# Resilience and Macrofinance

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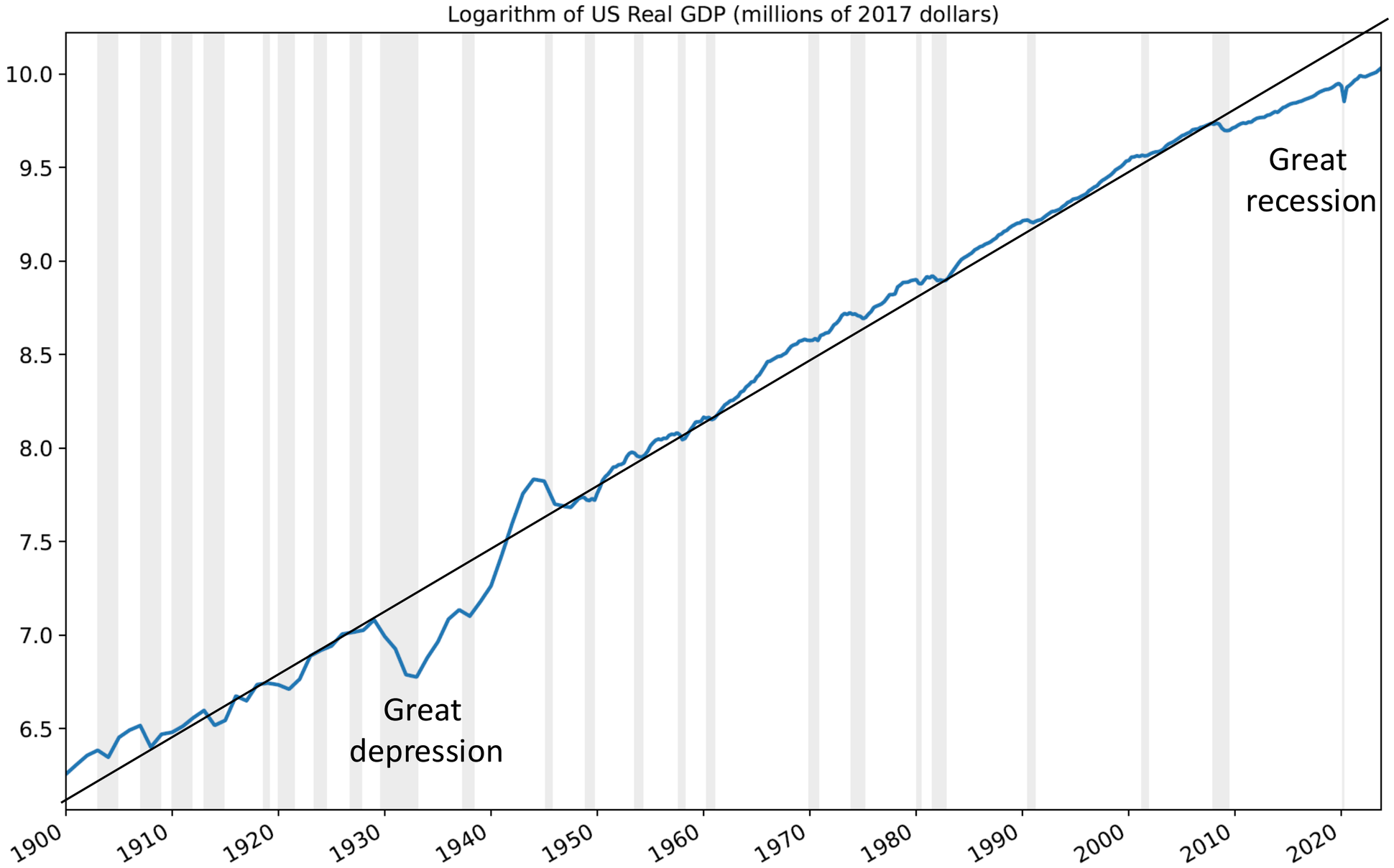
# Real US GDP in log scale: Financial Crises as Resilience Killers



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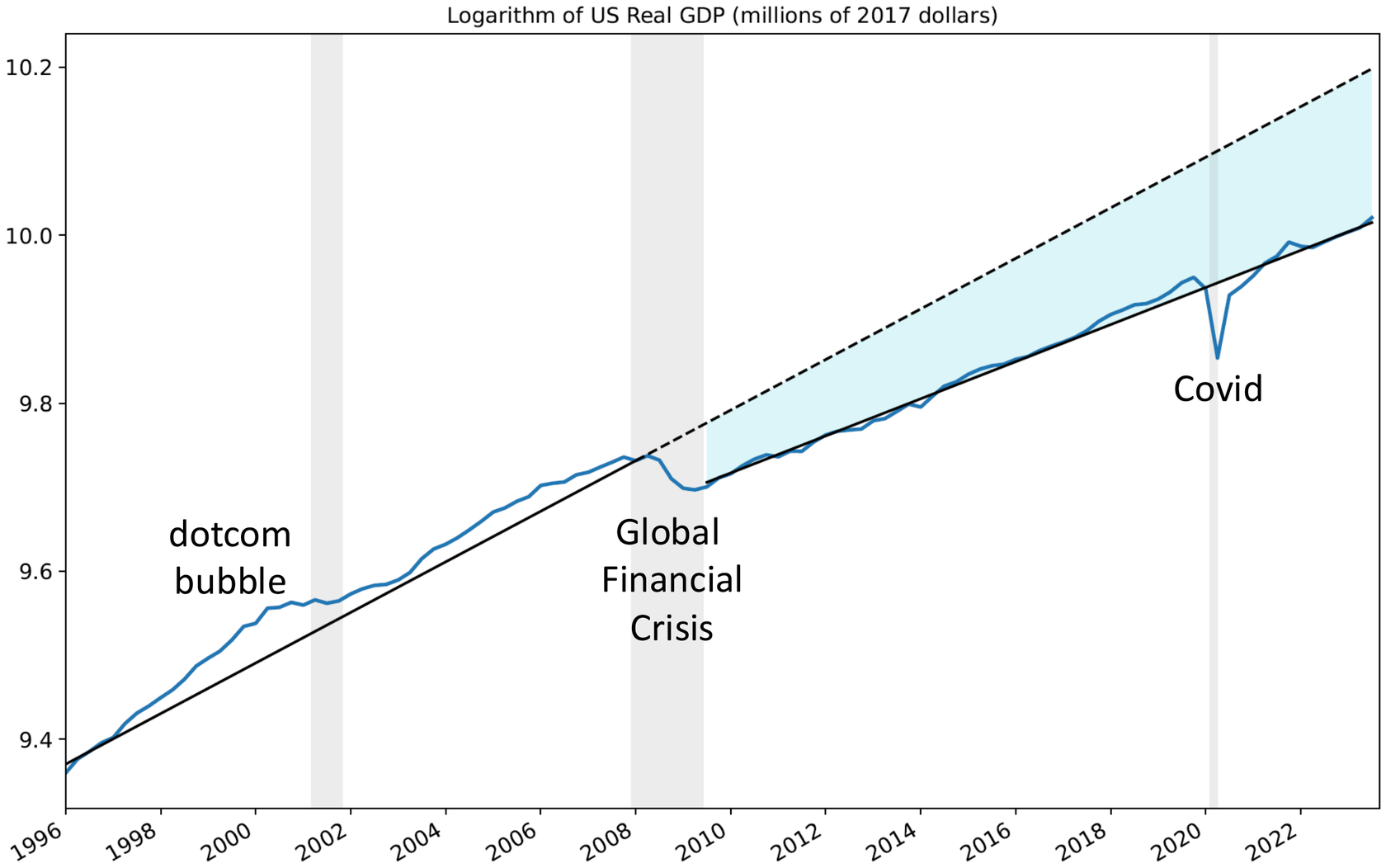



- Gap in 2024 alone ≈ $3-4 trillion ($26 minus $22)
- Gap over the years ≈ shaded area

- Non-resilience matters in
  - Levels
  - Growth rates

- After financial crises

- Long-run Risk = non-resilience in growth rates

# Macrofinance Models

- Stochastic dynamical system
- Agents **maximize** concave utility function – are risk averse
- "**System of Optimizers**"
  - Weights of type of agents change **+ behavior adjust**
  - Behavior depends on forecasted processes (rational expectations)
    - Future paths of **mean** and **risk**
  - Fully understand all exogenous and endogenous processes

- Financial frictions **limit risk sharing**
  - E.g. $N$-dimensional Brownian Motions, but contracts on contingent on $K < N$ Brownians

- Simplest version
  - 2 types: bankers and households
  - State variable: "wealth share" of bankers (endogenous process)

# Roadmap

## 1. Resilience

- Definition, Measure due to Behavioral Changes
- Risk vs. Resilience Management
- Macro vs. Micro-Resilience

## 2. Macrofinance Models

- First Generation: linear, mean-reversion
- Second Generation: tipping points, traps with escapes, volatility/risk dynamics …

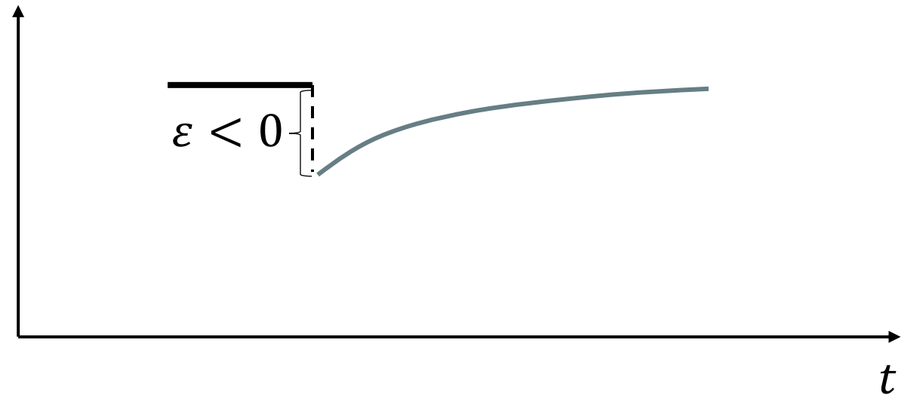
## 3. Macrofinance Themes and Resilience

- Safe Assets
- Government, Monetary and Fiscal Policy
- Financial Intermediary Sector and Financial Resilience
- Heterogeneity within Financial Sector

# Resilience

- A stochastic process (cash flow, return, GDP-level, -growth process) is **resilient**
  if the adaptability of **agents' behavior** leads it to bounce back after a shock to system.
  (portfolio, economy)

**Permanent shock**



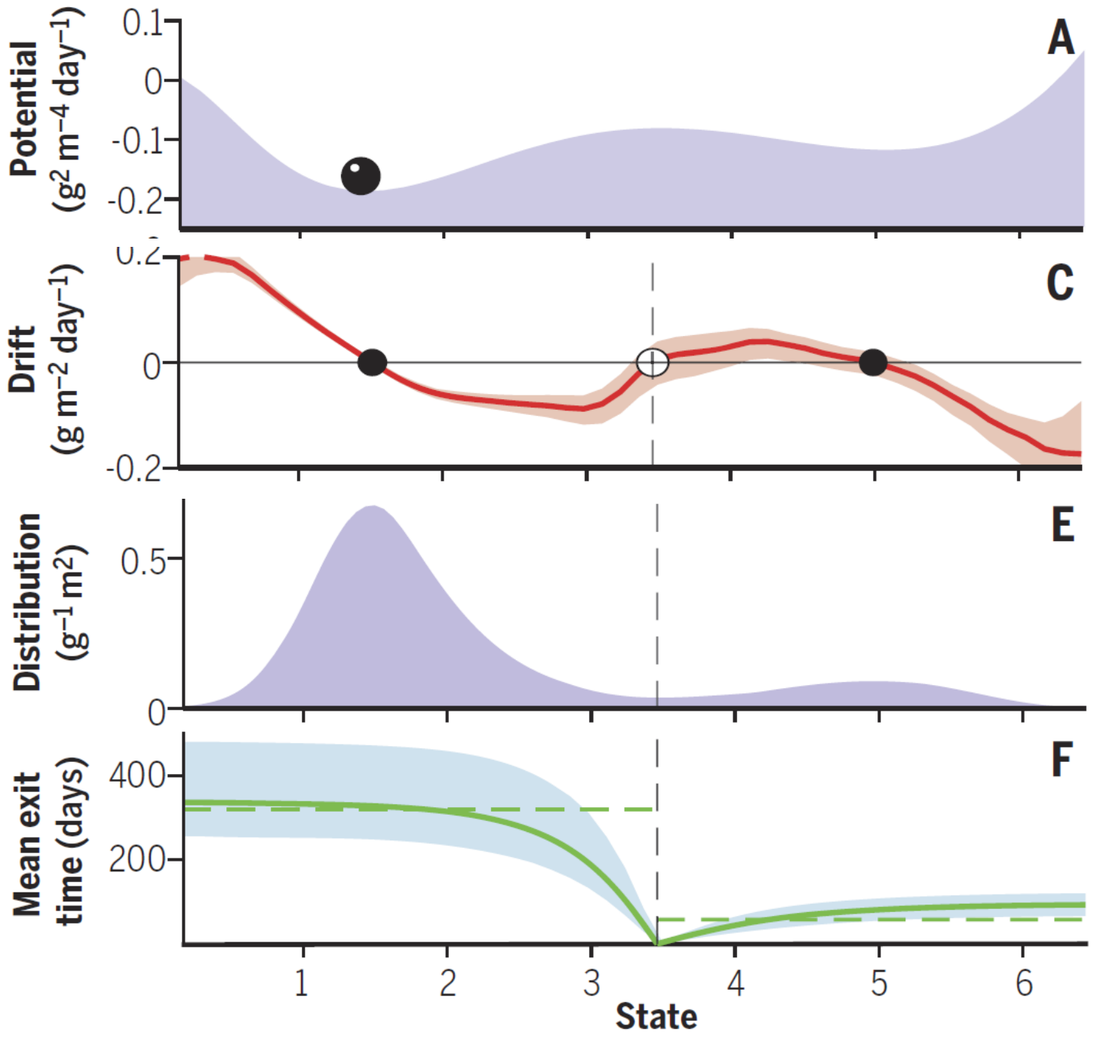

- **Risk Measures:**
  - Variance
  - Value-at-Risk (VaR)
  - Expected Shortfall (ES)

- **Resilience Measures (?):**
  - Mean-reversion
  - Half-life of a shock
  - Cumulative Impulse Response Function (IRF)

  **Mean exit time**

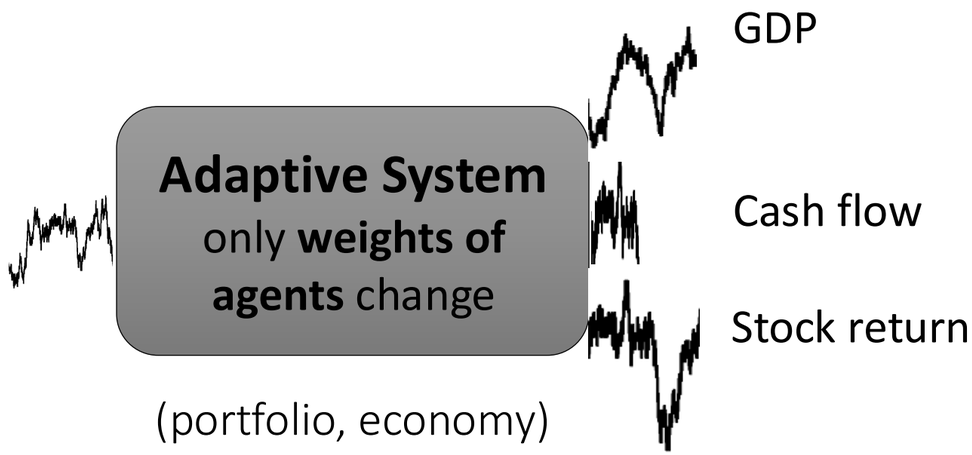
# Resilience Measure: (Mean) Exit Time

- for a **fixed behavior** of each type of agent




Arani, Carpenter, Lahti, van Nes, Schaffer, 2021

- Exit Time
  - Conditional on starting state
  - Unconditional **Mean Exit Time**
- Focus on time, ignores “how bad” deviation is
- Fixed behavior



# Resilience of a Stochastic Process due to Agents' Behavioral Change

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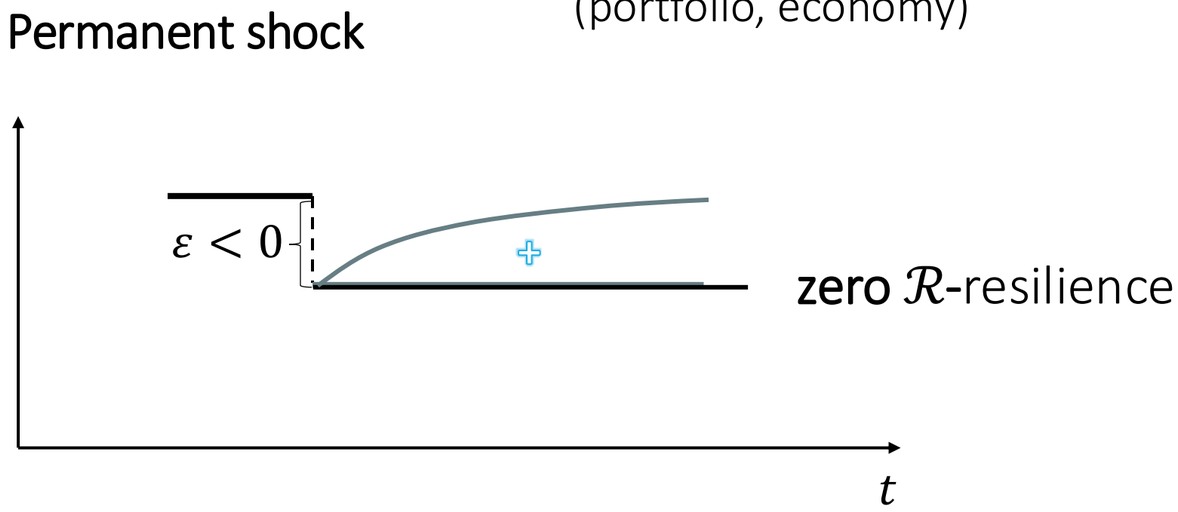


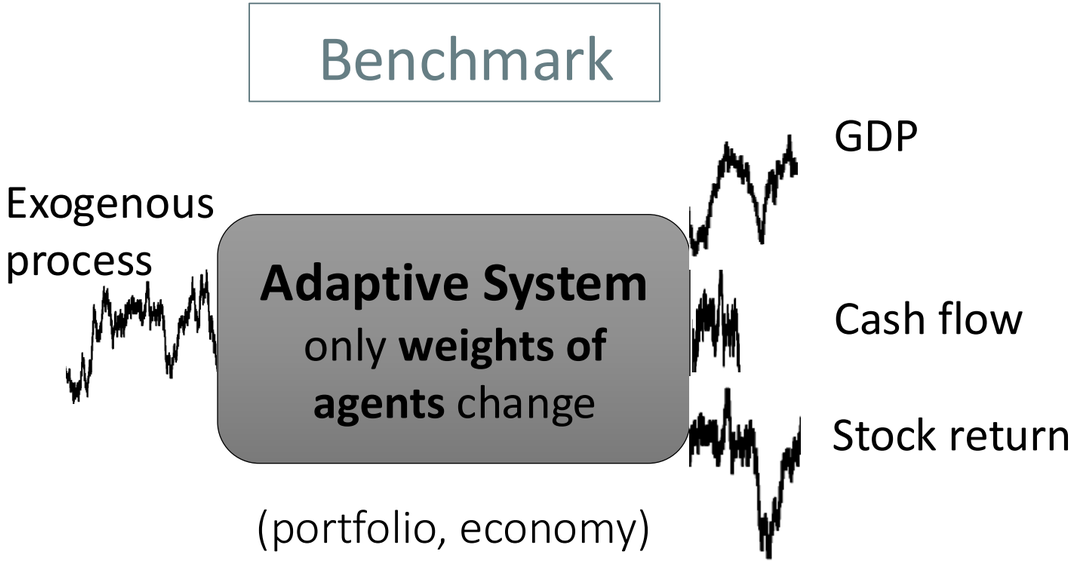

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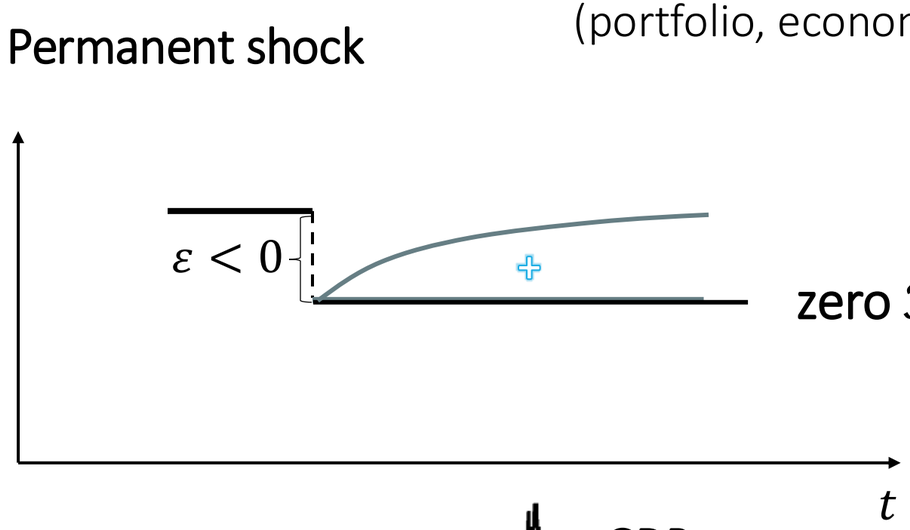
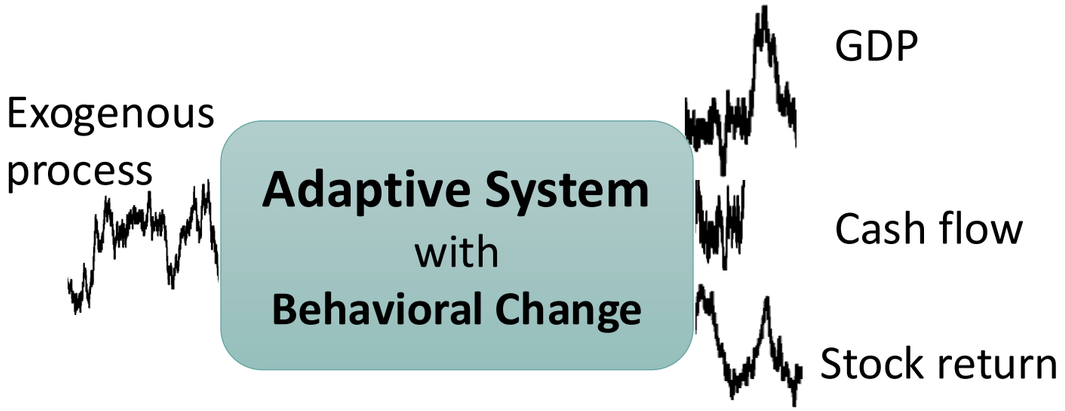
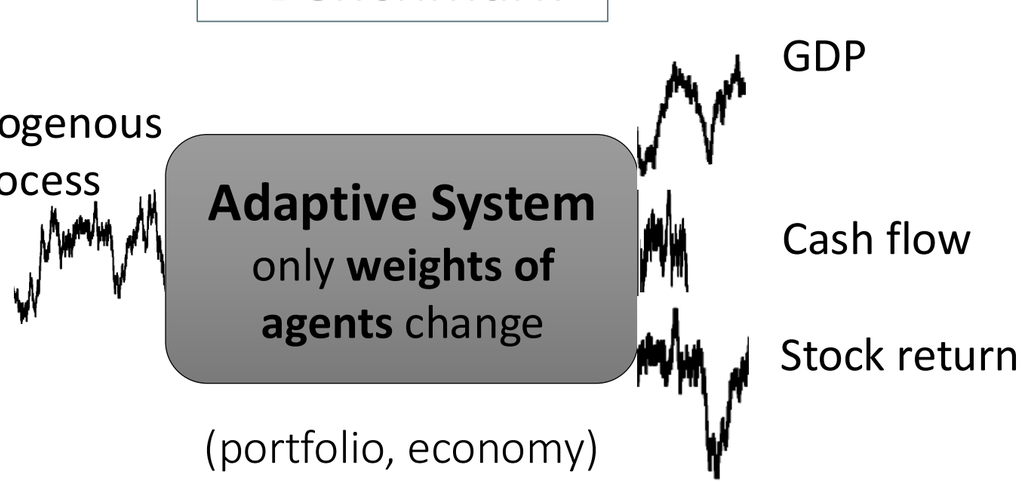



zero $\mathcal{R}$-resilience




relative to …

Benchmark



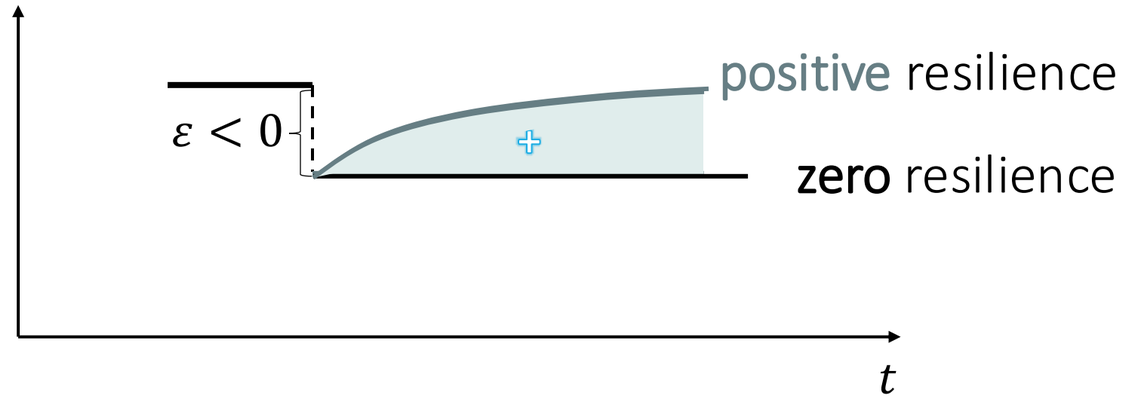

(portfolio, economy)

# $\mathcal{R}$-Resilience Measure: PV of "adaptability benefits"

discounted area

*- collapse path in a single number/statistic*

Permanent shock




- $\mathcal{R}$-Measure: PV of "benefits of adaptability of behavior and of system"
  - Zero-Benchmark: process absent any behavioral adaptability
    - Relative Resilience: relative to less adaptable system (e.g. one-time least costly adjustment)

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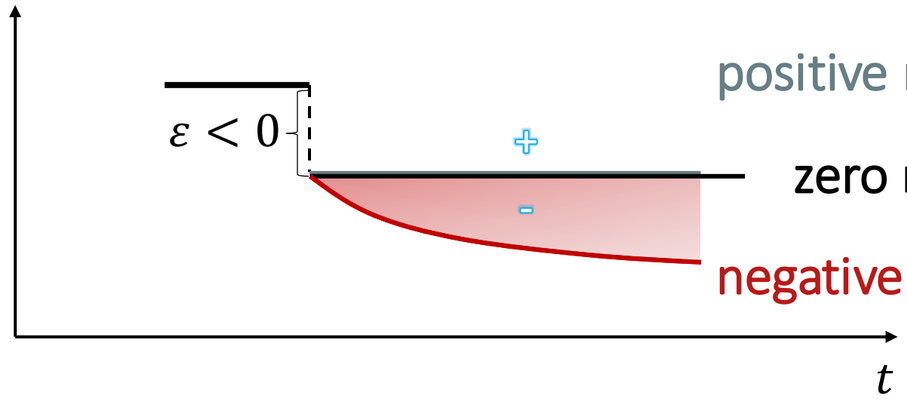


positive resilience

**zero** resilience

negative resilience

adaptation/reaction worsens

e.g. system hits **Trap**

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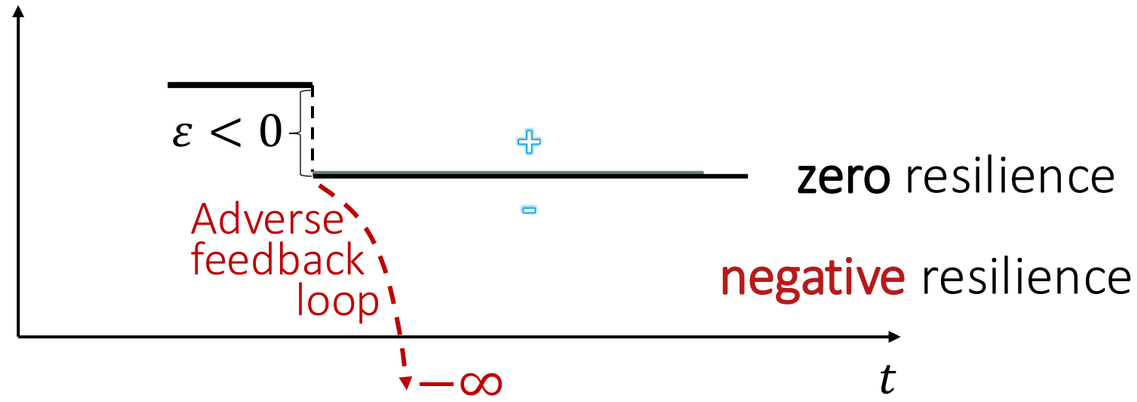


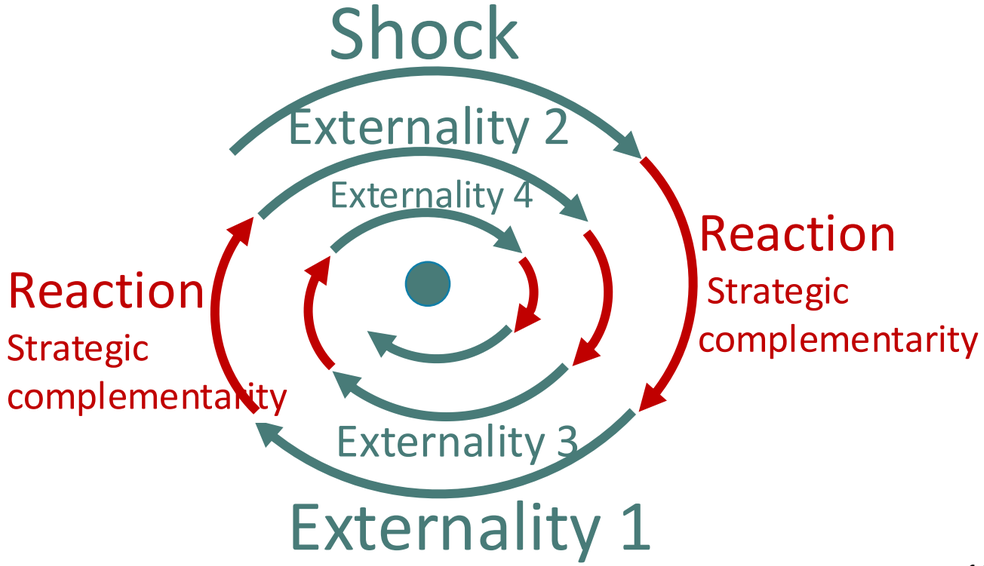

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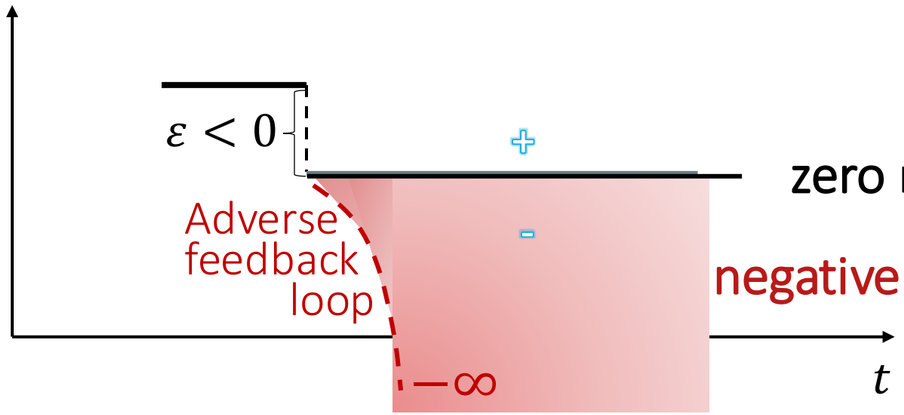



**zero** resilience

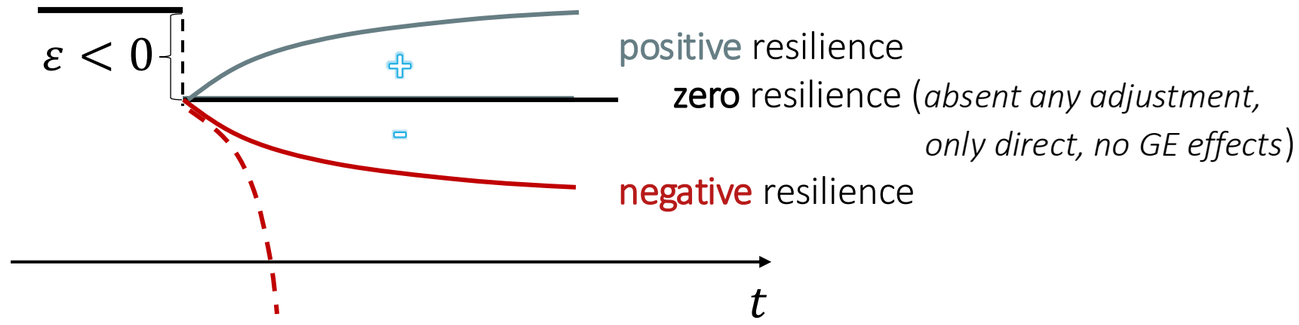
**negative** resilience

adaptation/reaction drastically worsens

e.g. system hits **Tipping Point**

# Measuring $\mathcal{R}$-Resilience

- Permanent exogenous **SHOCK** (detrended)



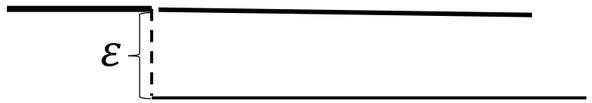

positive resilience

**zero** resilience (*absent any adjustment, only direct, no GE effects*)

negative resilience

- …. Temporary


- … Sunspots



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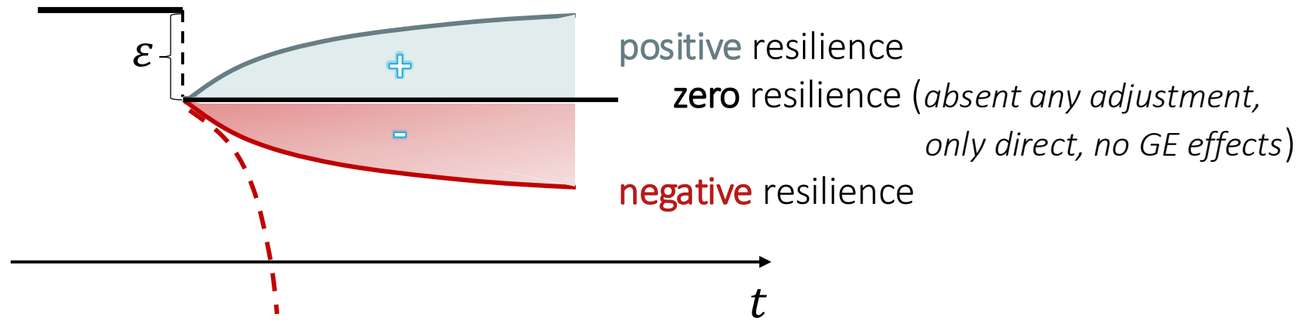


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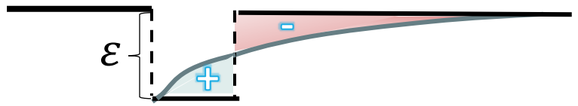


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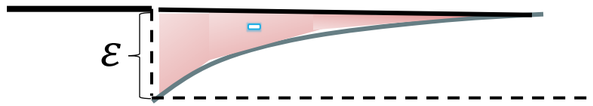
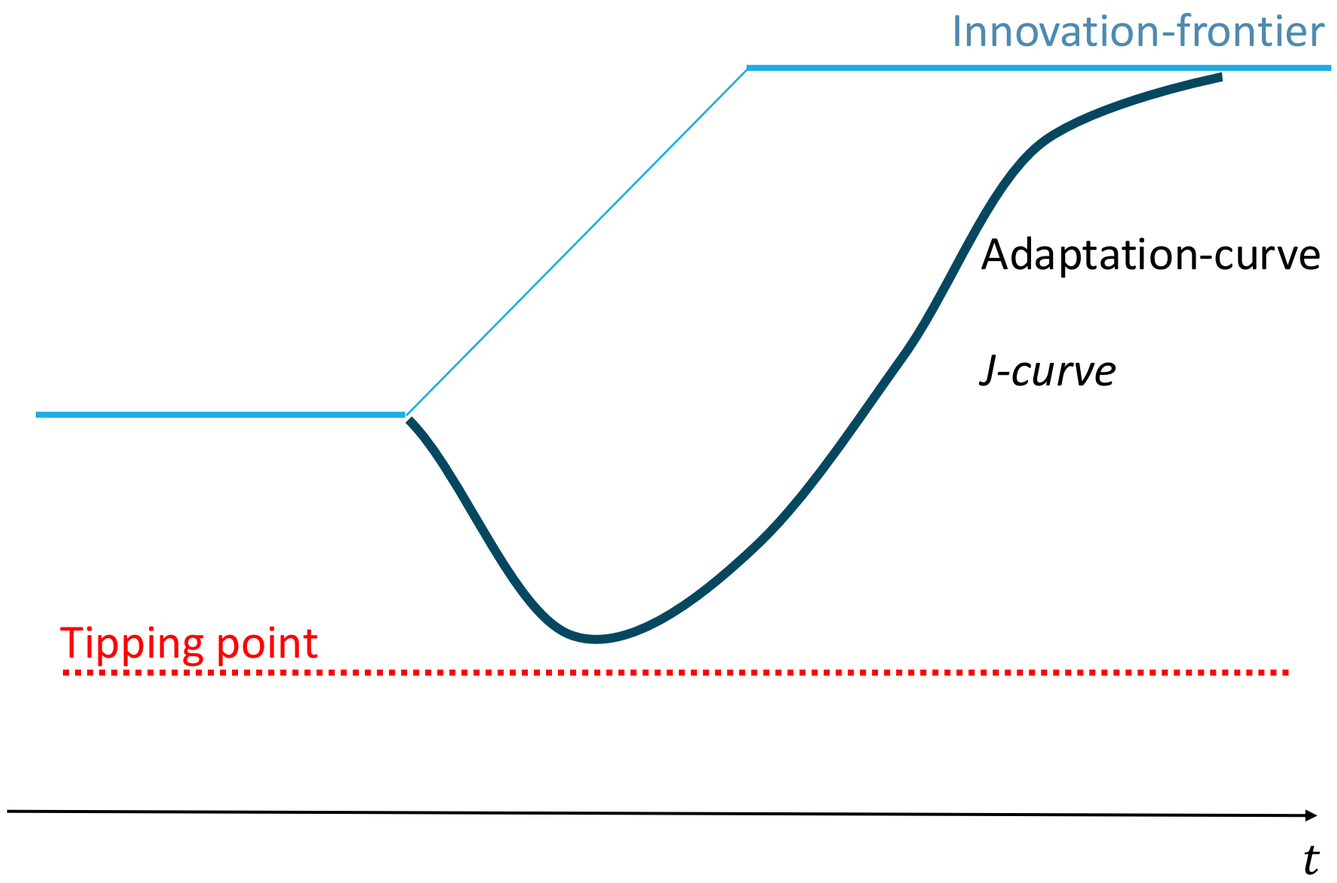


# Measuring $\mathcal{R}$-Resilience after SHIFTS

- **SHIFTS**



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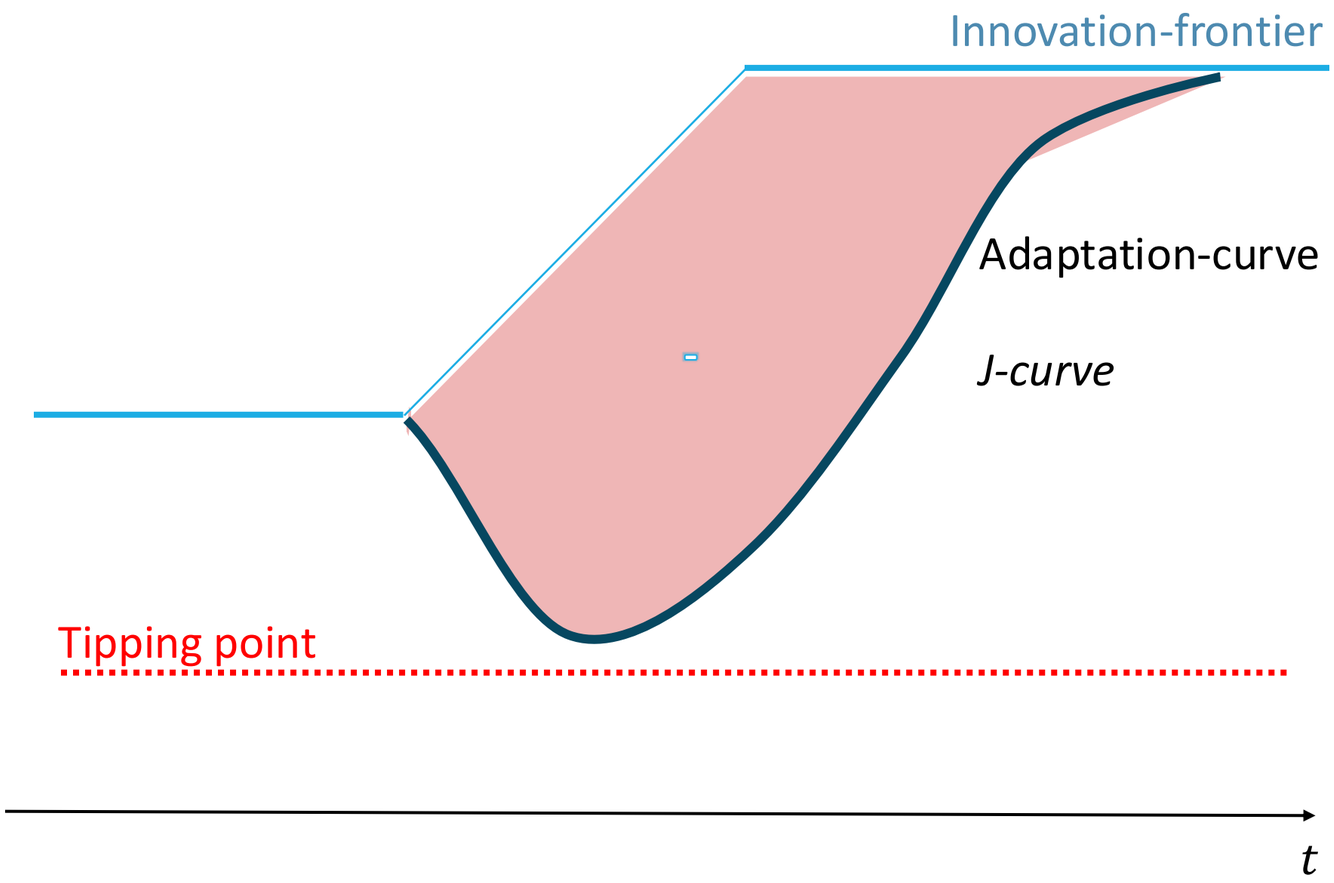

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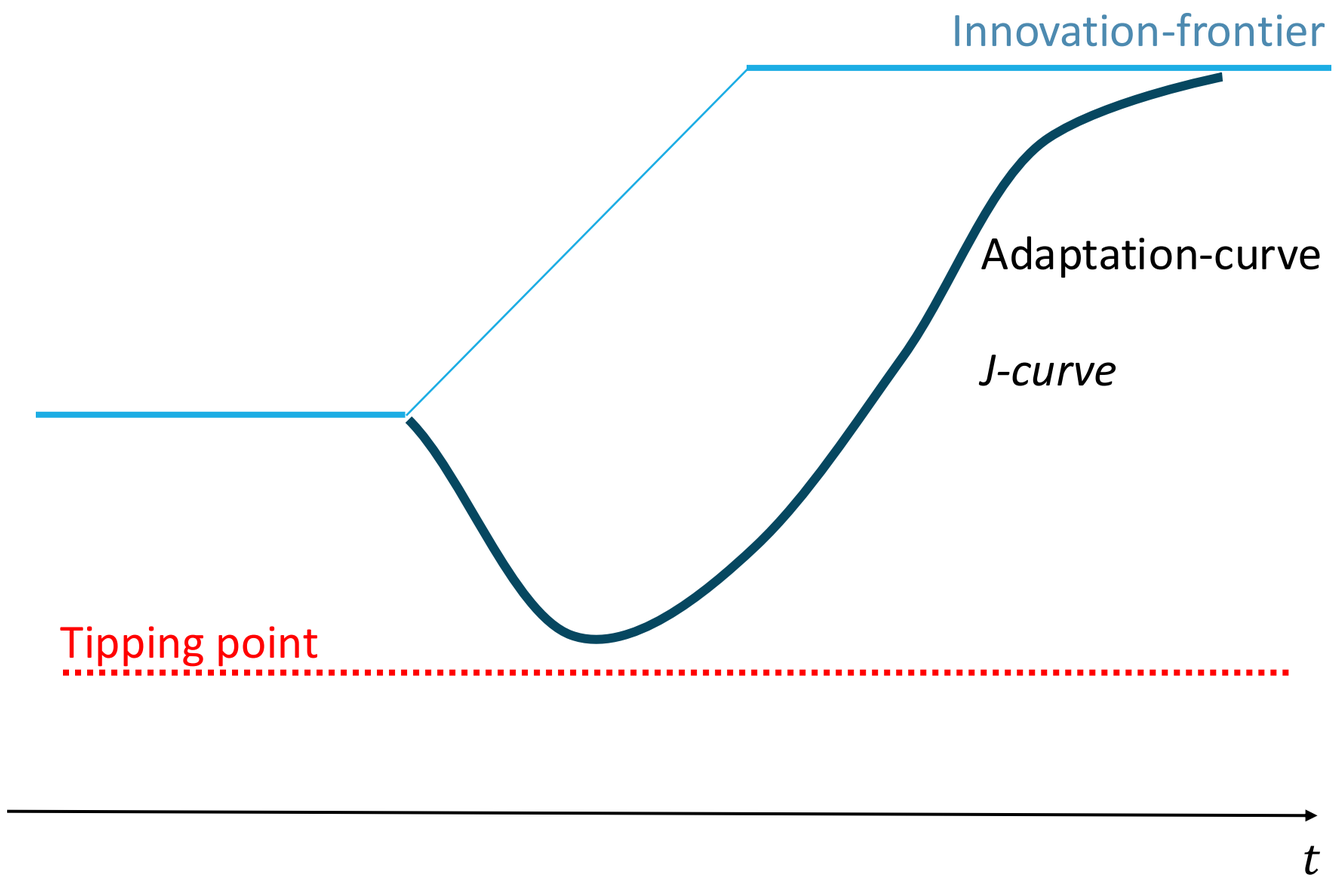

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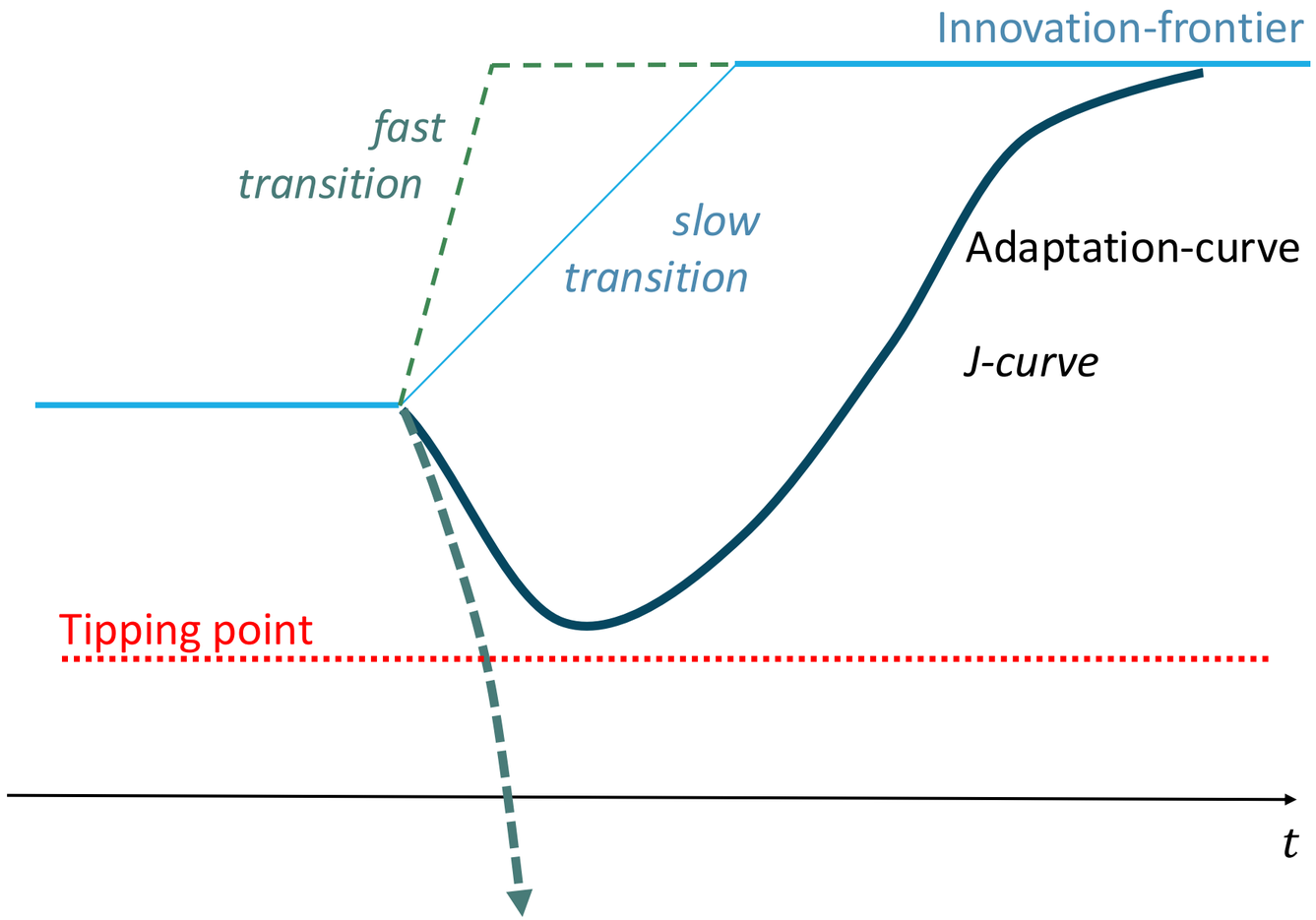

# Resilience Measure – more formally

- $\mathcal{R}$-Resilience is a "cumulative gap measure" btw.
  - $X_t^{\Phi}$ = Equilibrium process (with adjustment cost $\Phi$)
  - $X_t^{[0]}$ = No behavioral adjustment benchmark
- Conditional on shock $s_{t_0}$, given history $\underline{s}^{t_0-1}$

$$\mathcal{R}^{X,\Phi,[0]}\left(s_{t_0}\middle|\underline{s}^{t_0-1}\right) \coloneqq E_{t_0}\left[\sum_{t\geq t_0}\left(X_t^{\Phi}-X_t^{[0]}\right)|s_{t_0};\underline{s}^{t_0-1}\right]$$

- Unconditional … take ergodic unconditional expectations over all possible $t_0$-shocks

- *Generalizations/Modifications:* Apply to
  - Growth processes
  - Discounted process
  - Discounted utility flow $u(X_t)/(1+\rho)^{t-t_0}$

# Resilience and Related Concepts

- **Amplification/Mitigation** *instantaneous*
- **Persistence**, Recovery vs. Divergence
  Momentum vs. Reversals *delayed*
  *Property of stochastic process, not associated with behavioral adjustment*
- Propagation
  *cross section*
- Trend stationarity (after detrending)

- **Stability** vs. Resilience
  - Resilience involves change of subsystems (after large shock)
  - Stability … all subsystems revert back (after small shock)

# Roadmap

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- Risk vs. Resilience Management
- Macro vs. Micro-Resilience

## 2. Macrofinance Models

- First Generation: linear, mean-reversion
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## 3. Macrofinance Themes and Resilience

- Safe Assets
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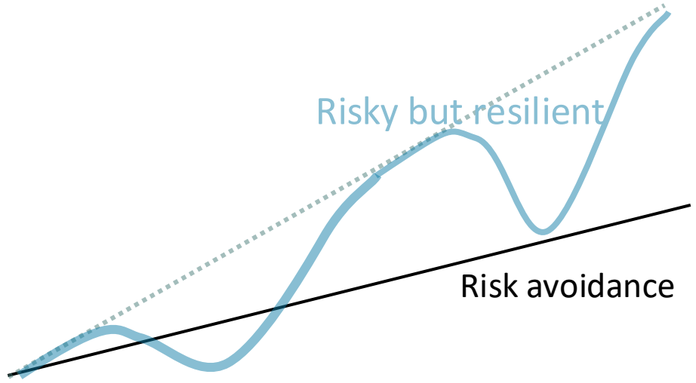
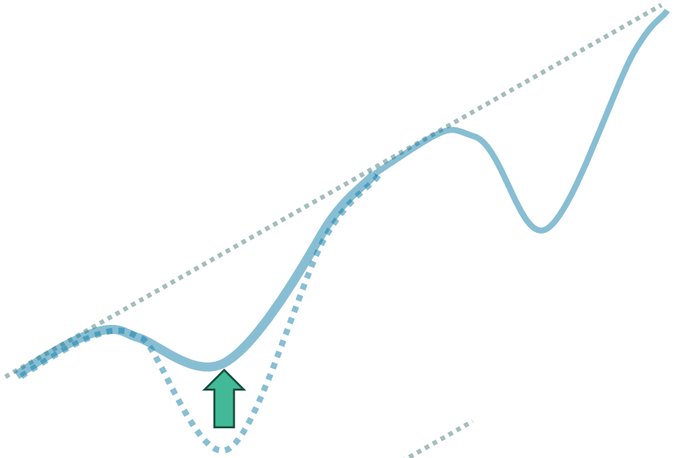
- Financial Intermediary Sector and Financial Resilience
- Heterogeneity within Financial Sector

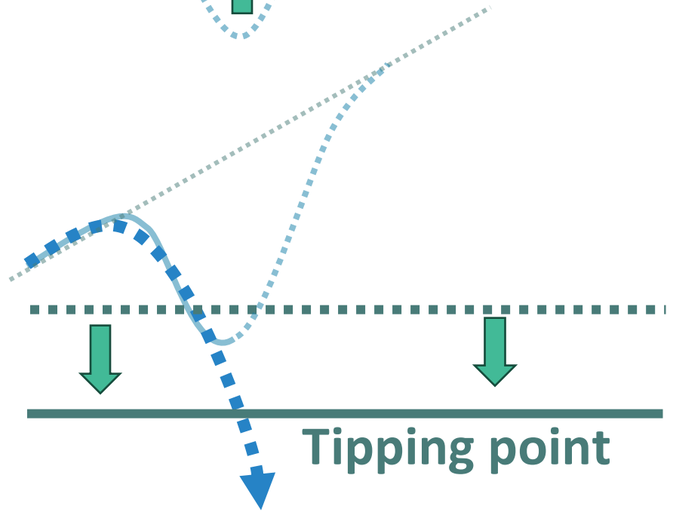
# From **Risk** to **Resilience Management**

temporary long-run Shift in Mindset




- **Risk** Management
  - **Avoid + diversify risk** at $t$, given $E_t[R_{t+1}]$
    (exposure to many shocks a bit rather highly to a particular one)
    - *"don't put all eggs in one basket"*
- **Resilience** Management: **Adapt after risk realization** at $t+1$
  - **Invest** at $t$ in positive **adaptability/agility**
    - **Substitutability + scalability:**
      **Liquidity**, elasticity of substitution, low adjustment costs, multi-sourcing
      (gain expertise/trading desk for several asset classes)
      - *"open many doors, so that one can easily and swiftly react"*
  - Push away adaptability inhibitors, **traps** and **tipping points**
    - **Buffers:** Equity capital, reserves, redundancies, **diversification**
      - *"build up a war chests/buffer"*






- Links: **Hedging demand** a la Merton,
  **Long-run Risk** can't be diversified, only adaptability

# Macro- vs. Micro-resilience: Aggregation of Resilience

- Micro-resilience of each subsector ⇏ Macro-resilience
  **Resilience Aggregation Paradox: A Fallacy of Composition**

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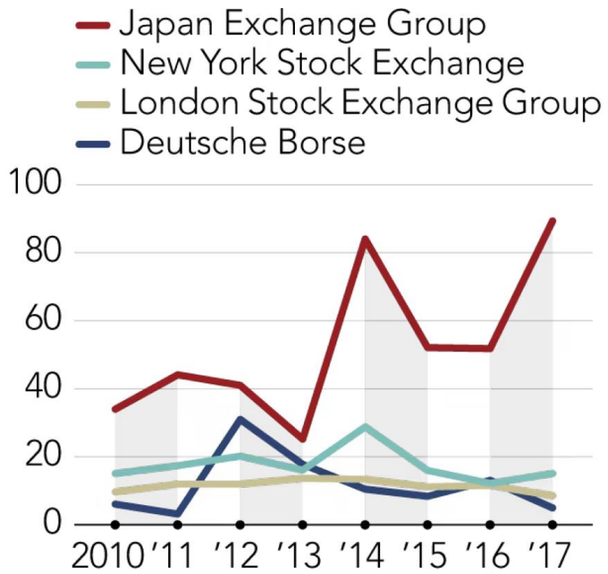
  **Resilience Aggregation Paradox: A Fallacy of Composition**

- Zombie firms: unproductive aging firms,
  that bind resources that should be freed up for new firms
  **no** Schumpeterian creative destruction

- Firms over 100 years old:

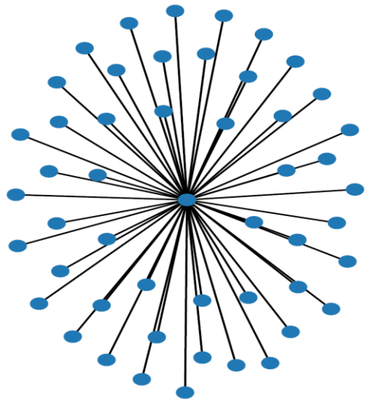
| Rank | Country | Number of companies | Ratio |
|---|---|---|---|
| 1 | Japan | 33,076 | 41.3% |
| 2 | United States | 19,497 | 24.4% |

Age of firms:

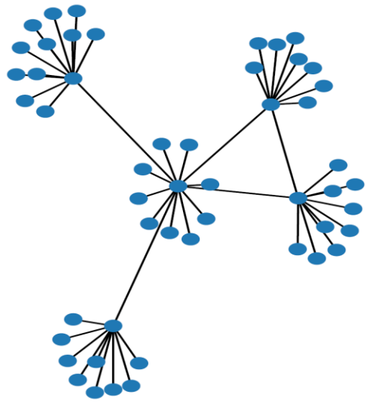


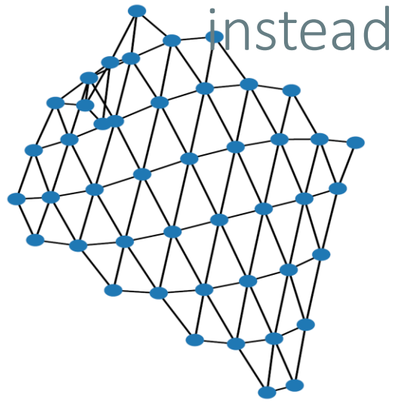
# Resilience and Networks

- **Systemic risk** across subsectors, or institutions
  - **Network** structure (diversification vs. spillovers) ⇒ **Co-Resilience** instead of CoVaR



centralized





distributed

- **Split** intermediary sector into
  - Banks — diversify risk, create money/safe asset
    - Traditional vs. shadow banks
  - Pension funds/life insurance — retirement savings
  - Asset managers — investing/risk sharing
  - How to segment intermediary sector? Models with many state-variables
    - Methodology: deep learning/neural networks algorithms

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# Macrofinance

- Model framework:
  - GE + Dynamics with aggregate impact + Heterogenous Agents focused
  - Financial Frictions (Sector) (not preference focused)
    - Debt issuance constraint (borrowing constraint, collateral/VaR constraint)
    - Equity issuance constraint
    - Incomplete markets: uninsurable idiosyncratic risk

- Policy Concerns: Growth/Efficiency ⟷ Stability/Resilience

Inequality

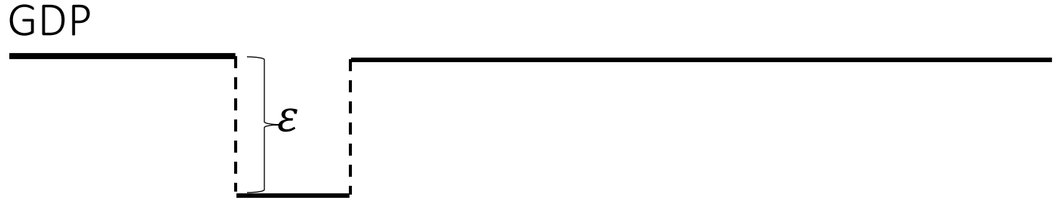
Government Financing

# **1. Log-linearized:** First Generation Macrofinance

- Focus on local dynamics around the steady state after a small shock
- Log-linearized approximation of dynamics around steady state
- Log-linearization implies that agents “think” there is no perceived risk (no risk premium)
- Ex-ante probability of an aggregate shock is assumed to be zero
- Absence of rich volatility dynamics

# 1. Log-linearized: First Generation Macrofinance

- Kiyotaki Moore 97




adaption in form of **fire-sales**

Bernanke, Gertler, Gilchrist 99

DSGE models

- Bewley 79, Aiyagari 94, …
  - Incomplete markets **Precautionary savings** depress risk-free interest rate $r^f$ = capital return

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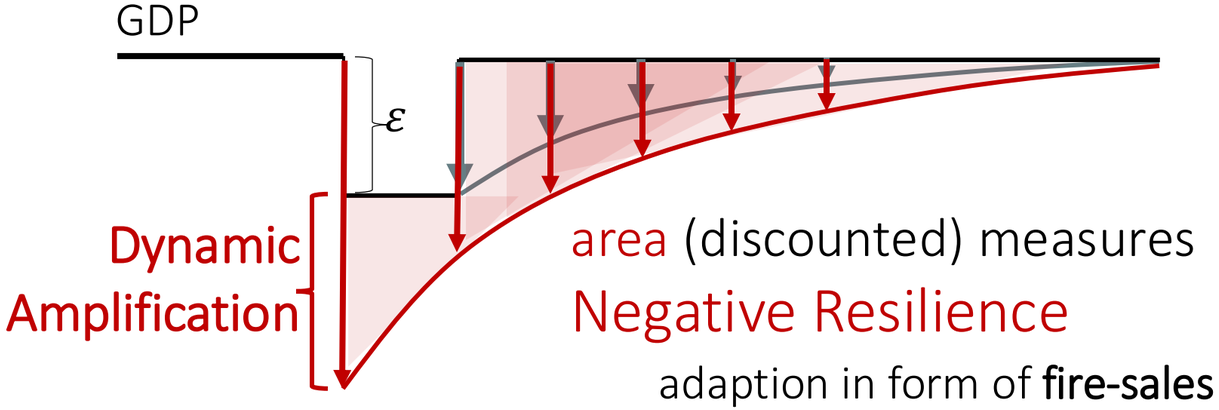


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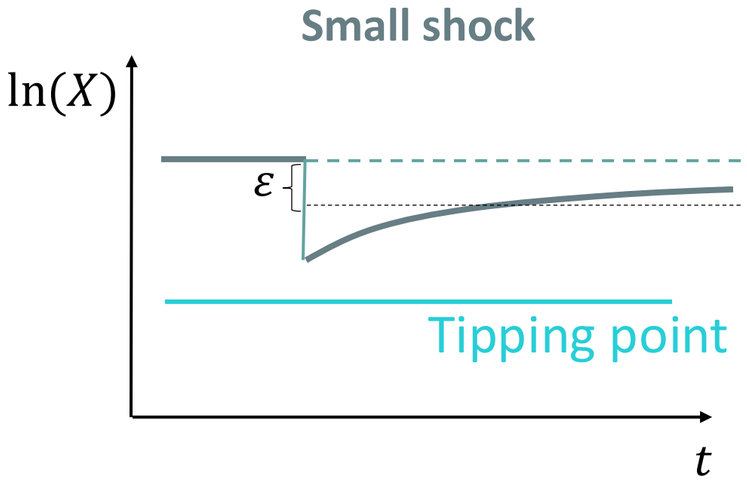
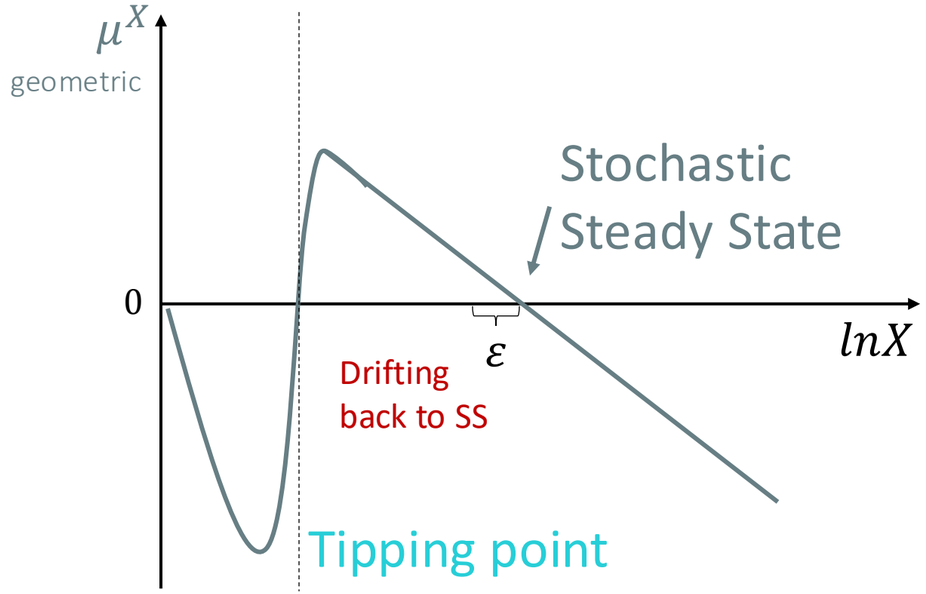
  - Incomplete markets, **Precautionary savings** depress risk-free interest rate $r^f$ = capital return

- **Limits Resilience Analysis due to log-linearity**
  1. No trap, No tipping points, …
  2. Agents expect deterministic recovery ⇒ no aggregate risk premium/precautionary savings

# **2. Non-linearities:** Second Generation Macrofinance

- **Traps, Tipping points** (Resilience killers)
  - Non-linear models are needed (perturbation around Steady State not meaningful)




- **Bursting Bubbles** hit **Tipping Points** (large bubble large drop)
  - **Bubbles: Lean vs. Clean**, run-up leads to larger shocks possibly over tipping point (drawdowns)

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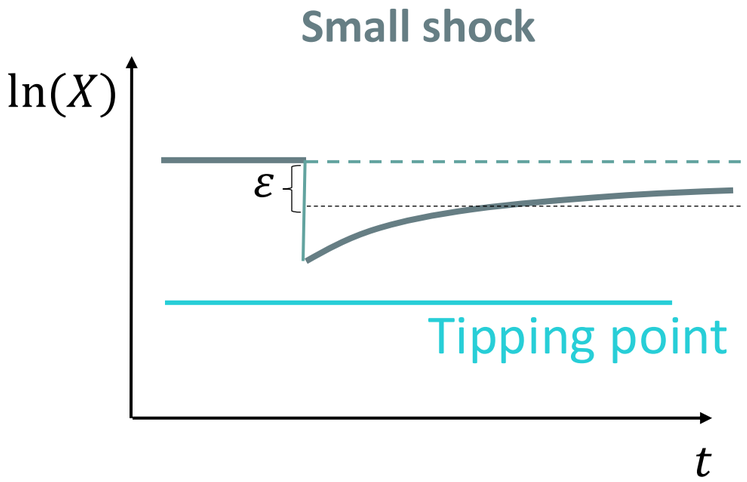
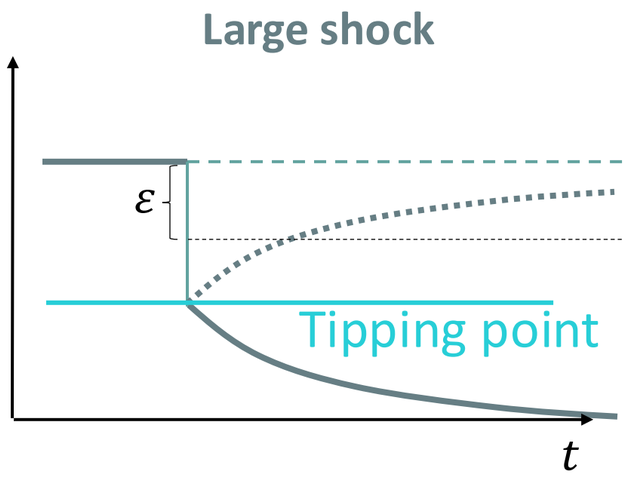
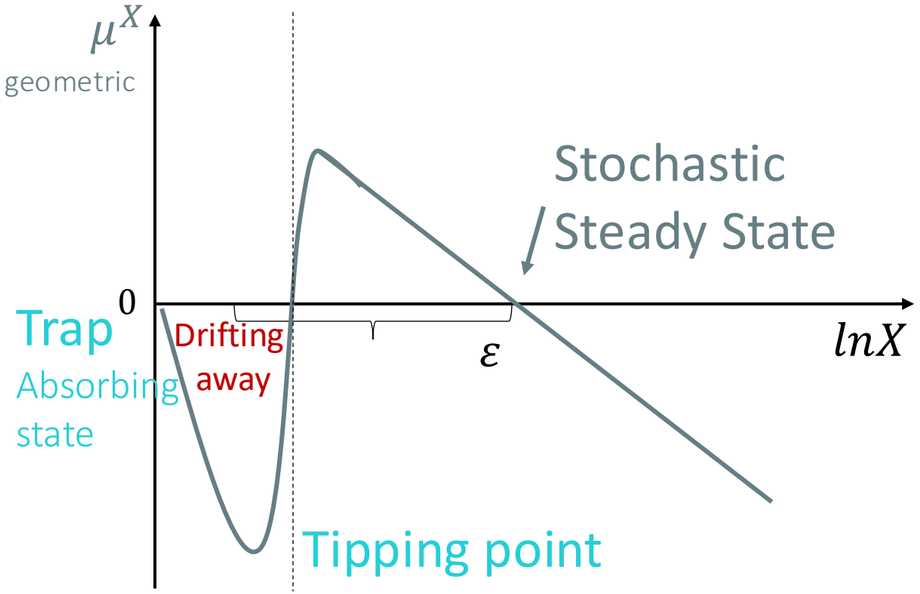


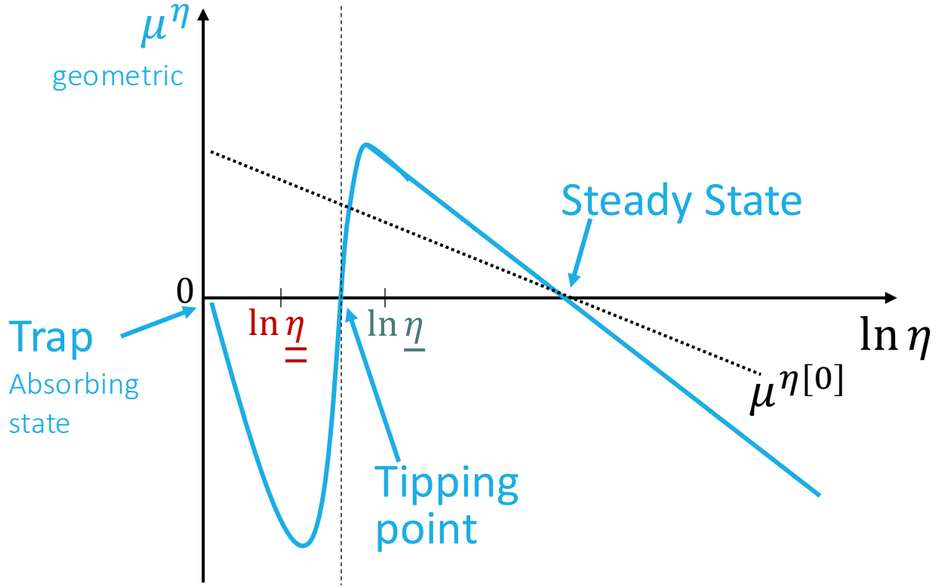



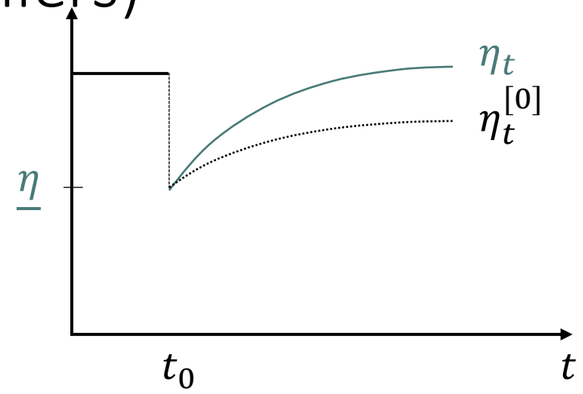

- **Bursting Bubbles** hit **Tipping Points** (large bubble large drop)
  - **Bubbles: Lean vs. Clean**, run-up leads to larger shocks possibly over tipping point (drawdowns)

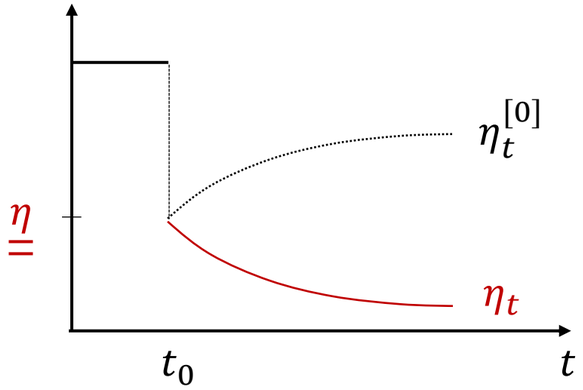
… with Abreu
Schularick et al … with Palia, Sastry, Sims

# 2. **Non-linearities:** Second Generation Macrofinance

- **Traps, Tipping points** (Resilience killers)
  - Non-linear models are needed

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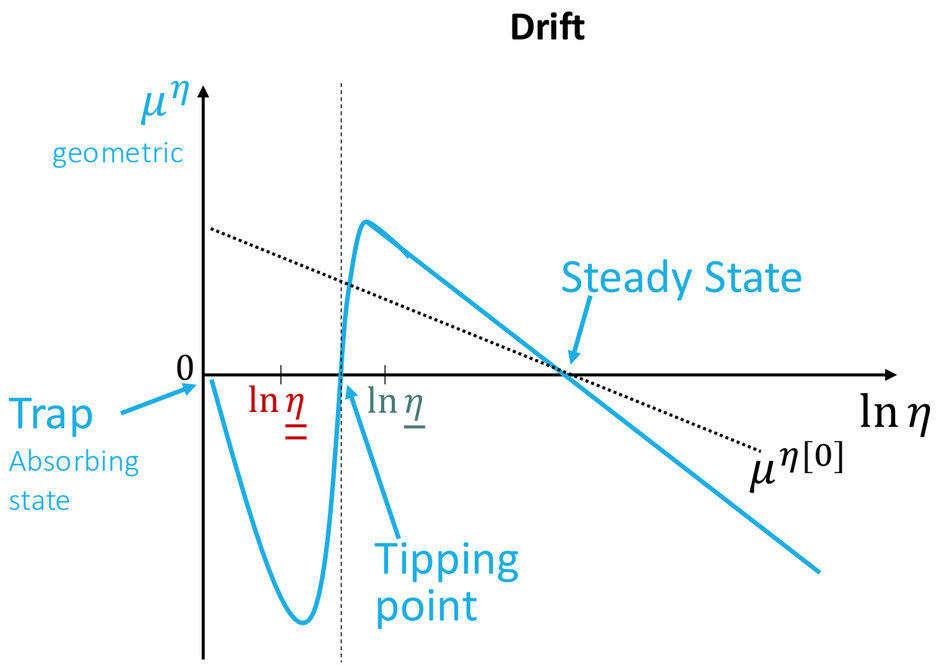


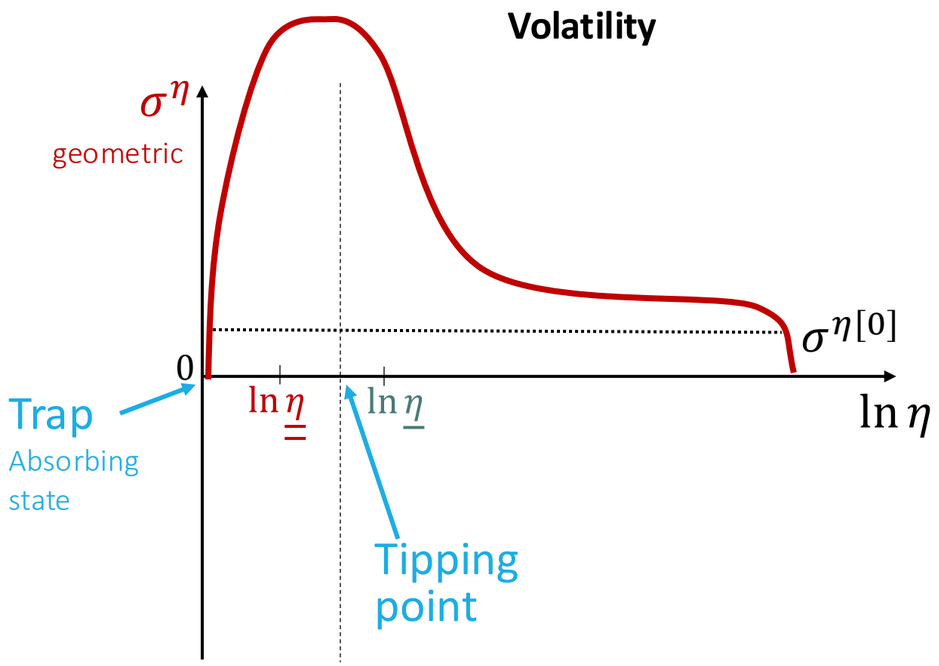


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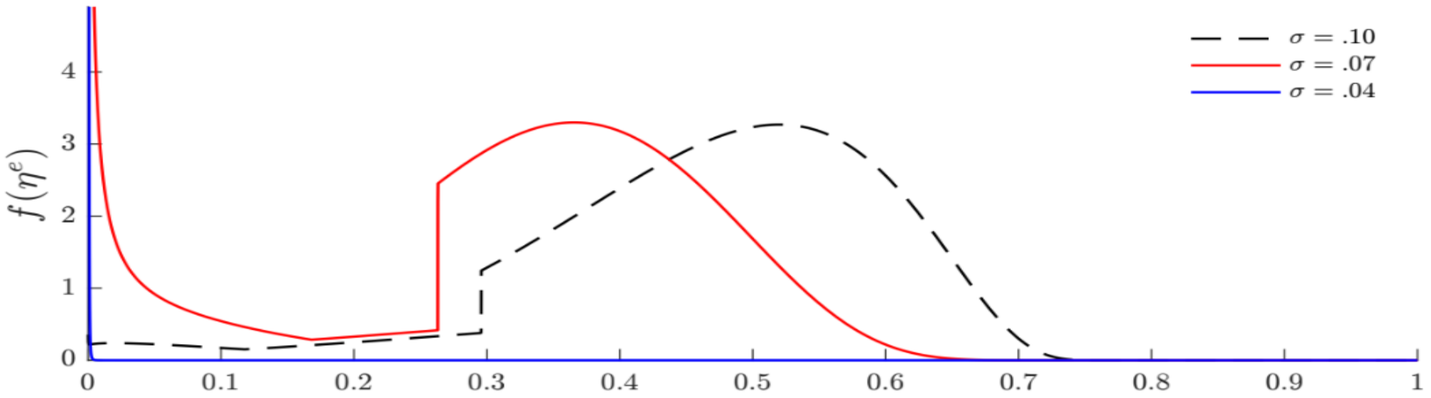
# 2. “Net Worth Trap”: Second Generation Macrofinance

- **Traps with Escape** (= double-humped stationary pdf) **vs. No Escape** (= absorbing state)



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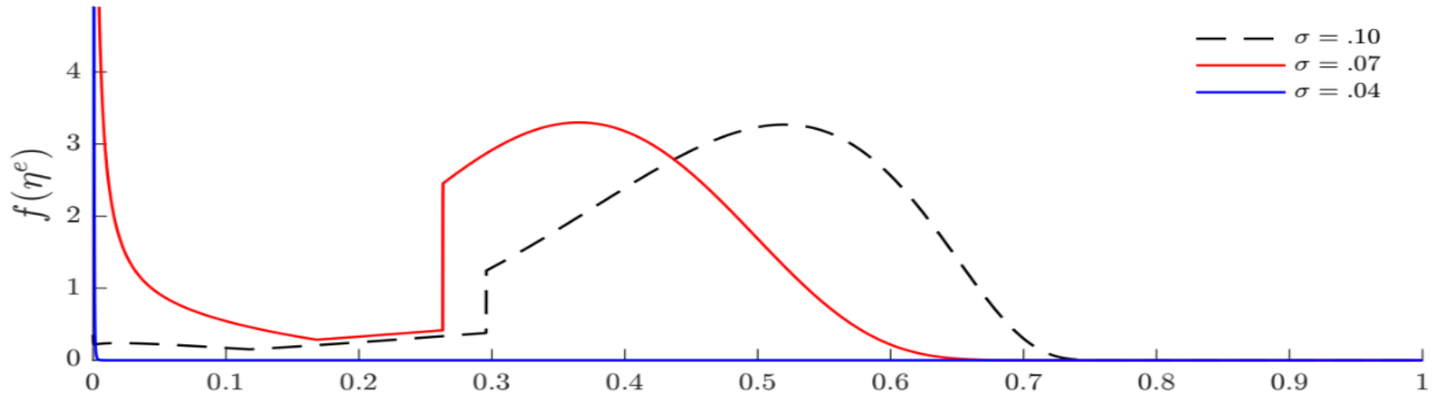



- **Dilemma:** (in models with endogenous net worth dynamics):
  - Crisis with **large price drop**
    ⇔ high expected returns going forward
    ⇒ investors' net worth grows fast
    ⇒ **crisis is not long-lasting**
- **Necessity for Net Worth Trap:**
  Investors prevented from taking advantage of high $\mathbb{E}_t[R]$
  - Financial (debt issuance) constraint
  - Belief/sentiment distortions

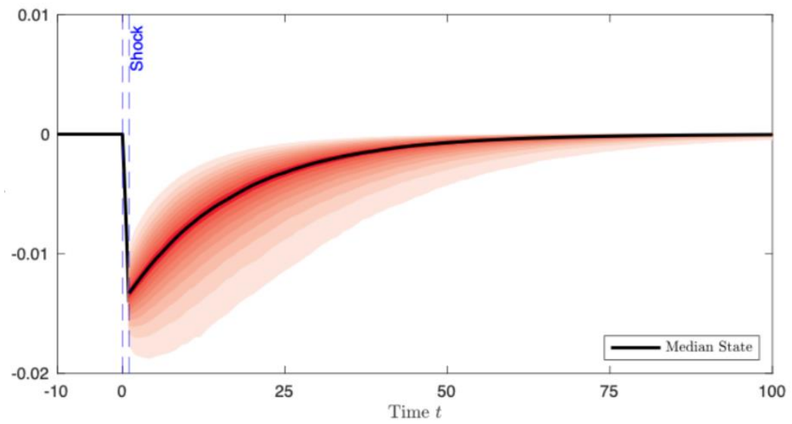
# 4. Volatility/Risk Dynamics: Second Gen. MacroFin

- "Risky Recovery" (perceived) **also changes behavior**
- **Time-varying** risk-taking
  - **Risk**
  - Price of risk
  - Debt constraints

  } Risk premium
- Time-varying **precautionary savings**

} ⇒ Resilience inhibitors

- Fan chart (generalized IRF)




  - Difference in distribution btw shock and no shock

# Roadmap

## 1. Resilience

- Definition, Measure
- Risk vs. Resilience Management
- Macro vs. Micro-Resilience

## 2. Macrofinance Models

- First Generation: linear, mean-reversion
- Second Generation: tipping points, traps with escapes, volatility/risk dynamics …

## 3. Macrofinance Themes and Resilience

- Safe Assets
- Financial Intermediary Sector and Financial Resilience
- Heterogeneity within Financial Sector
- Government, Monetary and Fiscal Policy

# a) **Safe Assets** and Resilience: Second Generation MacroFin

with Merkel, Sannikov … Reis

- ***Different Take:*** *It's not about getting safe return, but to do something with it.*
- Incomplete markets friction with **uninsurable idiosyncratic risk** (funding shocks)

  ⇒ agents can't insure each other against idio risk directly (each agent has individual Brownian)

  … but, they can **adapt**, i.e. sell safe asset after negative idiosyncratic shock
  - Safe asset is primarily held for service flow from retrading/adapting.

$$p_t = \mathbb{E}_t[PV_{\xi^{**}}(cash\ flow)] + \mathbb{E}_t[PV_{\xi^{**}}(service\ flow)]; \quad \xi^{**} = \text{SDF of representative agent}$$

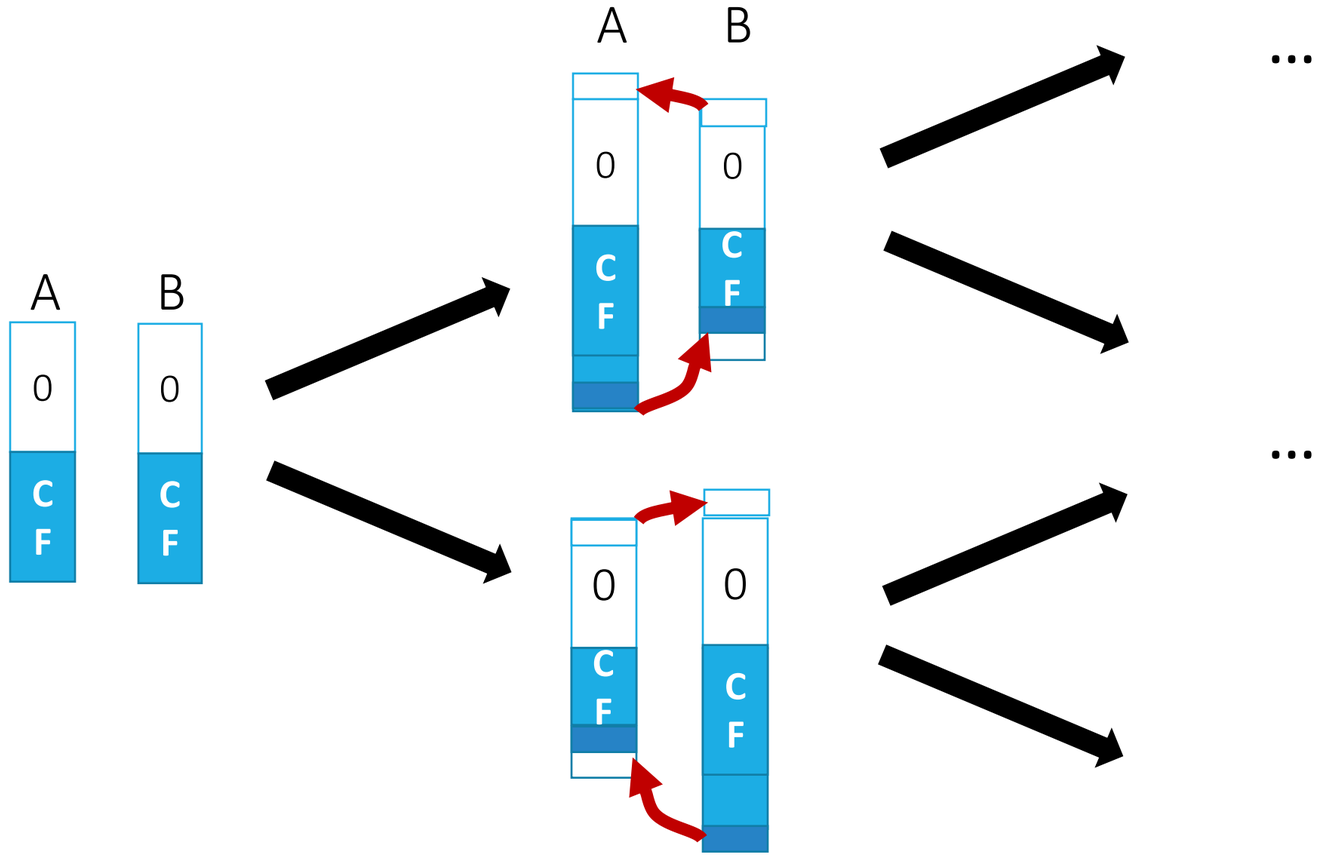
- Time-varying idiosyncratic risk that rises in downturns
  $\mathbb{E}_t[PV_{\xi^{**}}(service\ flow)]$ rises in downturns ⇒ **negative $\beta$**

⇒ Safe asset is an individual resilience tool and an aggregate hedging tool
- Idiosyncratic risk through individual re-trading/adapting
- Aggregate risk: ⇒ negative $\beta$

# 2. Gen MacroFin: Flight to Safe Assets, Uninsurable Idio Risk

… with Sebastian Merkel, Yuliy Sannikov

- **Safe asset** = good friend
  - Idiosyncratic risk: provides partial insurance through re-trading ⇒ Service Flow

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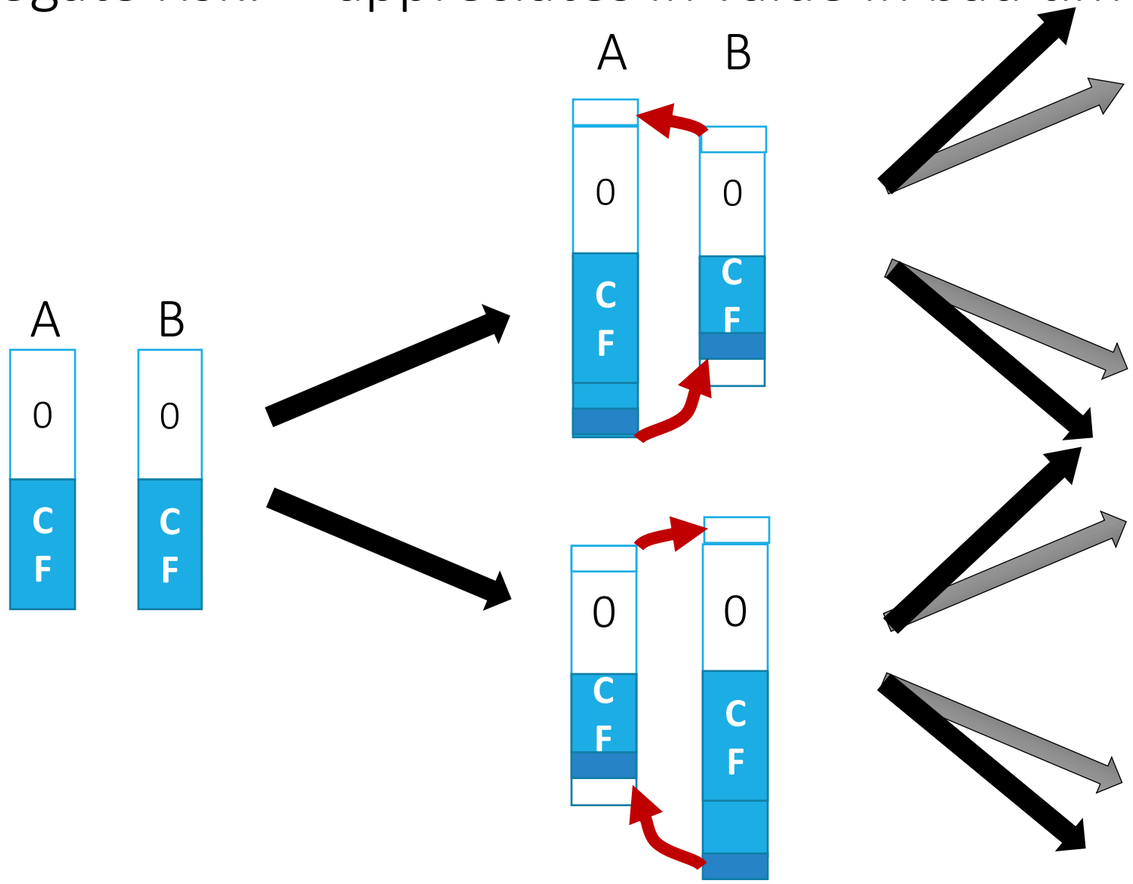


…

**In recessions:**

Risk is higher

- Service flow is more valuable
- Cash flows are lower
  (depends on fiscal policy)

…

…

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# a) **Safe Assets** and Macro-Resilience

- **Bubble-Safe Asset Complementarity**
  - $r < g$-Bubble condition is easier satisfied, since $E[r^{Safe\ Asset}]$ is depressed
    - uninsurable idio risk ⇒ precautionary savings depressing $r^f$
    - Negative $\beta$
    - … additional **convenience yield**
- **Loss of Safe-Asset-Status** = hitting a tipping point
  - Debt becomes informationally sensitive ⇒ asym. info ⇒ no retrading
  - Bubble bursts/jumps to another asset. Resilience destabilizer
- **Asymmetric supply** (not shortage) of safe asset leads to **Flight-to-Safety** in downturns
  - Provides resilience for (global) safe asset issuer (US, Germany, Japan …)
  - Hurts the resilience for other countries (EMDE)

- Retrading: Micro-resilience enhancer
- Loss of Safe-Asset-Status: Macro-resilience destroyer
  Asymmetric supply:

# d) Segmenting Financial Sector & Network Spillovers

- **Split** intermediary sector into
  - Banks — diversify risk, create money/safe asset
    - Traditional vs. shadow banks
  - Pension funds/life insurance — retirement savings
  - Asset managers — investing/risk sharing
  - How to segment intermediary sector? Models with many state-variables
    - Methodology: deep learning/neural networks algorithms

Acharya, …, Philippon … Jermann, Quadrini

Drechsler et al., …

Koijen, Yogo …

Xiong … Vayanos, Vila, …

Eisfeldt, Rampini

Gopalakrishna, Payne, Gu

- **Systemic risk** across subsectors, or institutions
  - **Network** structure (diversification vs. spillovers) ⇒ **Co-Resilience**

instead of CoVaR

Allen, Gale … Duffie

… with Adrian

# d) Public Sector and Policy Design: Gov. & Central Banks

- **Government Debt Issues** (Public Finance connection)
  - Exorbitant/**Safe Asset** Privilege/possibly bubbly
    - Deb valuation puzzle
  - Gov. debt maturity
  - Diabolic/Doom Loop/Sovereign-Bank Nexus
- **MacroPrudential Policy/Fin. Repression, LOLR/Bailout Policy** designs financial sector
  - MacroPru lowers dangers of Financial Dominance
- **Monetary Policy**
  - Risk-free interest rate, term + risk premium = (exo- + endogenous risk)*price of risk
  - Redistributive MoPo to lower risk premia ⇒ **Financial Sector Resilience ↑**
    - Bottleneck approach – which sector is balance sheet impaired
  - QE/QT
  - Size/Equity of Central Bank's balance sheet

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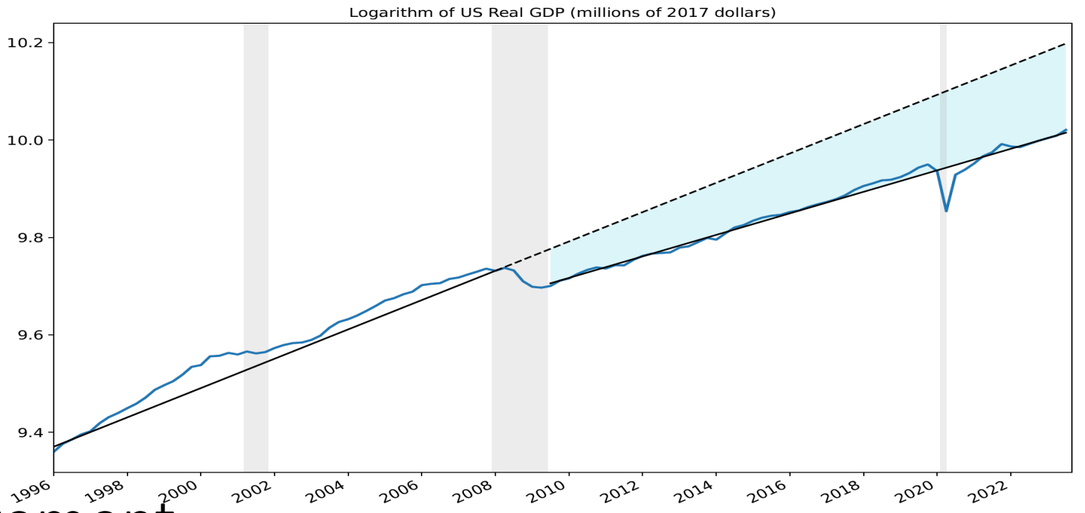
# Conclusion




- Financial **Resilience** is *first order* for **Macro**
  - Bubbles: Lean vs. Clean
- **Resilience Management** instead of only Risk Management
- **Traps, Tipping points** and **other resilience killer** (non-linearities)
- **Safe Assets** $\beta < 0$ ,
  - Micro: individual resilience via (portfolio) adjustment
    Macro: Bubble/Exorbitant Privilege ⇒ resilient fiscal policy, but loss of status
- **Financial Sector – Resilience spillovers (Co-Resilience)** within and to macro economy
- **Monetary Policy**, Financial Regulation/Bailout, Fiscal Policy ⇒ Resilience

# EXTRA SLIDES

# Risk vs. Resilience Management

- Static risk
- Dynamic resilience depends on
  - **Substitutability** btw input A and input B — partial equilibrium (holding prices fixed)
    - (asset A and B have similar risk profile)
    - No trading costs
  - **Scalability** of new input — general equilibrium
    - Risk profile changes due to GE effects

- A and B with low correlation or
  C and D with higher correlation but better substitutability and scalability

- Risk diversification
  - Correlation $\rho$
    - How many stocks/projects?
    - Which?

Resilience diversification

adjustment cost (fixed cost) - adaptability

High fixed costs, but easy to scale up (variable costs)

- Example: portfolio of 2 assets (with and without portfolio adjustment – same expected return)

- Risk preferences
  - $\frac{u''}{u'}c$

Resilience preferences

curvature and IES??? (two vs. multi periods)

# 1. First Generation Macrofinance (no risk premium, log-linearized)

- Kiyotaki Moore 97
  - Shock: zero-prob. temporary $a$-shock, $Y_t = aK_t$
  - Friction:
    - no equity issuance
    - debt collateral constrained
  - Zero $\mathcal{R}$-benchmark (no adaptation=no sale of capital)

Bernanke, Gertler, Gilchrist 99

log-linearized DSGE model

agents expect deterministic recovery

debt with costly state verification

$N_t \downarrow \Rightarrow$ bankruptcy prob. $\uparrow \Rightarrow$ funding costs $\uparrow$

no divestment (capital to consumption)

Future research: vary $\Phi$-cost

- Bewley 79, Aiyagari 94, …
  - Friction: Incomplete markets over idiosyncratic (endowment) risk, borrowing constraint
  - **Precautionary savings** depressed risk-free interest rate $r^f$ = capital return

- Linearization: ⇒ SS has to be in crisis region, stable SS ⇒ no tipping points, …
- Agents expect deterministic recovery ⇒ no additional precautionary savings

# 2. Gen MacroFin: Flight to Safe Assets, Uninsurable Idio Risk

… with Sebastian Merkel, Yuliy Sannikov

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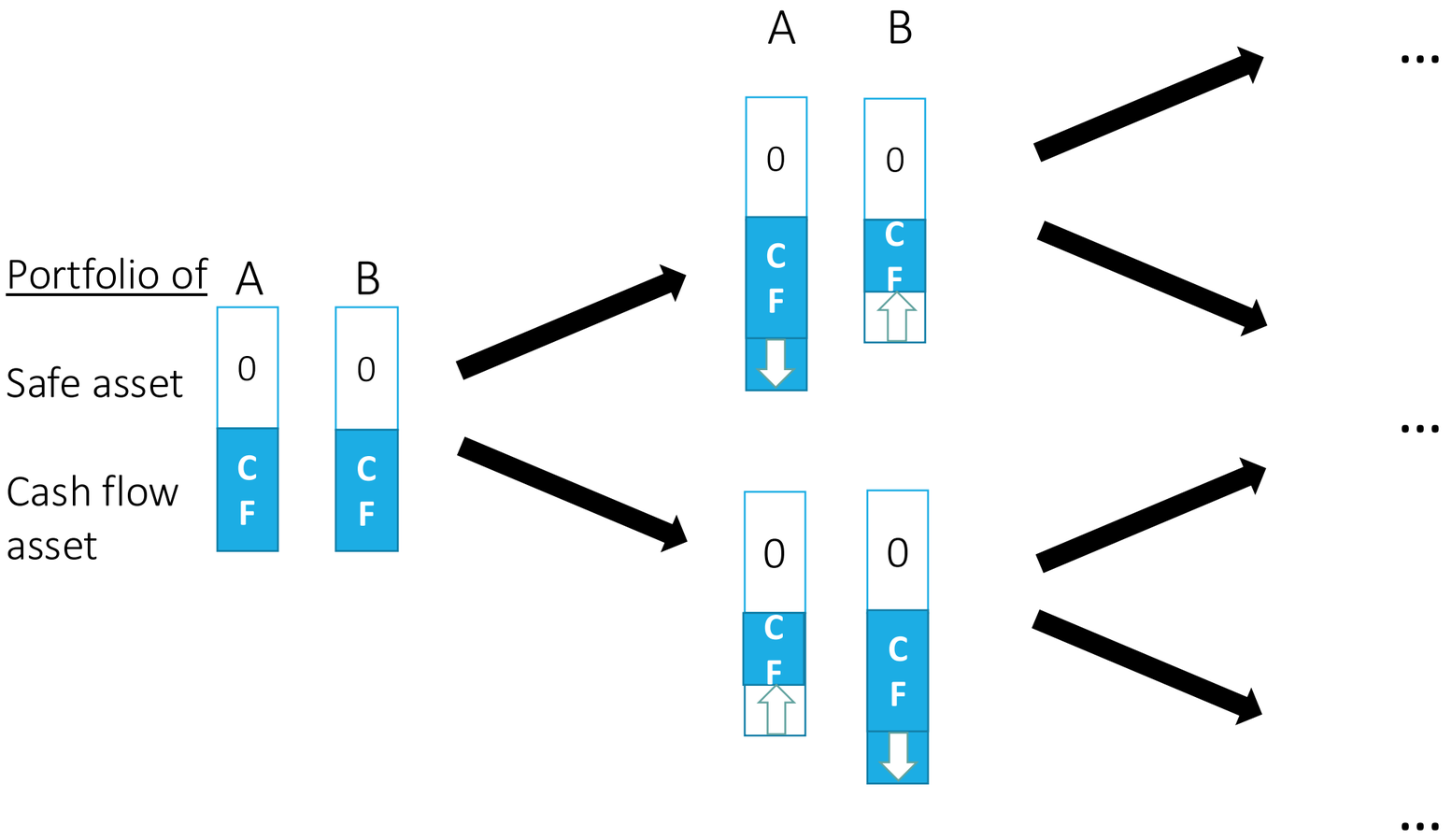

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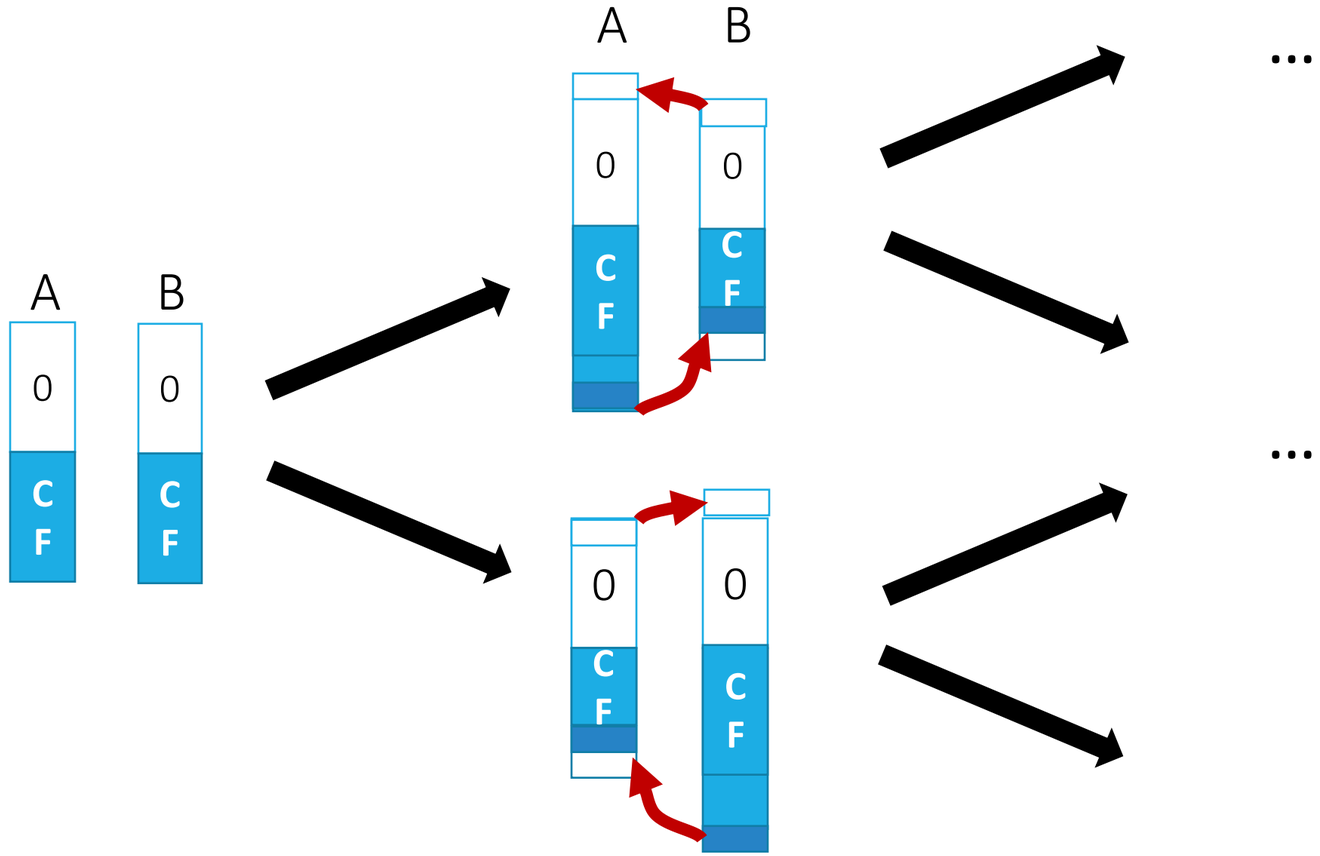


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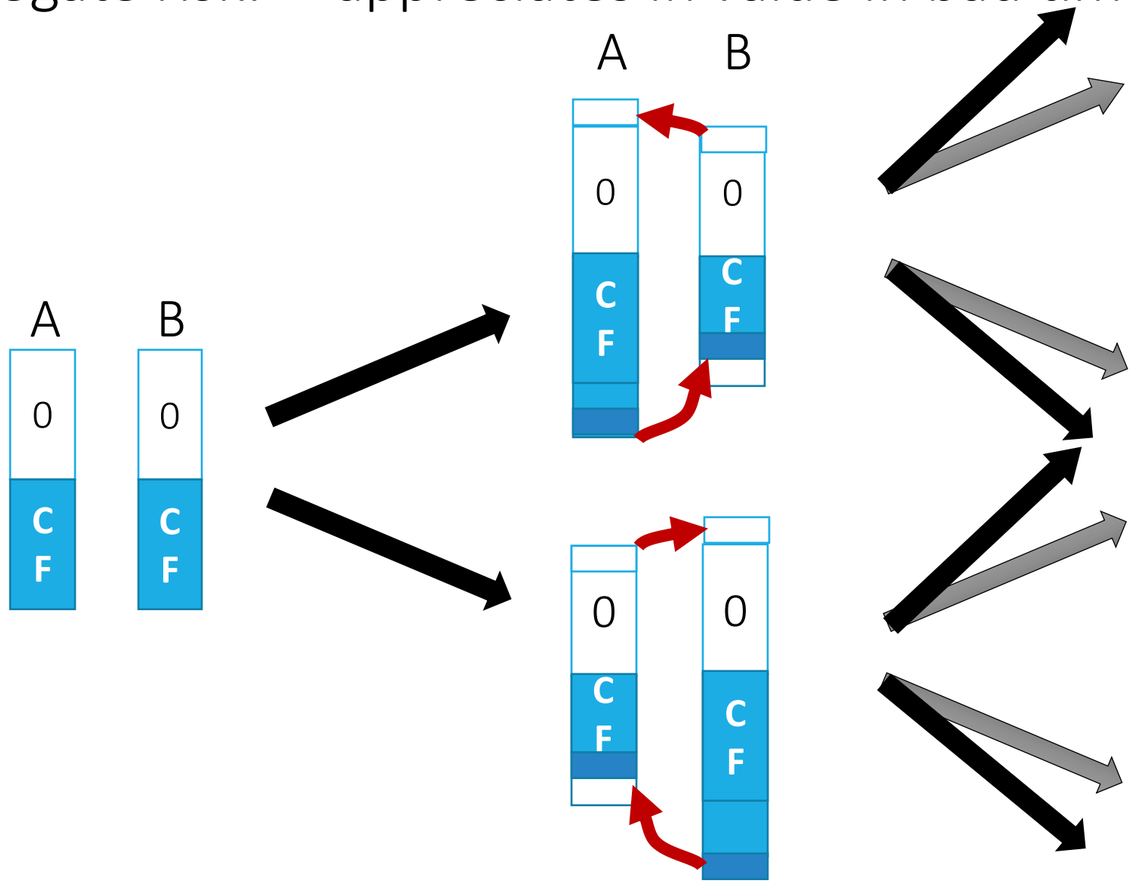


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# Resilience and Safe Asset

- Idiosyncratic risk (to $k$)
  - Assume adjustment to new k-target takes time (adjustment cost)
- With safe asset
  - Without adjustment cost
    – better risk-sharing (as one buys capital after destruction shock)
  - With adjustment cost
    - slowly rebalance portfolio and buy back some capital (to target level $\hat{k}$)

- Not at aggregate level but individual level

# MacroFinance: More than Intersection of Macro & Finance