NY Fed Conference
Climate Change: Implications for Macroeconomics

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Role of financial markets in the transition towards net zero

- Massive shifts in asset purchases
  - Share of ESG investments is rising
  - Central banks are conducting asset purchases or subsidize bank lending to certain firms
  - How do these shifts affect the capital allocation in the economy?

- Conventional view of central bank purchases:
  - monetary policy should aim for "market neutrality"
  - no mandate to favor particular firms
  - in practice: bond purchases proportional to bonds outstanding

- Plan for remarks:
  1. Current corporate bond holdings by the ECB (Papoutsi, Piazzesi & Schneider 2021)
  2. How do asset purchases work? How can they help in the transition towards net zero?
  3. Can asset purchases be market neutral?
Market shares by sector

Dirty Manuf = oil & coke, chemicals, basic metals, nonmetallic minerals

- Agriculture
- Automobile
- Dirty Manuf
- Utilities
- Transport
- Other Manuf
- Services
Market portfolio vs ECB portfolio

Dirty Manuf = oil & coke, chemicals, basic metals, nonmetallic minerals

Agriculture
Automobile
Dirty Manuf
Utilities
Transport
Other Manuf
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ECB portfolio overweights sectors with high emissions

Dirty Manuf = oil & coke, chemicals, basic metals, nonmetallic minerals

![Bar chart showing ECB portfolio holdings against emissions in various sectors.](chart.png)
Growth model with climate externalities & financial frictions

- Representative household with preferences over final consumption good

\[ \sum_{t=0}^{\infty} e^{-\rho t} u(C_t) \]

inelastically supplies one unit of labor

- Final good made from intermediate goods: N sectors, many varieties per sector

\[ Y_t = \prod_{n=1}^{N} (Y^*_n)^{\theta_n}, \text{ where } Y^*_n = \left( \sum_{i \in I_n} (y^i_t)^{1-\frac{1}{\sigma}} \right)^{\frac{1}{1-\frac{1}{\sigma}}} \text{ and } \sum_{n=1}^{N} \theta_n = 1 \]

- Firm-specific climate externalities in production

  ▶ TFP declines with temperature \( \eta_t \), temperature increases with emissions

\[ y^i_{t+1} = z^i_{t+1} (\eta_{t+1}) (k^i_t)^{\alpha_n} (l^i_t)^{1-\alpha_n}, \quad \eta_{t+1} = \eta_t + \sum_i \varepsilon^i_t \ y^i_t \]
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Holding costs

- resource costs in units of final goods
- costs for households to hold assets or intermediation costs
  - some assets are more costly than others: risk, but also liquidity and convenience
  - exposures to few factors ($F << l$), analogous to hedonic pricing in housing markets

- per unit cost $h(\beta_t)$ of holding capital depends on factor exposure $\beta_t$
  - exposure from capital $k_t^i$ described by $F \times 1$ vector $\beta^i$
  - total capital stock $K_t = \sum_i k_t^i$ has average exposure $\beta_t = (\sum_i \beta^i k_t^i) / K_t$
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Private intermediaries and firms

- Private intermediaries owned by households, choose asset holdings
  - FOC for capital by firm $i$ determines return premium
    \[ R_{t+1}^i - R_{t+1}^f = \frac{\partial h(\beta_t)}{\partial \beta_t^i} \beta^i \]
  - With climate risk factor
    - firms with higher climate-betas pay higher return premia
    - if intermediaries have more exposure $\beta_t$ to climate risk, climate exposure has higher price

- Firms choose inputs, maximize profits
  - FOC for capital
    \[ R_{t+1}^i = \text{cost of capital} = MPK \]
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Central bank purchase program

- CB can buy portfolio $\tilde{k}_t$ of capital
  - ability to issue safe debt to finance purchase $\tilde{d}_t = \sum_i \tilde{k}_i$
  - overall size of program $\delta_t = \tilde{d}_t / K_t$
  - costs $\tilde{h}(\tilde{\beta}_t)$ so debt stays safe to finance portfolio $\tilde{k}_t$ with exposure $\tilde{\beta}_t$
  - purchase reduces exposure of other household holdings $\beta_t = \beta^*_t - \delta_t \tilde{\beta}_t$, where $\beta^*_t$ is exposure of market portfolio
  - total per unit costs $h(\beta^*_t - \delta_t \tilde{\beta}_t) + \delta_t \tilde{h}(\tilde{\beta}_t)$ of holdings

- Frictionless benchmark
  - CB purchase program does not matter: total per unit costs independent of $\tilde{k}_t$
  - example: $h$, $\tilde{h}$ linear in exposure, with same slope coefficients

- CB can create value
  - example: $F = 1$, $h$, $\tilde{h}$ convex, small purchase program lowers costs
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How do CB purchases affect capital allocation across firms?

- Market portfolio shares $k^i/K$ lower if marginal holding cost higher

\[
\text{marginal product of capital} = \frac{R^i}{\text{cost of capital}} = R^f + \frac{\partial h(\beta^*_t - \delta_t \tilde{\beta}_t)}{\partial \beta^*_t} \beta^i
\]

- With frictions, misallocation: inefficiently low $k^i/K$, central bank has a role
  - CB trades factors: lowers exposure $\beta^*_t - \delta_t \tilde{\beta}_t$ of private intermediaries
  - CB reduces market prices of risk $\partial h/\partial \beta_t$
    - example: green CB purchases increase market price of climate risk
  - CB affects returns on all assets exposed to same factors & held by same intermediaries including corporate bonds issued by ineligible firms, CDS, bank loans – also stocks?
  - CB purchases are blunt instrument, cannot target the cost of capital of individual firms
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Market neutrality

- Market portfolio shares $k^i/K$ solve

$$\text{marginal product of capital} = \frac{R^i}{\text{cost of capital}} = R^f + \frac{\partial h(\beta^*_t - \delta_t \tilde{\beta}_t)}{\partial \beta_t^\top} \beta^i$$

- Our definition: market neutral policy does not change relative costs of capital $R^i - R^j$
  - market neutral policies do not change market portfolio $k^i/K$
  - start from laissez-faire equilibrium with no purchase program $\delta = 0$
  - comparative static to equilibrium with purchase program $\delta > 0$

- Market-neutral CB purchase program does not exist, counting equations and unknowns
  - change $F << I$ market prices of risk, leave $I - 1$ costs of capital unchanged
Market neutrality

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- Our definition: market neutral policy does not change relative costs of capital $R^i - R^j$
  
  $\Rightarrow$ market neutral policies do not change market portfolio $k^i/K$
  
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  - change $F << I$ market prices of risk, leave $I - 1$ costs of capital unchanged
Conclusion

- Return premium paid by each firm reflects exposures to few risk factors  
  - climate risk may be one of the risk factors

- CB purchases or other shifts in portfolios change the market price of each risk factor  
  - each firm has exposure to risk factors, determines their valuation  
  - including of climate risk

- Market neutral purchases by CB would leave capital allocation unchanged  
  - impossible because many firms and few factors  
  - instead: CB purchases reduce risk exposure of intermediaries, reduces market price of risk, benefits firms with higher exposure  
  - including higher climate risk exposure  
  - Data: ECB purchases overweigh sectors with higher emissions