Managing large-scale systematic risks

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1 – Outline


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Virus spreads through city
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CORONAVIRUS
All sporting events cance
Panic buying
Lockdown expan
th toll rises
-quarantine for two wee
advice
nd-washing
Elderly most at risk
Panic
irus hits stock market
VIRUS
utbreak identifie

Pandemic losses

- In the presence of a major pandemic event:
  - direct pandemic-related losses
  - indirect losses
- Countries may suffer extreme (short-term) losses
  - During a pandemic, governments take measures to contain the pandemic and to support the economy.
  - To contain the worldwide spread, it is important that all countries are able to take the necessary actions.

Fiscal spending of different countries

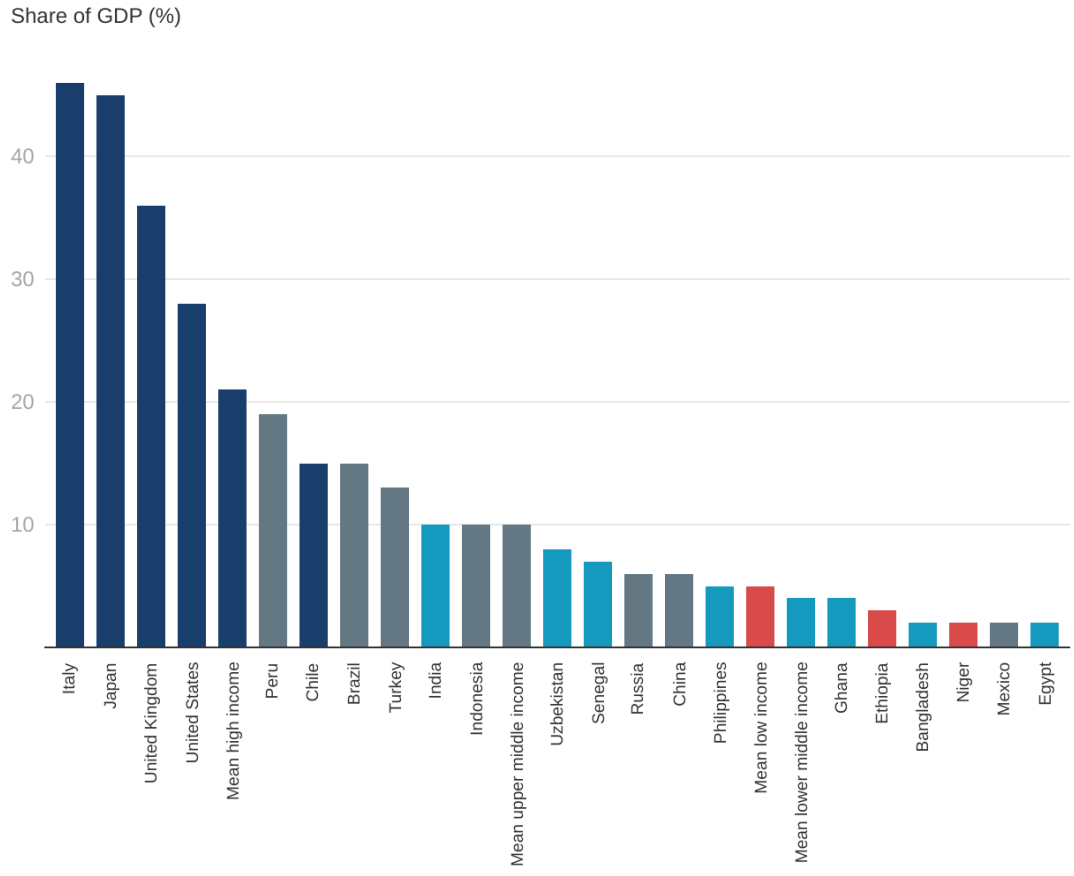


Figure. Fiscal response to the COVID-19 crisis. blue = High-income, gray = Upper-middle-income, light blue = Lower-middle-income, red = Low-income.
Source: WDR 2022 team, based on IMF (2021). Data from International Monetary Fund, "Fiscal Monitor Update," https://www.imf.org/en/Publications/FM/Issues/2021/01/20/fiscal-monitor-update-january-2021.

Mitigating of pandemic risks

- Pandemic risk is systematic
  - Pandemic losses in different countries are strongly positive dependent.
  - Diversification of pandemic risks is difficult.
- Heterogeneous risks:
  - Each country has its own severity distribution.
  - When and how much extra capital is needed depends on the country.
- Size of the pandemic losses
  - Heavy tailed risks.
  - Pandemic risks **cannot** be fully covered by traditional insurance.

Mitigating of pandemic risks

Evolution of the PEF

- Pandemic Financing Facility Fund[2]:
  - Launched in 2017 by the World Bank.
  - Goal: Transfer funds to developing countries.
  - A pandemic bond was introduced to provide the insurance coverage.
- Pandemic bond:
  - Investors fund the World Bank by paying a principal at initiation.
  - Donor countries (Australia, Germany and Japan) provide a series of coupon payments to compensate the investors.
  - In case of a pandemic, (part of) the principal is used to fund countries in need to respond to the pandemic.

[2] More information can be found here

Type of Note	Class A	Class B
Number of deaths	At least 2500	At least 250
Duration	Lasts for at least 12 weeks	Lasts for at least 12 weeks
Rolling total case	At least 250	At least 250
Cross-border spread	Regional or global	Needs to be in more than one country, each having had 20 or more fatalities
Growth rate	The total number of cases in IDA/IBRD countries must be growing at an exponential rate	The total number of cases in IDA/IBRD countries must be growing at an exponential rate
Virus type	Flu, Coronavirus	Filovirus, Coronavirus, Lassa Fever, Rift Valley Fever and Crimean Congo Hemorrhagic Fever

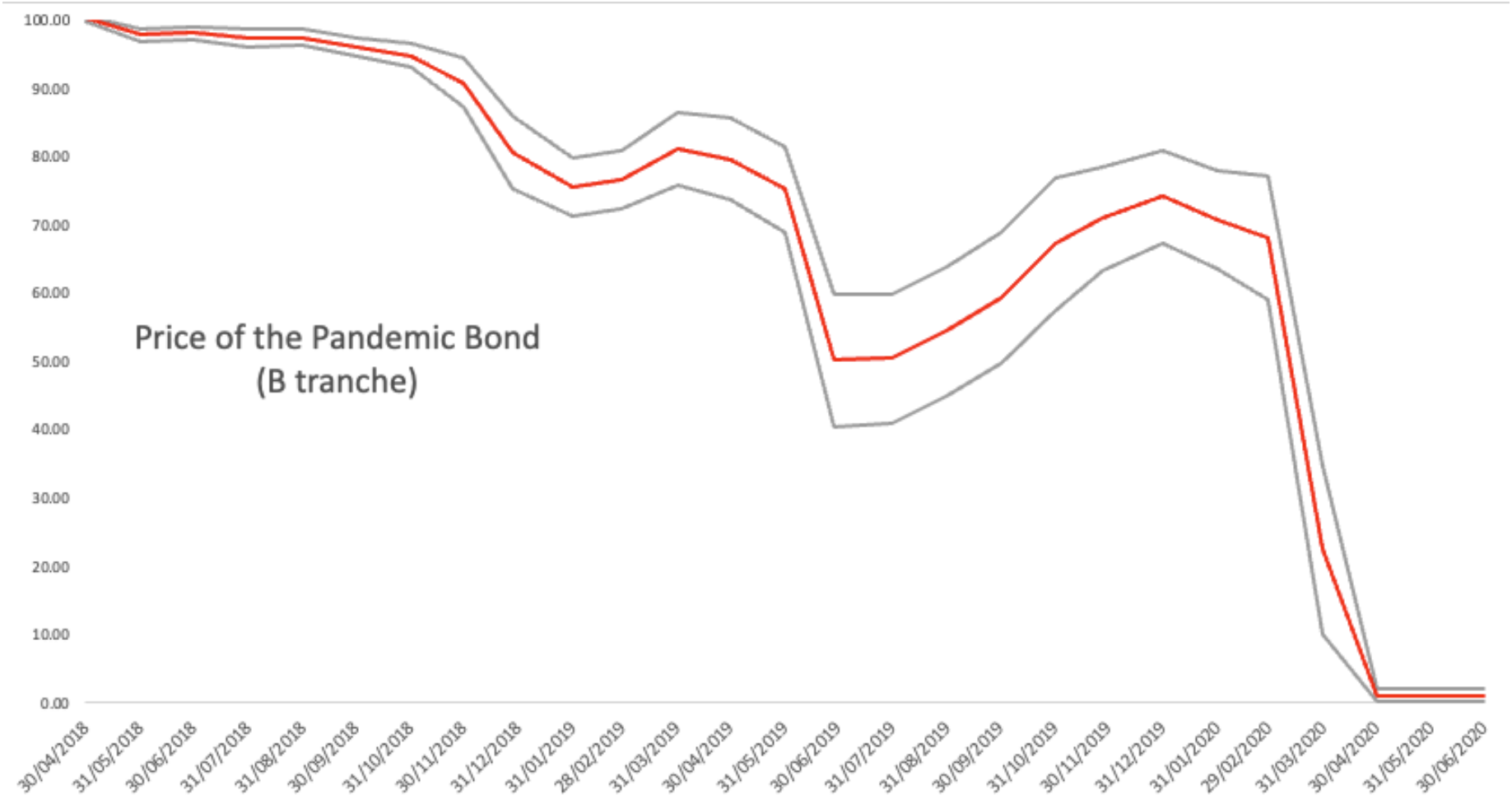
Table: The bond Payout triggers for the two types of pandemic bonds by the World Bank.

Evolution of the PEF

- Two type of pandemic bonds: class A and class B bonds.
  - Start date:July 7, 2017. Maturity date: July 15, 2020.
  - Class B bonds cover a wide range of viruses.
  - Class A bonds have a lower coupon than class B bonds.
  - Both bonds were triggered to payout on April 17, 2020.
  - On April 27, 2020, the PEF allocated US195.84 million to 64 of the world's poorest countries.
  - The PEF closed on April 30, 2021.

2 – The Pandemic bond of the World Bank

Price evolution



Drawbacks of the World Banks' pandemic bond

- Slow triggering mechanism:
  - The bond only paid out in 3 cases out of 60 pandemics.
- Donor fatigue:
  - The 3 donor countries only contribute and have no future benefits.
  - Developing countries only receive funds in case of a pandemic.
- Triggers are not country specific:
  - The bond cannot differentiate between countries.

- We introduce the class of

P2P Pandemic-linked securities.

- Transfer part of the risk to the financial market:
  - similar to CAT bonds, longevity bonds, etc.
- Use a peer-to-peer network between countries.
  - mutual support between countries.
- Reference:
  - Abdikerimova, Linders & Feng (2025). 'The P2P pandemic swap: decentralized pandemic-linked securities to develop health emergency financing solution', Working paper.

Structure

- A P2P pandemic swap has two sides:
  - **Investors:** are willing to provide insurance against pandemic risk in return for a periodic premium.
  - **Pool of countries:** collectively pay the insurance premium and support each other in case of a pandemic.
- A P2P pandemic swaps has two type of payments
  - **Fixed periodical premiums:** Transferring the losses to the investors will require paying a fixed premium.
  - **Random losses:** Whenever a pandemic loss occurs, part of these random losses will be covered by the investors.

3 – The P2P pandemic swap

Cashflows for the investors and the countries

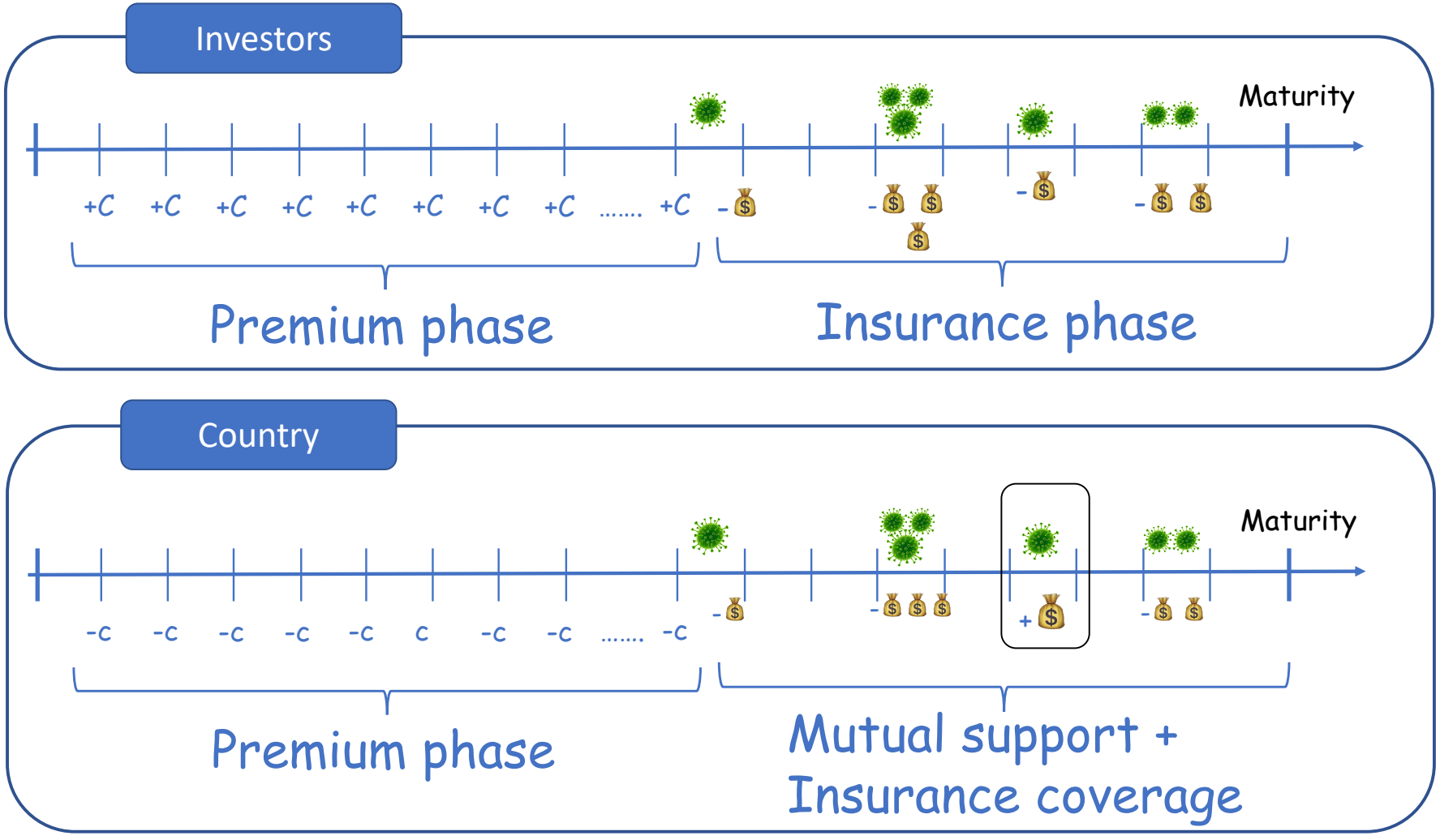


Figure. Cashflows for the investors and the countries.

Cashflows 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 benefit amount s_j:

$$\alpha_{ij} \times s_j = \text{Payment of country } i \text{ to country } j.$$

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

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

  - Max amount covered by the bond:

$$F = \sum_{j=1}^{n} \alpha_{0j} s_j.$$

Payments to country 1 in case of an event

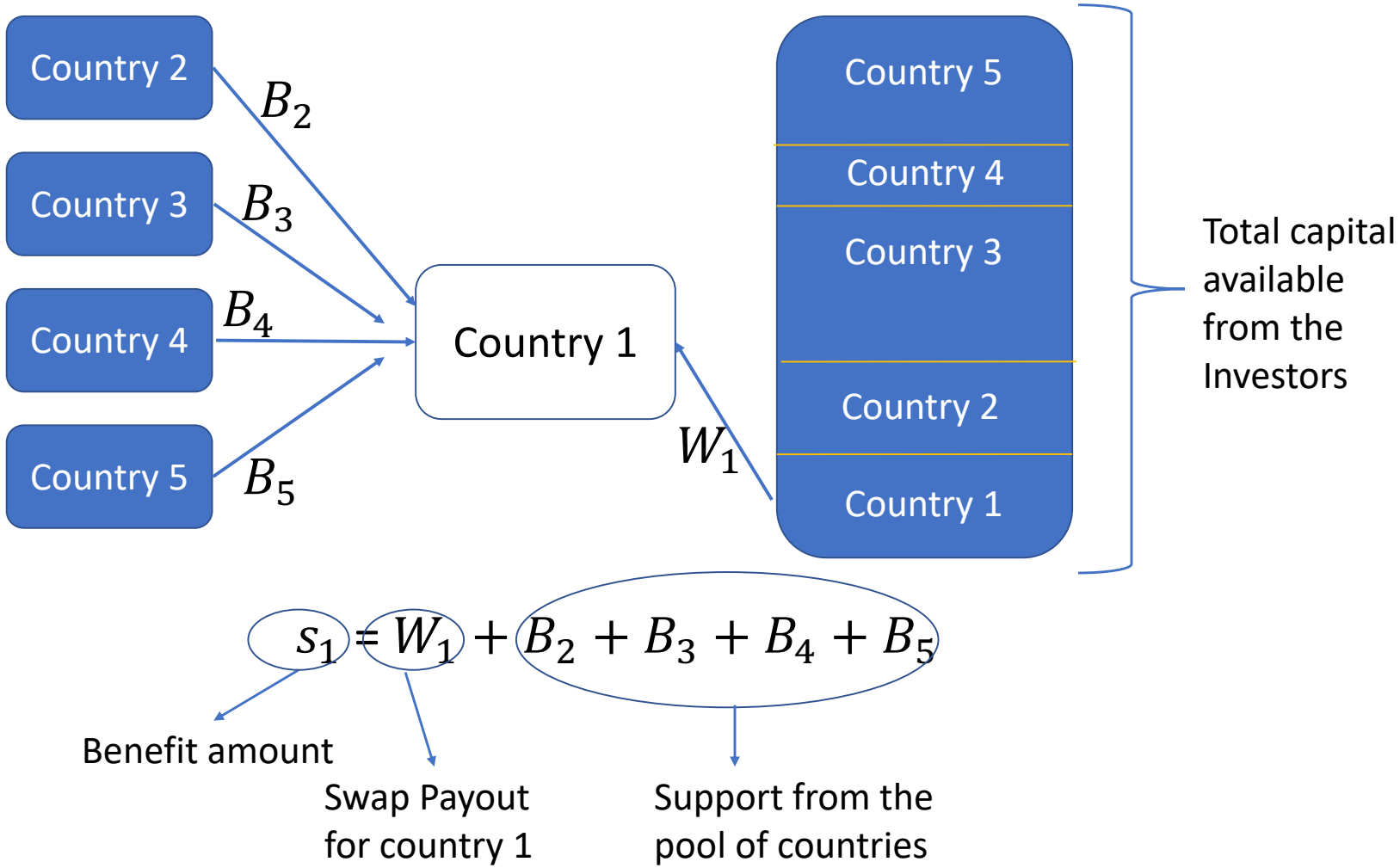


Figure. The payments which are made to country 1 in case a pandemic event occurs and country 1 is entitled to receive the benefit amount.

Modeling issues

- Dependence between the different countries:
  - We cannot assume independence.
  - Comonotonicity (extreme positive dependence)?
  - Copulas provide a more flexible approach, but do we have enough reliable data?
- Uniqueness of the system:
  - Transfers between the countries have to be predetermined.
  - The system has to be 'fair' for all participants.

Fairness

- All participating countries are
  - receiving payments in case they face a pandemic event,
  - support other countries,
  - pay a part of the coupon to the investors.
- Investors are
  - receiving periodical coupon payments;
  - contribute funds to countries in case of a pandemic event.
- Fairness:
  - We balance the cashflows of countries and investors.

Two country case

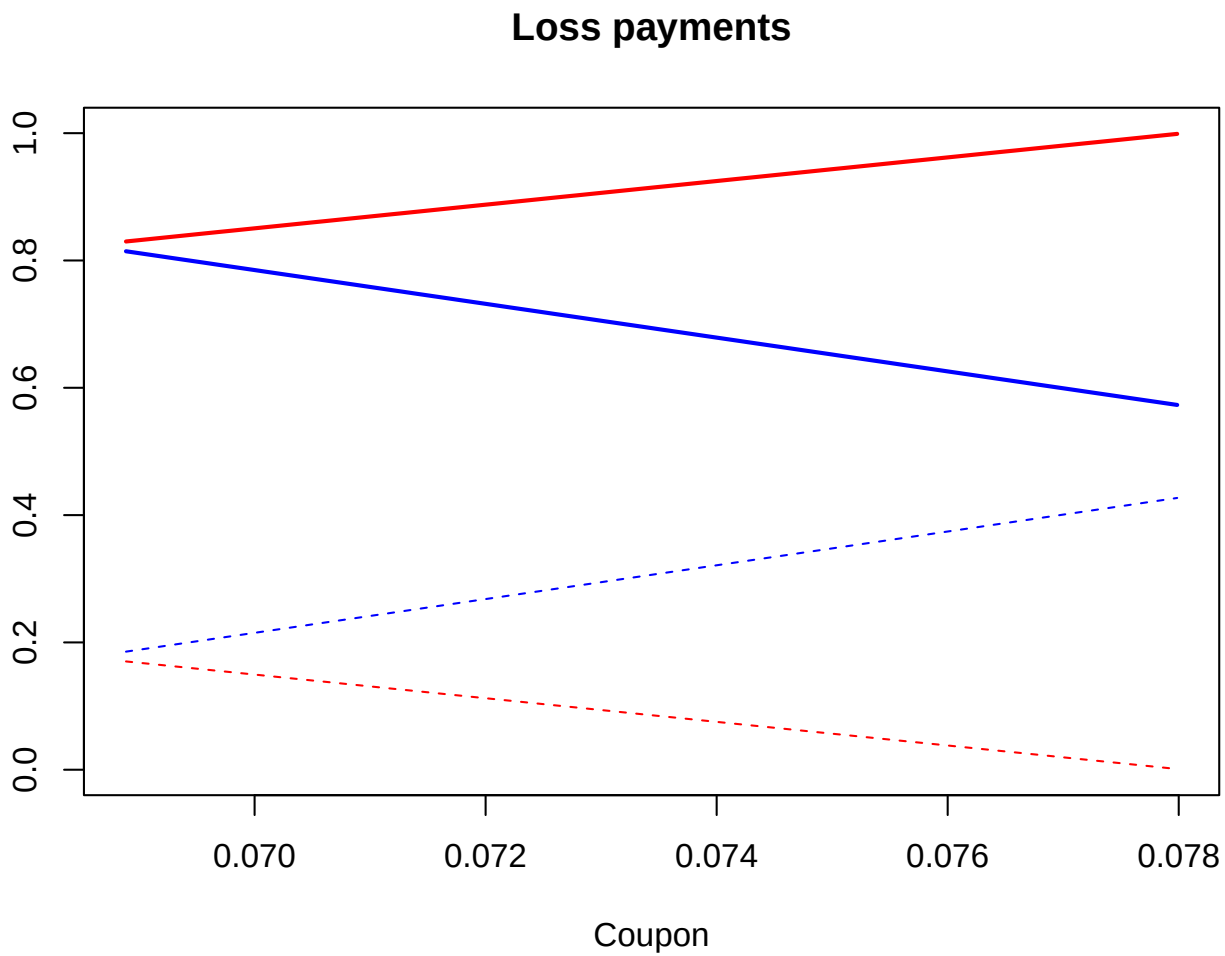


Figure. Solid lines: payments of the investors to country 1 (blue) and country 2 (red). Dashed lines are the payments between countries.

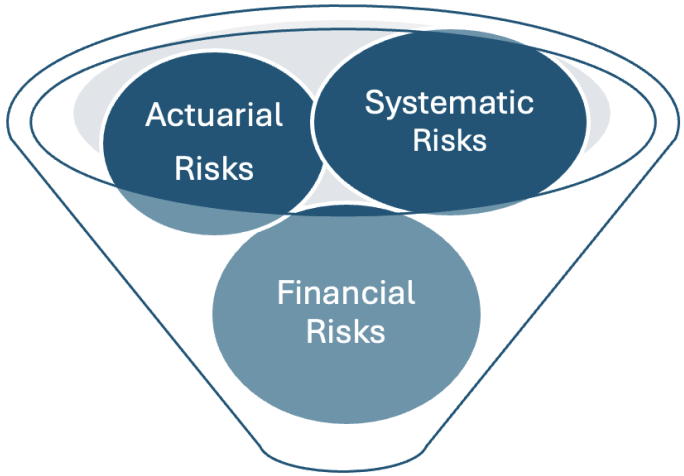
- Consider:

$$S = \text{ aggregate liability.}$$

- Examples:
  - portfolio of flood insurance;
  - aggregate losses due to pandemic risks;
  - portfolio of unit-linked products
- Hybrid claim:

$$S = f\left(\text{Financial risks}, \text{Actuarial risks}, \text{systematic risks}\right).$$

- Question: How to manage liabilities that are complex combinations of different type of risks?
  - Financial risks: Hedging, risk neutral measures.
  - Actuarial risks: diversification.
  - Systematic risks: large capital buffers.
- References:
  - Linders (2023) 'The 3-step hedge-based valuation: fair valuation in the presence of systematic risks', *ASTIN Bulletin: The Journal of the IAA*, 53 (2), 418 - 442.
  - Boonen, Dhaene, Linders & Ling (2025). 'Decomposing hybrid liabilities', Working paper.



Liability S

Hedging portfolio + Systematic part + Diversifiable part

Financial part + Residual part

- Hedging portfolio: Y^h
  - Linear combination of traded assets.
  - We take the mean-variance hedging portfolio.
- Diversifiable part Y^i:
  - Under some conditions on the dependence between the financial market and the actuarial risks,
  - $\frac{\mathrm{Var}[Y^i]}{N} \to 0, \quad \text{as } N \to +\infty.$
- Systematic part Y^s:
  - the part that cannot be hedged and cannot be mitigated by diversification.

Result

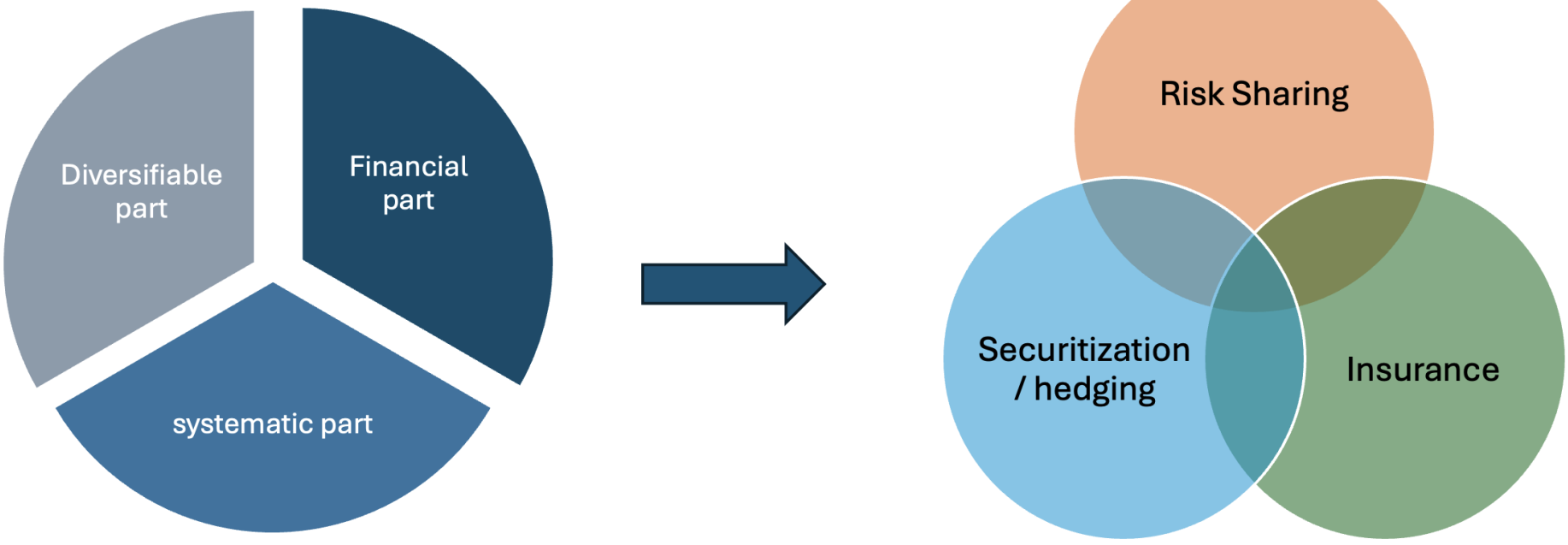
- Result 1: The three parts are uncorrelated:

$$\text{Corr}\left[Y^h, Y^s\right] = \text{Corr}\left[Y^h, Y^i\right] = \text{Corr}\left[Y^s, Y^i\right] = 0.$$

- Result 2: The diversifiable claim is orthogonal to any systematic and financial claim.

4 – Decomposing systematic risks

The next steps...



Thank you for your attention!

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And now, the end is near, and so I face the final curtain ...