Climate and transition macro-financial risks

Emanuele Campiglio[12]

[1]University of Bologna

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Last lecture

- Course presentation
- Short background recap
  - Climate change $\rightarrow$ climate damages to human societies
  - Solution: reduce GHG emissions
  - But, decarbonisation might trigger economic and financial disruptions
  - Find the right window to achieve a smooth and rapid low-carbon transition
- Today:
  - What risks are we exposed to?
- Next lecture:
  - How should our societies behave?

Outline for today

- Short intro on CRRs and NGFS framework
- Physical risks
  - No main reading, but pieces from a variety of sources
- Transition risks
  - Mainly following Semieniuk et al. 2021. Low-carbon transition risks for finance. WIREs Climate Change 12, e678. (Link to open access)
- But before we start..
  - What did you think of the assigned reading?

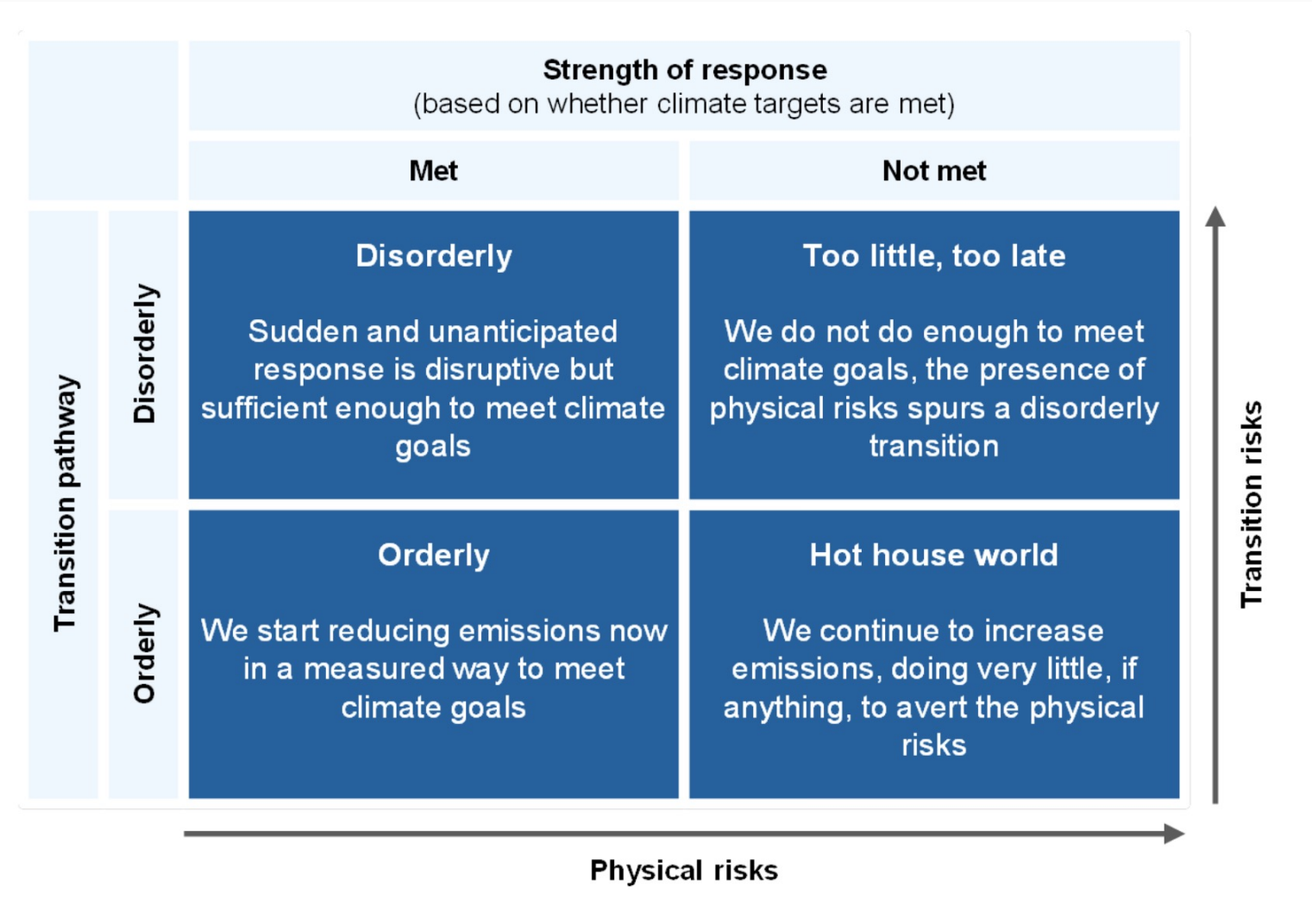
Climate-related risks

Climate-related risks - The Carney way

- Physical risks
  - 'the impacts today on insurance liabilities and the value of financial assets that arise from climate- and weather-related events, such as floods and storms that damage property or disrupt trade'
- Liability risks
  - 'the impacts that could arise tomorrow if parties who have suffered loss or damage from the effects of climate change seek compensation from those they hold responsible'
- Transition risks
  - 'the financial risks which could result from the process of adjustment towards a lower-carbon economy'

2015 Lloyd's speech by BoE governor Mark Carney

Climate-related risks - The NGFS way



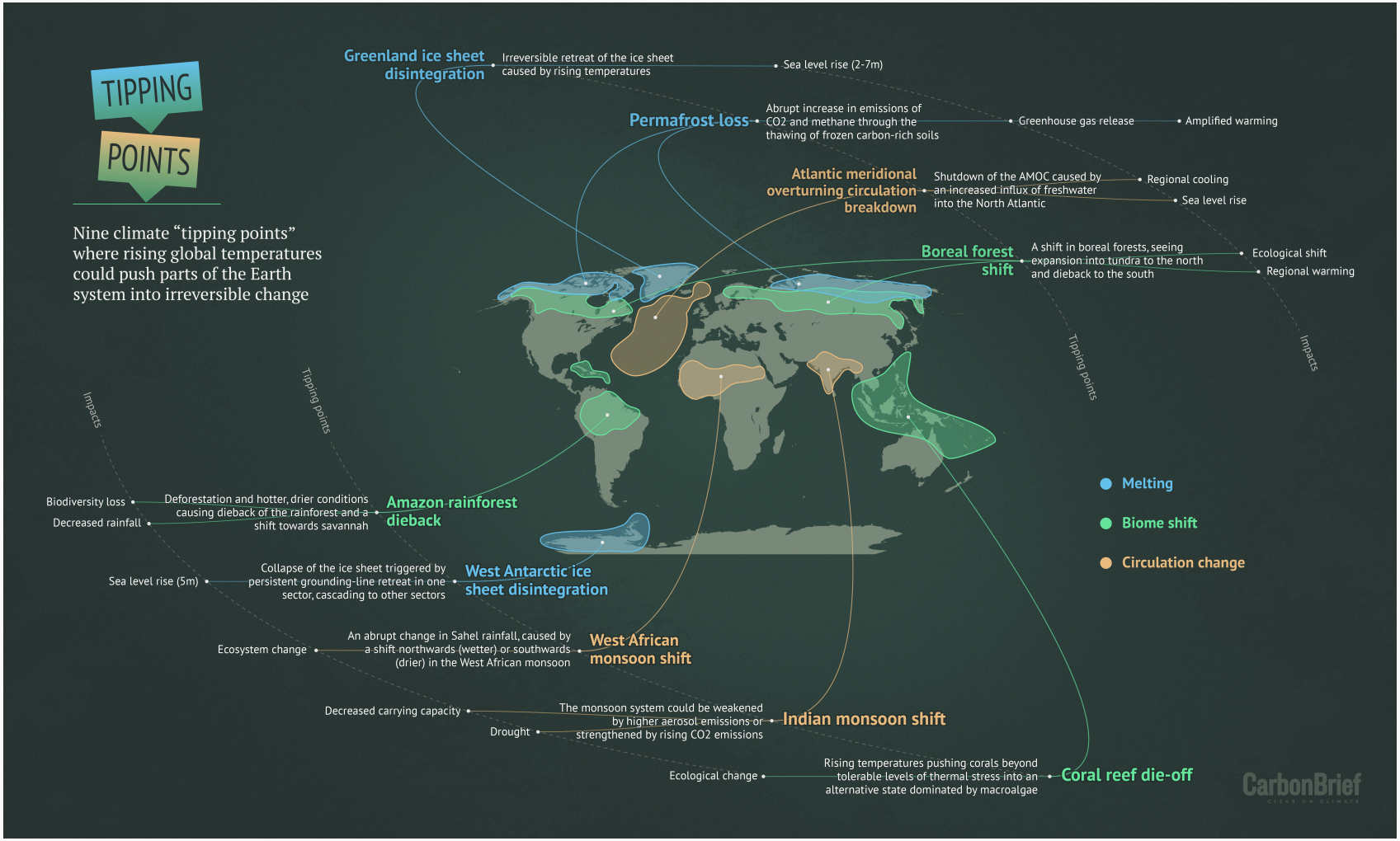
Source: NGFS (2019)

Physical risks

Acute and chronic climate hazards

- Acute hazards: point events triggered/exacerbated by climate
  - Extreme weather events (hurricanes, heat waves)
  - Floods, wildfires
- Chronic hazards: progressive shifts in climate patterns
  - Increasing temperatures
  - Rise of sea levels
  - Changes in precipitation ($\rightarrow$ droughts, water availability)

Tipping points



Source: Carbon Brief (2020)

Potential repercussions for firms

- Physical assets destroyed or damaged
  - Balance sheet effects (assets written down)
  - Loss of revenues or higher costs
- Disruption to trade routes
  - Inputs unavailable $\rightarrow$ Delayed production
  - Markets inaccessible or demand reduction $\rightarrow$ Lower revenues
- Decrease in labour productivity
  - Losses in production and revenues
- Higher adaptation costs
  - Relocation, air conditioning, heating
- Higher capital costs
  - Harder to get credit $\rightarrow$ Lower investments

Impacts for financial firms

- Insurance companies
  - Physical impacts increase claims
- Commercial banks
  - Physical impacts increase non-performing loans
- Financial investors
  - Physical impacts affect financial asset prices
- Financial asset price depend on expected payoffs, with a risk premium (expectations, sentiments)
  - Revision of estimated future payoffs
  - Revision of risk/uncertainty $\rightarrow$ change in risk premium
  - Endogenous revaluation driven by new valuation models

Dietz et al. (2016) on NCC

- What would be the impact of climate change on asset values?
  - Value at Risk (VaR): potential portfolio loss over a given time horizon, at a given probability
- Starting point: DICE 2010
  - Modified climate damages: on both growth and capital stocks
- Some assumption
  - Asset values = NPV of discounted cash flows
  - Corporate earnings constant % of GDP $\rightarrow$ same growth rates
  - Debt and equity perfect substitutes

Table 1 | The present value at risk of global financial assets from climate change between 2015 and 2100—the climate VaR.

Emissions scenario	1st pctl.	5th	Mean	95th	99th
BAU (expected warming of 2.5 °C in 2100)	0.46%	0.54%	1.77%	4.76%	16.86%
Mitigation to limit warming to 2 °C with 2/3 probability	0.35%	0.41%	1.18%	2.92%	9.17%

Source: Dietz et al. (2016)

Lamperti et al (2019)

- Dystopian Schumpeter meeting Keynes (DSK) model
- Climate change creates damages to:
  - Capital stocks
  - Labour productivity
- Firms loss of profitability
  - Higher ratio of non-performing loans
- Banks reduction of equity
  - When equity becomes negative, they are bailed out from the government

Lamperti et al. (2019) on NCC

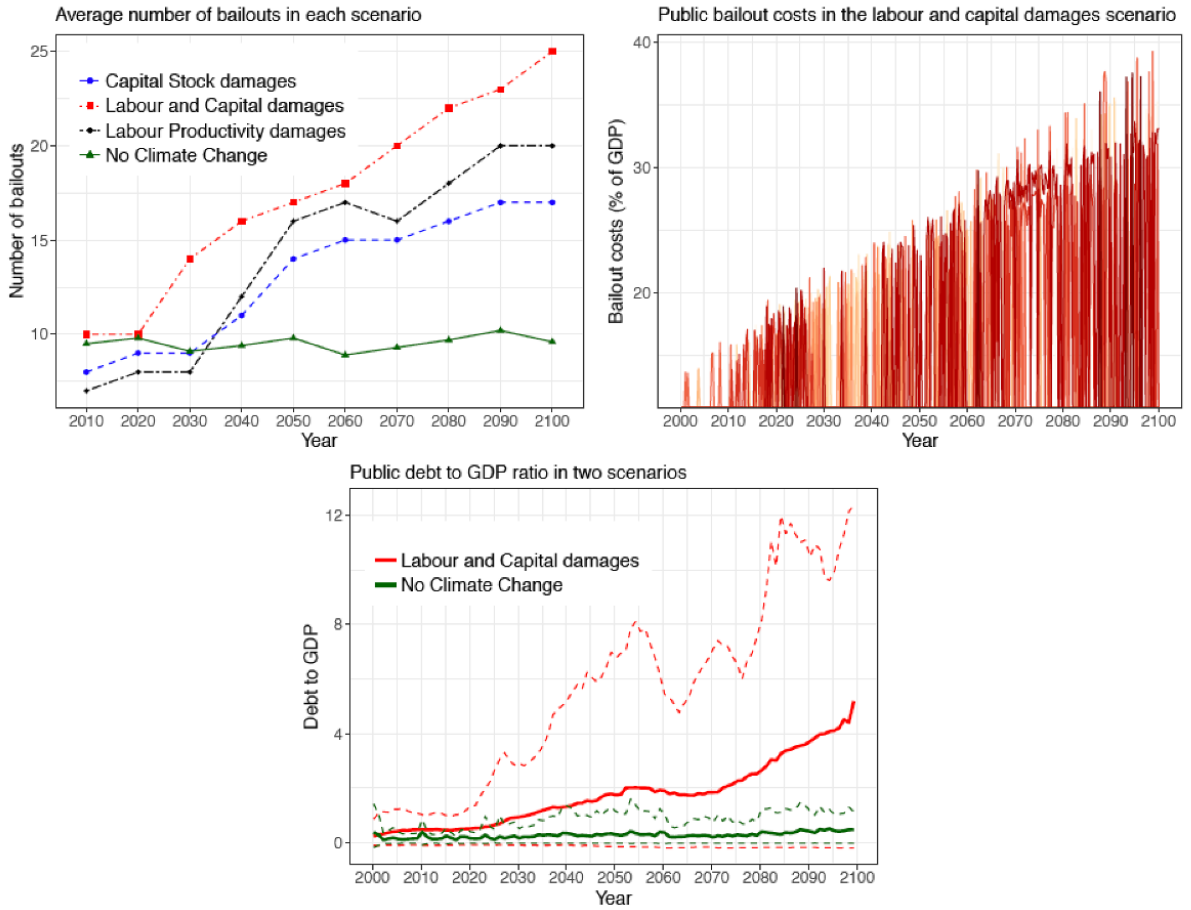
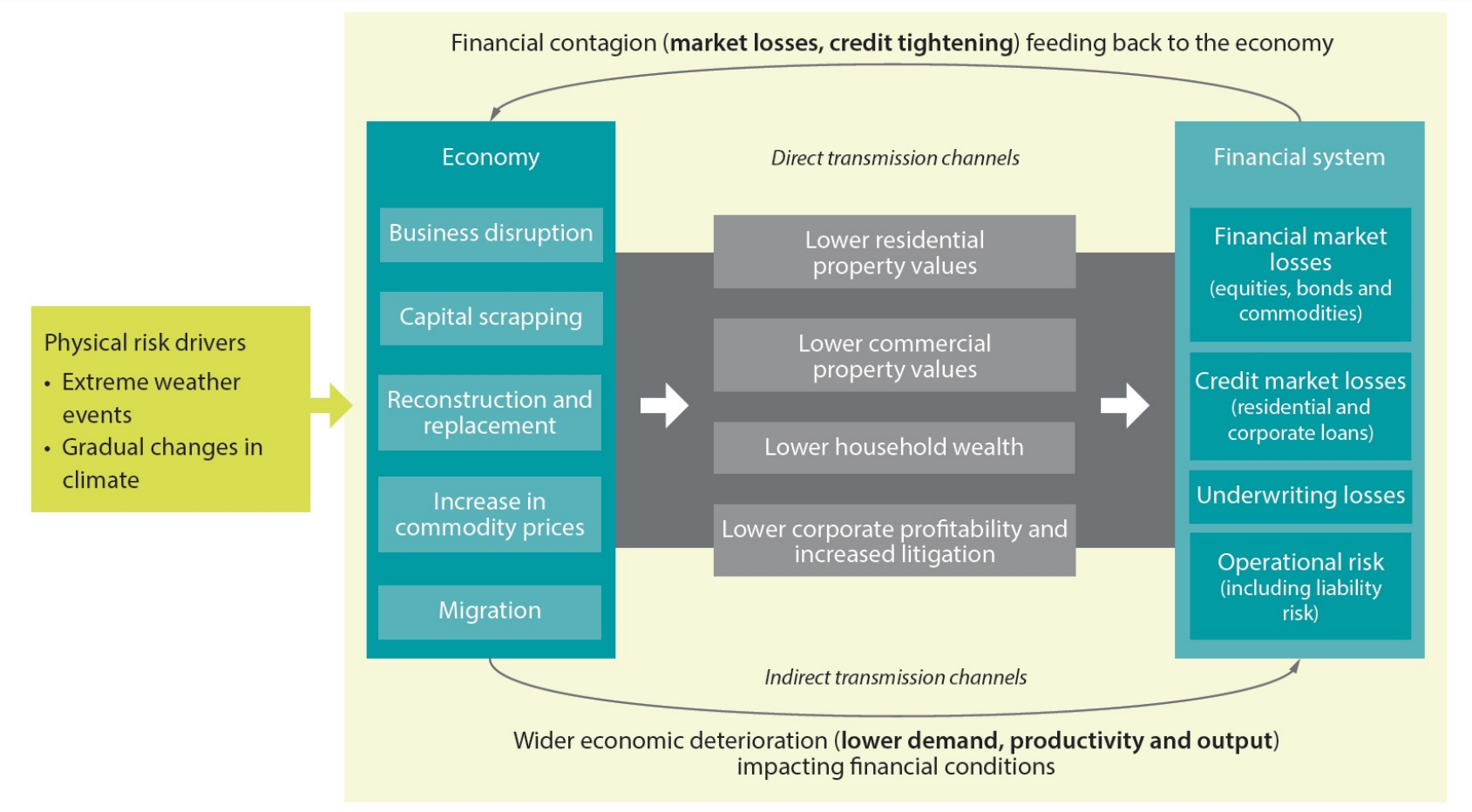


Figure 2: Ten years average number of bailouts (out of 500 simulations) in the three scenarios and in the baseline (top-left); bailout costs as share of GDP in the Labour and Capital Damages scenario, each line represents a model run (top-right); public debt behaviour in the Labour and Capital Damages scenario and in the No Climate Change scenario, solid lines are yearly averages (out of 500 simulations) and dashed lines are 90% confidence intervals.

Source: Lamperti et al. (2019)

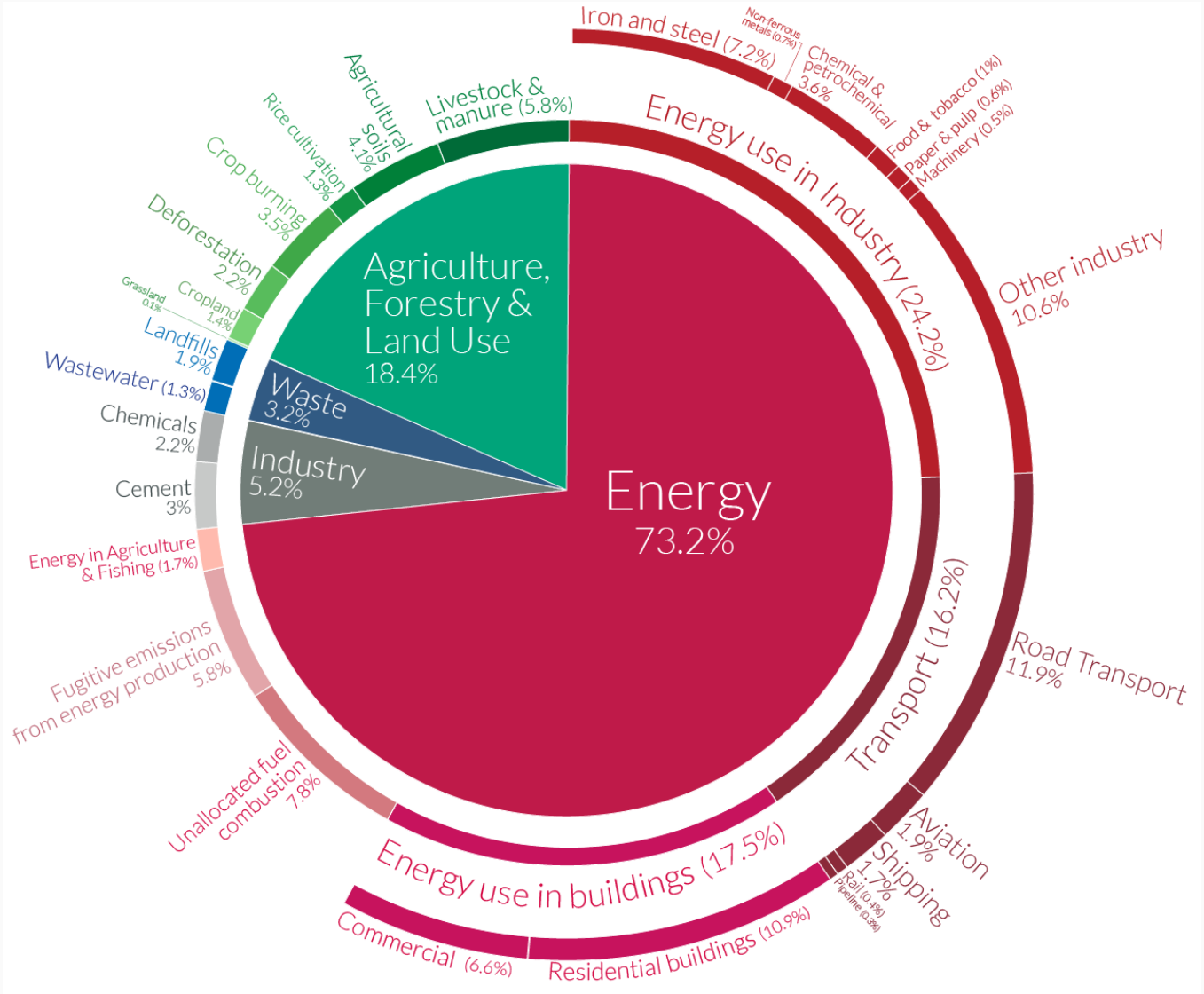
Physical risks (NGFS)



Physical risks for financial stability. Source: NGFS (2019)

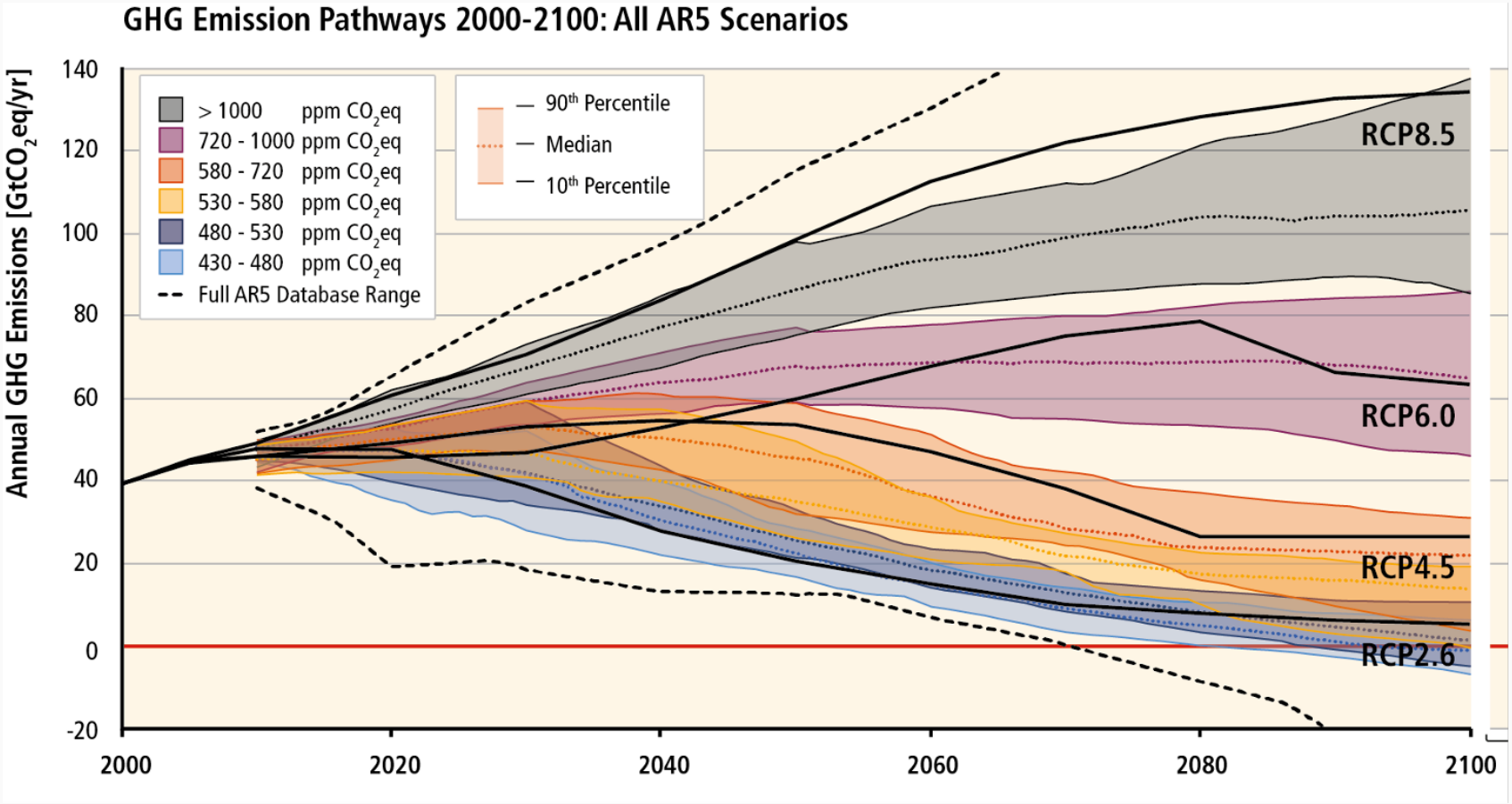
Transition risks

Where do emissions come from?



Global GHG emissions by sector in 2016. Source: Our World in Data

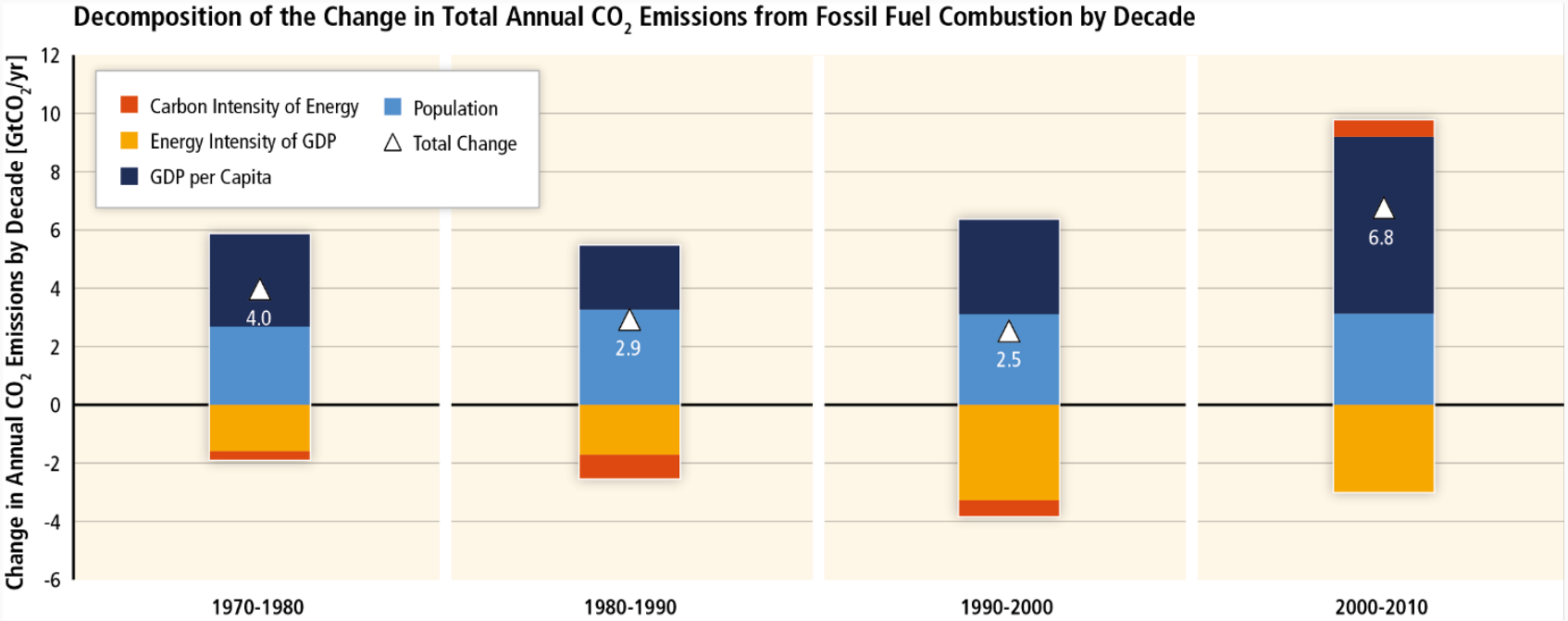
How should emissions change in the future?



Emission reduction pathways. Source: IPCC (2014)

GHG Emission drivers

- Kaya identity $CO_2 \equiv P \frac{Y}{P} \frac{E}{Y} \frac{CO_2}{E}$
  - CO_2: emissions; P: population; Y: income; E: energy

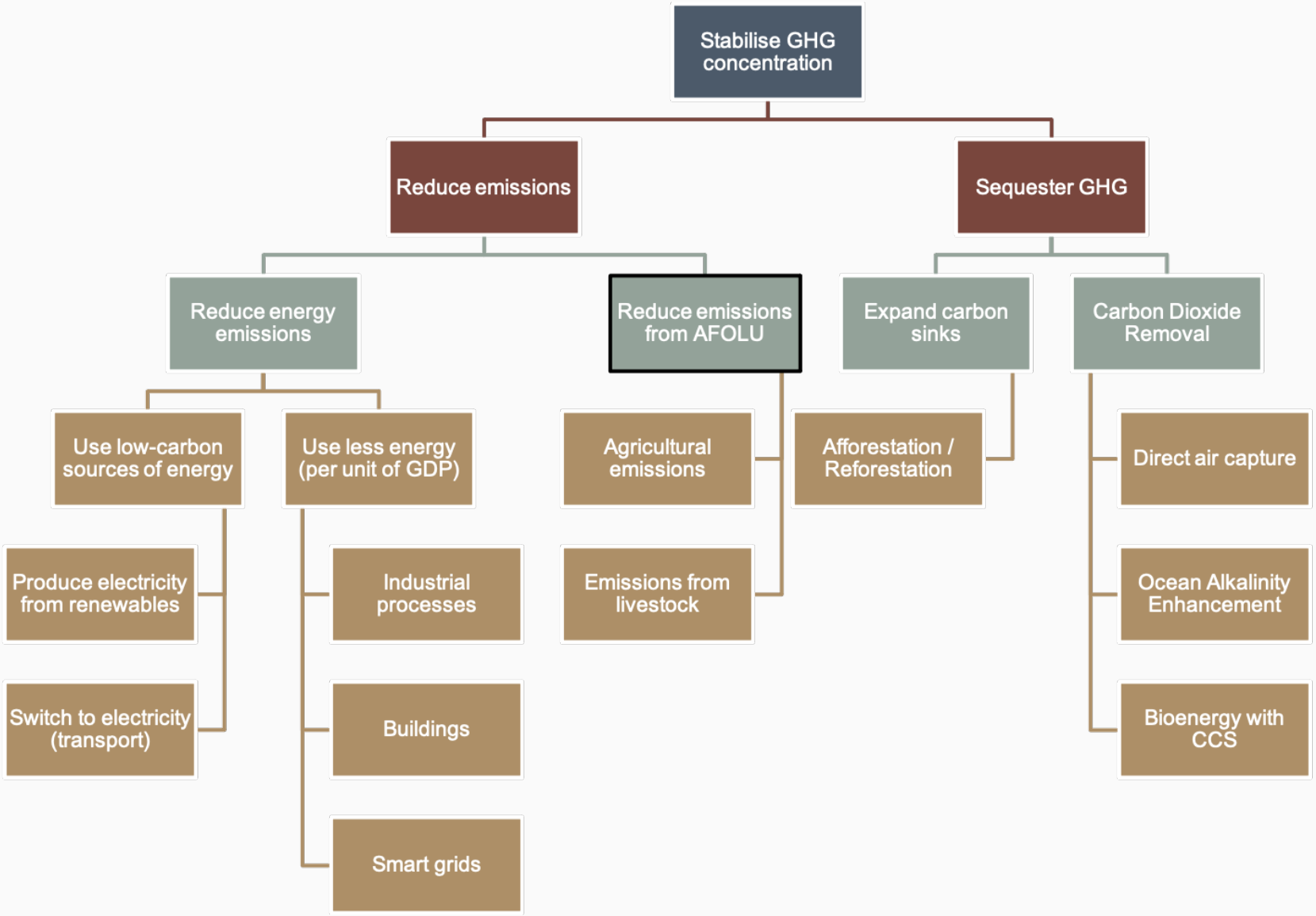


Source: IPCC (2014)

Levers to reduce emissions

- Reduce population
  - Population control measures, but very slow
  - Freedom issues (eg. one child policy in China)
- Reduce income
  - Degrowth; discussion on income-welfare links
  - Politically unpalatable and only applicable to high-income countries
- Improve production processes
  - Reduce energy intensity of GDP
  - Reduce emissions intensity of energy
  - This is what we refer to as ‘green growth’ or ‘decoupling’

Technological mitigation options

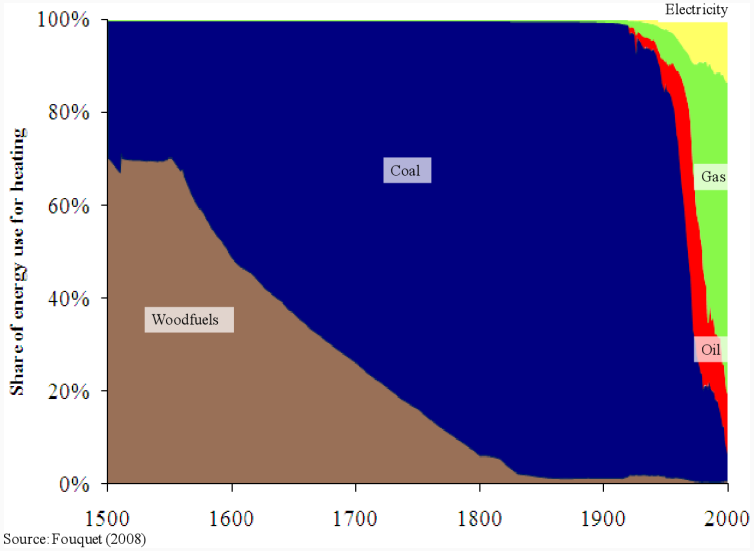


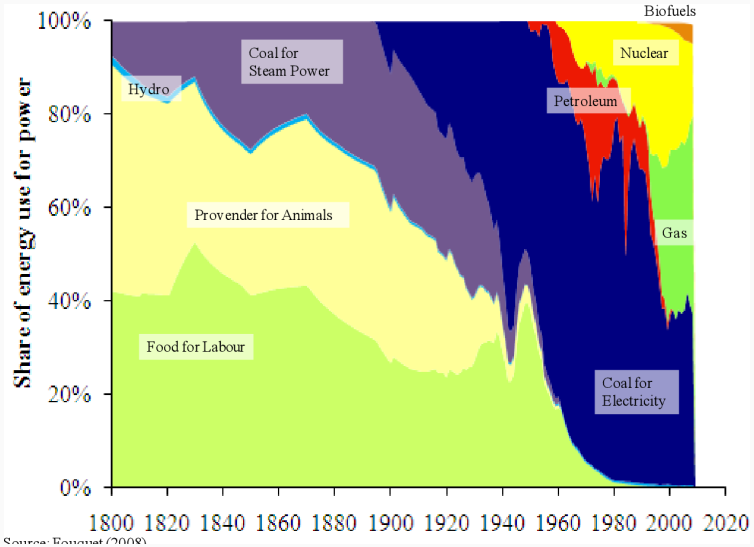
The tree of technological options to stabilise GHG concentration

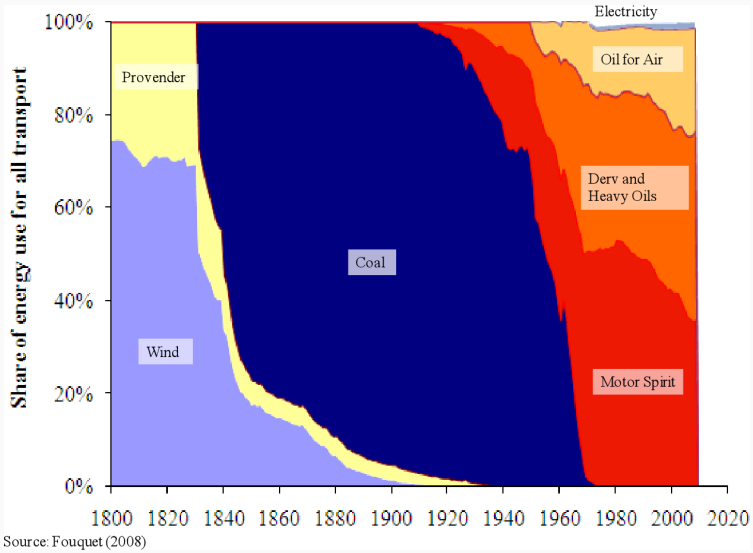
What does a low-carbon transition mean?

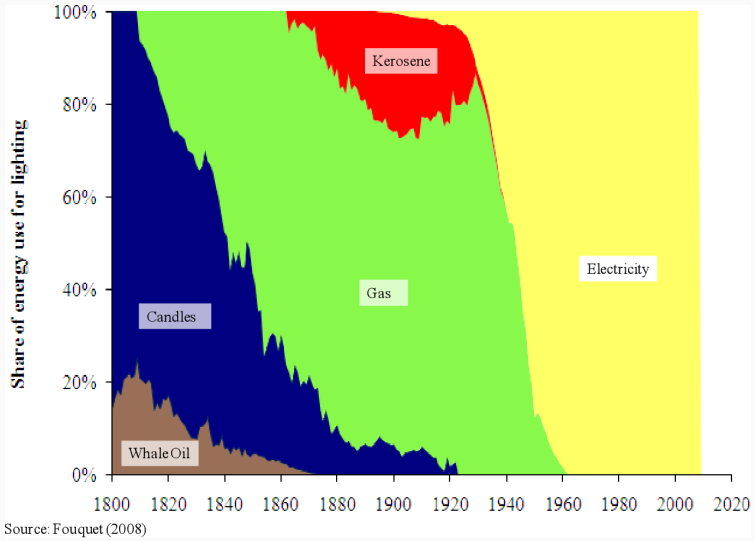
- Decarbonise electricity
  - Wind, solar and other renewable energies
- Electrification
  - E.g. Electric vehicles. But what about international transport
- New manufacturing processes
  - E.g. Electric arc furnaces; bio-plastics
- New agricultural/farming techniques
  - E.g. Nitrogen-fixing rotations (More details)
- Negative emission technologies
  - Carbon capture and storage
  - Direct air capture
- Radical breakthroughs
  - Geoengineering
  - Nuclear fusion

This is not the first technological shift (UK example)









Source: Fouquet (2008)

However, a major difference

- Technological transitions historically driven by the emergence of new, more productive, more profitable technologies
  - Market players move there by their own
  - There will be losers, but societal gains outweigh costs
- Low-carbon transition likely to require strong policy interventions to promote (still) unattractive technologies
  - Market players need to be pushed there
  - There will be losers; who benefits?

Transitions and finance

- Traditionally focus on financial risks from sunrise industries
- Schumpeterian vision of creative destruction
  - Credit necessary for innovation (credit creation by banks)
  - But innovation also calls for speculators
  - Asset overvaluation (link to Minsky)
  - When innovation slows down, over-indebtedness leads to defaults and possibly a financial crisis.
- Carlota Perez:
  - Aftermath of financial collapse reveals social issues
  - Regulatory intervention needed to redirect innovation
- Examples:
  - Mid-1800s financial crises linked to expansion of railways
  - 1929 crisis involved bubbles in radio, electricity, airplanes, automobile, petrochemicals
  - 2001 crisis was the result of the burst of the dotcom bubble

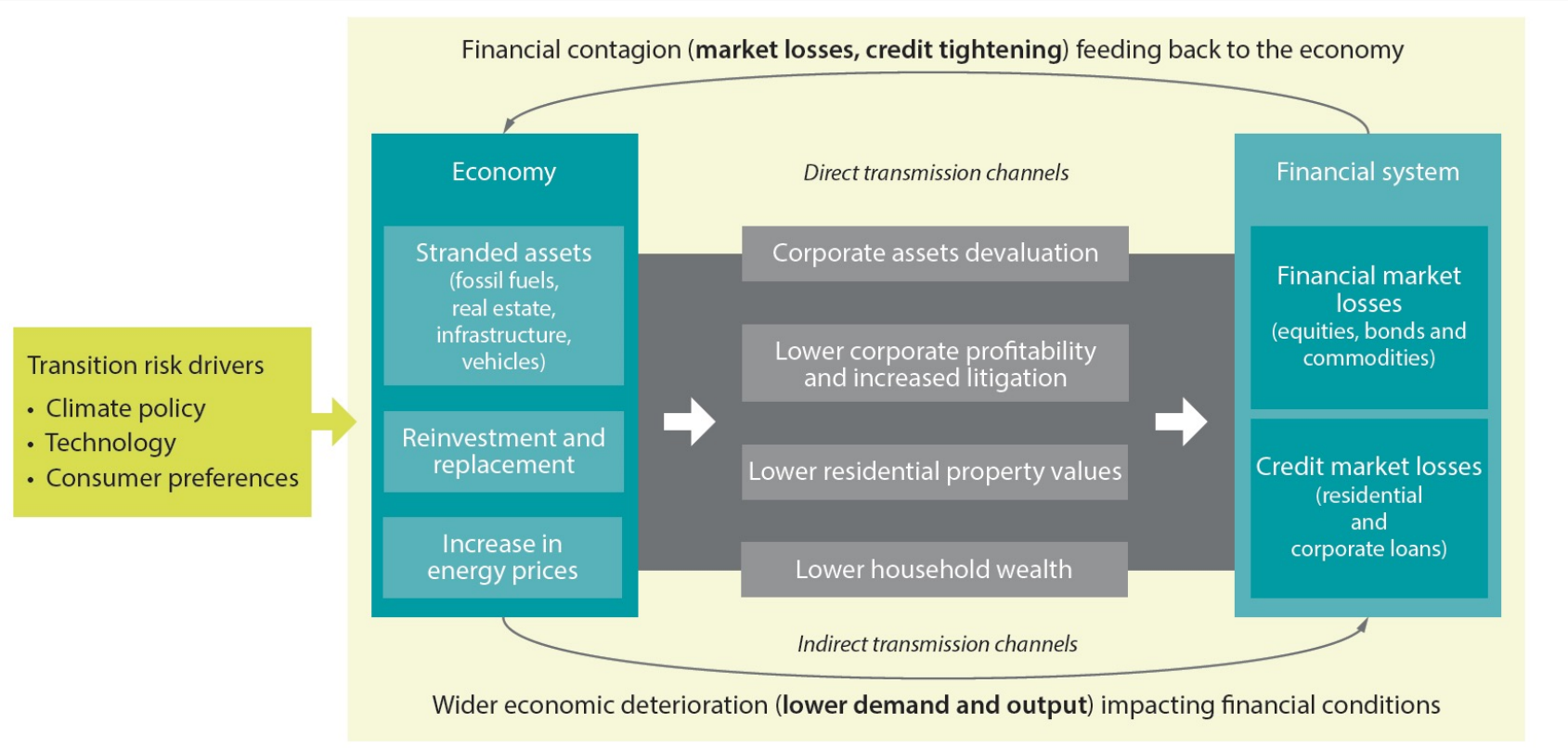
No signs of a green bubble for now

- Some signs of overvaluation and instability
  - Fast market capitalization of Ørsted, Tesla and others
  - Some significant defaults (e.g. Solyndra, Solarworld)
  - YieldCo bubble around 2015
- However, no systemic implications
  - Defaults and bubbles didn't affect much stability
  - Investments increasing but still far from what's needed
  - Not profitable enough to attract large investor crowds
- No general 'mania' in low-carbon sunrise industries
  - Caution: observer bias and timing

Concern is rather on sunset industries

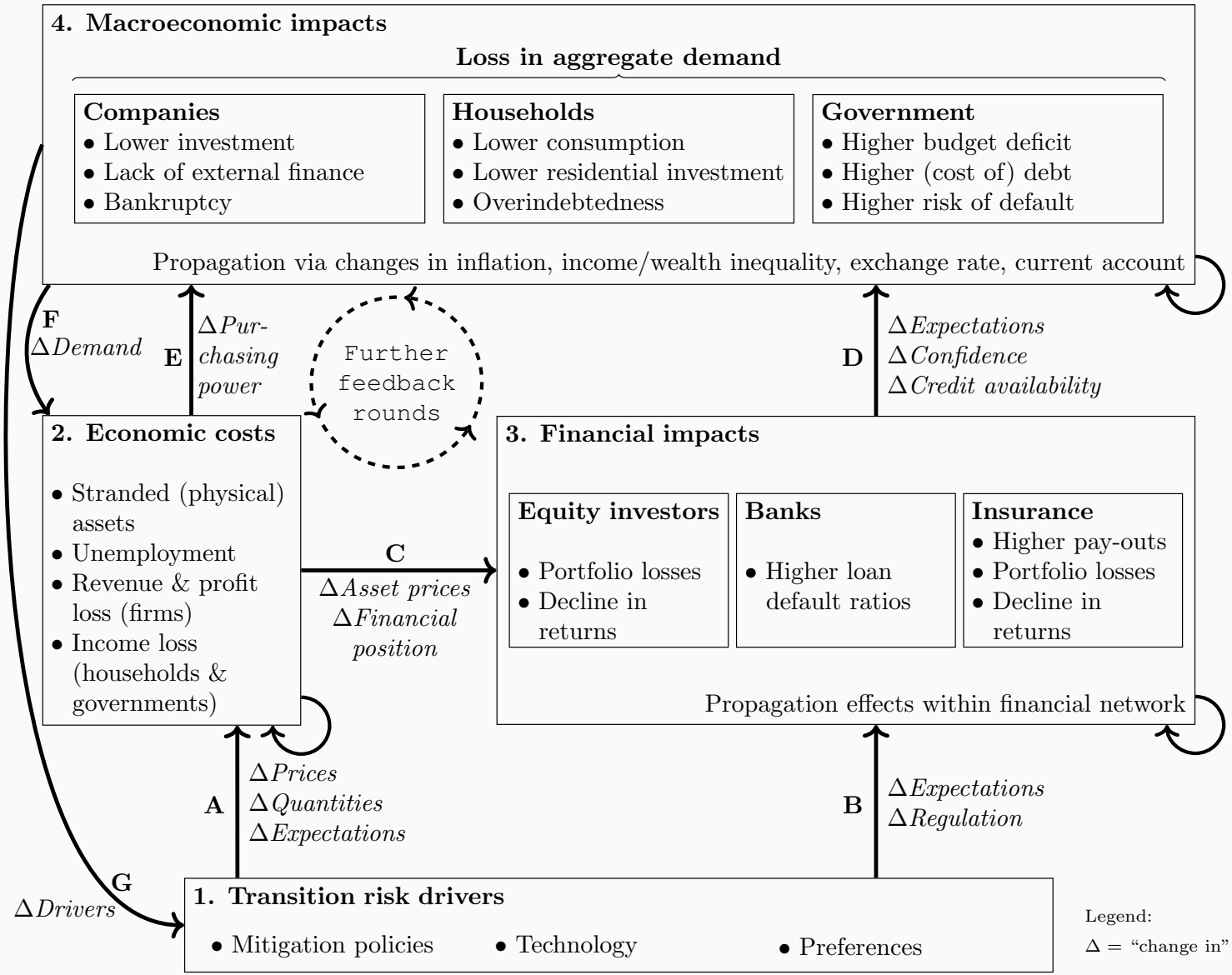
- Some worrying feature
  - Large and ramified sunset industries
  - Heavy reliance of productive sectors on them
  - Large exposure by banks and financial investors
  - High-carbon investments still often profitable (and safe!)
  - More integrated and financialized economy
- No comprehensive analytical framework so far

Transition risks (NGFS 2019)



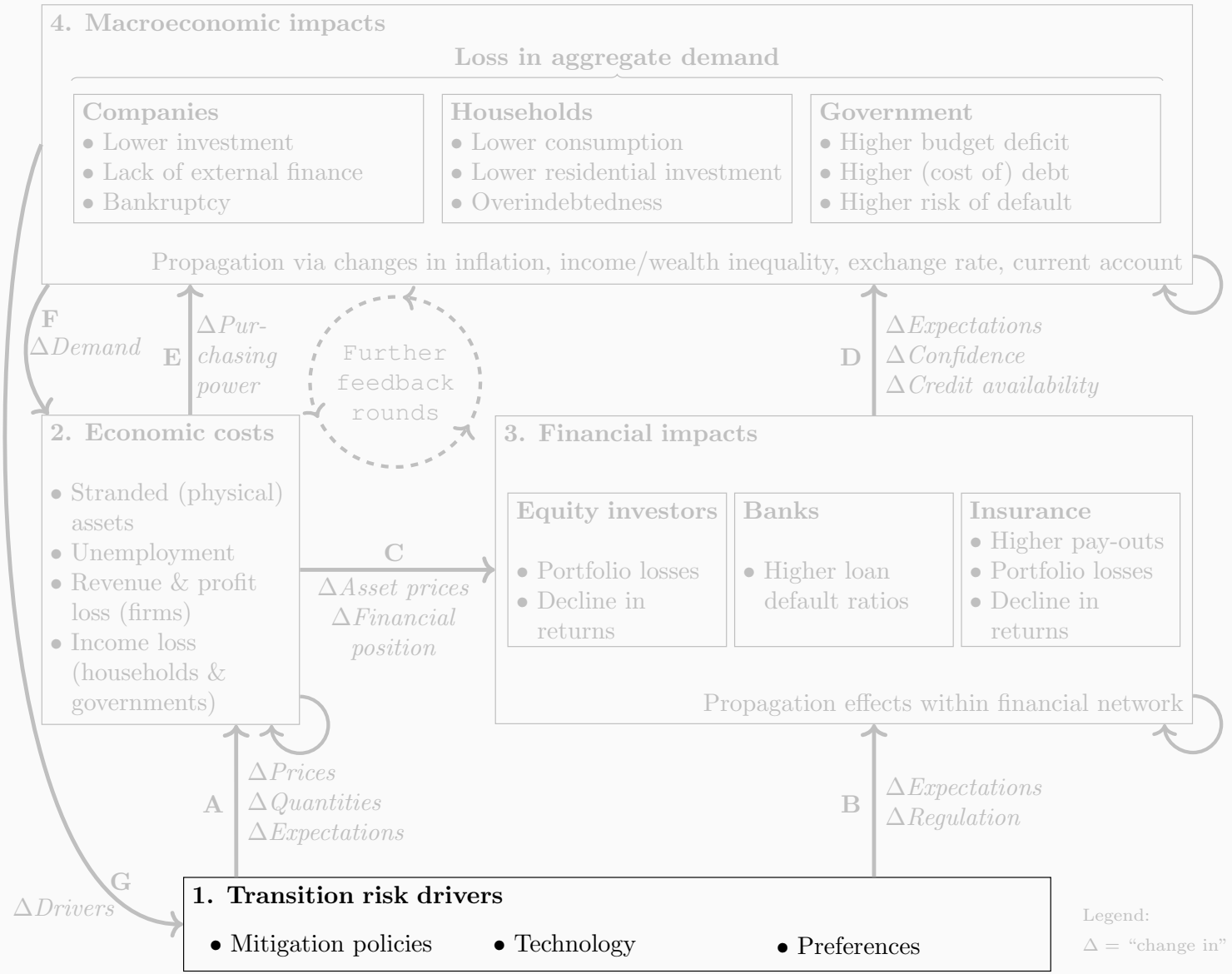
Transition risks for financial stability. Source: NGFS (2019)

Transition risks (Semieniuk et al. 2021)



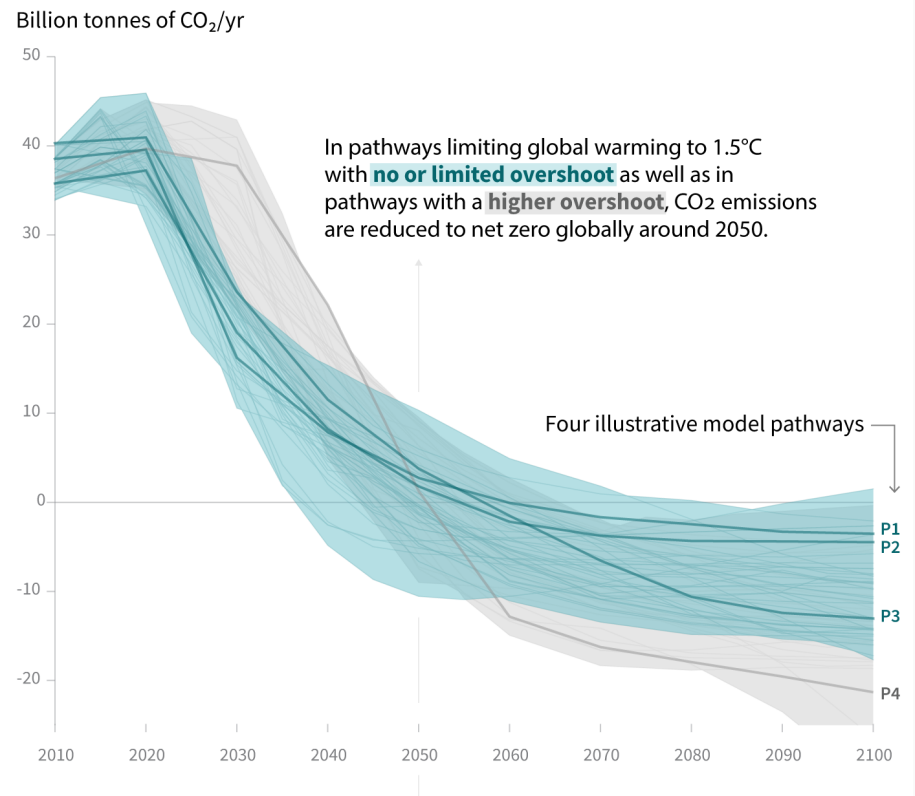
Transition risk drivers

Transition risk drivers



Policy objective: climate mitigation

- Paris Agreement:
  - Keep global temperatures well below 2°C
  - Pursue efforts to limit temperature increase to 1.5°C
- Mitigating climate change requires reducing greenhouse gas emissions
  - IPCC Special Report "Global Warming of 1.5°C" (link)

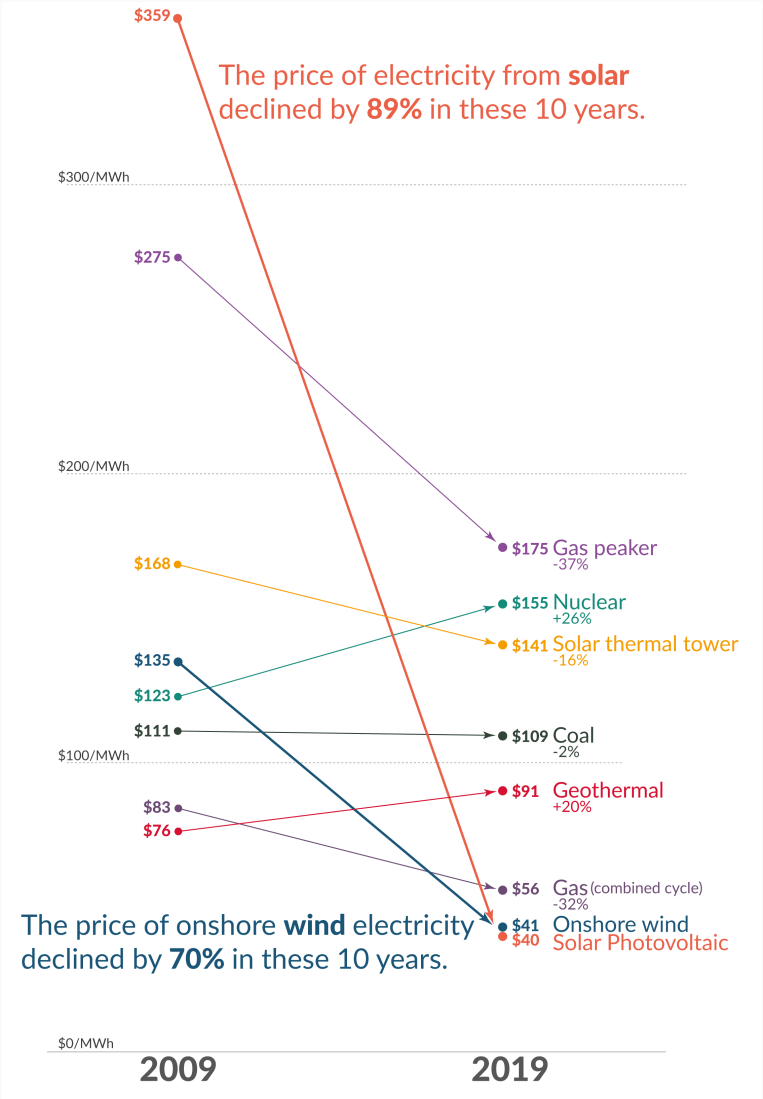


Policy strategies

- Carbon pricing
  - Aim: modify firms/consumer choices via fiscal incentives
  - Carbon taxes, cap-and-trade systems, subsidies (in or out)
  - Mixed success so far
- Supply-side policies
  - Target fossil producers rather than fossil consumers
- Other financial policies
  - Institutional feasibility
- How is a policy implemented?
  - Abrupt/late policy implementation narrative (see NGFS)

Technological progress

- Unexpectedly rapid technological progress
- S-curve technology trajectories
  - i.e. once it picks up pace, it will move rapidly!



Price of electricity from new plants
Source: Our World in Data (link)

Preferences

- Changes in preferences can lead to price changes and quantity restrictions
- Examples:
  - Boycott campaigns
  - Food labelling
  - Public mobilization against nuclear fission

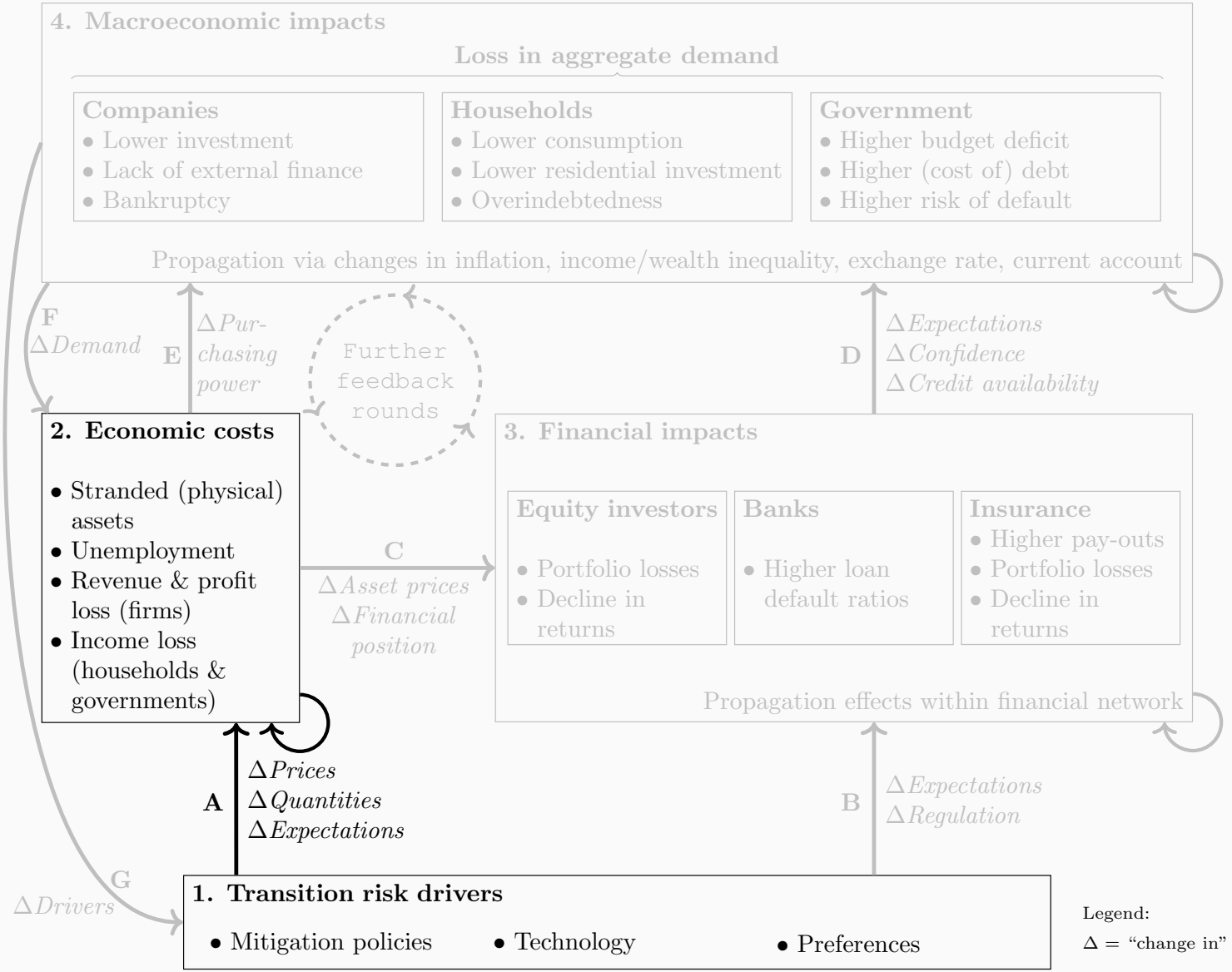
Greta Thunberg and Fridays for Future

The role of expectations

- How transition risk drivers materialise is relevant
  - A predictable policy strategy would smoothly push economic agents to decarbonise
  - An unanticipated policy shock is instead likely to cause large economic losses
- What are investors' expectations?
  - Either look at how they price financial assets..
  - .. or just ask them (surveys)
  - Both methods have limitations
- Are expectations 'correct', or at least 'rational'?
  - Limited information and ability to absorb it
  - Human behavioural biases (e.g. status-quo, confirmation)
  - Forecasting horizons (short-termism)

Economic costs

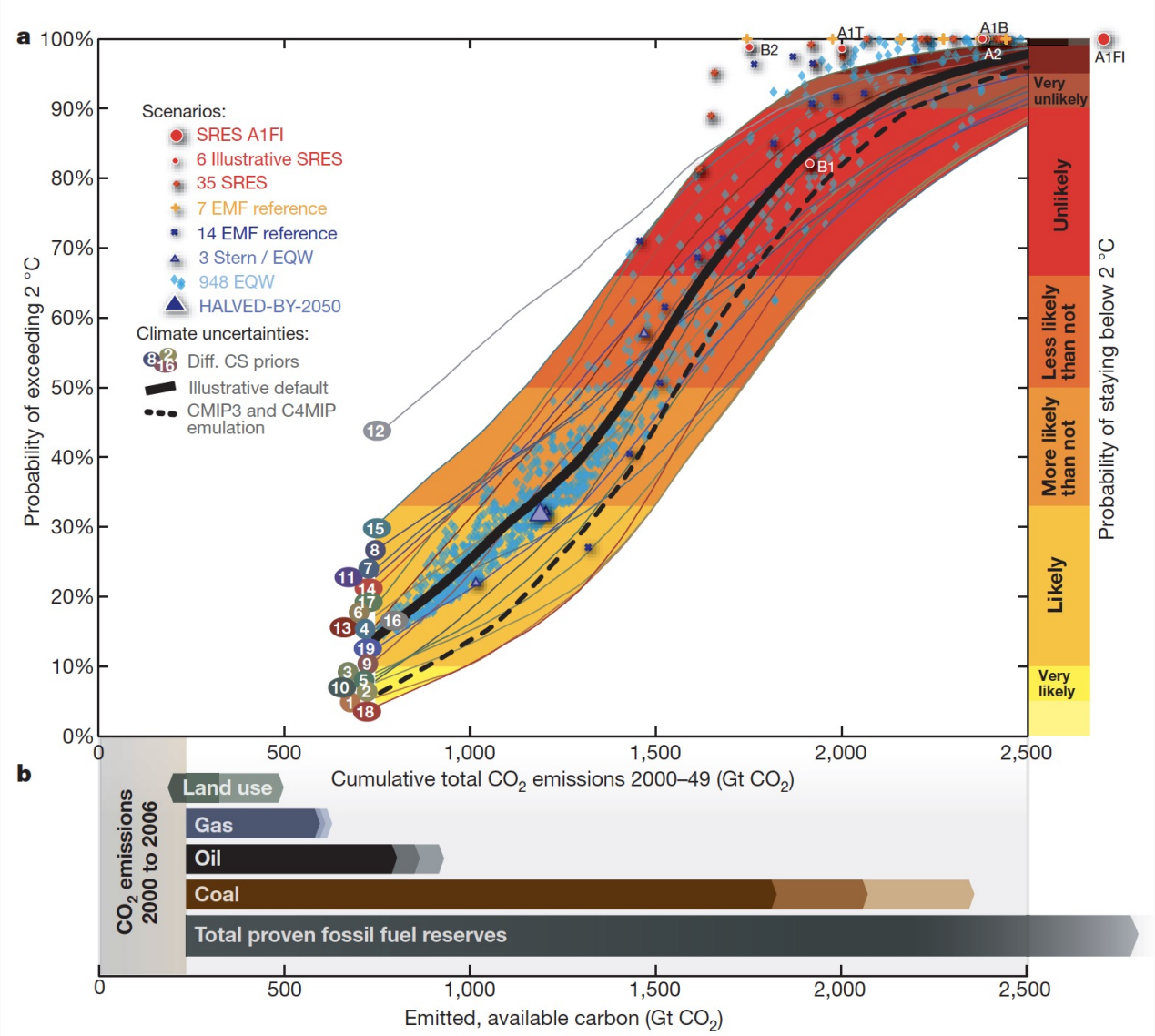
Economic costs



Asset stranding

- Stranding: Premature loss of monetary/operational value of assets
- Three main types of stranding
  - Reserves of fossil fuels
  - Stocks of productive man-made capital
  - Financial assets

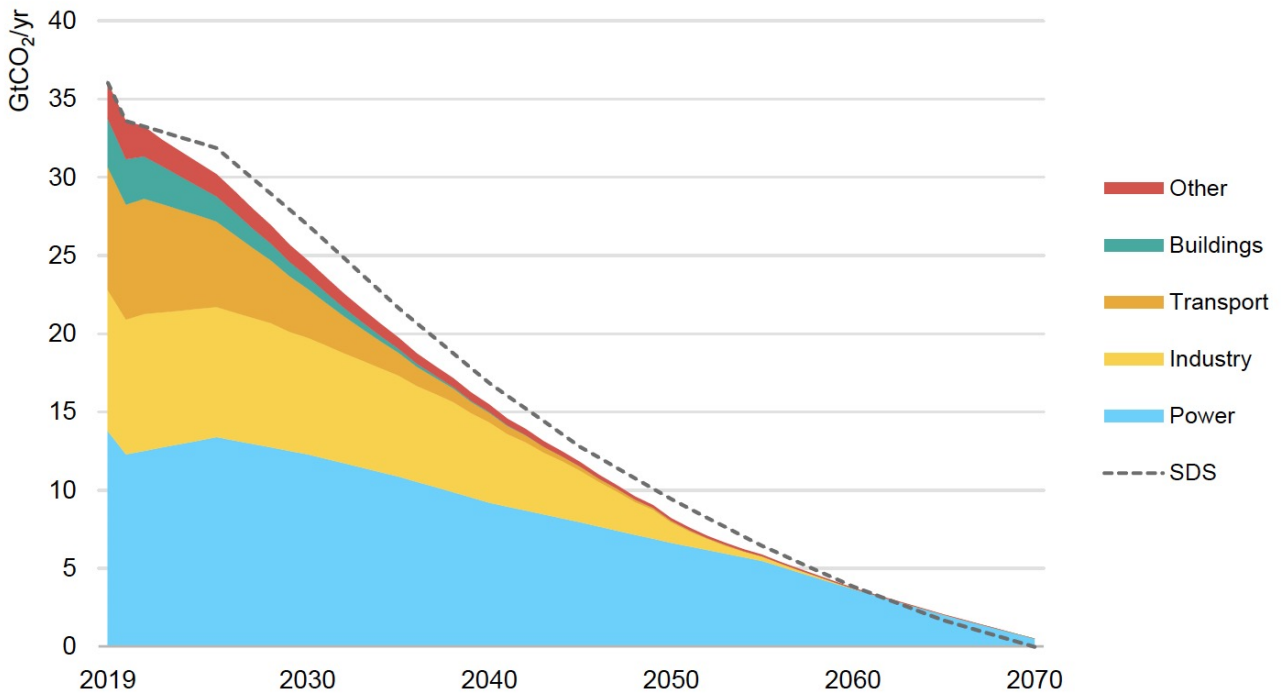
Stranding of fossil reserves



Meinshausen et al. 2009

Stranding of physical capital

Figure 7.5 Global CO_2 emissions locked in by existing energy-related assets by sector measured against the CO_2 emissions trajectory of the Sustainable Development Scenario, 2019-70



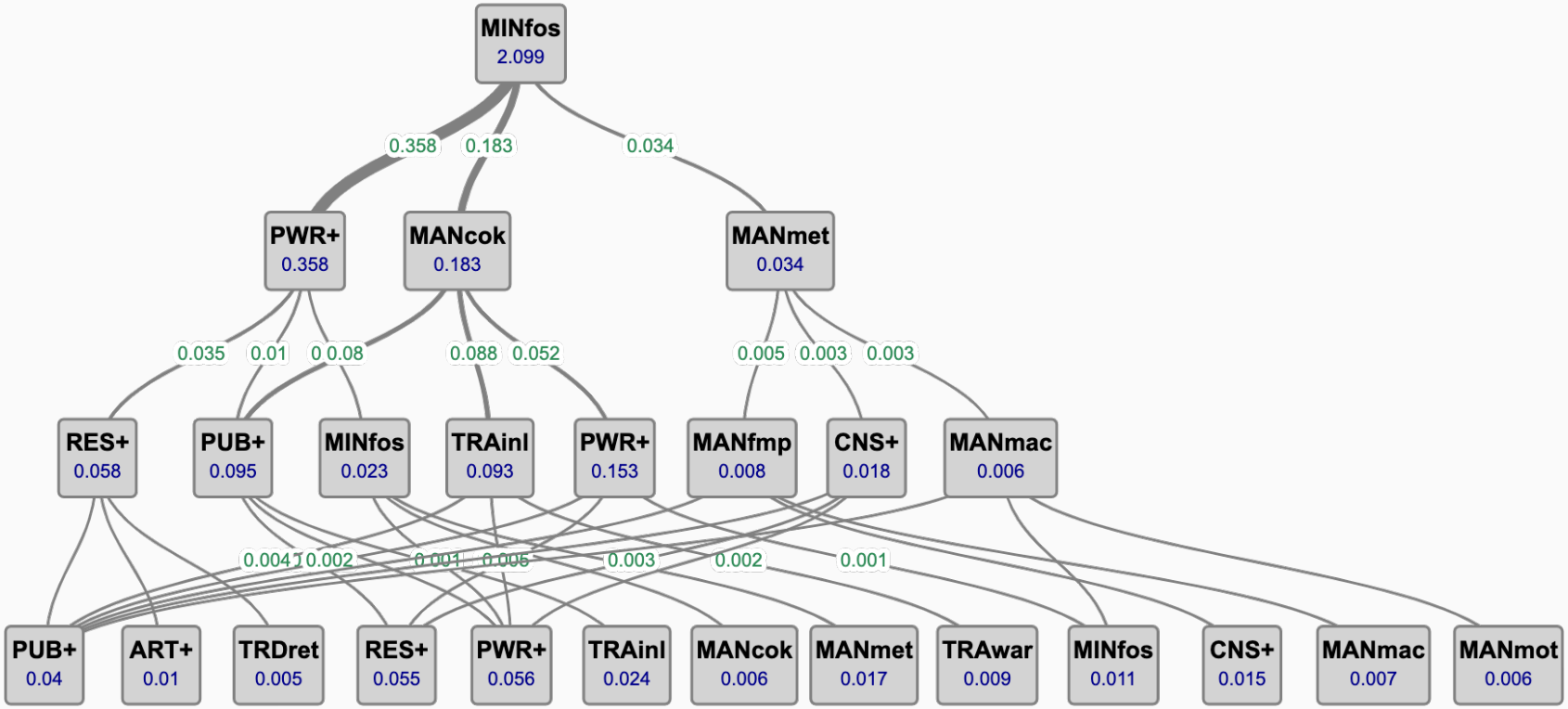
Notes: SDS = Sustainable Development Scenario. The sectors include assets under construction in 2019, the base year of this analysis. Analysis includes industrial process emissions which are accounted on a direct basis. Annual operating hours over the remaining lifetime remain as in 2019.

IEA Energy Technology Perspectives 2020

Economic costs

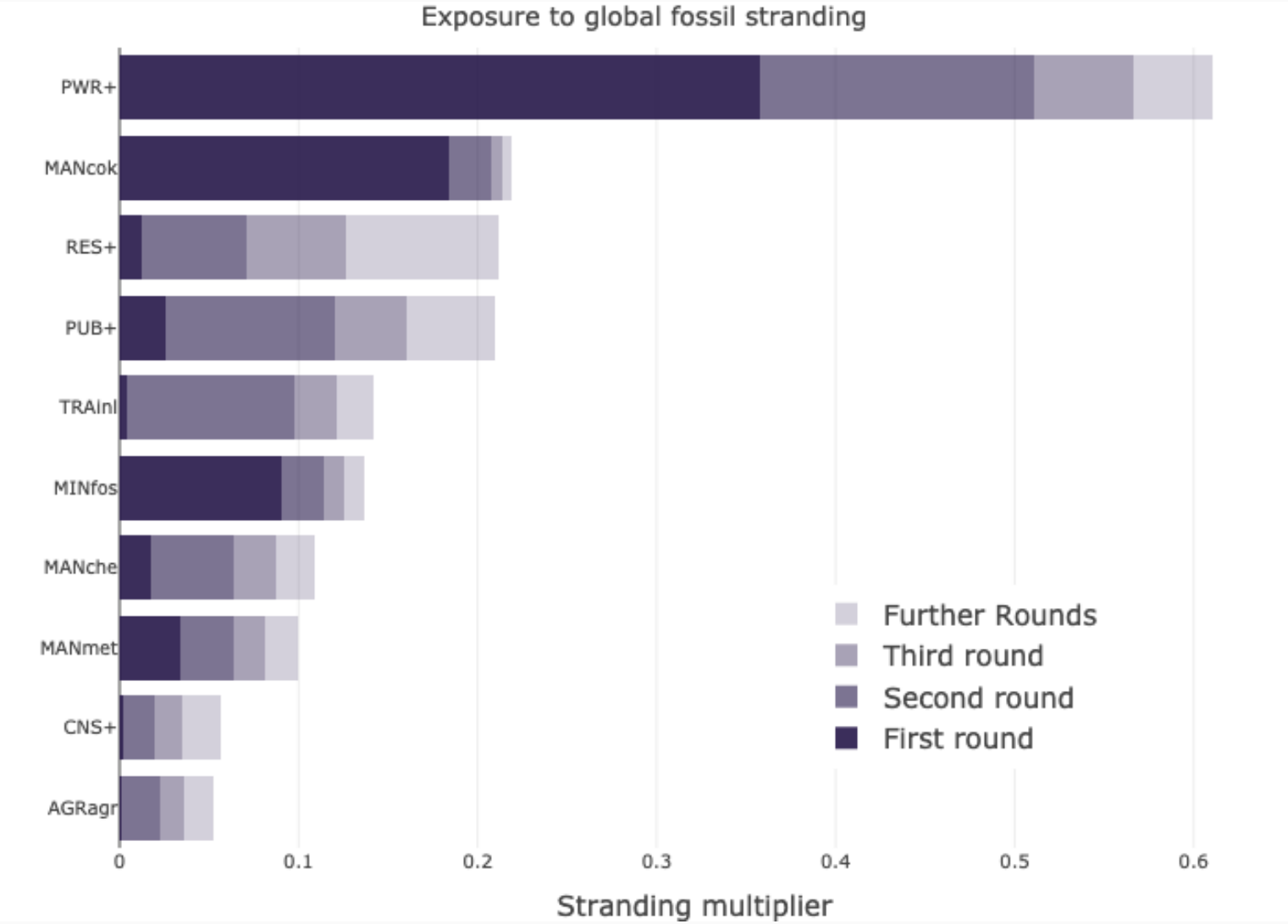
- Stranding of physical capital stocks mean:
  - Loss of capacity utilization
  - Premature retirement
  - Costly reconversion
- Stranding of employment
  - Requalification of workers
- Loss of tax revenues
  - Repercussions on public budgets
- Loss of real income
  - Carbon taxes tend to be regressive
- + Propagation within production networks!
  - Stranding not limited to fossil-intensive sectors

Stranding cascade from global fossil sector



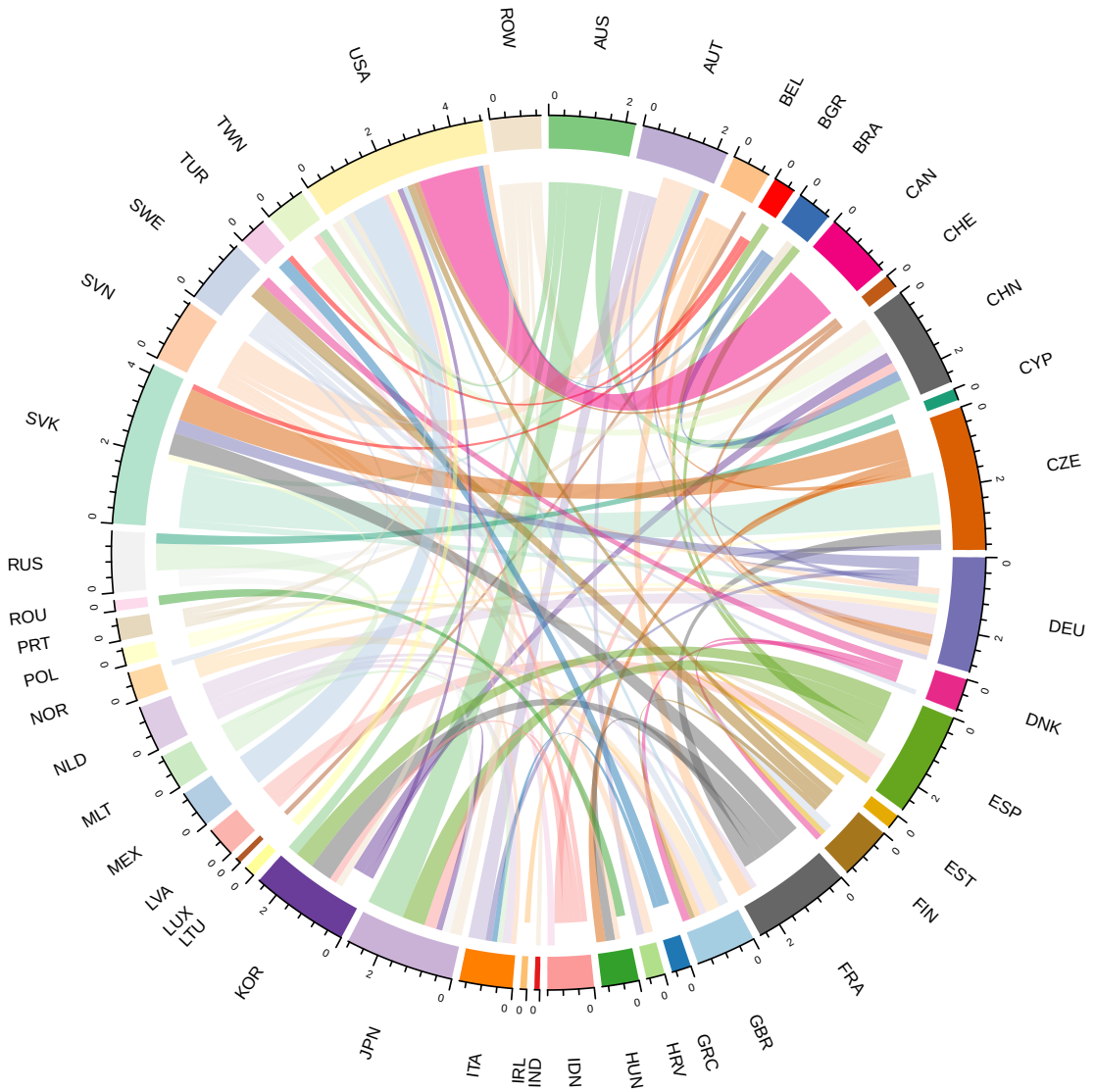
Source: Cahen-Fourot et al. (2021)

Rounds of effects of global fossil stranding

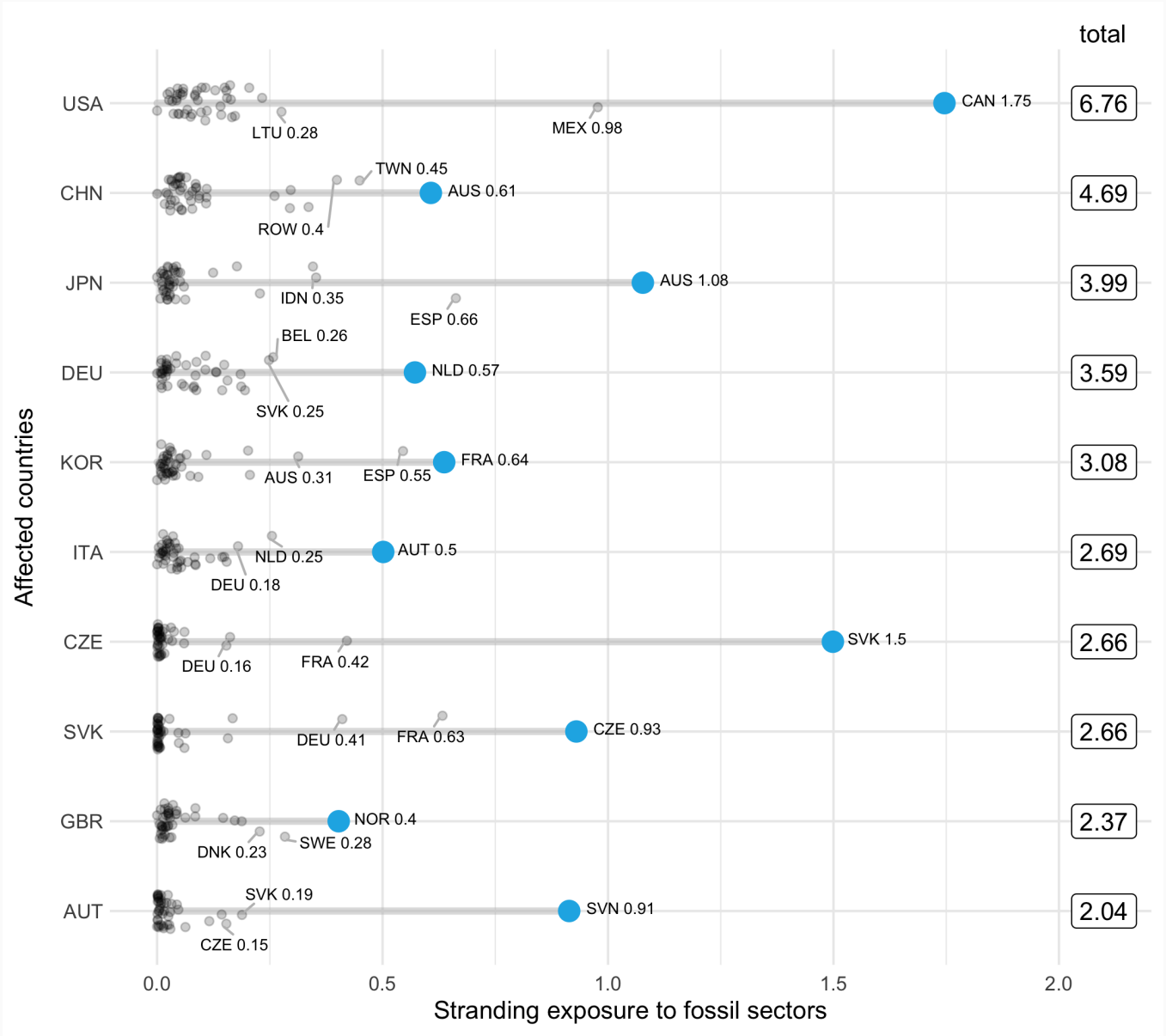


Source: Cahen-Fourot et al. (2021)

Cross-boundary fossil stranding

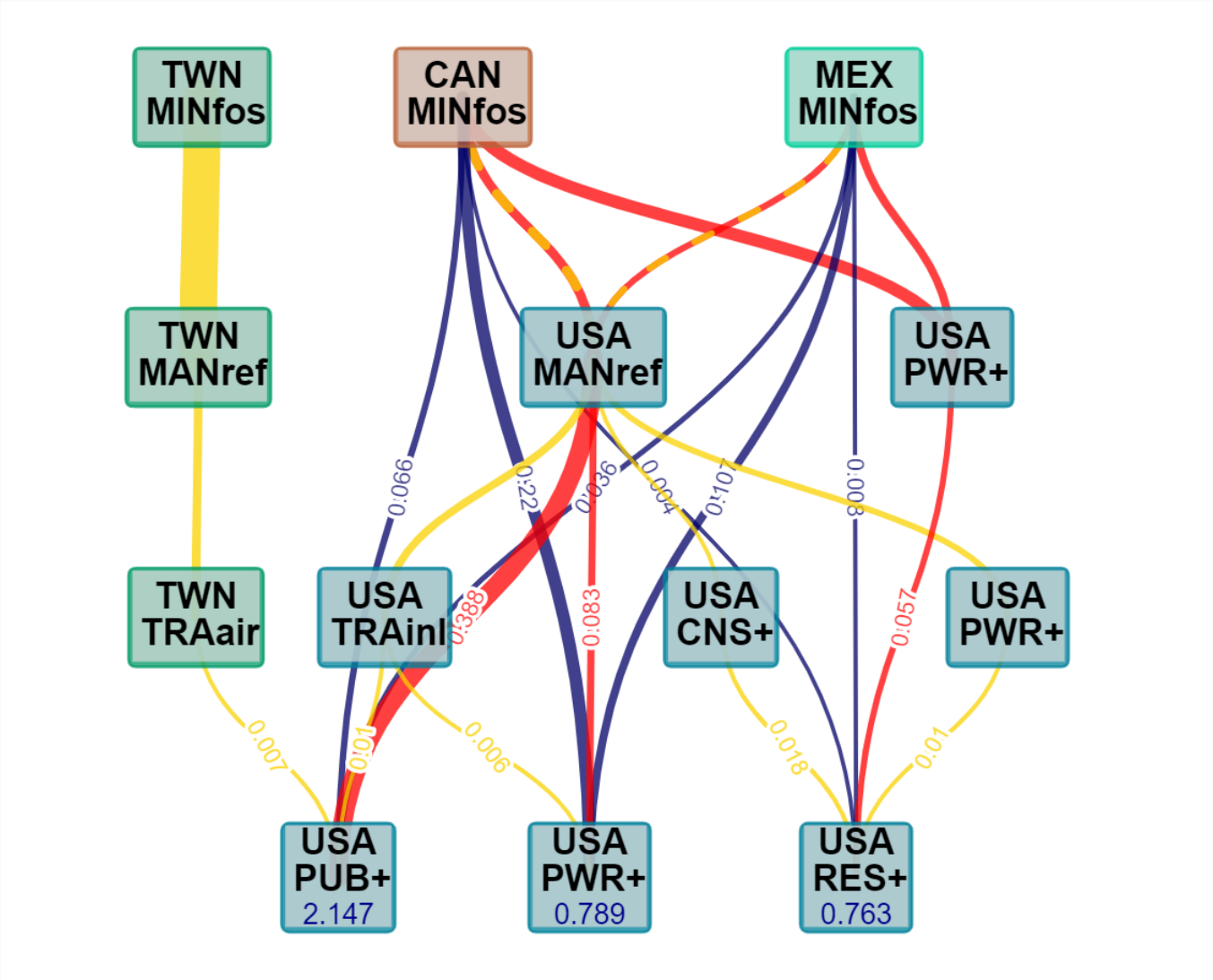


Countries with largest exposure to external fossil stranding



Source: Cahen-Fourot et al. (2021)

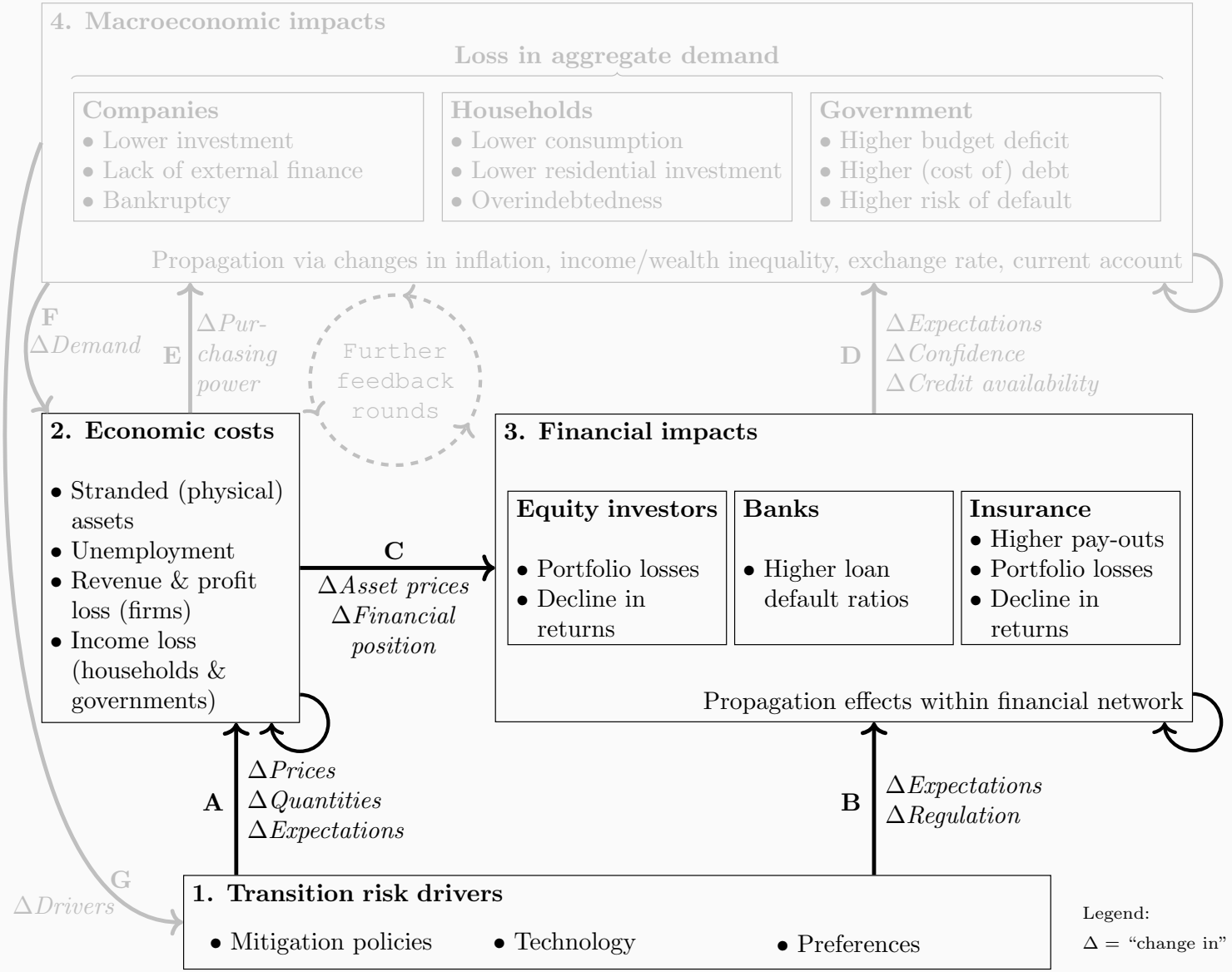
US Exposure network



Source: Cahen-Fourot et al. (2021)

Financial impacts

Financial impacts



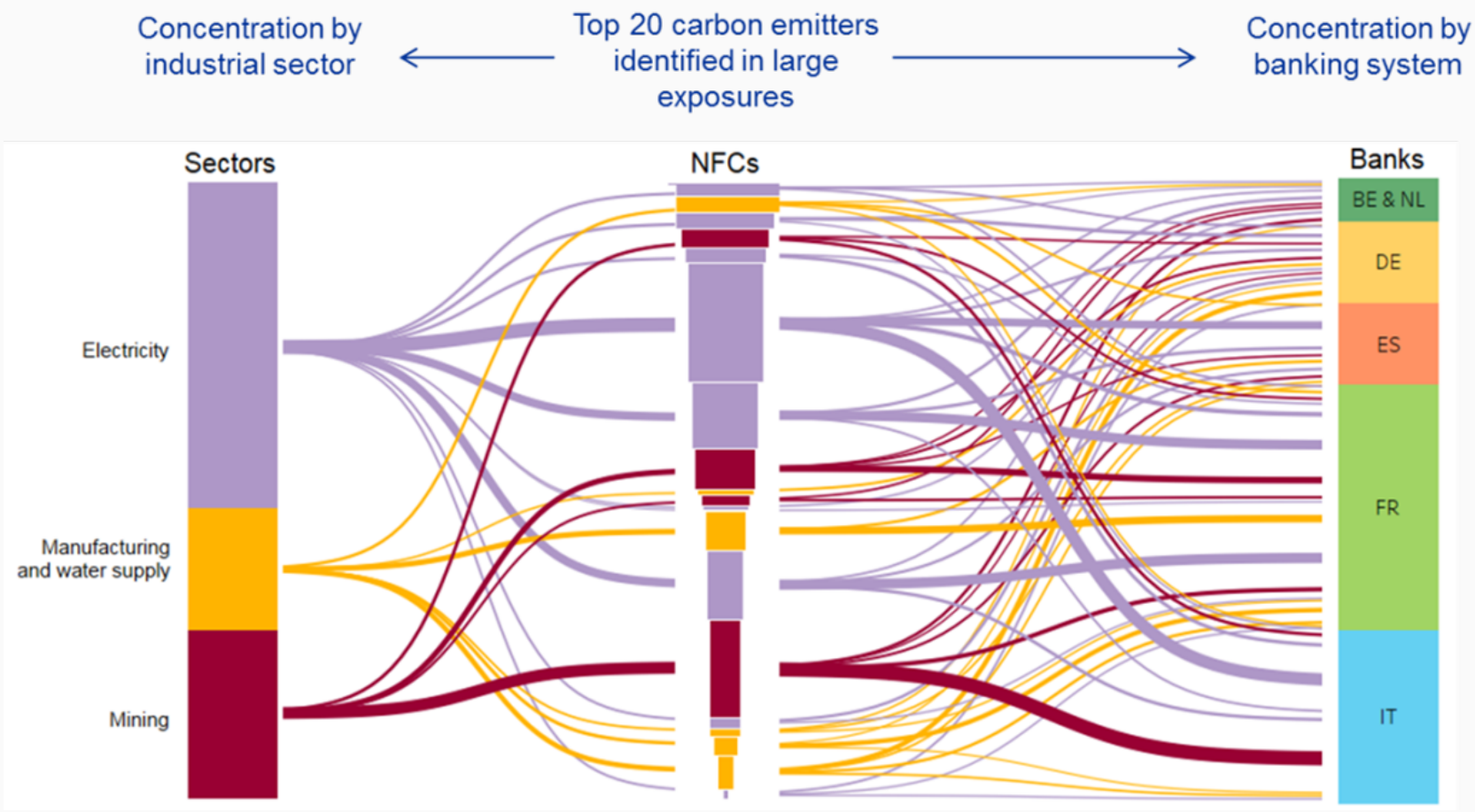
Financial impacts

- Direct impacts via:
  - Changes in expectations (leading to changes in mkt valuation)
  - Changes in actual regulation (e.g. disclosure requirements)
- Indirect impacts via impacts on firms:
  - Increase in non-performing bank loans
  - Increase in insurance claims
  - Decrease in market valuation following decline in profits
- Financial network effects
  - Banks' NPL affecting their market valuation
  - Change in collateral values

Repricing of assets

- Repricing of financial assets (sum of expected discounted cashflows)
  - Changes in expectations
  - Unexpected events
  - New valuation models
- Whoever holds the devalued financial assets will see their wealth diminished.
- Possible fire sales
  - Decline in prices instigates selling..
  - .. leading to further price declines

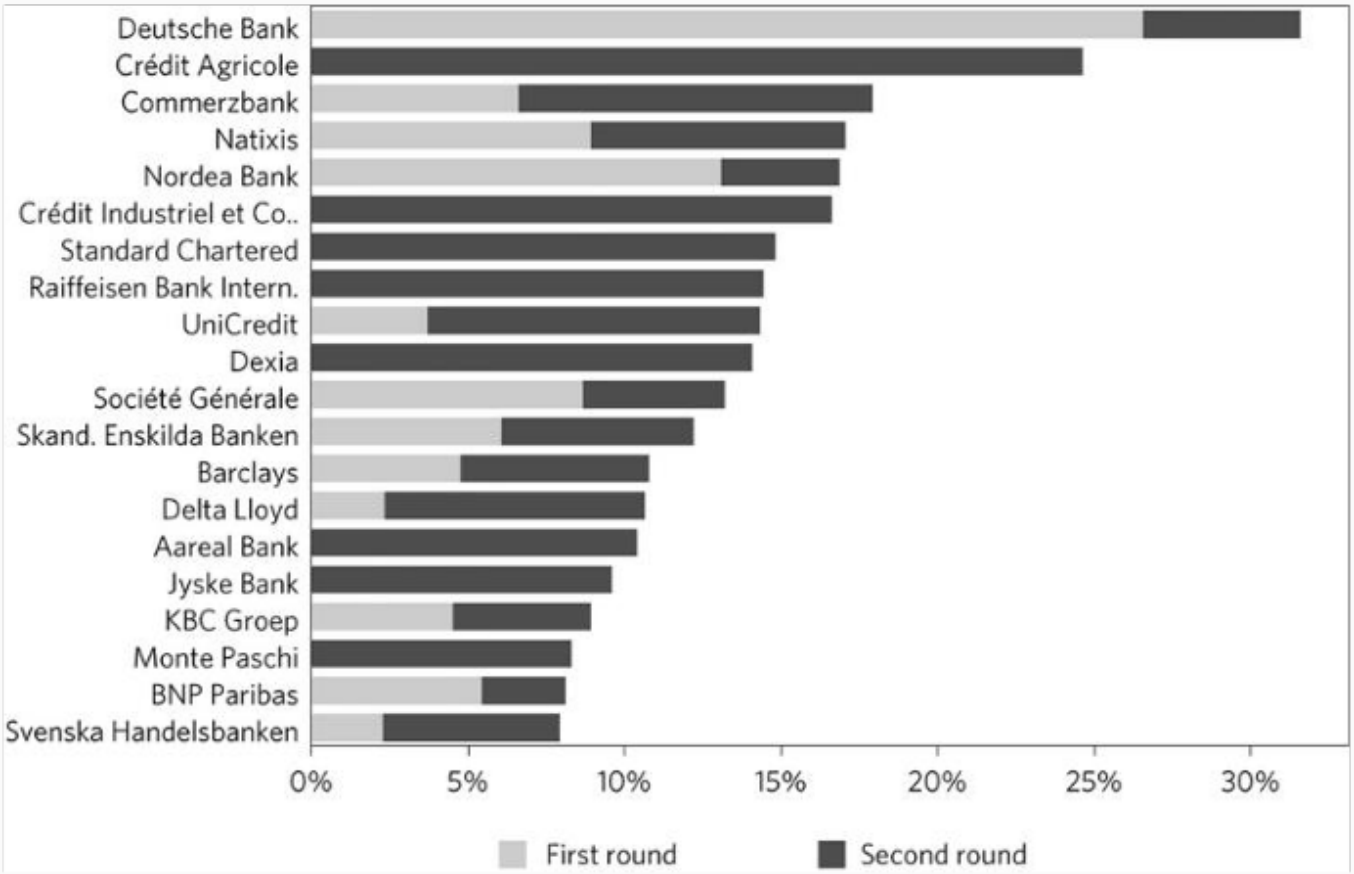
Studying exposure



Euro area banks' large exposures to reporting firms with the highest carbon emissions. Middle bar: height reports loans; width reports emissions. Source: Giuzio et al (2019)

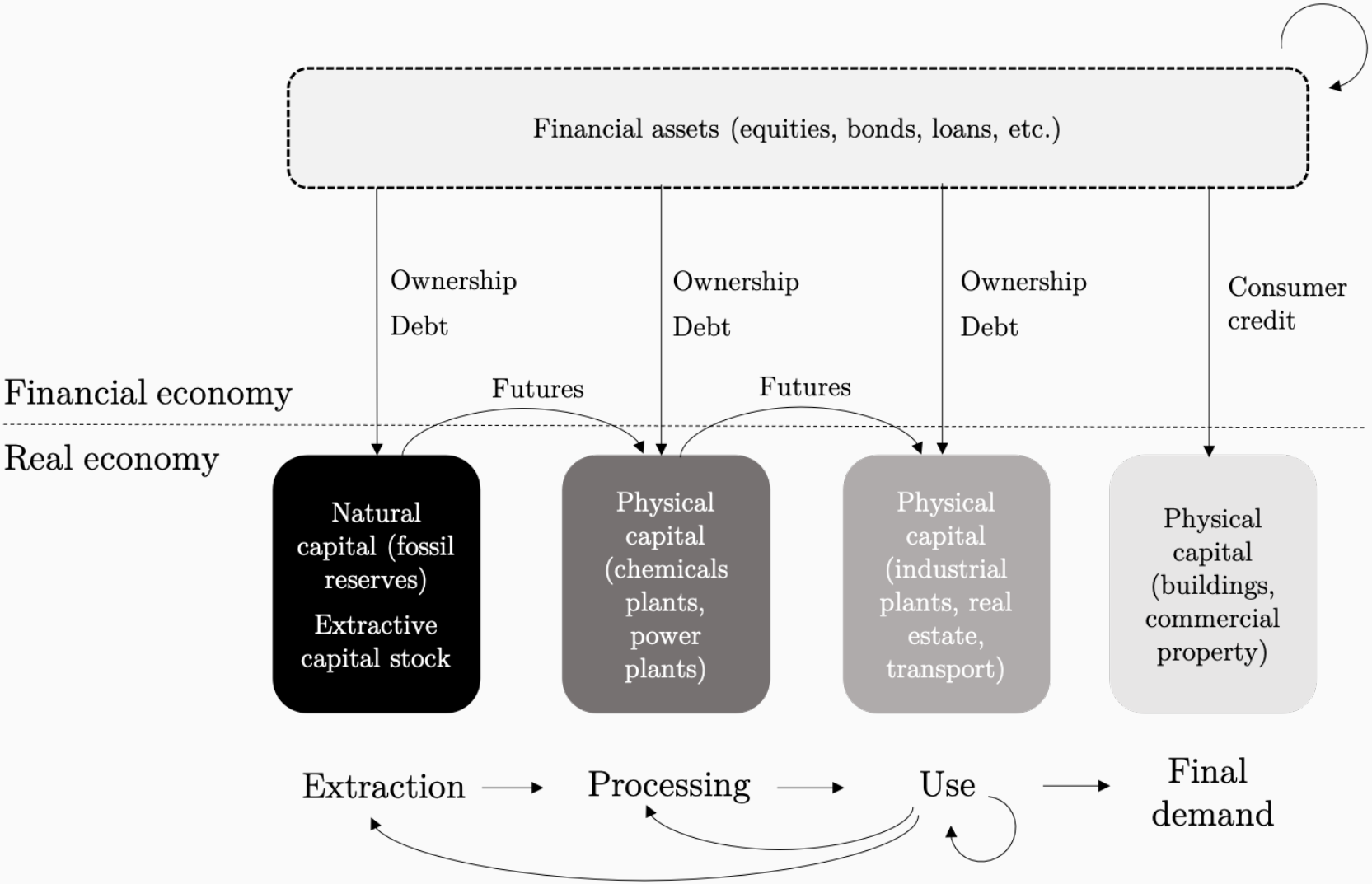
Financial networks

- Financial institutions heavily exposed to one another
- Indirect transition costs via financial networks



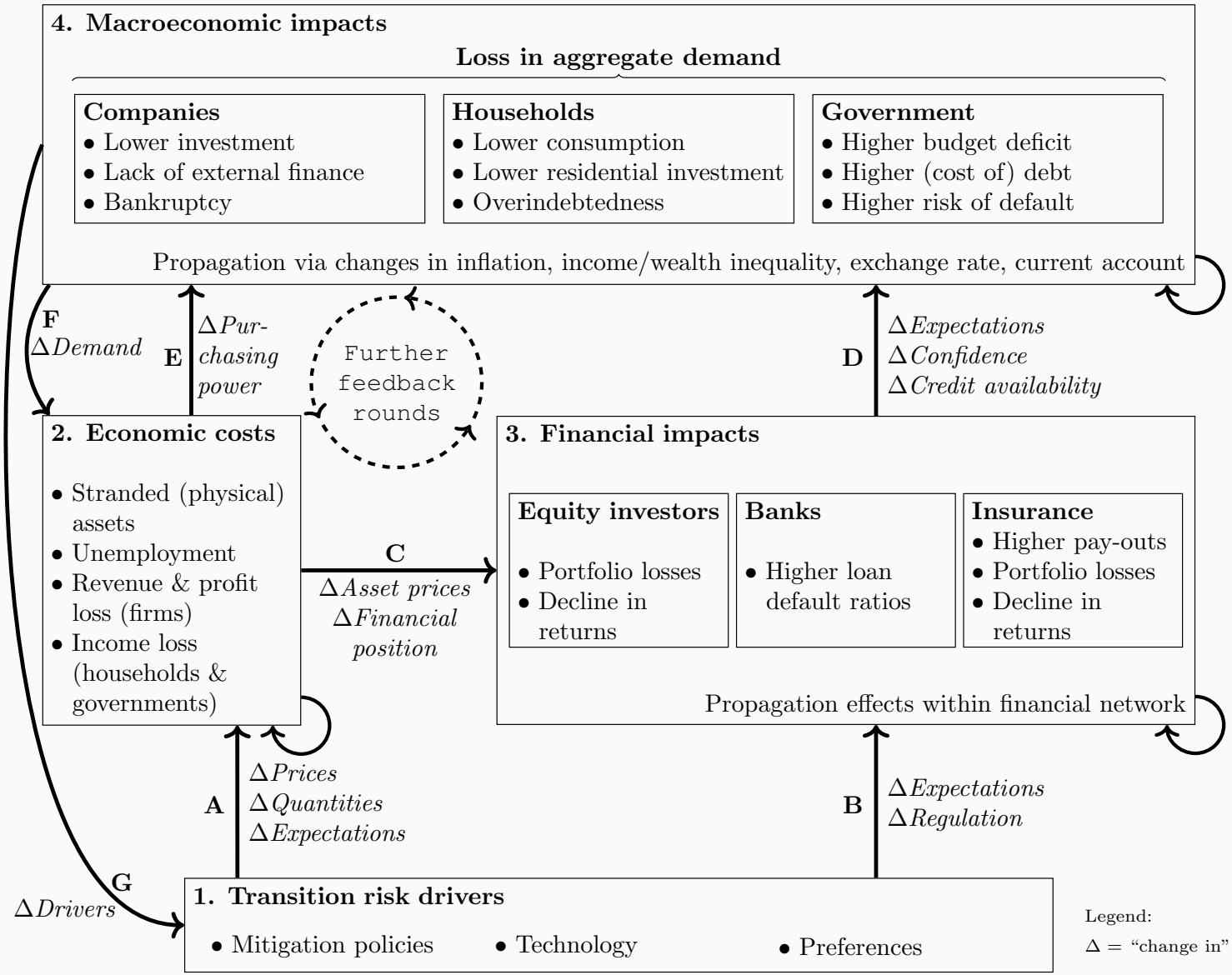
Losses in banks equity under the Fossil fuel + Utilities 100% shock. Source: Battiston et al 2017

Multi-layer perspective needed



Macroeconomic impacts

Macroeconomic impacts



Macroeconomic impacts

- Banking channel
  - Credit rationing via higher interest mark-ups or restrictions
  - This would in turn lead to a drop in investments
- Confidence channel
  - Less demand for investments from firms
  - Tobin's q and uncertainty roles
- Consumption channel
  - Loss of household income via unemployment or wealth decline
- Public debt channel
  - Increase in public spending (unempl. subsidies, bailouts, etc)
  - Possible increase in cost of emitting new debt
  - Possible impact also on corporate bonds.

A Climate Minsky moment?

- Additional macro impacts
  - Inflation rates, trade balances, exchange rates..
  - All contribute in depressing aggregate demand
- Climate Minsky Moment or Green Swan
  - A scenario in which misalignment of expectations with reality..
  - ..lead to an abrupt adjustment of financial assets..
  - ..which causes a loss of wealth..
  - ..depressing consumption and investment..
  - ..leading the economy in a recession.
- Avoid that at all costs!

Bolton et al. (2020)

Conclusions

Conclusions

- Anthropogenic emissions trigger climate change
  - Climate impacts might create large macro-financial disruptions
- Rapid low-carbon transition needed
  - But also transition might trigger macro-financial disruptions
- Need for a harmonised policy effort taking both into account
  - To have harmonised policies you need institutional coordination
- For next lecture:
  - Please read: Baer et al. (2021) It takes two to dance: Institutional dynamics and climate-related financial policies
  - Work in progress: comments welcome