Conceptual frameworks and empirical evidence

Climate macro & finance course 2022 - Lecture 2

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University of Bologna

Student presentations

- Matteo: Bolton and Kacperczyk (2021) - lecture 2
- Carmen: Moore et al. (2022) - lecture 3
- Rebecca: Gambhir et al. (2021) - lecture 3
- Angela: Dafermos et al. (2018) - lecture 4
- Adrianna: Rengs et al. (2020) - lecture 4
- Christian: Chenet et al. (2021) - lecture 5

Last lecture

- What's the problem?
  - Climate change $\rightarrow$ climate damages to human societies
  - Solution: reduce GHG emissions
  - Decarbonisation comes with costs
  - Goal: achieve a smooth and rapid low-carbon transition
  - We can study this problem with multiple methodologies (conceptual, empirical, modelling, political economy)
- Today:
  - Conceptual and empirical research (bundled together)
- Next lecture:
  - Move to modelling

Outline of today's lecture

- Three types of risks:
    - Physical, transition, liability risks
    - Different drivers but similar transmission channels
- Impacts on non-financial firms
    - Flow and stock impacts of climate/transition
    - Production network effects
- Impacts on financial firms
    - Bank credit and financial asset valuation channels
    - To what extent climate-related risks are already internalized?
      $\rightarrow$ Matteo' presentation on Bolton and Kacperczyk (2021)
    - Financial network effects
- Wider macro-financial impacts
    - Green Swans, Climate Minsky moment, disorderly transition
    - $\rightarrow$ Prospective modelling needed

Climate-related risks

- Physical risks
  - Impact of climate-induced phenomena on human activities
- Transition risks
  - Structural change towards a lower-carbon economy
  - Focus on high-carbon sunset industries
- Liability risks
  - Parties affected by climate change looking for compensation

2015 Lloyd's speech by BoE governor Mark Carney

Physical and transition risks

- Different initial drivers
  - Climate impacts vs structural change
  - .. although climate shock could lead to policy shock
- But similar transmission channels
  - Losses to firms (flow+stock effects)
  - Propagation effects via production networks → Macro impacts
  - → Losses to financial institutions (credit+valuation)
  - Propagation effects via financial networks
  - → Wider macro-financial impacts
  - → Feedback effects on transition process

Climate-related risk drivers

Climate and transition risk drivers

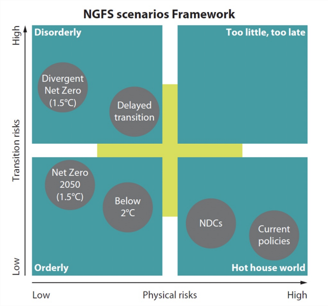
- Climate risk drivers
  - Acute hazards: hurricanes, heat waves, floods, wildfires
  - Chronic hazards: temperature rise, sea level rise, change in precipitations
- Transition risk drivers
  - Climate policies (e.g. carbon tax)
  - Technological transition (bubbles, decommissioning)
  - Volatility in preferences, beliefs and expectations

Transition risk drivers: mitigation policies

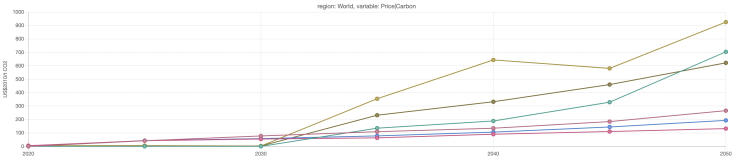
- We know policies will need to be implemented for environmental sustainability
  - Market failure narrative: Environmental externality allows for directed fiscal policy to internalise price
  - Carbon pricing: tax and/or emission markets
  - Other policies: command&control, supply-side policies, financial regulation..
- Implementation strategy matters. Two extreme scenarios:
  - Gradually rising carbon price schedule starting now. Everyone believes in it and uses it in investment plans
  - Large sudden increase in carbon prices nobody had foreseen, and possibly too late (climate impacts)

NGFS transition scenarios

- Network of Central Banks and Supervisors for Greening the Financial System (NGFS)
- NGFS scenarios often driven by policy shocks
- A late carbon tax introduction (2030) leads to steeper curve → Higher costs



Source: Bertram et al. (2021)



Carbon prices in ‘Below 2°C’ and ‘Delayed transition’ (NGFS Scenario explorer)

Endogenous carbon price volatility

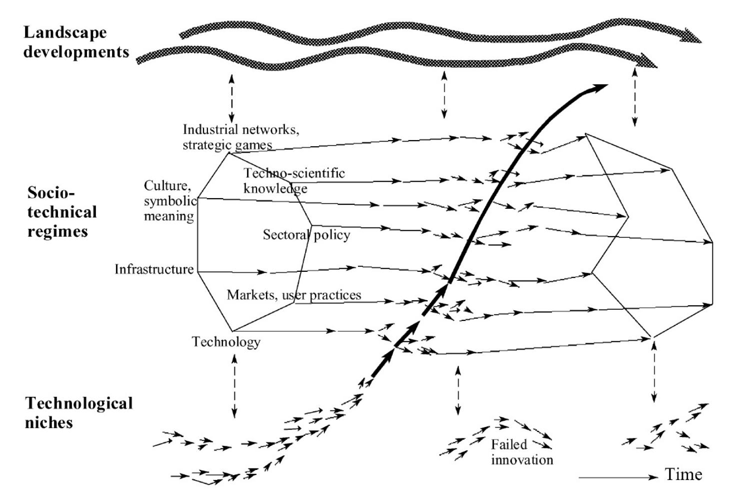
- E.g. Unanticipated increase in EU-ETS allowance price

EUA spot prices. (ICAP Allowance Price Explorer)

Transition risk drivers: technological shifts

- Two key processes in technological shifts:
  - Phase-in of new emerging technologies
  - Phase-out of old incumbent technologies
- Finance key in both processes:
  - Credit necessary to invest
  - Financial exposure to incumbent firms to be smoothly reduced
- Technological shifts can cause disruptions
  - Tumultuous phase-in can disrupt economic system and create bubbles
  - Sudden decommissioning or devaluation of assets can cause losses

The emergence of niches re-configures the regime



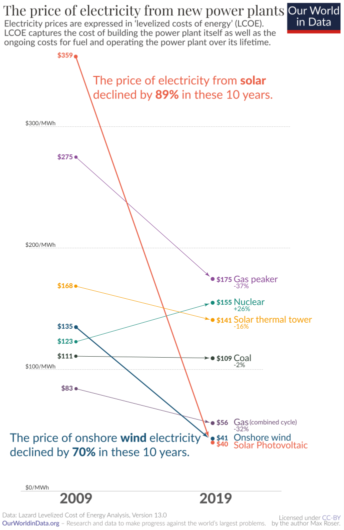
Multi-level perspective of technological transitions (Geels 2002)

Phase-in financial risks

- Literature traditionally focused on phase-in financial risks
  - Schumpeterian vision of creative destruction
  - Minsky moment: Innovation → Speculation → Asset overvaluation → Crisis
  - Perez: aftermath of financial collapse reveals social issues → Regulatory intervention needed to redirect innovation
- Historical examples:
  - Mid-1800s financial crises linked to expansion of railways
  - 1929 crisis involved bubbles in radio, electricity, aeroplanes, automobile, petrochemicals
  - 2001 crisis was the result of the burst of the dotcom bubble
- Is there a risk of a 'green' bubble?
  - Some signs of overvaluation and instability: fast mkt capitalizations (eg. Tesla); some defaults (Solyndra); YieldCo bubble in 2015; ESG craze
  - To what extent this has or will have systemic implications?

Rapid technological improvements in some fields

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



Levelised cost of energy (Our World in Data)

Phase-out financial risks

- Special features of low-carbon transition:
  - Societal drive (instead of market and innovation)
  - Restricted timeline to keep below 2°C
- $\rightarrow$ Phase-out risks cause more concerns
  - Carbon-intensive capital stocks to be abandoned before time?
  - Can we produce without fossils? $\rightarrow$ Supply-chain disruptions
  - Devaluation of associated financial assets?
- However, uncertainty on technological progress direction
  - Carbon capture and storage, direct air capture or geoengineering could allow fossils to survive

Transition risk drivers: Preferences, beliefs and expectations

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

Carbon Trust labels (Image source)

Greta Thunberg and Fridays for Future (Image source)

Volatility in beliefs and 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
- 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)

Four ways to capture climate-related beliefs and expectations

- Study asset prices and their movements through econometric methods
  - Eg. Bolton and Kacperczyk, 2021 → More on this later
- Elicit opinions via surveys
  - Eg. Krueger et al. (2020)
- Study communications
  - Tweets and social media posts, newspaper articles, speeches by officials, parliamentary acts, etc.
  - E.g. Engle et al. (2020)
- Run experiments
  - Experimental protocols online, in laboratory or in the field
  - E.g. Hagmann et al. (2020)

Impacts on non-financial firms

Flow effects

- Impact on revenues and expenditure of firms due to climate/transition
- Higher costs: More expensive intermediate inputs
  - Climate-induced supply disruptions (eg. extreme weather events destroying port infrastructure)
  - Carbon tax making energy and energy-intensive inputs more expensive
  - Possible credit rationing: higher financing costs
- Lower revenues: Demand-side effects
  - Impossibility to produce or to reach markets
  - Higher selling prices $\rightarrow$ purchasers buy less
  - Purchasers avoid your products (social stigma)
- $\rightarrow$ Lower profits
  - $\rightarrow$ Lower expected profits as well?

Stock effects

- Physical loss of assets
  - Destruction of factories and infrastructure from climate hazards
  - $\rightarrow$ write off company's balance sheet
- Loss of physical asset monetary value
  - If asset used less (reduced capacity utilisation)..
  - ..expected profits from future utilisation will be lower..
  - ..decreasing the market value of the asset
  - $\rightarrow$ write off company's balance sheet (?)
- Loss of human capital
  - Labour skills, productive knowledge, business networks
  - Reconversion possible but costly for some

Climate impacts on firms

- Acute hazards
  - Destruction of physical assets and human capital
  - Additional costs to reconstruct and replace
  - Disruption to trade routes
  - Inability to produce
  - Increase in commodity prices
  - Drop in demand
  - Relocation of households and firms $\rightarrow$ migration
- Chronic hazards
  - Devaluation of assets (eg. real estate)
  - Decrease in labour productivity
  - Change in agricultural yields
  - Increase in commodity prices
  - Relocation of households and firms $\rightarrow$ migration
  - Higher adaptation costs (eg. air conditioning)

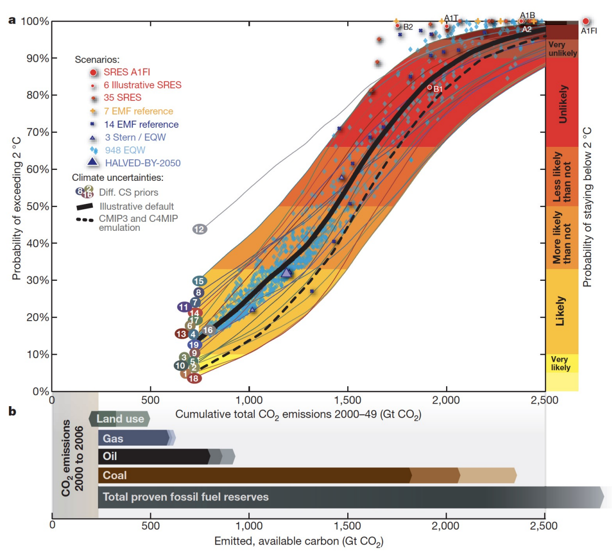
Transition impacts on firms

- Mitigation policies
    - Change in relative prices $\rightarrow$ reconfiguration of global value chains
    - Higher tax burdens
    - Higher energy prices for households
    - $\rightarrow$ Social unrest?
- Technological progress
    - Loss of demand for products
    - Devaluation of obsolete capital stocks
    - Excessive invstments $\rightarrow$ Overcapacity
- Change in beliefs and expectations
    - Loss of demand for products
    - Change in relative prices

Focus on asset stranding

- Stranding of physical assets can mean:
  - Asset abandonment
  - Reduction of lifetime asset (premature decommissioning)
  - Costly repurposing to alternative technologies (eg. coal to biomass)
  - Reduced capacity utilization
  - Loss of market value of the asset
  - $\rightarrow$ Entire or partial write-off from company's balance sheet
- Two main types of physical assets at risk of stranding
  - Reserves of fossil fuels
  - Stocks of productive man-made capital
  - $+$ Stranding of labour: unemployment

Stranding of fossil reserves

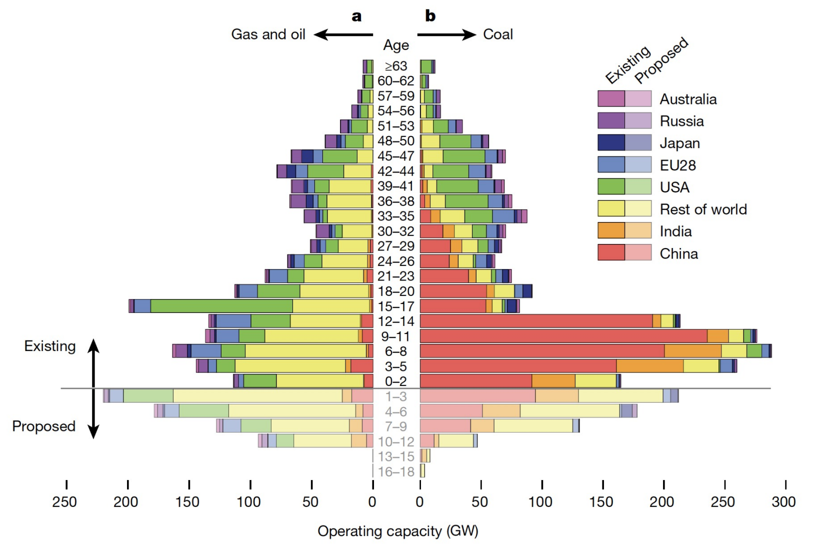


Fossil reserves and the 2°C target (Meinshausen et al. 2009)

'Committed' emissions in capital stocks

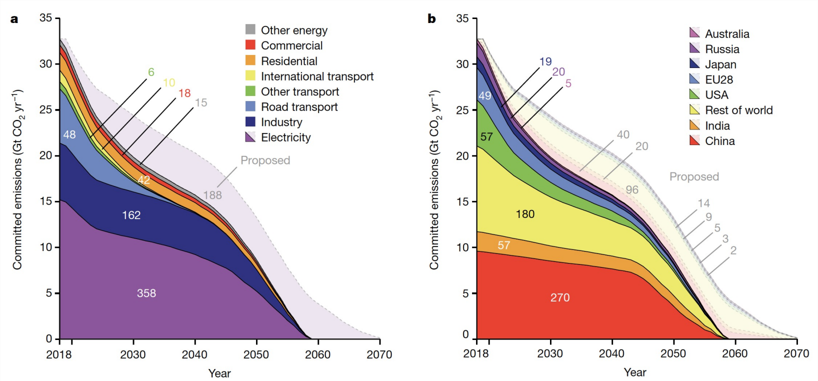
- Capital stocks often work in combination with fossil fuels
  - E.g. electricity plants, blast furnaces, cement kilns, chemical plants, buildings, transport infrastructure..
  - Emissions are already 'committed' by their existence, assuming certain lifetimes and utilisation rates
- Committed emissions are already close or above 2°C carbon budgets.
  - Either strand some of them or go beyond 2°C
  - No more high-carbon investments allowed

Long-lived capital stock in electricity generation



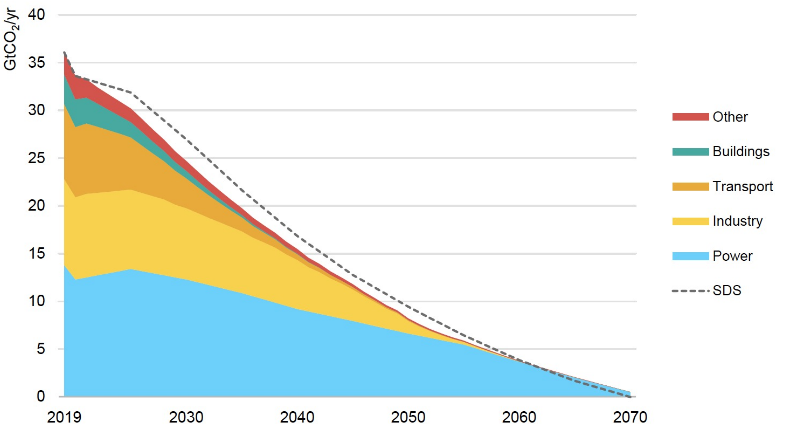
Age structure of global electricity-generating capacity. (Tong et al. 2019)

Committed CO_2 emissions



Committed annual CO_2 emissions from existing and proposed energy infrastructure, assuming historical lifetimes and utilization rates. (Tong et al. 2019)

IEA confirms assessment



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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.

Global CO2 emissions locked in by existing energy-related assets (IEA 2020)

Production networks

- Network theory
  - See Barabasi's 2016 book 'Network science'
- Production networks analysis
  - See Carvalho and Tahbaz-Salehi (2019) for a primer
  - They can be used to study global value chains, trade, aggregate dynamics, allocation of environmental responsibility.. (e.g Acemoglu et al. 2012 on Ecta)
  - Applied to carbon tax impacts - see for instance Devulder and Lisack (2020); Hebbink et al. (2018)
- Production networks, climate change and the low-carbon transition
  - SMOOTH research on the topic More details

Impacts on financial firms

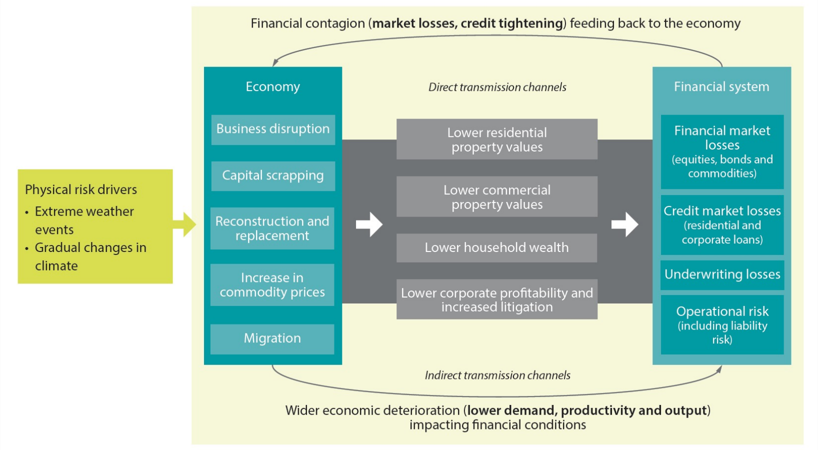
What is the financial system?

- Households and firms
  - Owners of savings
  - Borrowers (eg. mortgages)
  - Firms issue financial assets (bonds or stocks)
- Commercial banks
  - Loans to households and firms
  - Power to expand money supply
- Financial investors
  - Variegated crowd (VC, private equity, ETFs, etc)
  - Allocate money (savings) to firms and fin. institutions
- Insurance companies
  - Collect premiums, invest, pay claims
- Regulators and policy-makers
  - Government
  - Central banks
  - Financial supervisors

Climate-related impacts on financial firms

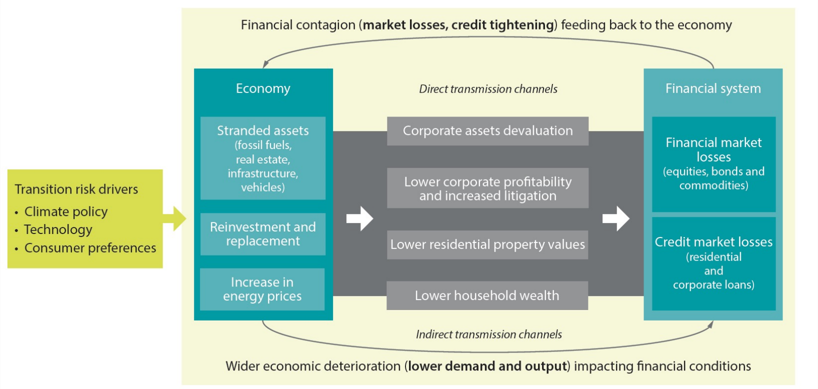
- Direct impacts via:
  - Changes in expectations (leading to changes in mkt valuation)
  - Changes in actual regulation (e.g. disclosure requirements)
- Indirect impacts via impacts on firms:
  - Increase in non-performing loans $\rightarrow$ Impact on banks' balance sheets
  - Increase in insurance claims
  - Decrease in firms' market valuation $\rightarrow$ Portfolio effects
    - Revision of estimated future payoffs
    - Revision of risk/uncertainty $\rightarrow$ change in risk premium
    - Endogenous revaluation driven by new valuation models
- Financial network effects
  - Banks' NPL affecting their market valuation
  - Change in collateral values
  - Fire sales of assets

Physical risks (NGFS 2019)



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

Transition risks (NGFS 2019)



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

The ‘carbon bubble’

- Unburnable carbon affects market cap of fossil fuel companies
  - Market cap function of future stream of profits from extracting and selling reserves
  - What happens if they remain in the ground?
- ‘Carbon bubble’ concept first proposed by Leaton (2011) and Leaton et al. (2013)
  - Reserves of top 200 companies in coal/oil/gas sectors (around 1/4 of total)
  - Incompatible with 2°C carbon budgets

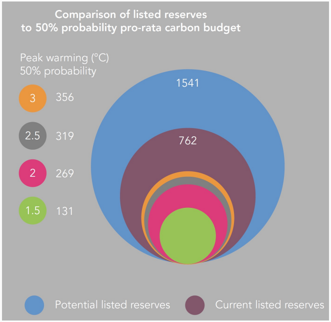


Figure: The carbon bubble (Leaton 2013)

Studying exposure

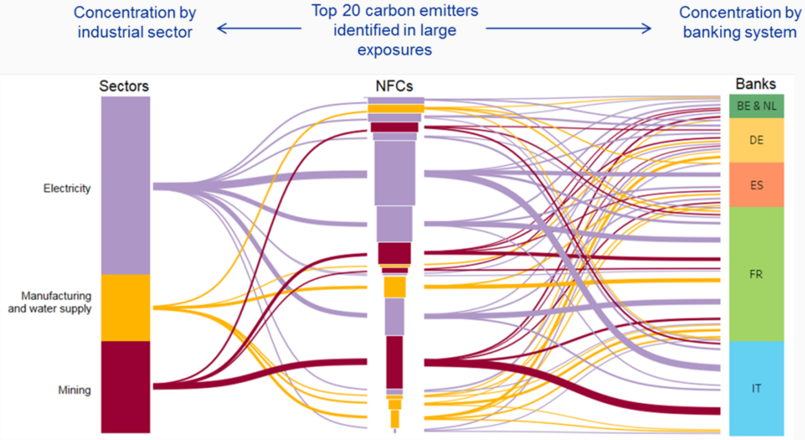


Figure: Euro area banks' large exposures to reporting firms with the highest carbon emissions. Middle bar: height reports loans; width reports emissions (Giuzio et al 2019)

Are transition risks priced in? Three hypothesis (B&K 2021)

- Carbon risk premium
  - Investors realize firms with high CO_2 emissions are exposed to transition risks..
  - .. and demand higher returns to hold their stocks
- Market inefficiency hypothesis
  - Financial markets are subject to inefficiencies and behavioural biases..
  - .. leading transition risks to be underpriced..
  - .. and to abnormal returns for low-carbon stocks (a higher α)
- Divestment hypothesis
  - High-carbon stocks are seen as 'sin' stocks and avoided by 'responsible' investors..
  - .. leading to higher returns for high-carbon stocks

Bolton and Kacperczyk (2020, 2021)

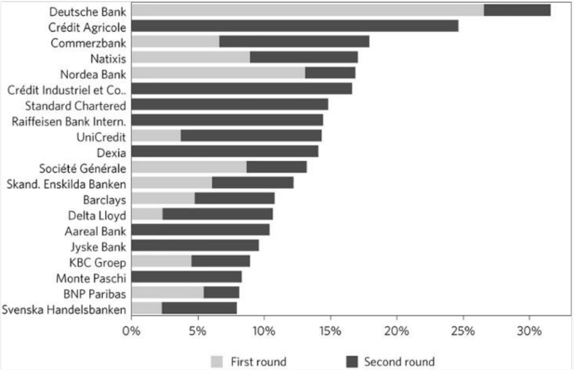
- They find evidence of a positive carbon premium
  - Valid for stock returns in a large number of countries
  - Higher returns associated to:
    - Higher total CO_2 emissions;
    - Growth in emissions;
    - But not emission intensity.
  - Significant divestment happening, but no effect on stock returns
    - Exclusionary screening in selected industries and based on emission intensity
- However, also results in the other direction
  - E.g. In et al. (2019) find a positive carbon alpha

But the debate has not settled yet

- Sen and von Schickfus (2020)
  - German climate policy aimed at reducing coal-fired electricity production
  - What's its effect on the market value of energy utilities?
  - $\rightarrow$ Investors account for stranding risks, but also expect to be compensated by government
  - Only possibility of no compensation lead to market revaluation
- Atanasova and Schwarz (2020)
  - Link between oil firms' value and their proved reserves
  - Sample of 600 North American oil firms for 1999-2018
  - Growth of reserves has a negative effect on firm value.
    - Effect stronger for oil producers with higher extraction costs
    - Effect stronger for undeveloped oil reserves located in countries with strict climate policies
- In et al. (2019)
  - They find a positive carbon alpha

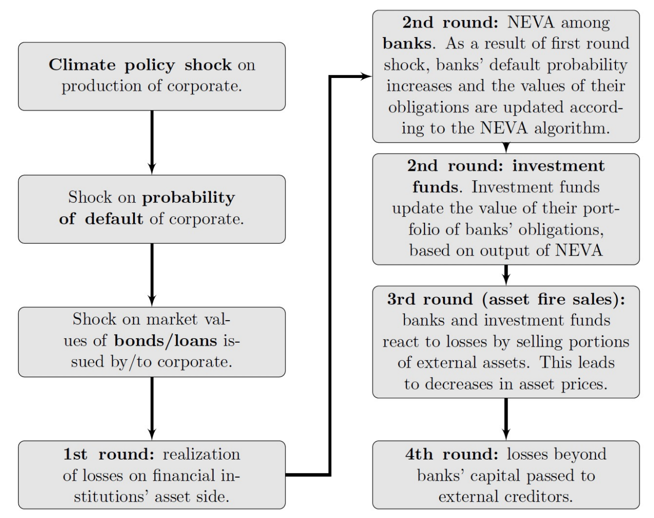
Financial networks and the transition

- Financial networks
  - Connections of cross-exposure among financial institutions
  - Financial contagion risks (Acemoglu et al., 2015)
- Battiston et al. (2017) on Nature CC



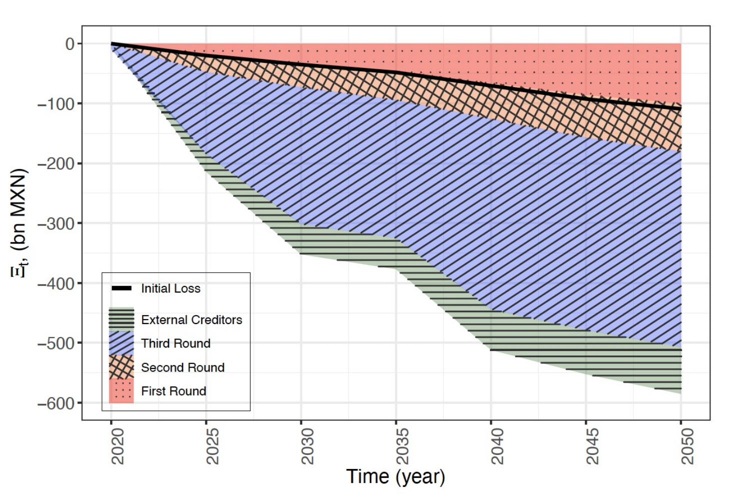
First- and second-round losses in banks' equity for most affected EU listed banks. 100% shock in fossil fuel and utility sectors (Battiston et al. 2017)

Roncoroni et al. (2021): Structure



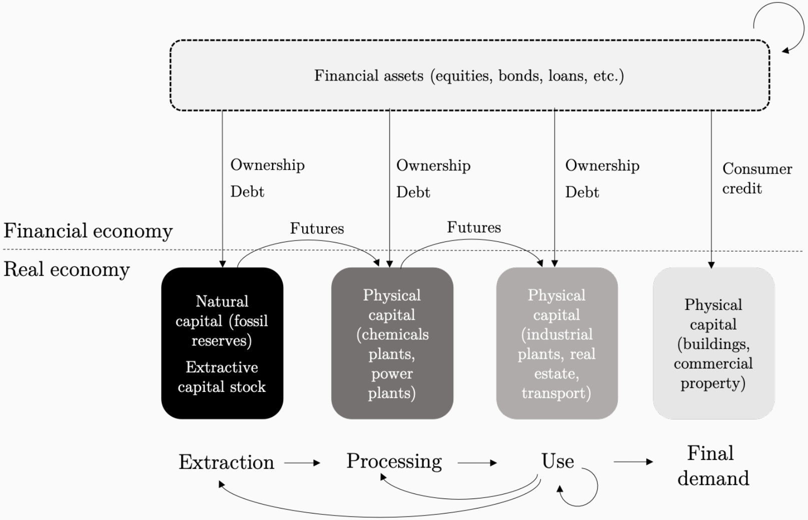
Contagion steps in Roncoroni et al. (2021)

Roncoroni et al. (2021): Results



Losses in the Mexican financial system (mild climate policy shock, weak market conditions) (Roncoroni et al. 2021)

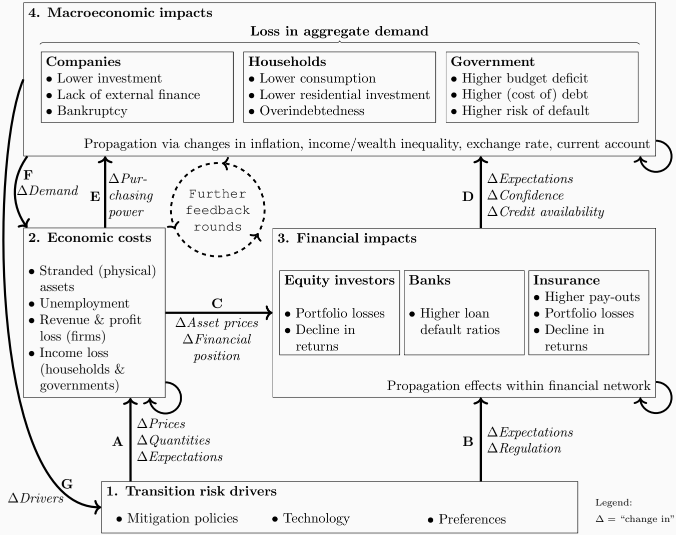
Multi-layer perspective needed



Figure

Macroeconomic impacts

Wider macroeconomic impacts



An overview of transition risks (Semieniuk et al. 2021)

Macro-financial transition channels

- 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
- Inflation channel
  - Higher prices for energy, materials, food products, or others
- 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

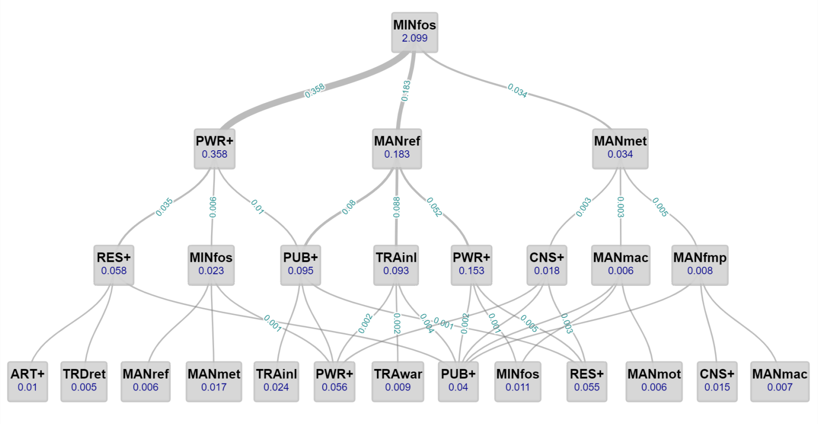
- Both climate change and the low-carbon transition could in principle trigger macro-financial disruptions
- The conceptual framework is being developed (focus on phase-out historical novelty)
- Empirical evidence? Still unclear
  - Exposure appears significant but possibly manageable, especially if risks are gradually internalised beforehand
  - Several methodological gaps
- What will happen?
  - $\rightarrow$ Prospective dynamic modelling needed (next lecture)

Additional slides: SMOOTH production networks research

SMOOTH research on production networks Back

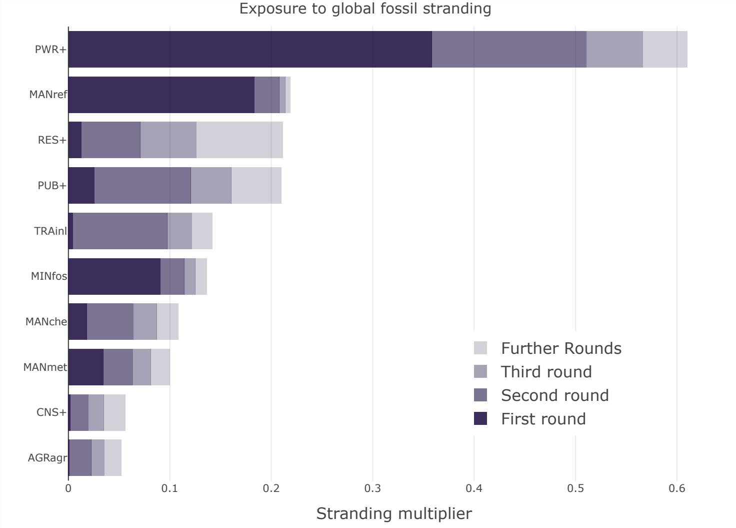
- Supply-side marginalist approach
  - Production networks combined with sectoral capital stock data
  - Supply-side 'marginal stranding multipliers'
  - Stranding as loss of physical capital utilisation
  - WIOD database
  - Paper in Energy Economics (Cahen-Fourot et al. 2021)
- Demand-side approach
  - Impact of a carbon tax ($40 per ton of CO2)
  - Three policy scenarios: i) global tax; ii) EU tax; iii) EU tax + CBAM
  - Methodological refinement I: input substitution
  - Methodological refinement II: consumption adjustments
  - Focus on global value chain and network positioning

Stranding cascades from marginal shock in global fossil sector



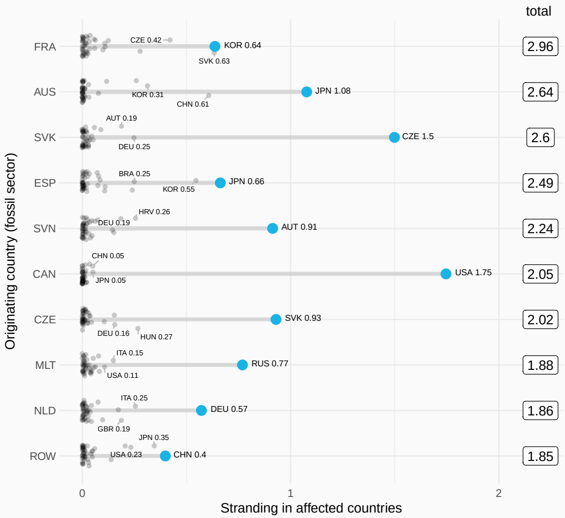
Source: Cahen-Fourot et al. (2021)

Cahen-Fourot et al. (2021): Rounds of stranding



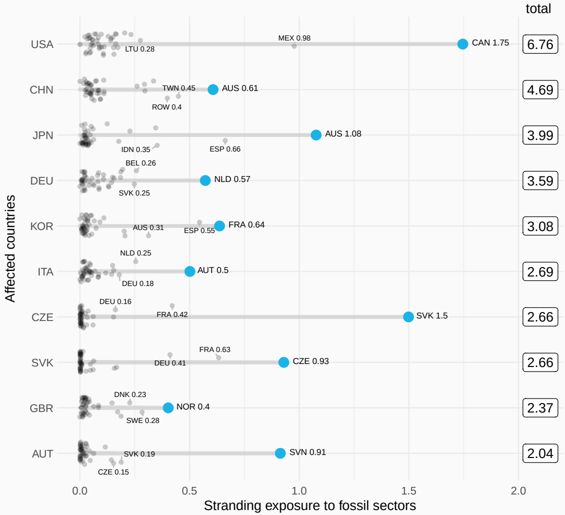
Source: Cahen-Fourot et al. (2021)

Cahen-Fourot et al. (2021): Cross-boundary stranding effects



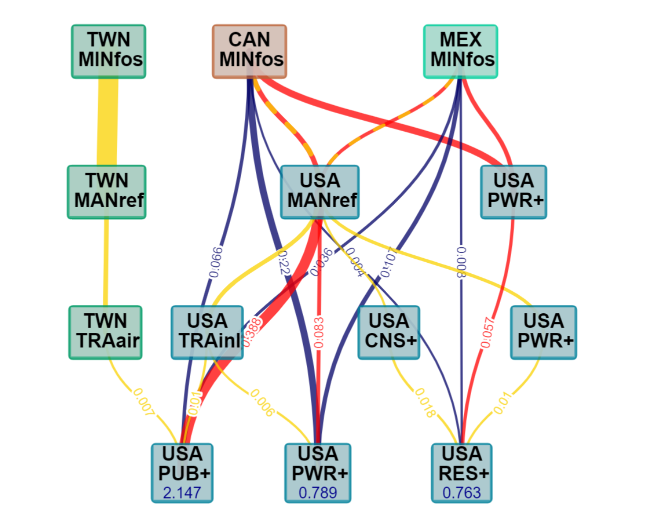
Source: Cahen-Fourot et al. (2021)

Cahen-Fourot et al. (2021): Exposure to cross-boundary stranding



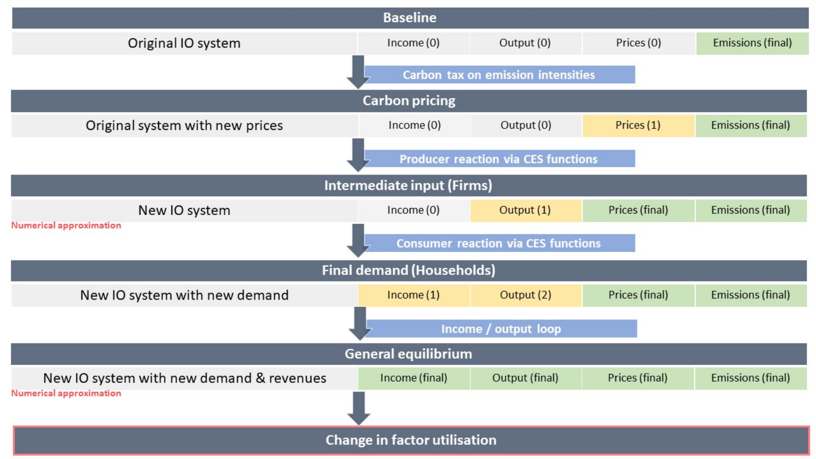
Source: Cahen-Fourot et al. (2021)

Cahen-Fourot et al. (2021): Stranding exposure (USA)



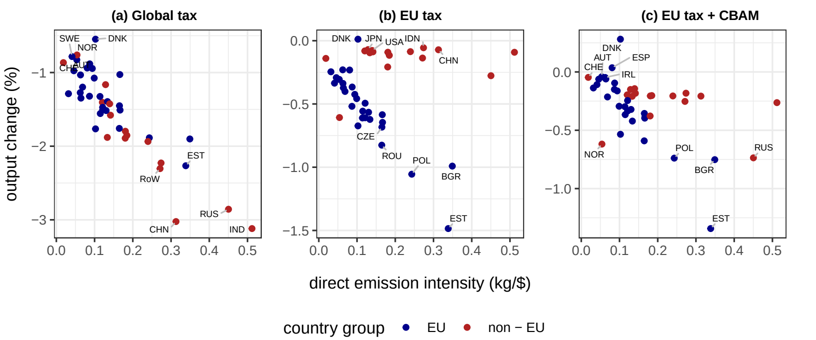
Source: Cahen-Fourot et al. (2021)

Demand-side approach (Campiglio, Massoni, Trsek)



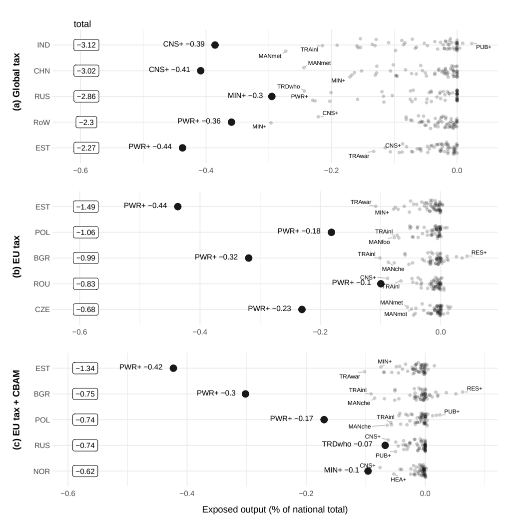
Model steps (Campiglio et al. 2022)

Network effects of carbon pricing



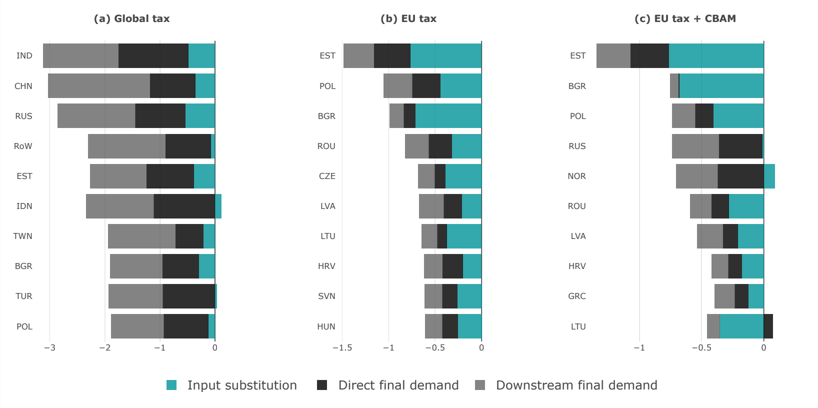
Direct emission intensity and output loss (Campiglio et al. 2022)

Network effects of carbon pricing



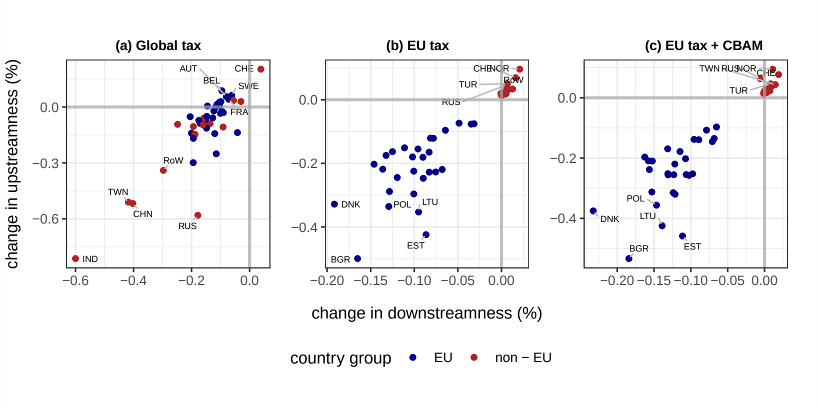
Relative changes in output - Most exposed countries (Campiglio et al. 2022)

Network effects of carbon pricing



Drivers of output loss - Most exposed countries (Campiglio et al. 2022)

Network effects of carbon pricing



Recomposition of global value chains (Campiglio et al. 2022)