The macroeconomic effects of the climate insurance protection gap

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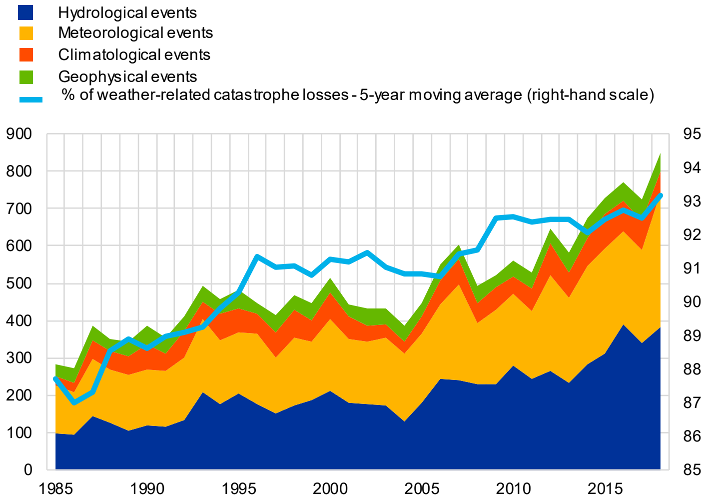
Natural hazards, but man-made disasters

- Full impact depends not just on natural trigger, but also on exposure and vulnerability
- Projecting impact of climate change means considering not just the hazard, but other factors of mitigation and exacerbation

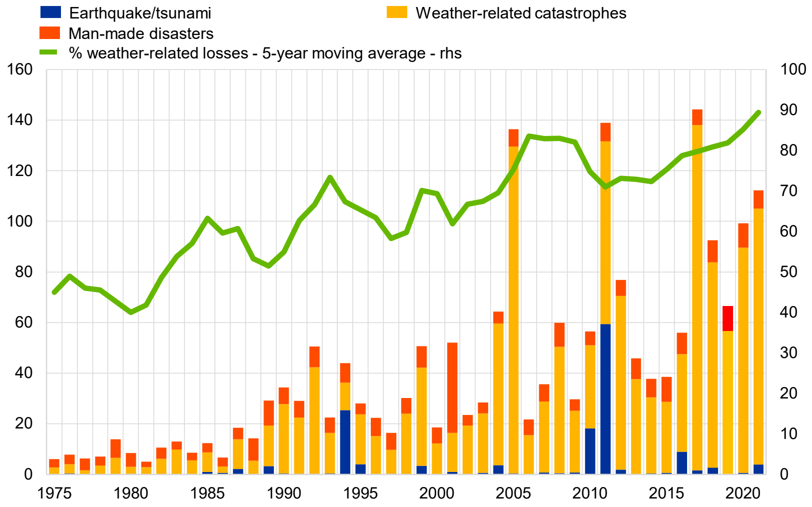
Number of relevant natural loss events worldwide

(1985-2018; left-hand scale: number of events; right-hand scale: percentages)



Global insured catastrophe losses

(1985-2021; left-hand scale: USD billions; right-hand scale: percentages)



Sources: Swiss Re Institute, Munich Re NatCatService and ECB calculations.

The role of insurance

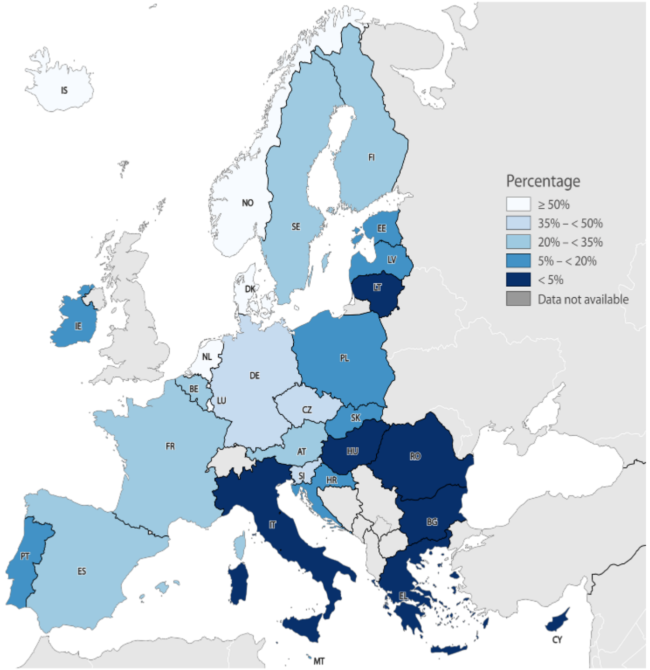
Insurance is an important source of resilience

- Insurance appears to help speed up reconstruction
- Macro and micro evidence on the benefits of insurance (Von Peter et al., 2024; Poontirakul and Noy, 2017)

Already a substantial protection gap

- Only 1/4 of climate-related catastrophe losses are insured in Europe
- This insurance protection gap could widen as a result of climate change

Average share of insured economic losses caused by weather-related events in Europe



Source: EIOPA dashboard on insurance protection gap for natural catastrophes, European Environment Agency CATDAT.

Contribution

1. Theoretical model

Demonstrates short-term protective benefit of insurance

2. Empirical analysis

Provides evidence of how insurance has helped mitigate impact of past disasters

3. Scenarios of future impact of disasters

Estimates the impact of warming coincide and wider protection gap on GDP

4. Policy discussion

Provides policy options to reduce the climate insurance protection gap

1. Modelling output in the face of natural disasters and climate change

- We model output as a function of capital, temperatures and natural disasters
- Capital is sensitive to long-run changes in temperatures and to intermittent but highly destructive natural disasters
- Damages upon a disaster can be mitigated by insurance, which is also sensitive to changes in temperatures

$$Y = K\omega_0 e^{-\omega(T-T^*)}\left[1-\left(1-We^{-\psi(T-T^*)}\right)(1-Z)\right]$$

Symbol	Parameter	Symbol	Parameter	Symbol	Parameter
Y	Output	Z	Share of undamaged capital upon disaster	ω_0	positive constant
K	Capital	W	Share of insured damaged capital	ω	sensitivity of physical capital to climate change
T	temperature	T^*	historical norm of temperature	ψ	sensitivity of disaster probability to climate change

1. Modelling output in the face of natural disasters and climate change

Impact of natural disasters on capital

When disasters hit, output is reduced by the uninsured share of damaged capital, the protection gap

$$Y = K - (1 - W)(1 - Z)K$$

The probability of disasters is fixed.

Our findings

1. Insurance can help mitigate the macro-financial and welfare impact of catastrophes

1. Modelling output in the face of natural disasters and climate change

Impact of climate change on capital

In the long-run, capital is sensitive also to changes in climate variables like T (Kahn et al, 2021)

$$Y = K\omega_0 e^{-\omega(T-T^*)}[1-(1-W)(1-Z)]$$

We focus here on the direct impact of global warming on capital and keep the probability of disasters fixed.

Our findings

1. Insurance can help mitigate the macro-financial and welfare impact of catastrophes
2. Climate change is likely to have an increasingly negative impact on welfare

1. Modelling output in the face of natural disasters and climate change

Impact of climate change on insurance

Climate change affects also the cost and availability of insurance, and the protection gap can widen

$$Y = K\omega_0 e^{-\omega(T-T^*)}[1-(1-We^{-\psi(T-T^*)})(1-Z)]$$

The frequency and severity of disasters depend on climate change.

Our findings

1. Insurance can help mitigate the macro-financial and welfare impact of catastrophes
2. Climate change is likely to have an increasingly negative impact on welfare
3. Impact is likely to be magnified by a reduction in insurance coverage

2. Empirical evidence on the macroeconomic impact of the protection gap

Abstracting from climate change, our model implies that the GDP growth rate of country *c* at time *t* is a function of damages from natural disasters and insurance

$$GDP\ growth\ rate_{c,t} = \beta_1 * damaged\ capital_{(\%GDP)c,t} + \beta_2 * Share\ of\ insured\ damages_{c,t} * damaged\ capital_{(\%GDP)c,t} + CountryFE_c + TimeFE_t + \epsilon_{c,t}$$

$\beta_1 < 0$ damages from natural disasters negatively affect GDP growth

$\beta_2 > 0$ insurance mitigates this impact

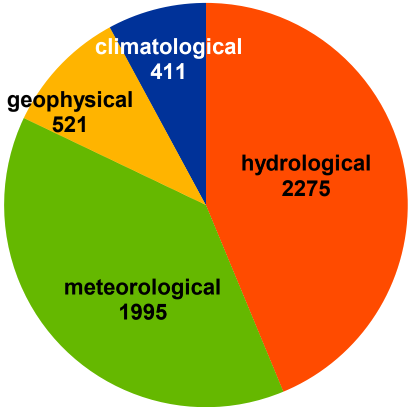
2. Empirical evidence on the macroeconomic impact of the protection gap

Dependent variable: quarterly real GDP growth rates from OECD for 45 countries

Explanatory variables: disaster data from EMDAT

- Data on over 5000 disaster events since 1996, but insured only for 657 events, on average larger
- Imputation to obtain over 2000 events with insured/uninsured split
- The average disaster cost is 0.16% of GDP, while the average share of insured losses is 47%.

	Damages	Insured	Uninsured	# events
Original dataset				
Information on (un)insured losses	$2.1 tr	$0.7 tr	$1.4 tr	657
Information on total damage only	$0.6 tr	-	-	1654
No information on damage	-	-	-	2891
Total				5202
Dataset with imputed values				
Information on (un)insured losses	$2.7 tr	$0.9 tr	$1.8 tr	2066
Information on total damage only	<$0.1 tr			245



Sources: EM-DAT, OECD and authors' calculations.
Notes: values in constant 2010 USD

2. Empirical evidence on the macroeconomic impact of the protection gap

Sample	(1) Original	(2) Imputed	(3) Original	(4) Imputed
Damages as a share of GDP (%)	**-0.24***	**-0.23***	**-0.22***	-0.18
	(0.07)	(0.05)	(0.08)	(0.11)
Damages as a share of GDP *	**0.0036***	**0.0037****	**0.0034****	**0.0027***
Share of insured losses	(0.06)	(0.04)	(0.04)	(0.08)
Lag of GDP growth			-0.042	-0.015
			(0.68)	(0.88)
Country fixed effects	Y	Y	N	N
Quarter fixed effects	Y	Y	Y	Y

Notes: Panel regression using standard errors clustered by country. *, **, *** denote significance at 10, 5 and 1% confidence level. P-values are reported in parentheses.

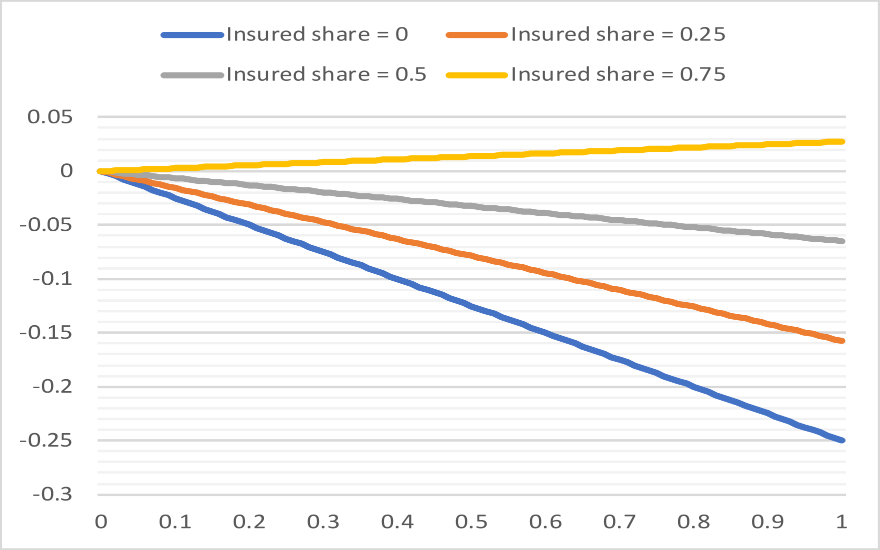
2. Empirical evidence on the macroeconomic impact of the protection gap

The higher the insurance coverage, the lower the impact of disasters on GDP growth:

- Following a disaster loss of 1% of GDP, the quarterly GDP growth rate is estimated to decline by **0.25 pp** in the absence of insurance coverage.
- If half the losses are insured, the GDP growth rate falls by **0.06 pp**.
- For unusually high shares of insured losses (75%), estimates suggest an increase in GDP growth by **0.04 pp**, reflecting swift reconstruction activity

Impact of natural disasters on quarterly GDP growth rate by size of damage and insured share

(x-axis: total damage as a share of GDP (in %); y-axis: simultaneous impact on quarterly GDP growth rate in percentage points)



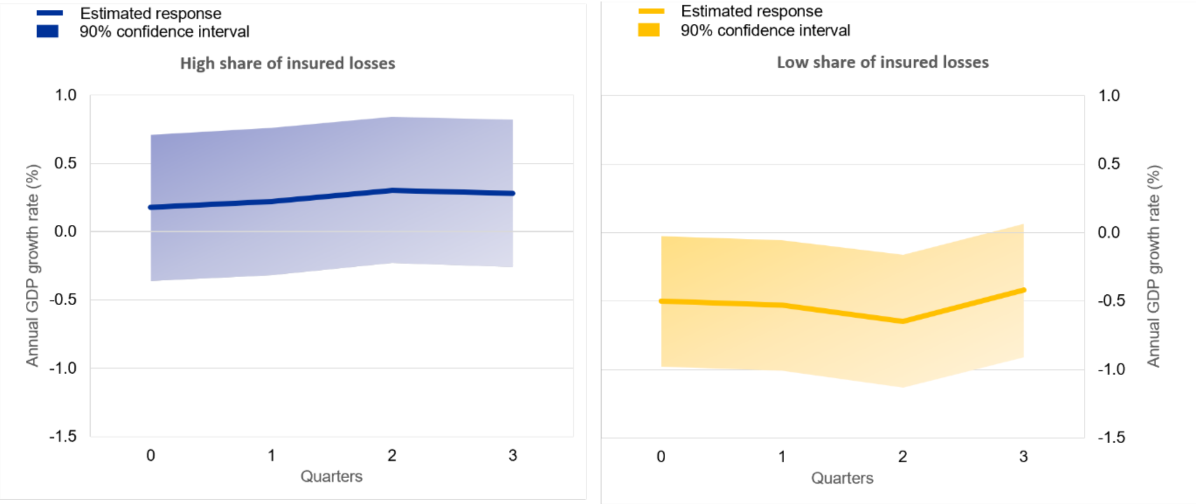
Sources: EM-DAT, OECD and authors' calculations.

2. Empirical evidence on the macroeconomic impact of the protection gap

- GDP growth rates decrease following large-scale disasters, when insurance coverage is low.
- Insurance supports GDP growth after disasters, as (prompt) payouts support reconstruction.

Impact of insured vs uninsured losses from a large-scale disaster on annual GDP growth rate

(y-axis: impact on annual GDP growth rate (%); predictions up to three quarters ahead after a large-scale disaster)



Sources: EM-DAT, OECD and authors' calculations.

3. Impact on GDP under climate change and protection gap scenarios

Moderate and severe climate scenarios: 2 and 3-degree temperature increases by 2100

JRC PESETA IV estimates based on IPCC climate change scenario: Annual GDP losses from disasters are projected to increase by 2.5-4.5 times by the end of this century

Expected annual damages from climate-related catastrophes

EU and UK (2015 values)	Baseline (1981-2010)	2100 1.5° C	2100 2° C	2100 3° C
Windstorm	4594	11260	11393	11422
Droughts	9048	24723	31457	45380
River flood	7809	24072	33081	47824
Costal flood	1400	10900	110600	239400
Total	22851	70955	186531	344026
Total	0.17%	0.19%	0.41%	0.76%

The role of insurance protection gap

We project our empirical estimates forward to assess the future impact of natural disasters on European GDP, under different levels of insurance protection gap

Sources: JRC PESETA IV and authors' calculations.

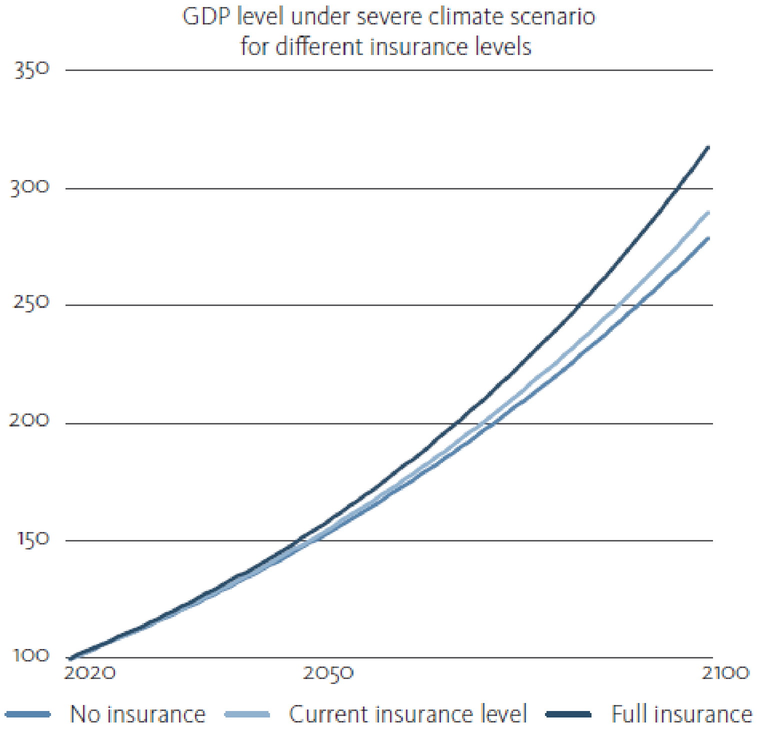
Notes: values in million EUR. Last row as share of GDP.

3. Impact on GDP under climate change and protection gap scenarios

Our findings

- Differences in insurance coverage could have significant economic effects
- By 2050, the difference between full insurance and no insurance is over 3% under the severe scenario
- By the end of the century, the difference widens to around 14%

Caveats: significant uncertainty around estimates 30-80 years into the future; no adaptation or mitigation measures



Sources: JRC PESETA IV and authors' calculations.

4. Conclusions and policy implications

- Climate change has the potential to impair the stable provision of insurance services and credit → impact on households, firms, banks and sovereigns.

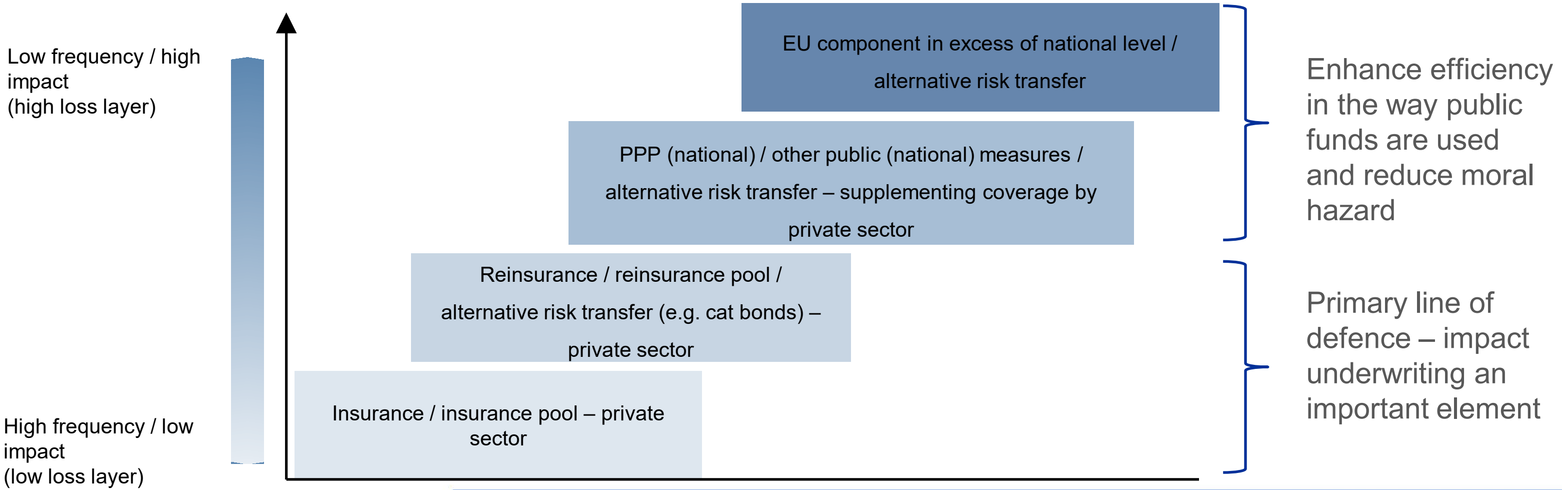
- Data gaps on climate loss and (un)insured losses need to be closed.

- Policy should aim to reduce protection gap while incentivising adaptation and risk reduction from policyholders.

4. Conclusions and policy implications

Policy options to reduce the climate insurance protection gap

- Improve private insurance solutions via impact underwriting
- Enhance risk assessment, risk prevention and risk transfer to address limits of the private insurance market and provide a public backstop for more frequent hazards, e.g. via public-private partnerships and capital markets
- Include a European public component, to promote adaptation and complement existing instruments



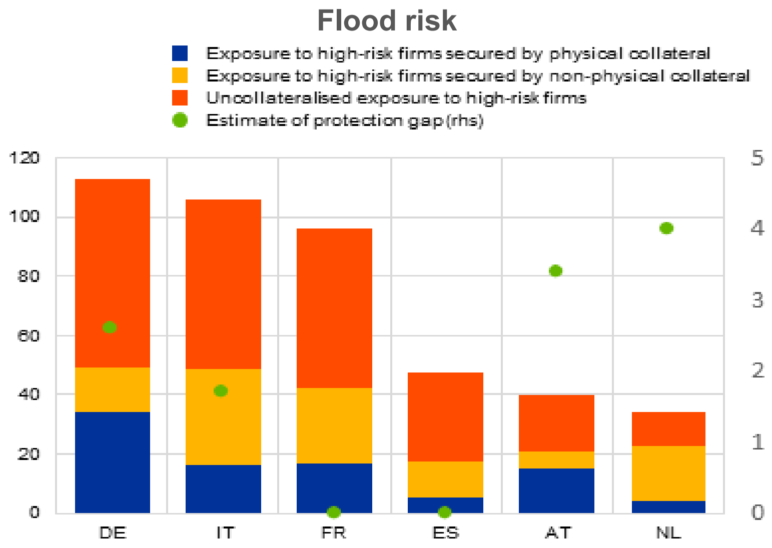
THANK YOU!

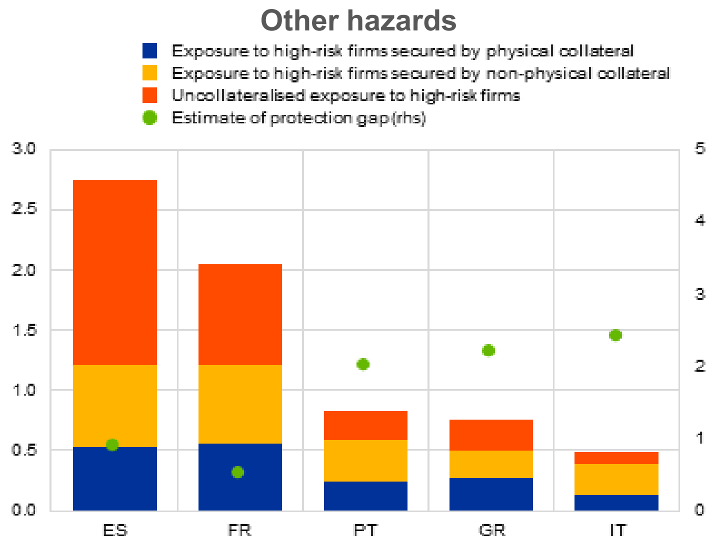
Background

Bank-insurance nexus

Exposure of euro area banks towards high-risk firms for floods and all other hazards

(lhs: euro billions; rhs: protection gap score)





Sources: EIOPA Dashboard, Anacredit, 427 and ECB calculations.
Notes: Credit exposures to NFCs above €25,000 are considered; NFC location used to assign risk levels refers to the head office and the location of subsidiaries of the largest listed firms. Only NFCs domiciled in areas that are classified as high-risk or red flag are included. The country breakdown refers to the firm's domicile. The total collateral value at instrument level is capped at the value of the instrument. The protection gap of firms is proxied by the protection gap score of its country.

Impact of natural disasters on capital

Output can be spent in consumption, investment and insurance premiums

$$Y = C + (I + \Phi) + P$$

where $\Phi(I, K)$ captures the effects of depreciation and costs of installing capital.

Capital is not perfectly liquid → C and I are not perfectly substitutable

There are two types of investments

$$I = I_R + I_N$$

The marginal return on reconstruction is higher than the marginal return on new capital

→ After disasters, investment is first devoted to replacing the destroyed capital.

→ But there may be financial, technical and institutional constraints

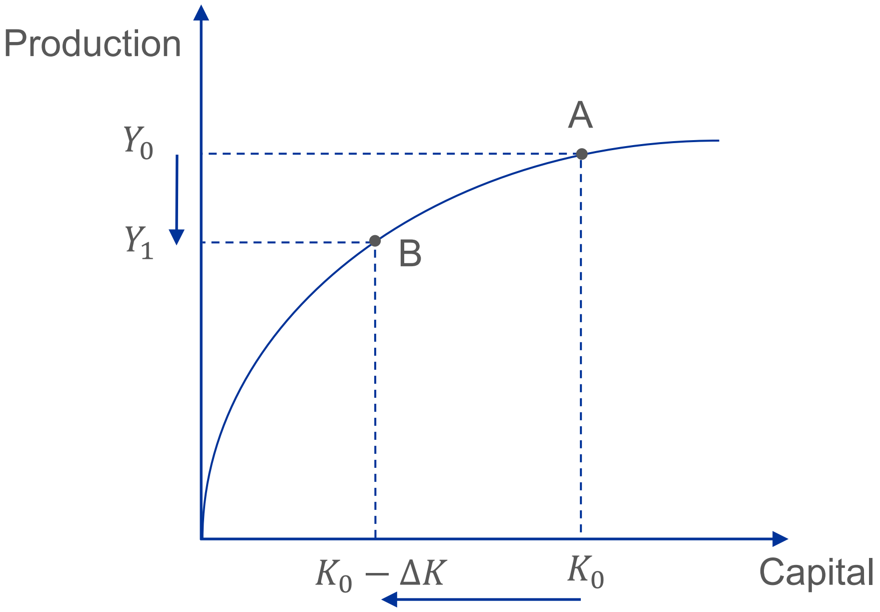
Symbol	Parameter	Symbol	Parameter
C	consumption	I	investment
P	insurance premiums	I_R	investment towards reconstruction
$\Phi(I, K)$	cost function	I_N	investment into new capital

Impact of natural disasters on capital

In a standard macroeconomic model, the (replacement) value of an asset is equal to its future output.

→ Losing €1 in asset is equivalent to losing €1 in (discounted) output.

This is valid only if capital can be freely and instantaneously reallocated



See [Hallegatte and Vogt-Schilb, 2019]

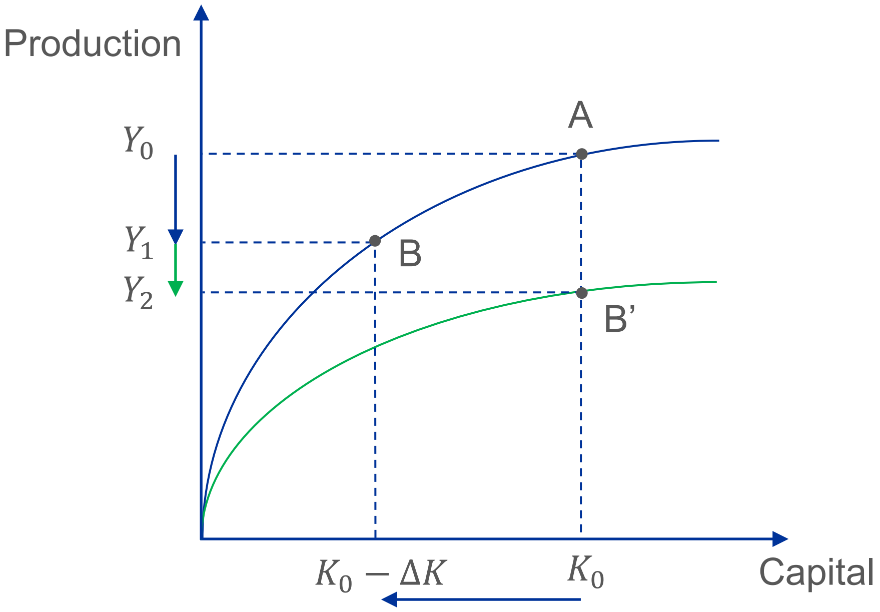
Impact of natural disasters on capital

Without reallocation and reconstruction, the impact of a disaster is the sum of:

- a reduction in the stock of capital (drop in K): Y_0 to Y_1
- a misallocation of the residual stock compared to optimal (drop in TFP): Y_1 to Y_2

→Over the short run, losing €1 in asset is equivalent to losing €2 in (discounted) output

Reconstruction has a higher marginal returns than other investments



See [Hallegatte and Vogt-Schilb, 2019]

Impact of natural disasters on capital

All investment is devoted to reconstruction and output losses are reduced to zero exponentially with time R. Output losses after t_0 are:

$$\Delta Y(t) = \mu \Delta K e^{-(t-t_0)/R}$$

The duration of the reconstruction phase determines the macroeconomic cost.

If damages can be repaired immediately, output losses will be zero, but consumption will be reduced to reconstruct ($\Delta C = \Delta K$). If there is no reconstruction, output losses will be permanent (R = ∞) and will be absorbed by consumption ($\Delta C = \Delta Y = \mu \Delta K$).

→ The net present value of consumption losses is larger than direct losses when reconstruction takes some time.

Symbol	Parameter	Symbol	Parameter
R	time of reconstruction	μ	average productivity of capital, Y/K

Impact of natural disasters on capital

The price of insurance claims is modelled as

$$p(W, Z) = \alpha\pi(1 - Z)W$$

where α reflects the insurance risk premium, $\pi(1 - Z)$ is the expected damage of a disaster and $\pi(1 - Z)W$ is the amount of damage insured.

We assume that if the probability of a catastrophe increases, the demand for insurance – and therefore K_i – will also increase as the benefit of insurance will be larger. But insurance supply is limited by insurers' risk aversion.

Symbol	Parameter
α	insurance risk premium

Impact of natural disasters on capital

The capital stock is subject to stochastic fluctuations and jumps, and evolves as

$$dK_t = \Phi\,(I_{t-}, K_{t-})dt \;+ \sigma K_{t-} dB_t - (1 - W)(1 - Z)K_{t-} dJ_t$$

where J is a jump process reflecting the probability of a natural catastrophe.

When the jump arrives, it destroys K_d, which is a fraction $(1 - Z)$ of capital K. In the presence of insurance, this fraction is reduced by $(1 - W)$ times.

The expected growth rate is then

$$\bar{g} = \phi(i^*)dt \;- \pi\, E(1 - W)(1 - Z)$$

Symbol	Parameter	Symbol	Parameter
B	standard Brownian motion	σ	diffusion volatility of the capital stock growth
J	jump process with fixed but unknown arrival rate π	$\bar{g}$	expected growth rate
t_-	pre-jump time	i^*	optimal investment-capital ratio