DISASTER RISK FINANCING AND INSURANCE PROGRAM (DRFIP)

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Ex-ante evaluation of the cost of alternative sovereign DRFI strategies

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Sovereign DRFI impact appraisal project

Aims to develop a **quantitative** impact appraisal tool that results in headline figures on the **probabilistic impact** of sovereign DRFI programs.

COST

Annual average $ expenditure on SDRFI program

IMPACT

Annual average microeconomic/health impact on people

Research question

- Suppose you assume that a Government's contingent liability to disasters is fixed

- How should a government choose an optimal combination of financial instruments to finance this liability?

Research to date

"There are very few evaluations of sovereign insurance and risk finance schemes. Experts attribute the lack of available knowledge to sensitivities surrounding the issues, donors not wishing to make their reports public, and the relative newness in the use of such financial instruments in the developing world."

Source: Hinds, R. (2013) *Sovereign Insurance and Risk Finance Schemes for Disaster Management*

Using DRFI to build financial resilience

Theoretical model

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Proposed model

The model considers alternative DRFI strategies combining five different potential instruments:

1. Reserves or contingency funds
2. Contingent credit at concessional interest rates
3. Risk transfer such as indemnity or parametric insurance, reinsurance, and catastrophe bonds or swaps
4. Post-disaster budget reallocations
5. Post-disaster borrowing

Model

- Finite number of states $s: \{1,2, \ldots S\}$.
- Level of government disaster expenditure, Θ_s, exogenous for each state s.
- Finite number of financing instruments $\mathrm{i}: \{1,2,3,4,5\}$.
- $\theta_{is} \in \mathbb{R}$ is the amount of disaster expenditure in state s met by instrument i
- $\Theta_s = \sum_{i=1}^{5} \theta_{is}$, the required level of expenditure must be met exactly.
- Two period model. Ex-ante choice of financing strategy, ex-post choice of funds expenditure.

Timeline

Ex-ante decisions

Government decides quantity of each financing instrument ex-ante

a. Size of ex-ante financed reserve fund, $R \geq 0$

b. Size of contingent credit facility, $C \geq 0$

c. State-contingent claim payment schedule for risk transfer, $T_s \geq 0 \forall s$

Timeline

Nature reveals the state of the world

$$s: \{1,2, \ldots . S\}$$

Timeline

Ex-post decisions

Government decides how to fund expenditure so that $\Theta_s = \sum_{i=1}^{n} \theta_{is}$:

a. Reserve fund: $0 \leq \theta_{1s} \leq R$

b. Contingent credit: $0 \leq \theta_{2s} \leq C$

c. Risk transfer: $0 \leq \theta_{3s} \leq T_s$

d. Post-disaster budget reallocations: $0 \leq \theta_{4s} \leq B$ (where B is exogenous cap)

e. Post-disaster borrowing: $\theta_{5s} \in \mathbb{R}$

Cost formulae: reserves

$$\textit{Cost of financing disaster losses through reserves} =$$

$$R\ x\ \frac{1+i}{1+d} - (R - \theta_{1s})\ x\ \frac{1+r}{1+d}$$

R = Size of reserve

θ_{1s} = Loss expenditure met by reserves

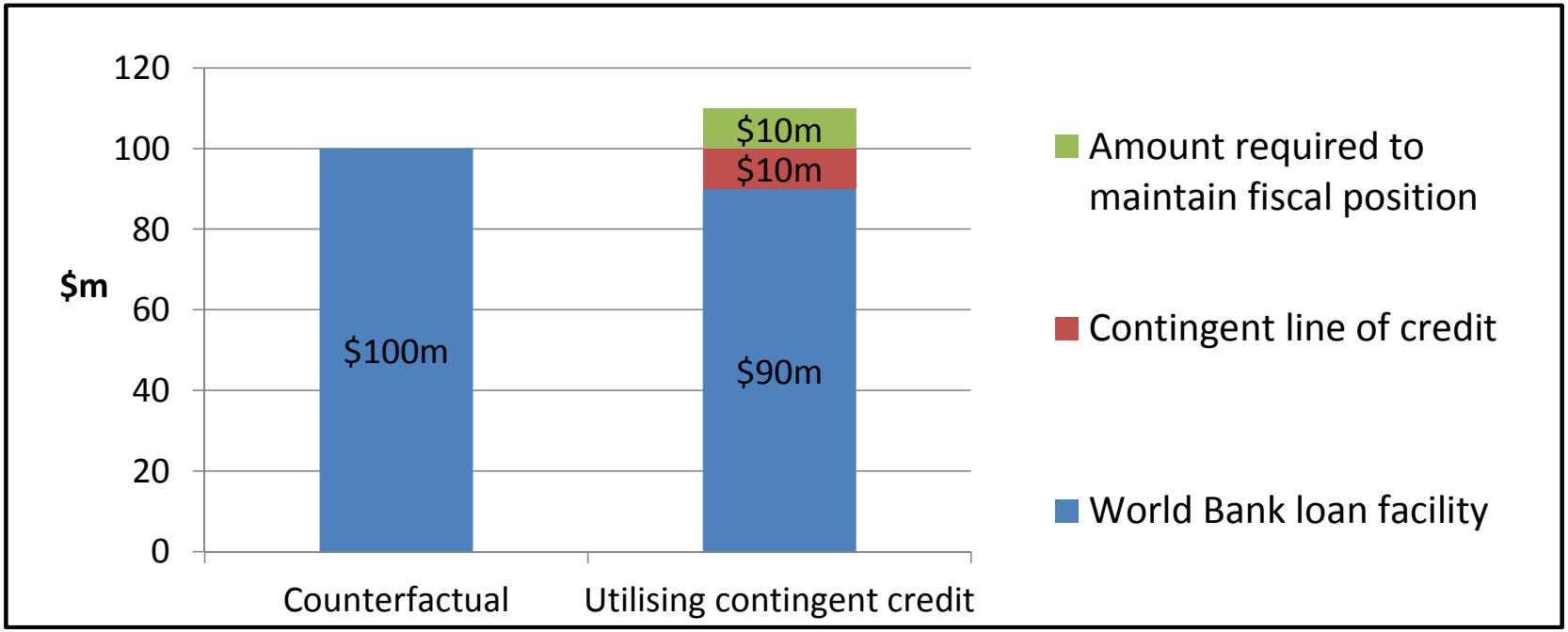
i = interest rate on ex-ante borrowing

d= discount rate

r = investment return

Opportunity cost of concessional contingent credit

- The cost of contingent credit depends on whether the government is crowding out cheap credit



Cost formulae: contingent credit (formula 1)

$$\textit{Cost of financing disaster losses through contingent credit} =$$

$$\theta_{2s}\, x\, \frac{1+c}{1+d} + C\, x\, \frac{i-c}{1+d} + F$$

C = Size of contingent credit

θ_{2s} = Loss expenditure met by contingent credit

c = interest rate on contingent credit

i = interest rate on ex-ante borrowing

d= discount rate

F = arrangement fee

Cost formulae: contingent credit (formula 2)

$$\textit{Cost of financing disaster losses through contingent credit} = \frac{\theta_{2s}\, x\, (1+c)^g}{a_{\overline{t-g|c}}}\, x\, \frac{a_{\overline{t-g|d}}}{(1+d)^g} + F$$

θ_{2s} = Loss expenditure met by contingent credit

c = interest rate on contingent credit

t = term of loan

g = grace period

F = arrangement fee

$a_{\overline{n|i}}$ =The present value of an annuity-immediate is with term ***n*** and interest rate ***i***

Cost formulae: risk transfer

$$Cost\ of\ financing\ disaster\ losses\ through\ risk\ transfer =$$

$$Expected\ loss\ to\ insurance\ x\ Pricing\ multiple$$

Cost formulae: budget reallocation

$$\boldsymbol{Cost\ of\ financing\ disaster\ losses\ through\ budget\ reallocation} =$$

$$\theta_{4s}\boldsymbol{x}\ \frac{\mathbf{1}+\boldsymbol{h}}{\mathbf{1}+\boldsymbol{d}}$$

$\boldsymbol{\theta_{4s}}$ = Loss expenditure met by budget reallocation

h = hurdle rate for government investments

d = discount rate

Cost formulae: post-disaster debt

$$Cost\ of\ financing\ disaster\ losses\ through\ post-disaster\ debt =$$

$$\frac{\theta_{5s} x\ p\ x\ D\ x\ (1+e)^g}{a_{\overline{t-g|e}}}\ x\ \frac{a_{\overline{t-g|d}}}{(1+d)^g} + \frac{\theta_{5s} x\ (1-p)\ x\ (1+e)^g}{a_{\overline{t-g|e}}}\ x\ \frac{a_{\overline{t-g|d}}}{(1+d)^g}$$

θ_{5s} = Loss expenditure met by budget reallocation

p = Proportion of losses relating to disaster relief and recovery

D = Delay factor applied to loss

e = Interest rate charged on amounts borrowed

d = Discount

t = Term of repayment including grace period

g = Grace period

$a_{\overline{n|i}}$ =The present value of an annuity-immediate is with term ***n*** and interest rate ***i***

Lemma 1

Ex-post efficiency is achieved by the government expending funds from each instrument consecutively.

- For any given state of the world a government will spend in a layered approach, expending the cheapest funds first.
- This arises from linearity assumptions over cost function (e.g. cost of ex-post credit does not depend on total amount of ex-post credit)

Lemma 2

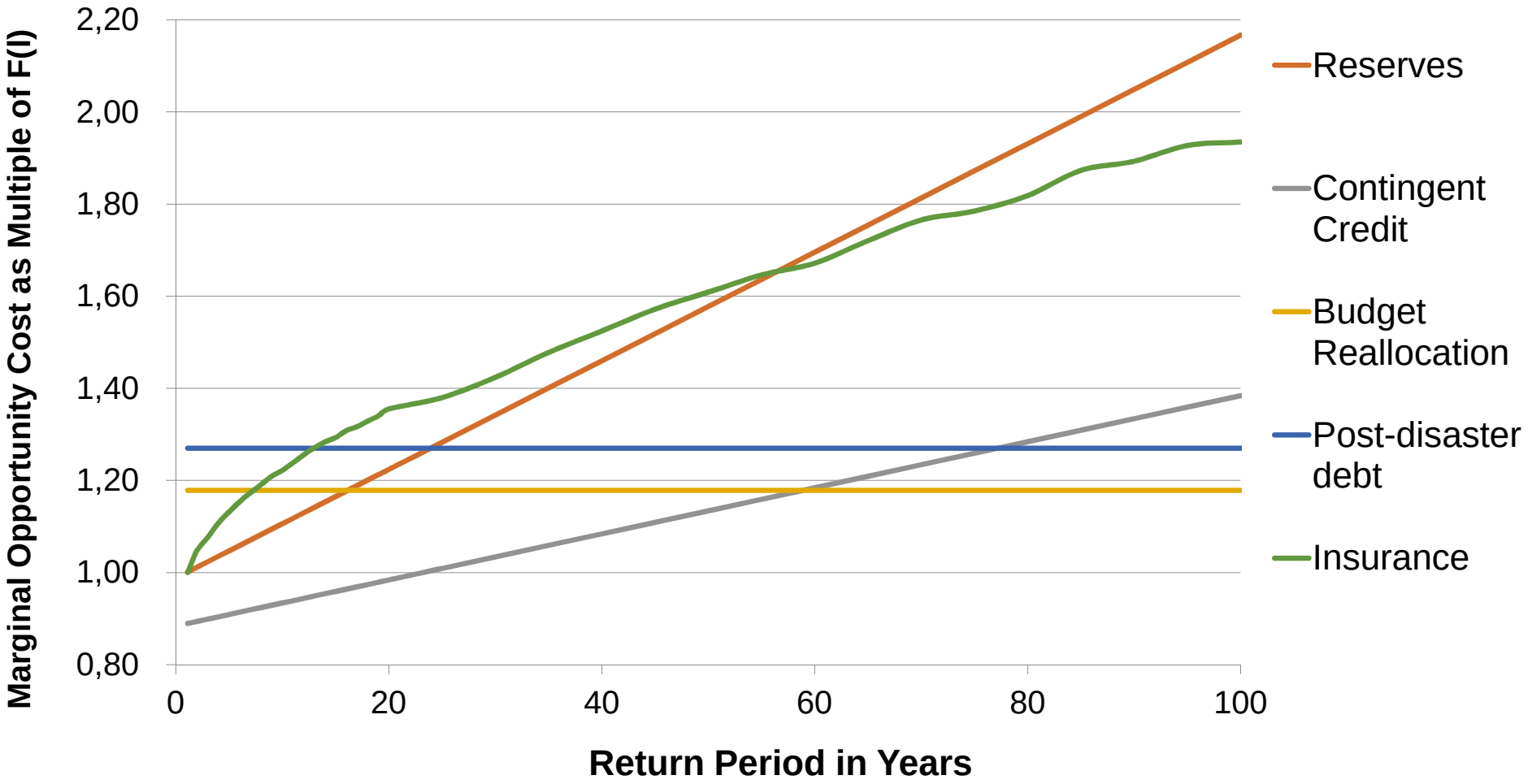
The way expenditure is financed does not depend on the state only the amount of expenditure and income from risk transfer

- The income from parametric risk transfer will depend on the loss according to the index upon which the product is based. This will determine the expenditure met by the other instruments.

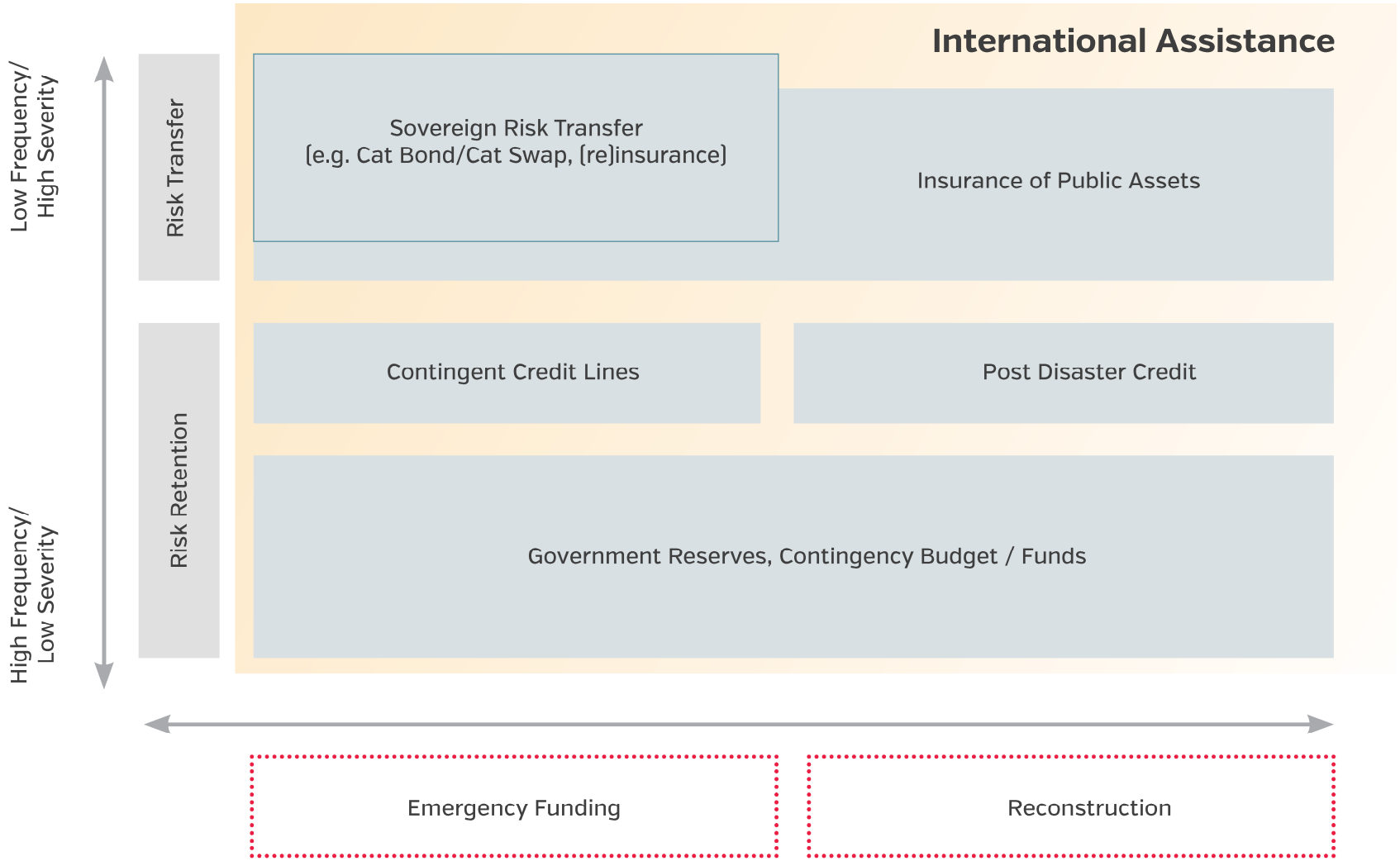
Theorem 1

If the government's objective is to minimise expected opportunity cost, ex-ante efficiency is achieved by the government implementing a layered financing strategy, with each layer determined by the instrument with the lowest marginal opportunity cost in that interval.

Theorem 1


Marginal Opportunity Cost as Multiple of F(I)
2,20
2,00
1,80
1,60
1,40
1,20
1,00
0,80
0
20
40
60
80
100
Return Period in Years
Reserves
Contingent Credit
Budget Reallocation
Post-disaster debt
Insurance

Theorem 1 is consistent with layered approach promoted by WBG/GFDRR



Applications

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Strategies considered

- ***Base case:*** Mixture of reserves, post-disaster budget reallocations and emergency borrowing

- ***Strategy A:*** Addition of concessionary contingent credit
- ***Strategy B:*** Addition of parametric risk transfer
- ***Strategy C:*** Addition of both

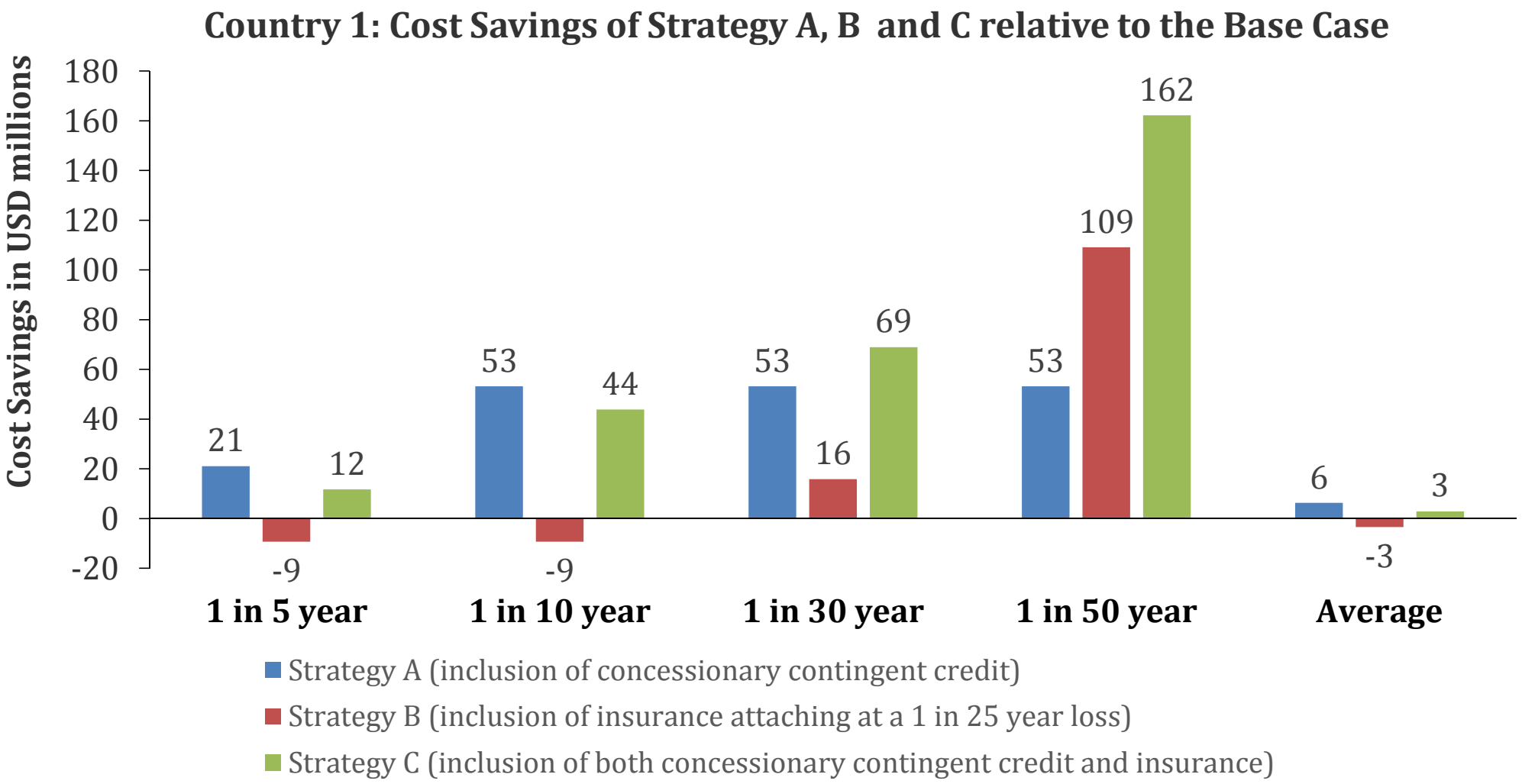
Country 1

- Large diversified economy
- High recurrent risk of disasters from both earthquakes and tropical cyclones (22 cyclones a year on average)
- No change in marginal interest rate is expected post-disaster
- No opportunity cost of using concessionary contingent credit
- Significant World Bank engagement to clarify liabilities and develop DRFI solutions

Country 1: Alternative SDRFI strategies

- ***Strategy A:*** Addition of $500m concessionary contingent credit from the World Bank
- ***Strategy B:*** Addition of parametric catastrophe bond, attaching at a 1-in-25 year loss with maximum payout of $300m.
- ***Strategy C:*** Addition of both

Country 1 results



Implications for government decision-making

- The most cost-effective strategy depends on the objectives of the government:
  - If the government prioritizes protection against frequent events (e.g. less than 1-in-10 years) Strategy A is cheapest
  - If a government also requires protection against severe events, Strategy C is cheapest.

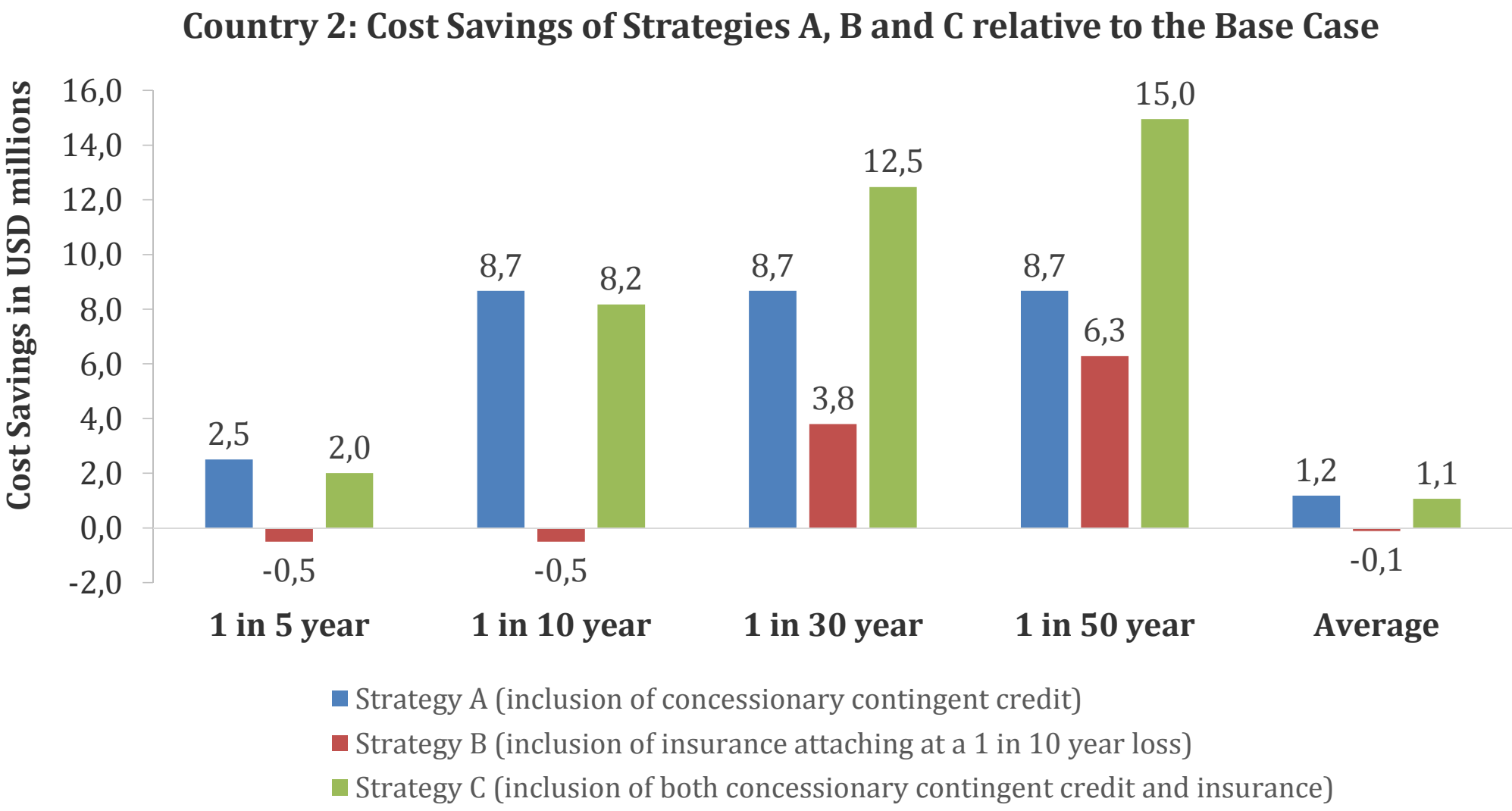
Country 2

- Small island developing state (SIDS), heavily dependent on service and tourism industries
- Low recurrent risk of disasters but highly exposed to catastrophic cyclone events
- Reasonable debt to GDP ratio, but disaster could have big cost relative to GDP
- Borrowing after a large disaster would be slow and costly
- There exists an opportunity cost of using concessionary contingent credit
- Significant World Bank program to establish a parametric insurance risk pool in the region

Country 2: Alternative SDRFI strategies

- ***Strategy A:*** Addition of $20m concessionary contingent credit from the World Bank
- ***Strategy B:*** Addition of parametric insurance, attaching at a 1-in-10 year loss with maximum payout of $9m.
- ***Strategy C:*** Addition of both

Country 2 results



Remarks on results

- Both case studies are consistent with the theoretical results. In both cases a tiered strategy of different financing instruments offers the greatest savings
- Ex-ante financing instruments lead to greater savings at higher return periods for Country 2 due to the high cost of borrowing in a post-disaster environment

Conclusion

- The framework looks only at one part of evaluating sovereign DRFI strategies, but results can be powerful and useful
- Results are intuitive and fairly robust to parameter assumptions
- A key assumption in this framework is that a government's contingent liability is known – to get a complete picture this assumption must be relaxed