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.
  - Both climate damage and transition risks should be internalised
  - Strength of drop in fossil firms valuation function of well-informed rational expectations of financial players

- However: deeper complexity.
- Behavioural finance insights (Simon, 1959; Shiller, 2015; Lo, 2017)
  - Financial investors may be disregarding climate transition risks and overpricing high-carbon financial assets beyond what would be 'rational' (Critchlow, 2015; Silver, 2017; Thoma and Chenet, 2017; Weber, 2017)

- 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 build a macroeconomic model of the transition to a low-carbon capital stock
  - BAU scenario captures macro/financial effects of the transition
- 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
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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)
  - Integrated Assessment Models (IAMs)
  - DSGE macro/monetary modelling (Comerford and Spiganti, 2017)
  - 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)
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▶ Macro sectors represented through their balance sheets
  ▶ Households, firms, banks, government, central bank, ..
  ▶ Attention to stock-flow consistency:
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- Dynamics not driven by optimisation
  - Economy as out-of-equilibrium system populated by non-rational agents
  - Positive rather than normative approach (historical validation)
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- Set of behavioural equations:
  - Consumption, investment, portfolio allocation, wage setting, ..
  - Combination of empirical evidence and theoretical assumptions
  - Adaptive expectations

\[ Y = C + I + G \text{ rather than } Y = AK^{\alpha}L^{1-\alpha} \]

- Demand-side approach
- Endogenous money
  - Money is not a veil, and banks are not just intermediaries
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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 (+)

\[ g_x = \eta_0 + \eta_1 u^e_x - \eta_2 r_{r}, x \lambda_x, -1 + \eta_3 q_x, -1 \]
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\[ g_x = \eta_0 + \eta_1 u_x^e - \eta_2 r_{rl,x} \lambda_{x,-1} + \eta_3 q_{x,-1} \]

- 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

\[ q_x = \frac{e_x \cdot p_{x,e}}{k_{h,x} \cdot p_h + k_{l,x} \cdot p_l - L_x} \]
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 \((e_c, e_h \text{ and } e_l)\) and a risk-free asset \((M_f)\) (Brainard and Tobin, 1968):

\[
\begin{pmatrix}
M_f \\
p_{c,e}e_c \\
p_{h,e}e_h \\
p_{l,e}e_l
\end{pmatrix} =
\begin{pmatrix}
\lambda_{10} & \lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} \\
\lambda_{20} & \lambda_{21} & \lambda_{22} & \lambda_{23} & \lambda_{24} \\
\lambda_{30} & \lambda_{31} & \lambda_{32} & \lambda_{33} & \lambda_{34} \\
\lambda_{40} & \lambda_{41} & \lambda_{42} & \lambda_{43} & \lambda_{44}
\end{pmatrix}
\begin{pmatrix}
1 \\
R_m \\
R_c \\
R_h \\
R_l
\end{pmatrix} V_{fc}^e.
\]

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

- Consumption Equity
- High-Carbon Equity
- Low-Carbon Equity
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
Playing with market sentiments

- We then study how climate market sentiments might modify this transition scenario
- We focus in particular on two parameters:

\[
\theta \in [0, 1] \text{ representing climate financial apathy}
\]

\[
\hat{k}_{\ell} = (1 - \theta) \hat{k} - \sigma h_{\ell} \hat{k}_{\ell}
\]

The larger is \( \theta \) the more will financial investors divert expected capital growth from the low-carbon to the high-carbon capital sector

\[
\phi \in [0, 1] \text{ representing investors' climate blindness or, alternatively, the stickiness of their expectations}
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\[
\hat{P}_{\text{r}, \ell} = (1 - \phi) \hat{k}_{\ell} + \phi \hat{k}_{\text{r}, \ell}
\]

The larger is \( \phi \) the stronger is their tendency to stick to their previously expected capital values rather than adapting to the actual ones

\[
\lambda_{i,0} \text{ for each sector is then set to the share of the present value of capital evolution}
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Determined using perceived capital stocks and expected growth rates
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   $$\hat{k}_{l, l}^e = (1 - \theta) \frac{\hat{k} - \sigma_{h, h} \hat{k}_{h, h} - \sigma_{h, l} \hat{k}_{h, l}}{1 - \sigma_{h, h} - \sigma_{h, l}}$$

   - The larger is $\theta$ the more will financial investors divert expected capital growth from the low-carbon to the high-carbon capital sector.

2. A parameter $\phi \in [0, 1]$ representing investors' *climate blindness* or, alternatively, the stickiness of their expectations

   
   $$k_{Perc, l} = (1 - \phi) k_{l, l} + \phi k_{e, l}, l$$

   - The larger is $\phi$ the stronger is their tendency to stick to their previously expected capital values rather than adapting to the actual ones.

- $\lambda_i, 0$ 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.
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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 $\theta$ and $\phi$ on the low-carbon transition (I)

High-carbon sector exit period

Output volatility index
The effect of $\theta$ and $\phi$ on the low-carbon transition (II)

Physical stranded assets

Financial stranded assets
Main results (I)

- Climate apathy $\theta$ have stronger effects than blindness $\phi$
  - However, $\phi$ might change the dynamics in non-trivial ways when $\theta$ is high enough
- For values of $\theta$ 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 $\theta$ 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 $\theta$:
  - 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
Conclusions

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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.
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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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