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:

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

  - 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 est loss is triggered.
  - The

Conditions for the payments

- Conservation of zero balance for risk sharing

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

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 ow of countryi at time t_j:

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

  - The bene t 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 countryi:

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

wherer is the risk-free rate which is assumed to be deterministic an constant.

The expected present value for the countries and the investors

- Expected present value of the cash flows for country i

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

- 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 $t_i \cdot i_i$.

An intensity model: dependence

- Ordered probabilities:

$$e^{l_1} \quad e^{l_2} ::: \quad e^{l_n}.$$

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

- We assume:

$$P[t_{i+1} \quad tj\ t_i \quad t] = 1, \text{ for } i = 1, 2, :::, n \quad 1.$$

  - If a payment for country i was triggered before t, all riskier countries also received their bene t 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:

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

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

The single-trigger case

- Assume a single trigger:

Two country case

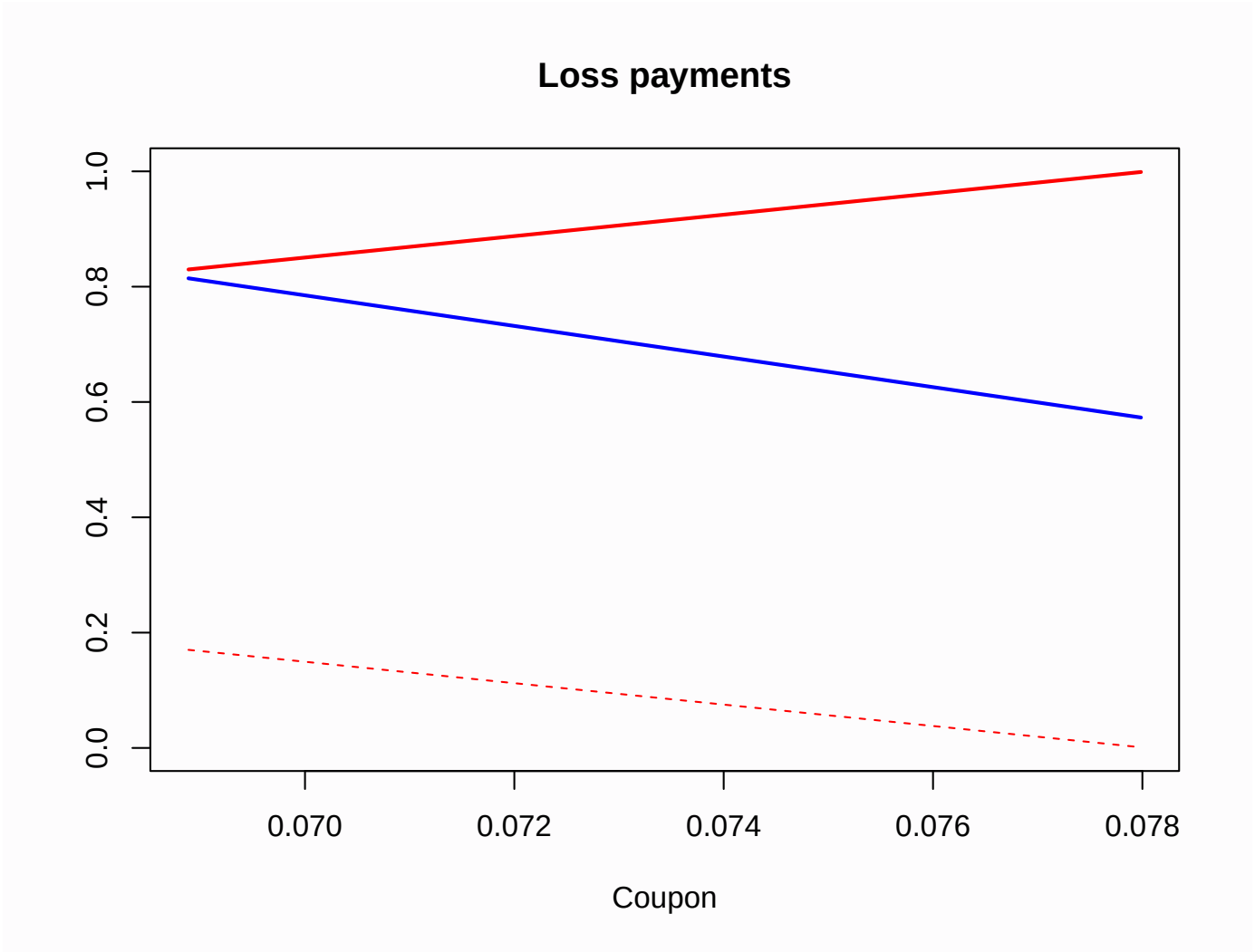

Figure. Solid lines: payments of the investors to country 1 (blue) and country 2 (red). Dashed lines are the payments between countries.

Two country case

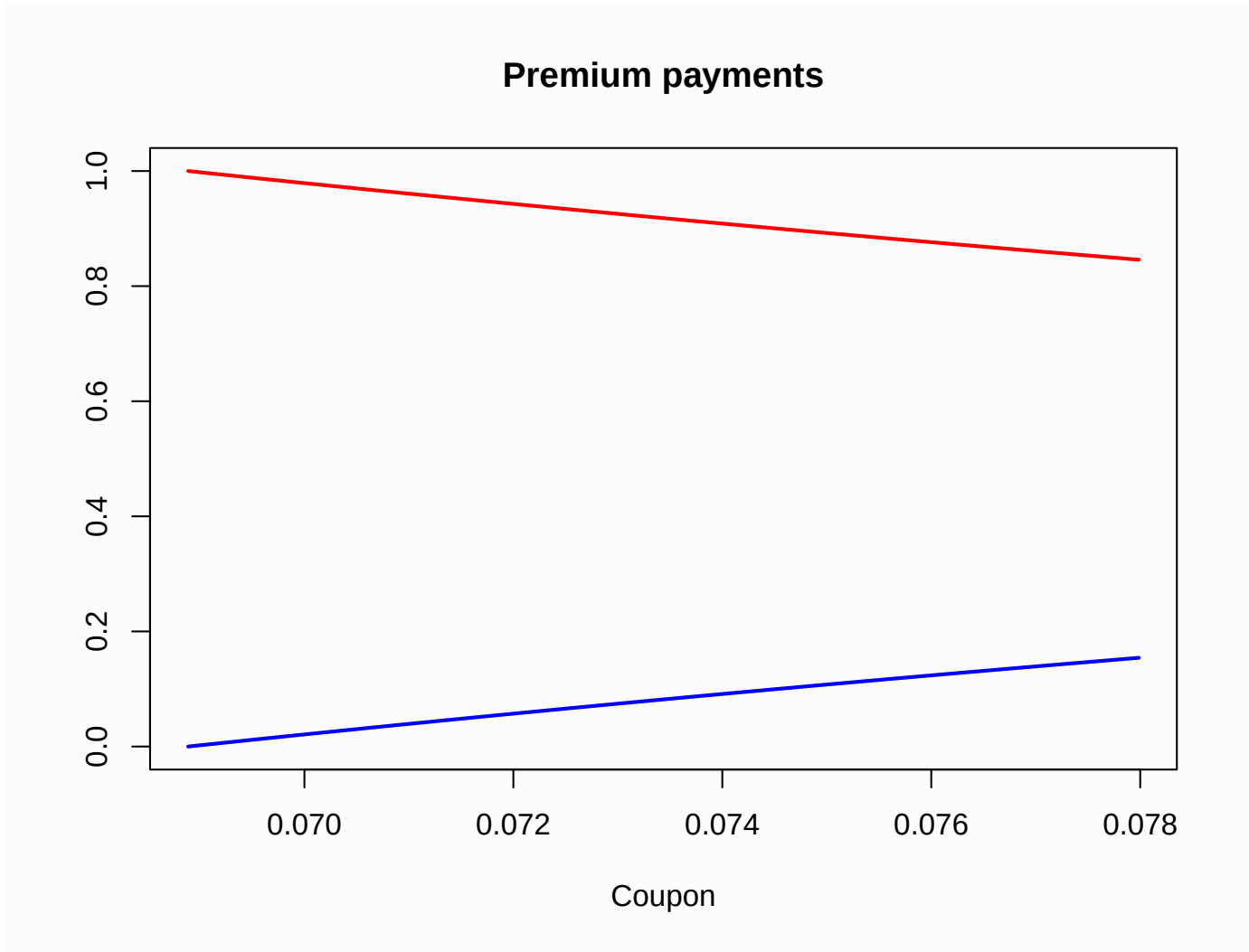

Figure. The proportion of the premium payment paid by country 1 (blue) and country 2 (red).

Thank you for your attention!

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5 { References

- Abdikerimova, S & Feng (2022). Peer-to-peer multi-risk insurance and mutual aid. European Journal of Operational Research 299(2), 735-749.
- Chen, X., Chong, W.F., Feng, R. & Zhang, L. (2021). Pandemic risk management: Resources contingency planning and allocation. Insurance: Mathematics and Economics 101, Part B, 359-383.
- Denuit M., Dhaene J. & Robert C.Y. (2022). Risk-sharing rules and their properties, with applications to peer-to-peer insurance. Journal of Risk and Insurance, vol. 89(3), 615-667
- De Spiegeleer,J. & Schoutens, W. (2019). 'Pricing Contingent Convertibles: A Derivatives Approach', he Journal of Derivatives (2012), 20(2), 27{36.
- Dhaene, J. & Goovaerts, M. (1997). On the dependency of risks in the individual life model. Insurance: Mathematics and Economics 19(3), 243{253
- German Insurance Association (GDV). 2020. Green paper|Supporting the economy to better cope with the consequences of future pandemic events.
- Lindskog, F. & McNeil, A. J. (2003). Common poisson shock models: Applications to insurance and credit risk modelling. ASTIN Bulletin 33(2), 209{238
- Marshall, A. & Olkin, I. (1967). A multivariate exponential distribution. Journal of the American Statistical Association 62, 30{44.
- Richter, A. & Wilson, T. (2020). Covid-19: implications for insurer risk management and the insurability of pandemic risk. The Geneva Risk and Insurance Review (2020) 45:171{199
- World Health Organization (2017). Pandemic in uenza risk management: a WHO guide to inform and harmonize national and international pandemic preparedness and response. World Health Organization.