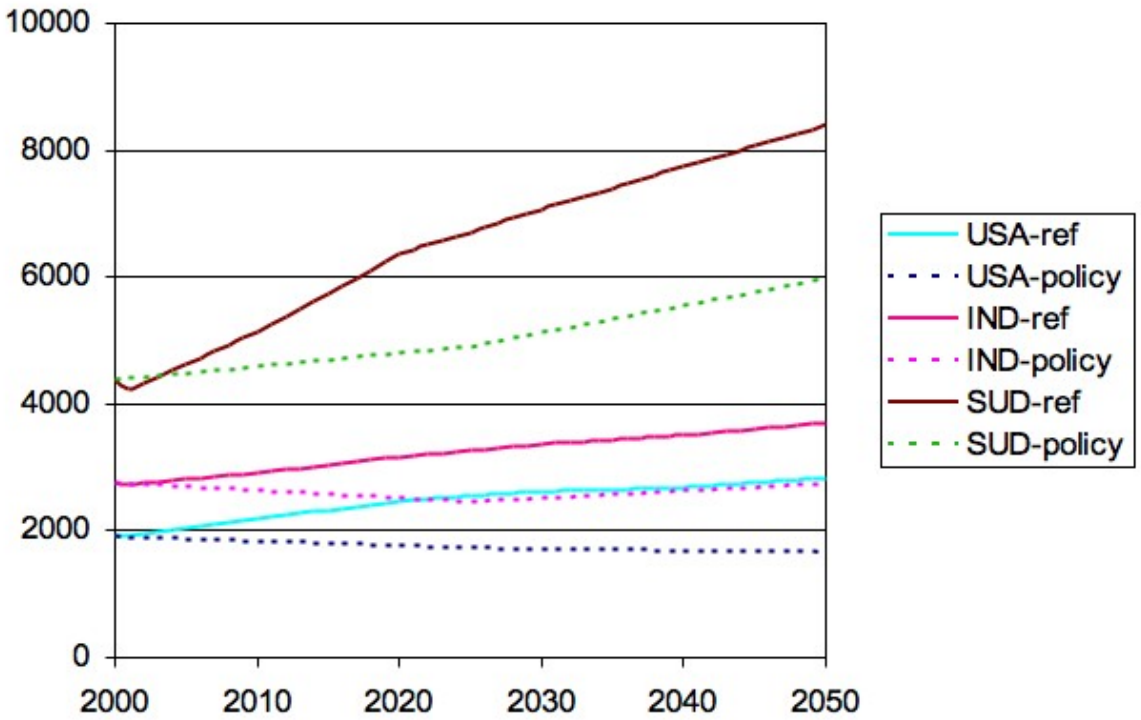

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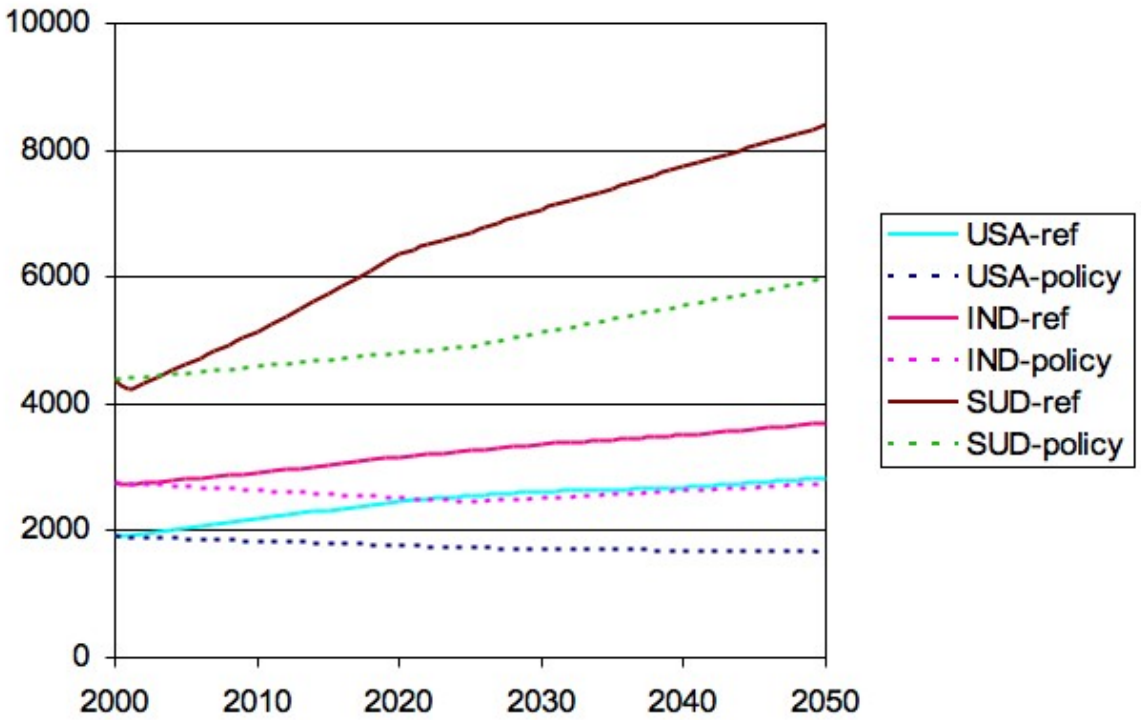

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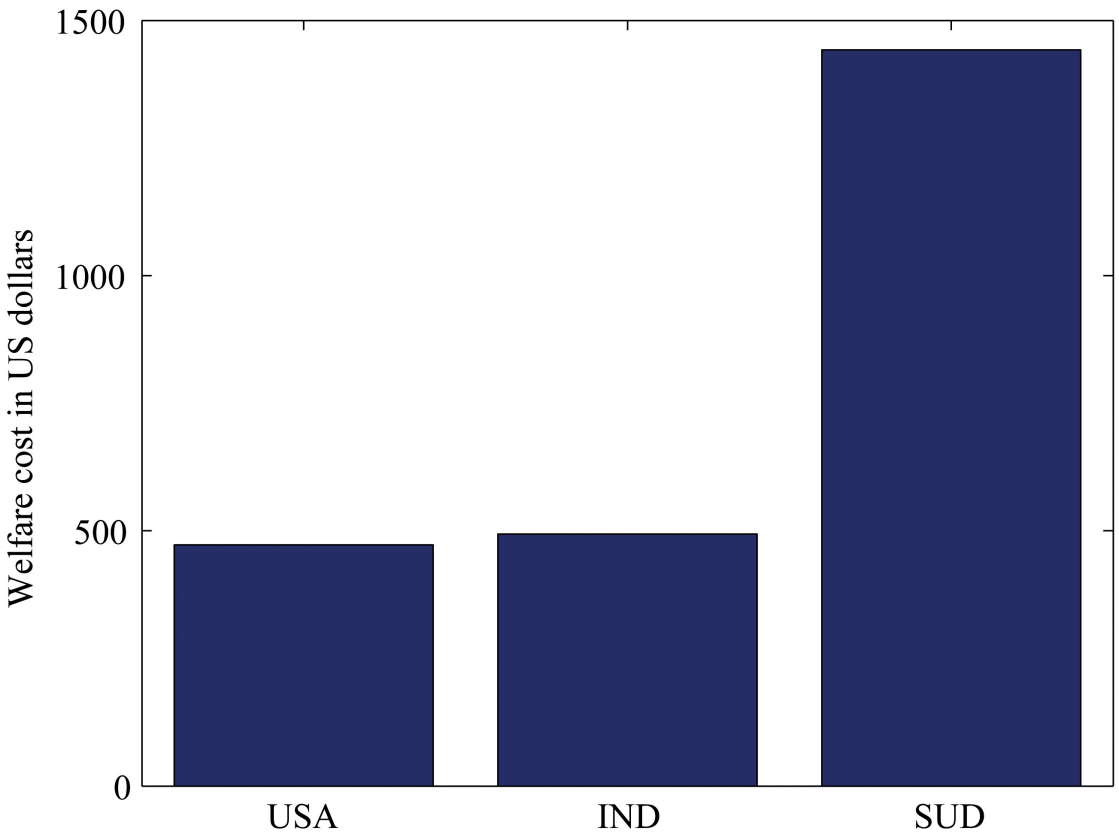

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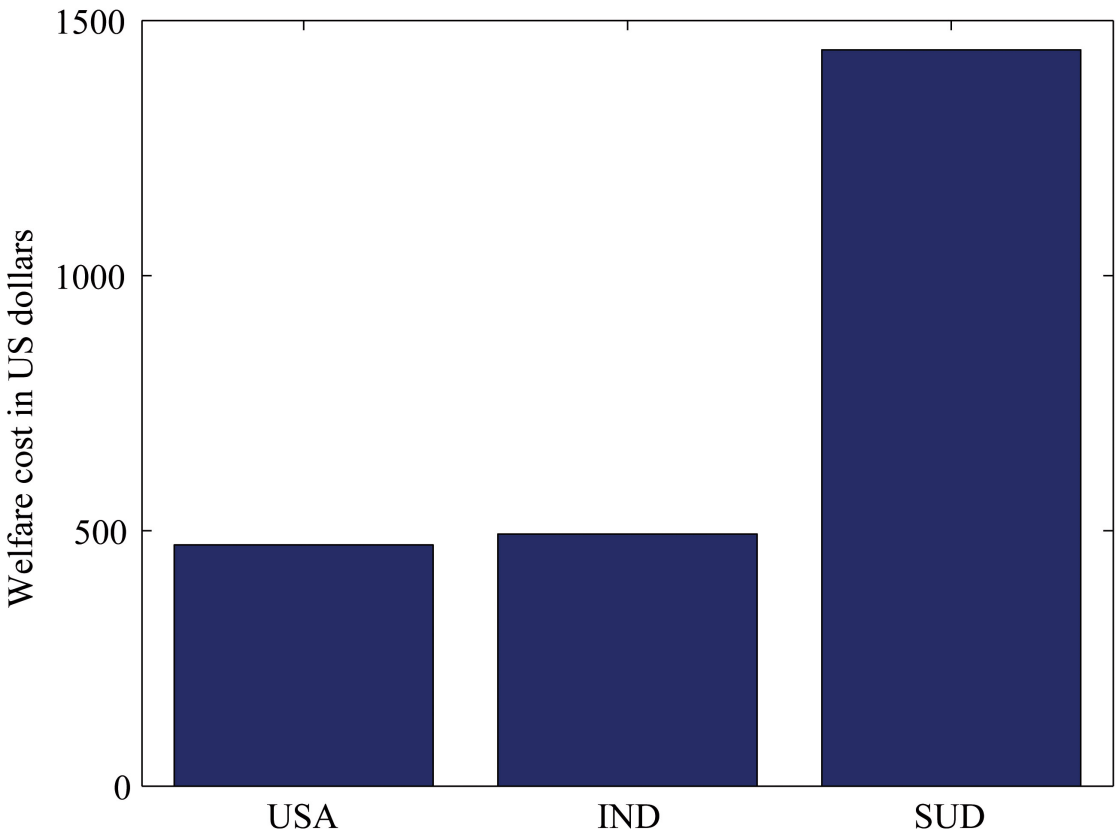

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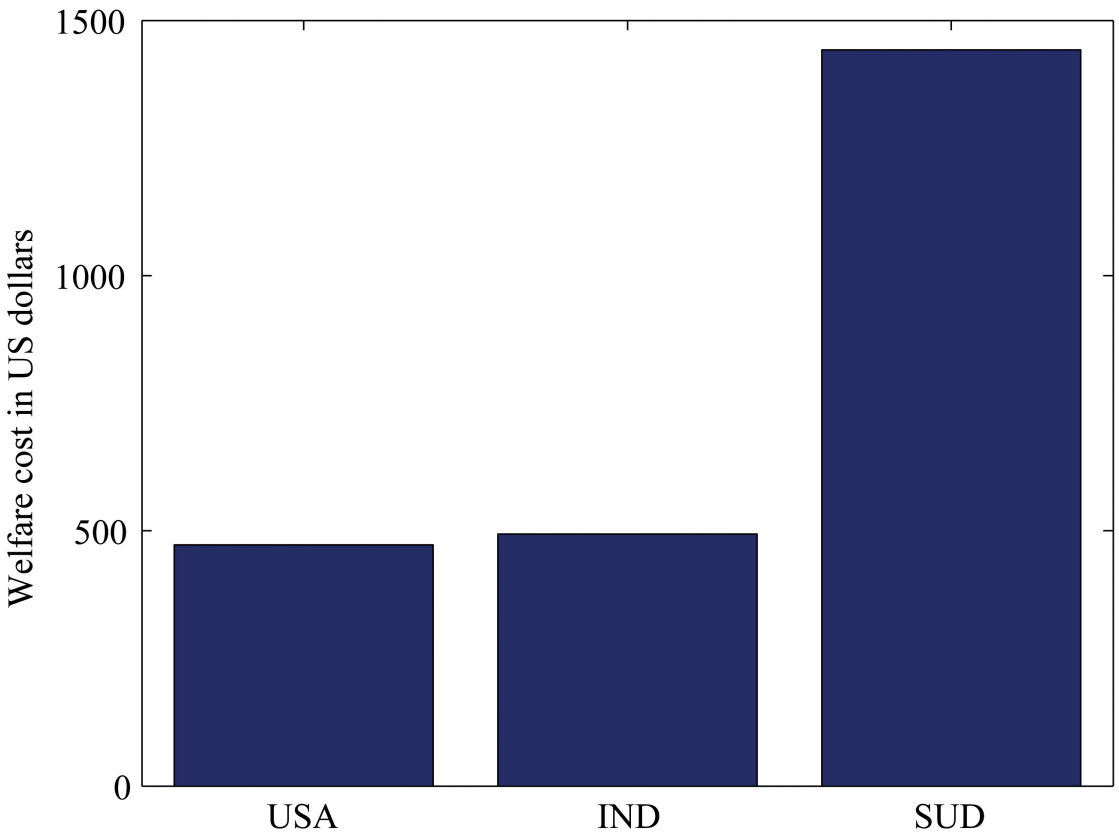

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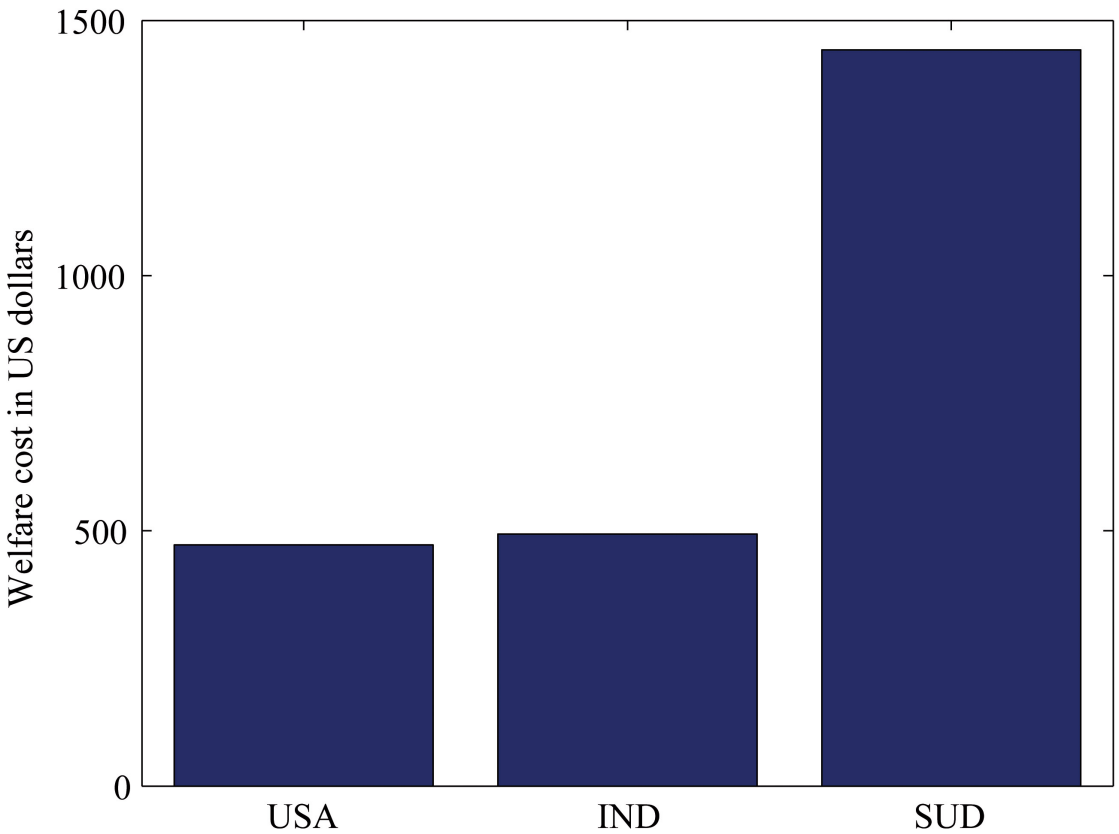

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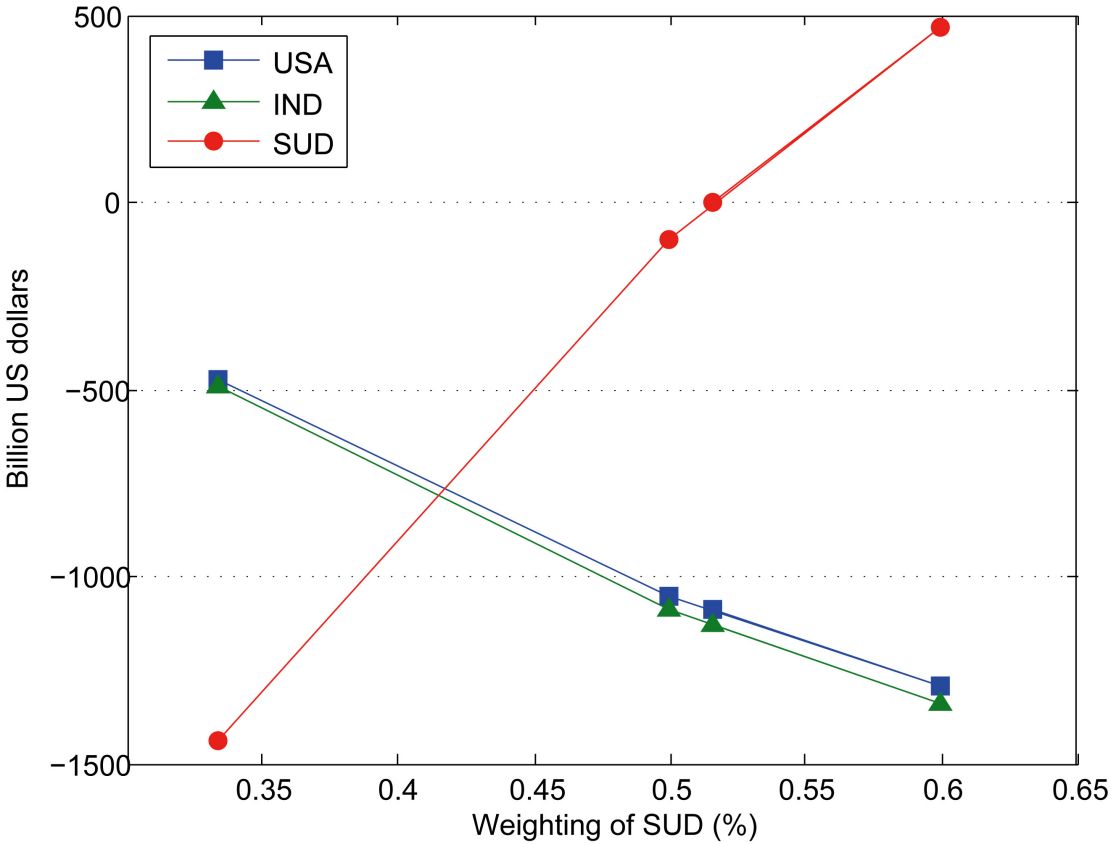

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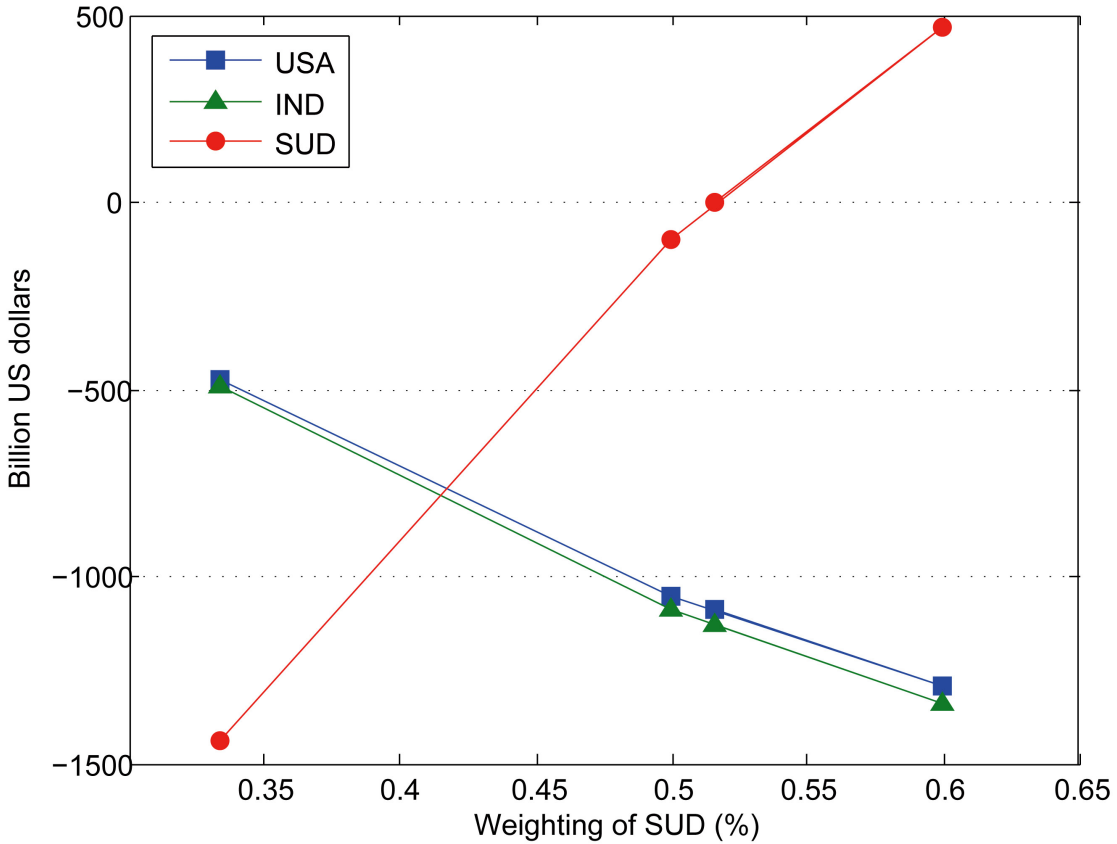

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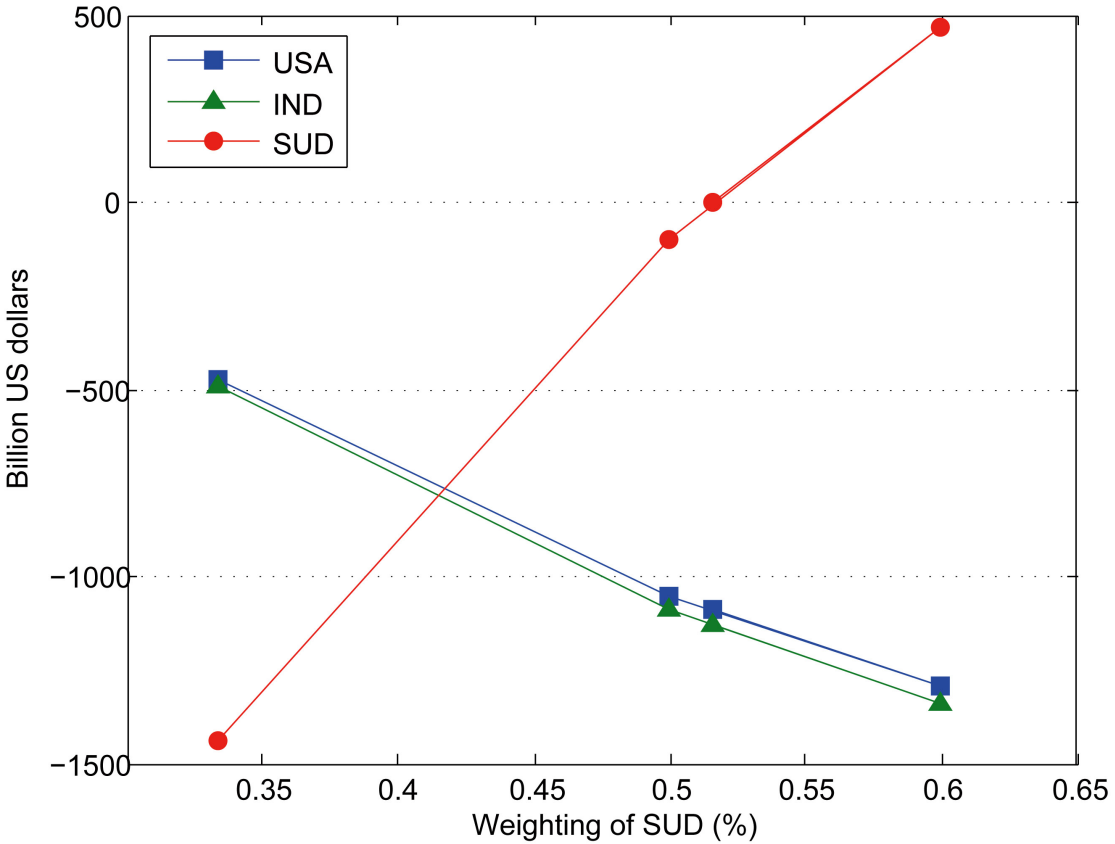

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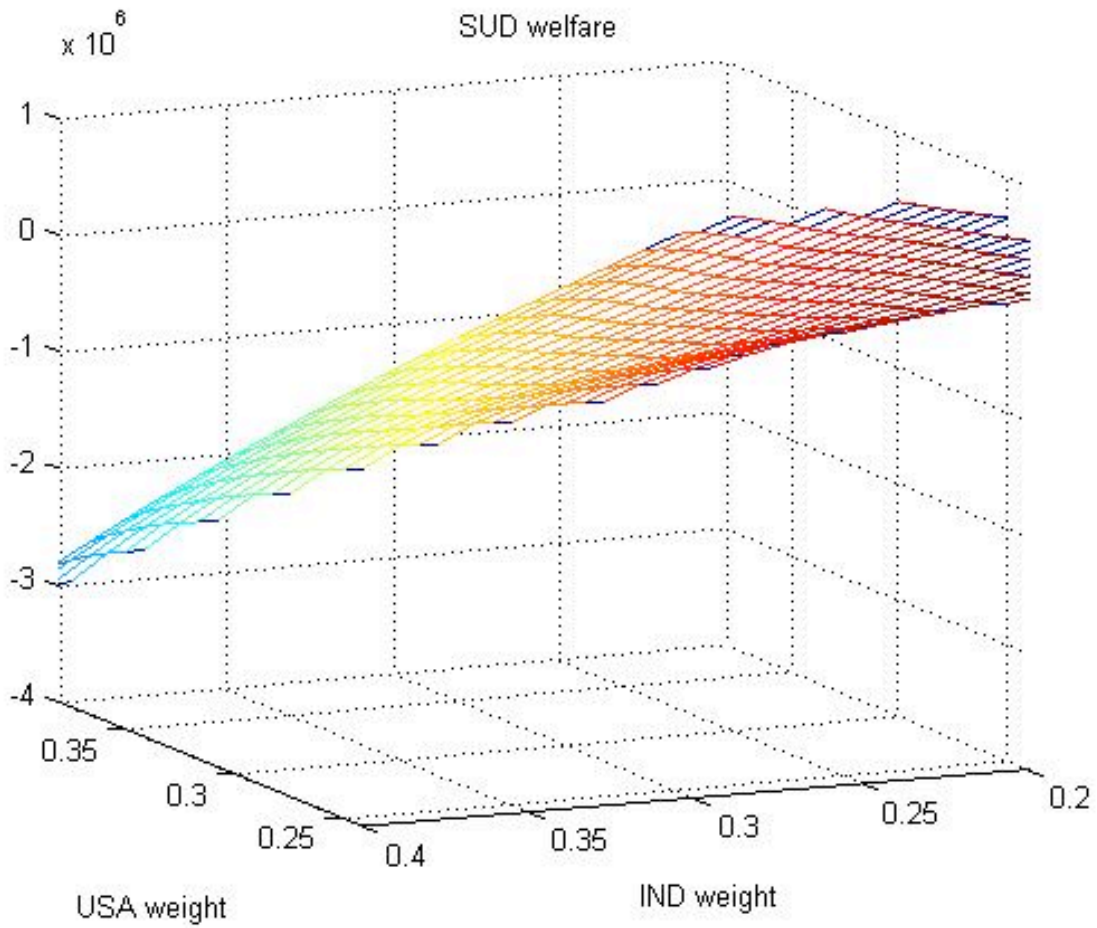

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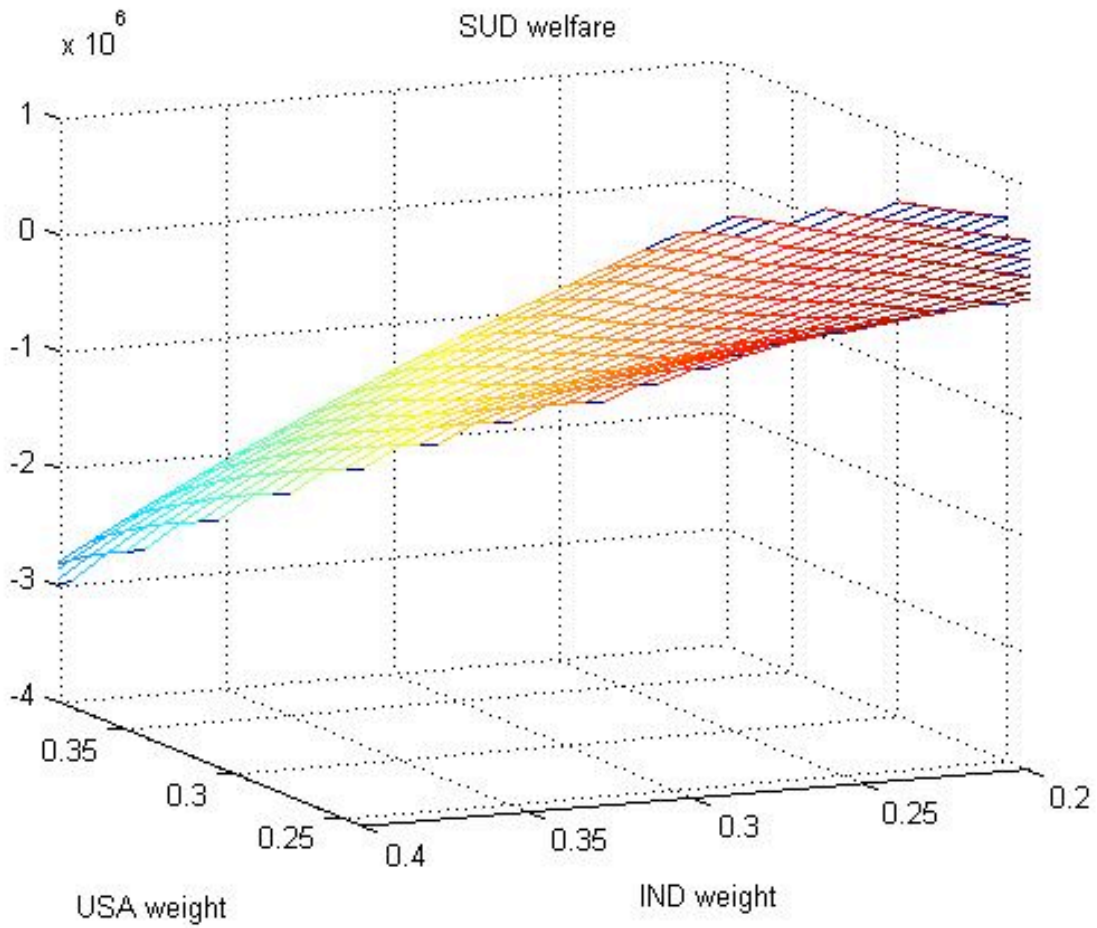

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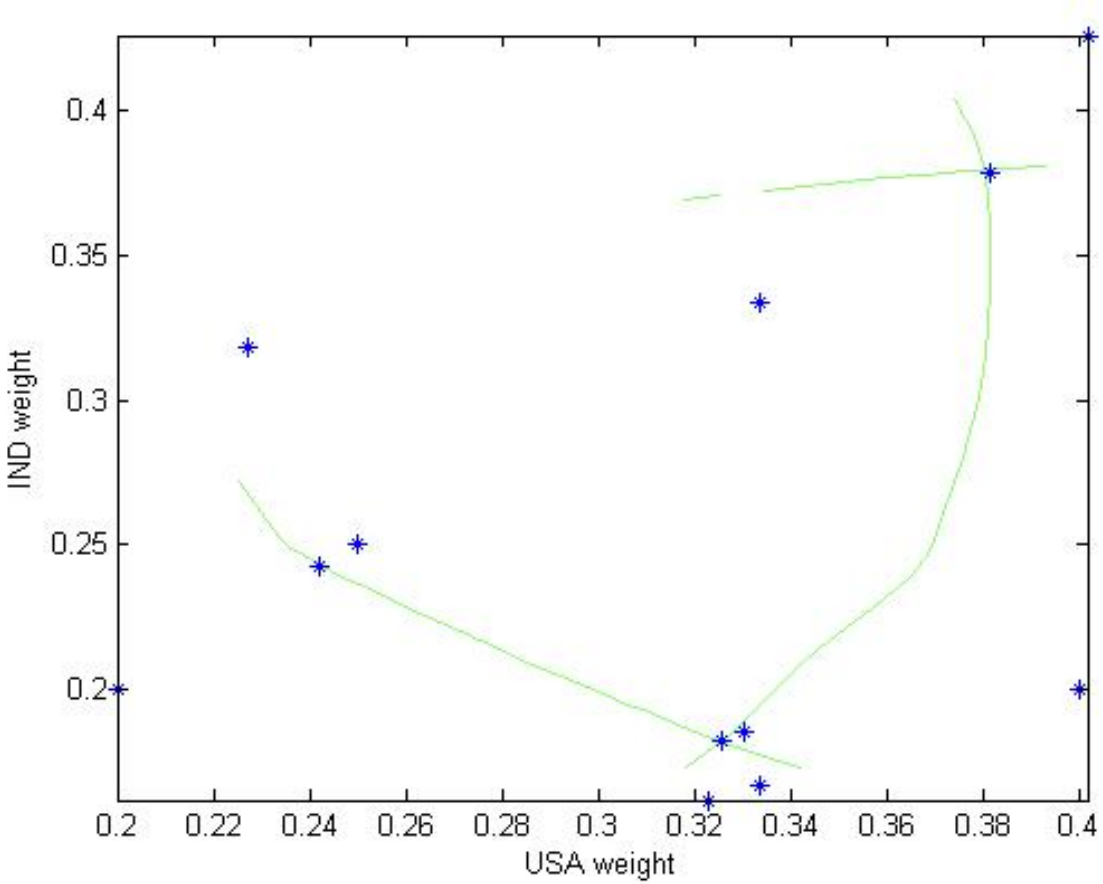

- Nobody is better off (compared to the BaU),
- USA weight between 0.16 and 0.38,
- IND weight between 0.18 and 0.37,
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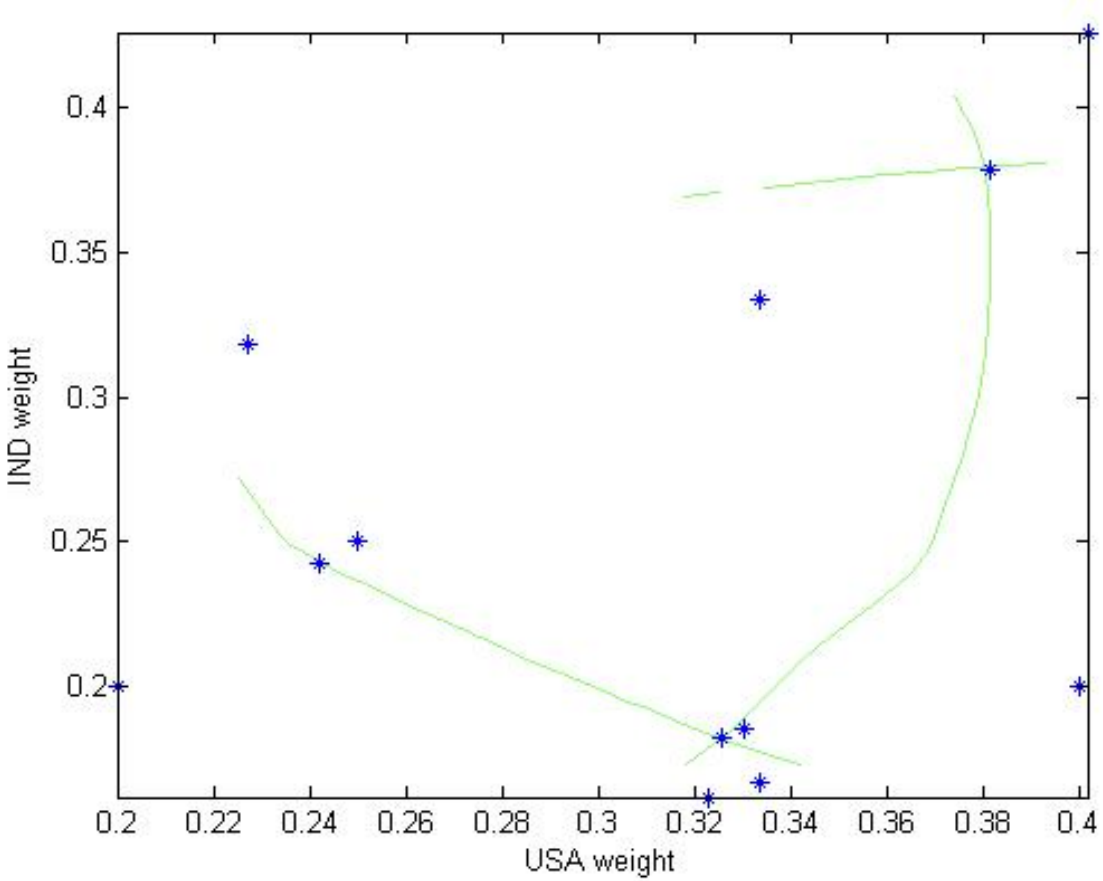

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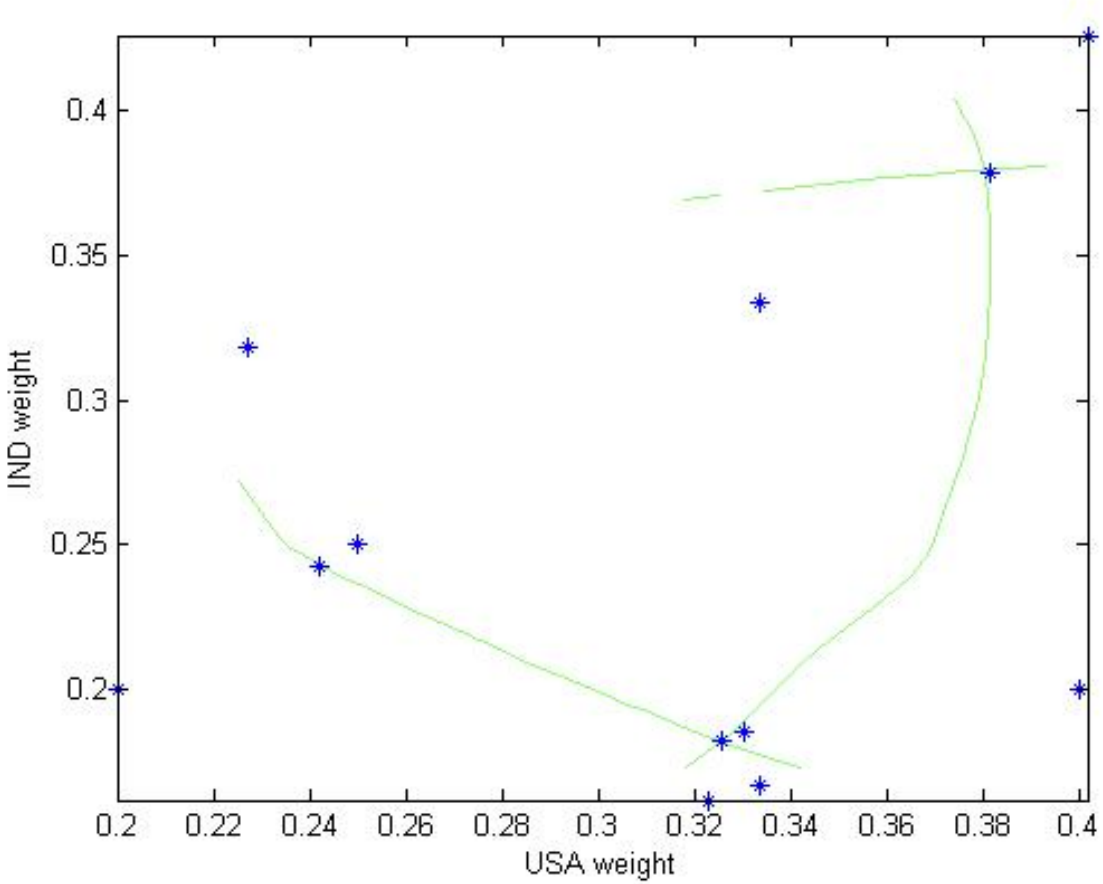

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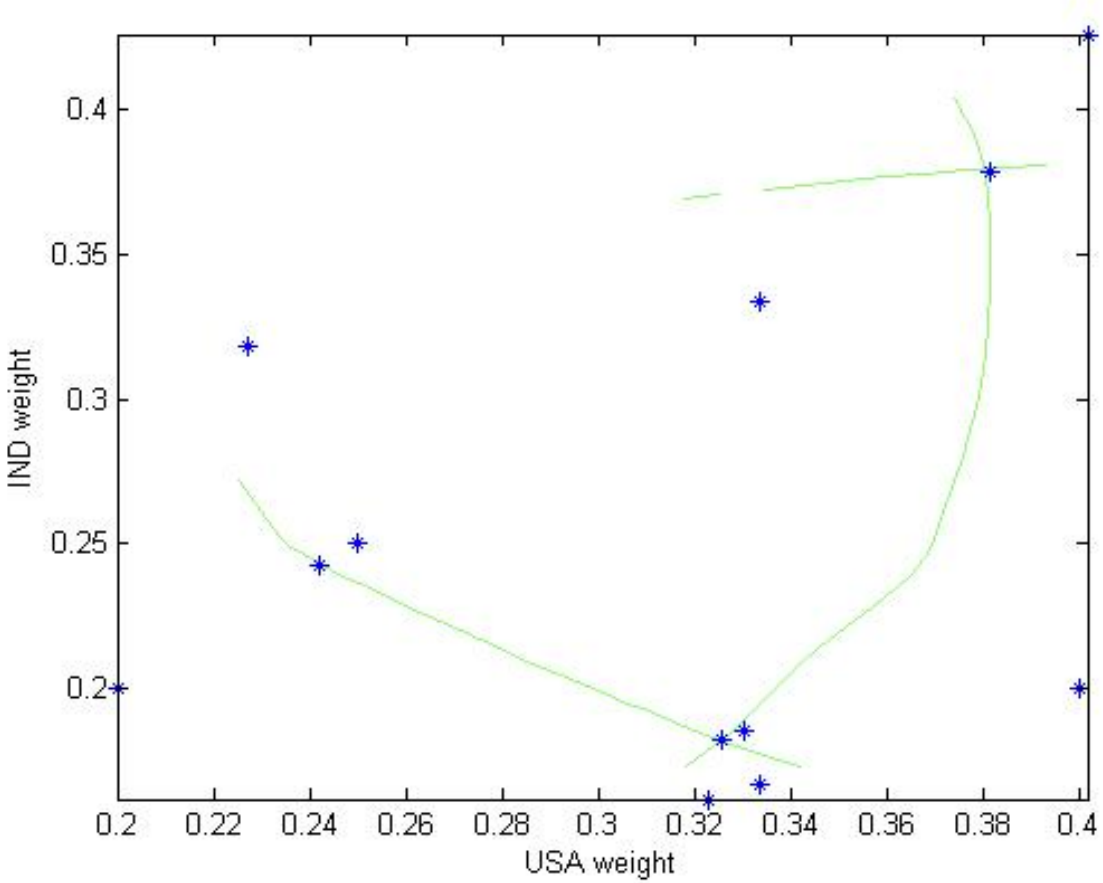

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- Test “realistic” weighting and burden sharing (e.g. population, GDP, etc)
- Introduce the uncertainty on climate sensitivity (EMF22)
- Formulate a stochastic coupled game

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