NY Fed Conference
Climate Change: Implications for Macroeconomics

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Stanford & NBER

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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?
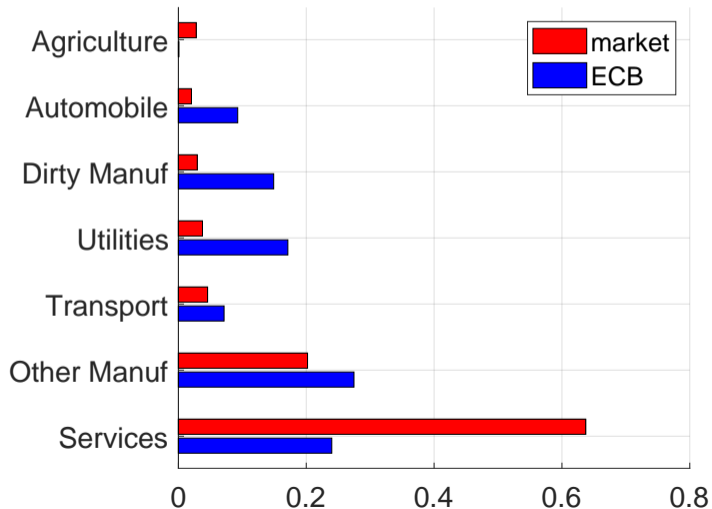 3. Can asset purchases be market neutral ?

Market shares by sector

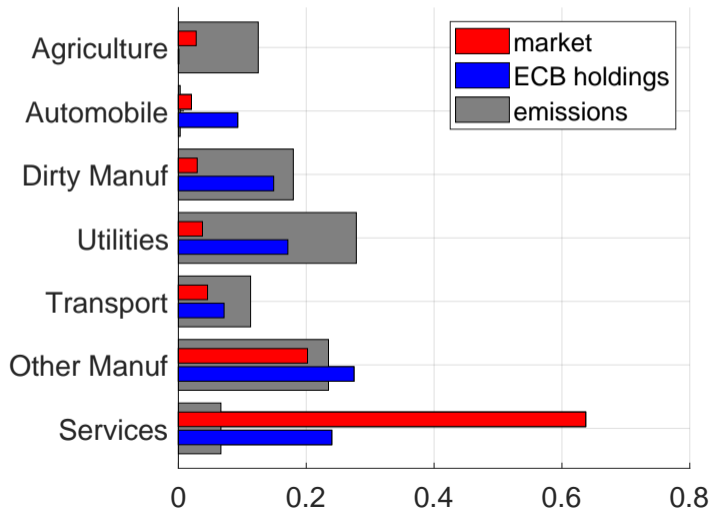Dirty Manuf = oil & coke, chemicals, basic metals, nonmetallic minerals
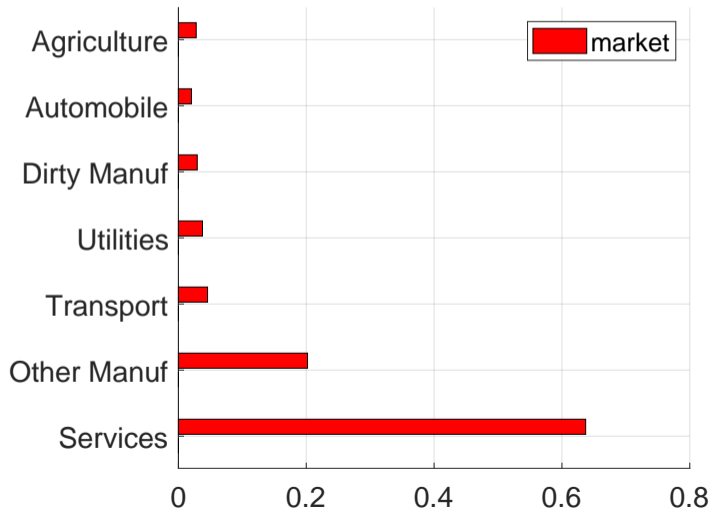
Market portfolio vs ECB portfolio

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

ECB portfolio overweighs sectors with high emissions

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

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

$$Y_t = \prod_{n=1}^{N} (Y_t^n)^{\theta_n}, \text{ where } Y_t^n = \left(\sum_{i \in I_n} (y_t^i)^{1-\frac{1}{\sigma}} \right)^{\frac{1}{1-\frac{1}{\sigma}}} \text{ and } \sum_{n=1}^{N} \theta_n = 1$$

- Firm-specific climate externalities in production

  - TFP declines with temperature η_t, temperature increases with emissions

  $$y_{t+1}^i = z_{t+1}^i (\eta_{t+1}) (k_t^i)^{\alpha_n} (l_t^i)^{1-\alpha_n}, \quad \eta_{t+1} = \eta_t + \sum_i \varepsilon_t^i y_t^i$$

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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 ($F << I$), analogous to hedonic pricing in housing markets
- per unit cost $h(\beta_t)$ of holding capital depends on factor exposure β_t
  - exposure from capital k_t^i described by $F \times 1$ vector β^i
  - total capital stock $K_t = \sum_i k_t^i$ has average exposure $\beta_t = \left(\sum_i \beta^i k_t^i\right)/K_t$

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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

  $$R_{t+1}^i - R_{t+1}^f = \frac{\partial h(\beta_t)}{\partial \beta_t^\top} \beta^i$$

  - With climate risk factor
    - firms with higher climate-betas pay higher return premia
    - if intermediaries have more exposure β_t to climate risk, climate exposure has higher price

- Firms choose inputs, maximize profits
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  $$R_{t+1}^i = \text{cost of capital} = \text{MPK}$$

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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 $\tilde{d}_t = \sum_i \tilde{k}_t^i$

  - 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 β_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

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

- With frictions, <u>misallocation</u>: 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

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- 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

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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