The P2P pandemic swap: decentralized pandemic-linked securities

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- Pandemic risk is systematic
  - Strong positive dependence.
  - Diversi cation of pandemic risks is di cult.
- Heterogeneous risks:
  - When and how much extra capital is needed depends on the country
- Size of the pandemic losses
  - exceeds the capacity of the insurance market;

- We introduce the class of

  P2P Pandemic-linked securities.

- Transfer part of the risk to the nancial market:
  - similar to CAT bonds, longevity bonds, CDOs, etc.
- Use a peer-to-peer network between countries.
  - mutual support between countries.
  - Abdikerimova & Feng (2022) and Denuit, Dhaene & Robert (2022).

Cash ows in case of a pandemic event

- The countries are organised in a P2P network
  - In case a payment is triggered for country j, each country pays a share of the bene t amount s_j:

$$a_{ij} \quad s_j = \text{Payment of country } i \text{ to country } j.$$

- Pandemic swap:
  - Insurance for the losses which are not covered by the pool.

$$a_{0j} \quad s_j = \text{Amount the investors pay to country } j.$$

The investors

- Premium Income:
  - Payment dates:

$$0 < t_1 < \dots < t_N = T.$$

  - The pool of countries collectively fund the premiums:

$$cFD_t = \text{Premium paid at each payment date}$$

- Bene t payments:
  - Premium payments stop when the rst loss is triggered.
  - The

Conditions for the payments

- <u>Conservation of zero balance for risk sharing</u>

$$\sum_{i=0,i\neq j}^{n} a$$

Conditions for the payments

- Principle of indemnity

$$0 \quad a_{ij} \quad 1, \quad i,j \quad 0. \tag{3}$$

- Maximum principal loss.

$$\sum_{j=1}^{n} s_j a_{0j} = F. \tag{4}$$

  - In the most extreme event where all countries will be triggered, the fu amount F will be used.

The expected return for the countries and the investors

- The cash flow of country i at time t_j:

$$R_i(t_j) = s_i I_i(t_j) - a_{i0} F c \Delta t I_0(t_j) - \sum_{k=1, k \neq i}^{n} a_{ik} s_k I_k(t_j).$$

  - The benefit payment in case of a triggering pandemic event.
  - The premium payment in case no payment was yet triggered.
  - P2P payments to other countries.

- The time-0 return for country i:

$$R_i = \sum_{j=1}^{N} e^{-r t_j} R_i(t_j),$$

where r is the risk-free rate which is assumed to be deterministic and constant.

The expected present value for the countries and the investors

- Expected present value of the cash flows for country i:

$$E[R_i] = s_i q_i - a_{i0}(F c \Delta t)\, p_0 - \sum_{k=1, k \neq i}^{n} a_{ik} s_k q_k.$$

- Fairness of a P2P pandemic swap:
  - The P2P pandemic swap is fair if the expected present value for each country is zero:

$$E[R_i] = 0, \text{ for } i = 1, 2, \ldots, n.$$

Fairness

- Result:
  - If the P2P bond is fair, we have that $\mathbb{E}[R_0$

An intensity model: the marginal probabilities

The time that the payment for country i is triggered is t_i.

An intensity model: dependence

- Ordered probabilities:

$$e^{-\lambda_1} \geq e^{-\lambda_2} \geq \dots \geq e^{-\lambda_n}.$$

  - Country 1 is the safest country. Country n is the riskiest.

- We assume:

$$P[t_{i+1} \leq t \mid t_i \leq t] = 1, \text{ for } i = 1, 2, \dots, n-1.$$

  - If a payment for country i was triggered before t, all riskier countries also received their benefit payment before time t.

An intensity model: dependence

- Triggers are ordered:
  - The first country to receive a benefit payment is the riskiest country, followed by the 2nd riskiest country, etc.
  - See also Dhaene & Goovaerts (1997).
- Premium payments:

$$E[I_0] = p_0 = \frac{e^{-(\lambda_n + r)\Delta t}\left(1 - e^{-(\lambda_n + r)T}\right)}{1 - e^{-(\lambda_n + r)\Delta t}}.$$

  - The expectation only depends on the intensity of the riskiest country.

The single-trigger case

- Assume a single trigger:

Two country case

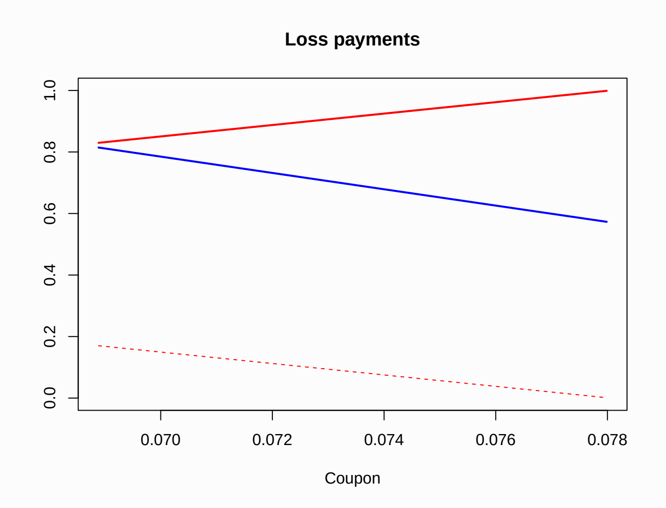

Figure. Solid lines: payments of the investors to country 1 (blue) and country 2 (red). Dashed lines are the payments between countries.

Two country case

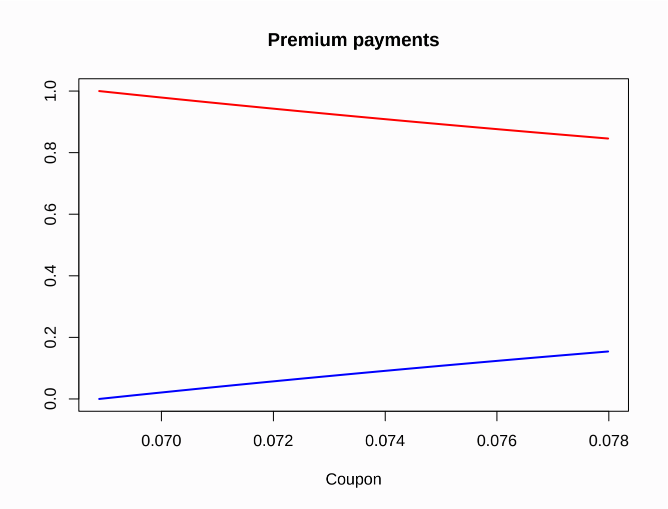

Figure. The proportion of the premium payment paid by country 1 (blue) and country 2 (red).

Thank you for your attention!

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