Climate financial bubbles: How market sentiments shape the transition to low-carbon capital

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Are climate risks internalised in financial asset prices?

- Efficient Market Hypothesis (Fama, 1970): asset prices fully reflect information available to rational profit-maximizing actors.
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- However: deeper complexity.
  - Behavioural finance insights (Simon, 1959; Shiller, 2015; Lo, 2017)
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- Possible drivers of climate financial apathy:
  - Widespread perception of low-carbon investment as a relatively unprofitable niche market
  - Educational background not related to energy/climate
  - Misaligned professional incentives
  - Human limited rationality
  - Behavioural biases (e.g. status-quo, confirmation)

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- We modify the expectations of financial investors introducing:
  - *Climate financial apathy*. Disbelief in the low-carbon sector development prospects
  - *Climate blindness*. Limited observation of low-carbon sector development
- Summary of results:
  - Apathetic expectations on average lead to:
    - Slower transitions, or no transition
    - Higher stranded physical assets
    - Higher stranded financial assets
  - However: strongly non-linear effects

The methodology

- What would be needed to study stranded assets?
  - Representation of physical assets and their utilisation rates
  - Representation of financial assets (credit, bonds, equities)
  - Endogenous mechanisms determining financial asset prices
  - A short/medium-term perspective to allow for volatility

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- Lines of research to look at:
  - Growth theory (Rozenberg et al., 2014, Baldwin et al., 2017)
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  - DSGE macro/monetary modelling (Comerford and Spiganti, 2017)

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- Alternative: Stock-flow consistent (SFC) macroeconomic modelling
  - Stress on balance sheet interactions and monetary flows/stocks
  - Surge in popularity after the financial crisis (Burgess et al., 2016)
  - Some application to Schumpeterian innovation (Caiani et al, 2014) and climate issues (Dafermos et al., 2017; Monasterolo and Raberto, 2017)

SFC macroeconomic modelling

- Macro sectors represented through their balance sheets
  - Households, firms, banks, government, central bank, ..
  - Attention to stock-flow consistency:
    - Monetary flows recorded as payment for a sector and receipt for another
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- Demand-side approach
  - $Y = C + I + G$ rather than $Y = AK^{\alpha}L^{1-\alpha}$
  - Demand determines input factor utilisation

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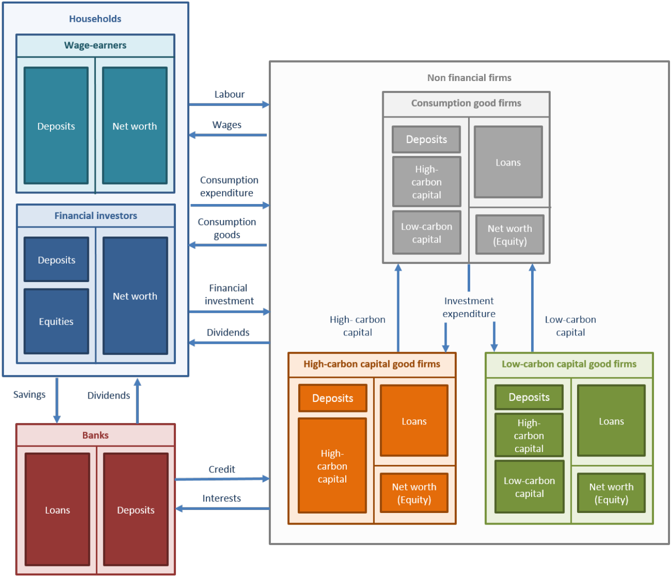
  - Demand determines input factor utilisation
- Endogenous money
  - Money is *not* a veil, and banks are *not* just intermediaries

The structure of the model



Overview of the model

- Households. We distinguish between:
  - Wage-earning households (w): work and consume
  - Financial investors (f): allocate their wealth across financial assets; income from dividends and capital gains
- Firms producing the single consumption good (c):
  - Employ labour and capital to produce
  - Physical capital can be high- or low-carbon
- Firms producing capital goods:
  - High-carbon sector (h) only employs high-carbon capital
  - Low-carbon sector (l) employs high-carbon capital in the first periods of existence, only low-carbon capital after
- All productive sectors (c, h, l) issue equities whose price is determined by supply-demand interaction
  - Low-carbon sector IPO
- Firms finance investment through retained earning and bank credit
  - Banks (b) accommodate any loan demand but apply different interest rates across sectors depending on sectoral return rates

Physical investment decisions (I)

- Firms of the three sectors decide how much they desire to invest (Fazzari and Mott 1986, Caiani et al., 2014) depending on:
  - Expected capacity utilization (+)
  - Real interest rate (-)
  - Leverage ratio (-)
  - Tobin's q as a measure of market valuation (+)

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- Tobin's q, q_x is the ratio between the market value of equity (number of shares multiplied by their price) and its book value (difference between assets and liabilities) (Tobin1969)
  - $q > 1$: Financial markets value sectoral equities *more* than book value of net capital stock: *Easier* for firms to raise finance and invest
  - $q < 1$: Financial markets value sectoral equities *less* than book value of net capital stock: *Harder* for firms to raise finance and invest

$$q_x = \frac{e_x.p_{x,e}}{k_{h,x}.p_h + k_{l,x}.p_l - L_x}$$

Physical investment decisions (II)

- Consumption good firms then allocate a portion $\beta \in [0,1]$ of total investment to low-carbon capital, depending on relative capital unit costs (labour)

$$\beta = \frac{1}{1+\beta_0 e^{\beta_1 \Delta UC}}, \quad \Delta UC \equiv UC_{l,c} - UC_{h,c}$$

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- Assumption: low-carbon capital less expensive than high-carbon
  - We want to abstract here from *why* the transition takes place
  - Aim of the study: study how financial expectations might impact the transition *even when* low-carbon capital is more convenient
  - Moving beyond carbon pricing (Fay et al., 2015; Campiglio, 2016)

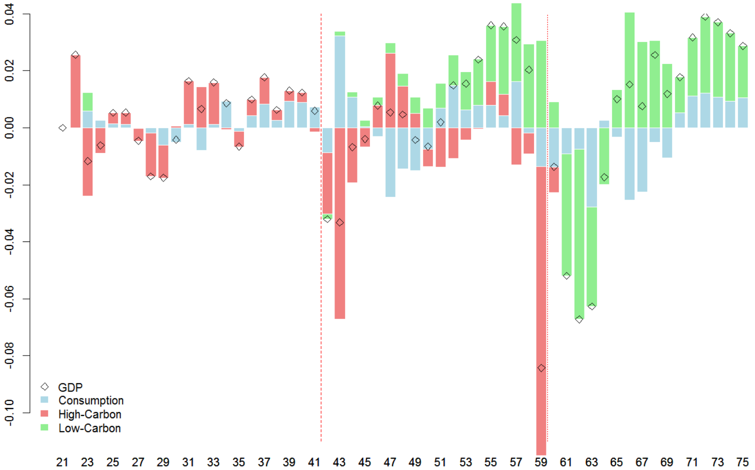
Financial investment decisions

- Financial investors allocate their financial wealth among the equities of the three sectors (e_c, e_h and e_l) and a risk-free asset (M_f)(Brainard and Tobin, 1968):

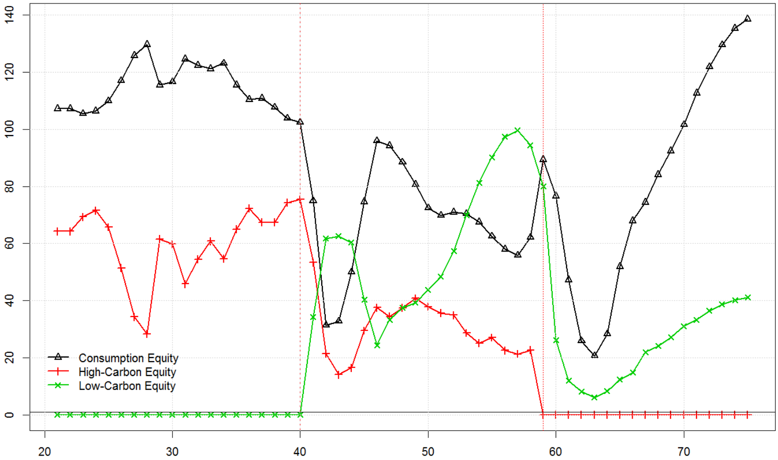
$$\begin{pmatrix} M_f \\ p_{c,e} e_c \\ p_{h,e} e_h \\ p_{l,e} e_l \end{pmatrix} = \begin{pmatrix} \lambda_{10} & \lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} \\ \lambda_{20} & \lambda_{21} & \lambda_{22} & \lambda_{23} & \lambda_{24} \\ \lambda_{30} & \lambda_{31} & \lambda_{32} & \lambda_{33} & \lambda_{34} \\ \lambda_{40} & \lambda_{41} & \lambda_{42} & \lambda_{43} & \lambda_{44} \end{pmatrix} \begin{pmatrix} 1 \\ \mathrm{R}_m \\ \mathrm{R}_c \\ \mathrm{R}_h \\ \mathrm{R}_l \end{pmatrix} V^e_{fc}.$$

- Investors allocate their wealth according to (Tobin 1969):
  1. A long-run term - the vector of $\lambda_{i,0}$ - that depends on the expected share of capital of each sector; in the long-term the allocation of wealth reflects the relative sectoral shares (Tobin's $q = 1$)
  2. A short-run term that depends on sectoral relative returns and creates fluctuations.

Change in sector output as share of GDP - Baseline scenario



Sectoral equity prices - Baseline scenario



Three crucial moments in the baseline scenario

1. Short-lived recession after low-carbon sector appearance
   - Reduction in high-carbon capital price (target return on capital)
   - Lower inflation produces an increase in the real interest rate
   - Higher interest rate affects consumption firms investment negatively
   - Increased employment and higher Tobin's q lead back to growth
2. In period 40, low-carbon sector IPO:
   - Wealth is reallocated towards low-carbon sector
   - High-carbon and consumption equity prices drop, leading to a decrease in Tobin's q and physical investment
   - Lower demand for high-carbon capital and high-carbon equities
3. Default of high-carbon sector in period 59
   - Banks write off loans to high-carbon sector
   - Declining output and drop in equity values
   - Higher inflation (target return on capital) drives down real interest rates
   - Low interest rates stimulate low-carbon and consumption sectors
   - Tobin's q recover, stimulating further investment

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2. A parameter $\phi \in [0, 1]$ representing investors' *climate blindness* or, alternatively, the stickiness of their expectations
   - $k^{Perc}_{l,l} = (1-\phi)k_{l,l} + \phi k^e_{l,l,-1}$
   - The larger is ϕ the stronger is their tendency to stick to their previously expected capital values rather than adapting to the actual ones

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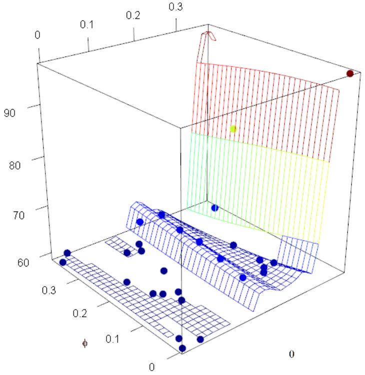
- $\lambda_{i,0}$ for each sector is then set to the share of the present value of capital evolution
  - Determined using *perceived* capital stocks and *expected* growth rates

How does this change the transition?

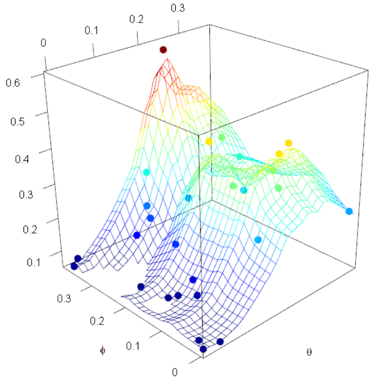
We run numerical simulations over the parameter domains and observe the effects on:

- *Exit period*: number of periods for the high-carbon sector to default
- *Output volatility*: Sum of variation coefficients of real sectoral output
- *Physical stranded assets*: Quantity of existing capital stock in high-carbon sector before default
- *Financial stranded assets*: market capitalization of the high-carbon capital sector before default

The effect of θ and ϕ on the low-carbon transition (I)

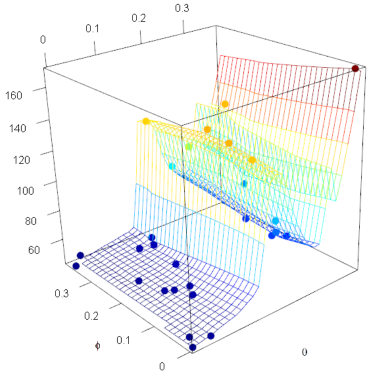


High-carbon sector exit period

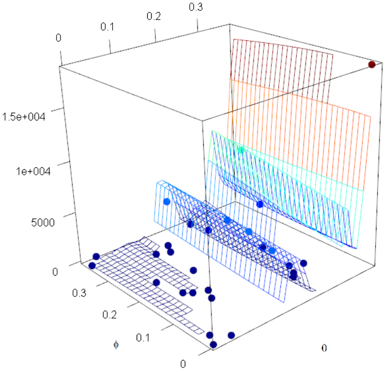


Output volatility index

The effect of θ and ϕ on the low-carbon transition (II)



Physical stranded assets



Financial stranded assets

Main results (I)

- Climate apathy θ have stronger effects than blindness ϕ
  - However, ϕ might change the dynamics in non-trivial ways when θ is high enough
- For values of θ above 0.4 the transition does not take place
  - The low-carbon sector expands but not enough to drive the high-carbon sector out
- Higher values of θ on average lead to:
  - Slower transitions
  - Higher output volatility,
  - Higher stranded physical assets
  - Higher stranded financial assets

Main results (II)

- However, strong non linear effects of θ:
  - Smooths the business cycles naturally emerging out of the transition
  - Limits growth and financial boom coming from low-carbon sector
  - Artificially spurs financial values without underlying real variables
- Lower values of apathy
  - Volatility dimension dominates; high-carbon sector spurred artificially via finance until capacity utilisation is too low to sustain growth
- Higher values of apathy:
  - Smoothing of the business cycle dominates volatility: lower output leads to lower stranded assets

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  - Higher levels of climate apathy extend the length of the transition period and increase the amount of physical and financial stranded assets.
  - Relevance of feedbacks and non-linear effects
- Policy implications
  - Increase information circulation (Task-Force on Climate-Related Financial Disclosure)
  - Support climate-friendly financial instruments (green bonds)
  - Stronger research from central banks and financial regulators on (climate stress testing)

Thank you!

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