# How unconventional is green monetary policy?

Melina Papoutsi
ECB

Monika Piazzesi
Stanford & NBER

Martin Schneider
Stanford & NBER

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Disclaimer: The views expressed in this presentation do not necessarily reflect those of the European Central Bank or the Eurosystem.

# Question

- Should central banks buy green bonds?
  - not a mandate? market neutrality?
  - many large asset managers moving to towards ESG?

- This paper
  - evidence on footprint of ECB's CSPP corporate bond purchasing program
  - theoretical framework for thinking about color of monetary policy

# Message

- Evidence: ECB CSPP purchase program favors dirty firms
  - compare ECB bond portfolio to market portfolio of equity + debt
  - → ECB portfolio tilted towards high emission sectors
  - announcement effect on cross section of yield spreads
  - → larger drop for riskier firms, especially if liquid & dirty

- Theory: growth model with climate externalities & financial frictions
  - consistent with *factor structure* in bond premia & CSPP announcement effects, purchase programs lower prices for market risk & climate risk
  - if program has macro effects, it has cross-sectional effects ("market neutrality" elusive)
  - if carbon tax available, optimal program should focus on financial frictions
  - in absence of carbon tax, trading a climate risk factor can be beneficial
  - this talk: simpler version of model without endogenous capital structure

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# Evidence on ECB corporate bond purchases

- ECB CSPP program
  - announced March 2016, current holdings 350bn Euro
  - eligible bonds: Euro area, nonfinancial, good enough rating
  - bonds purchased in proportion to outstandings (idea: "market neutrality")
- Compare ECB bond portfolio to "market portfolio" of equity + debt at sectoral level
  - measure actual ECB holdings, including via auxiliary finance companies
  - three measures of market portfolio, results here based on capital income from Eurostat
  - sectoral scope 1 emissions from Eurostat

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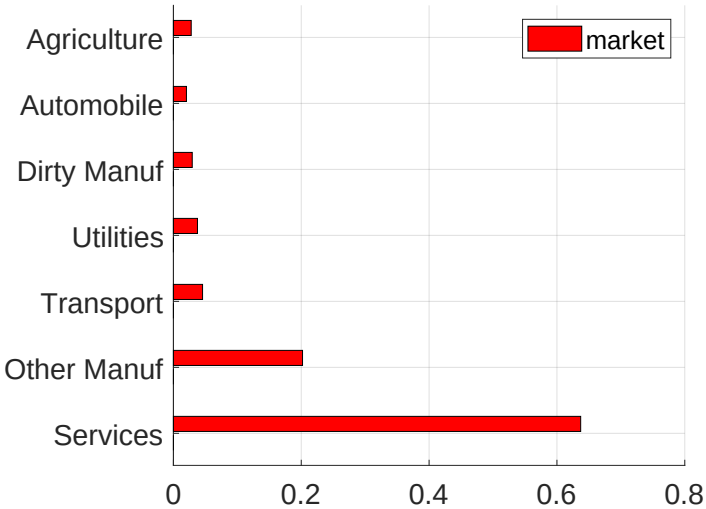
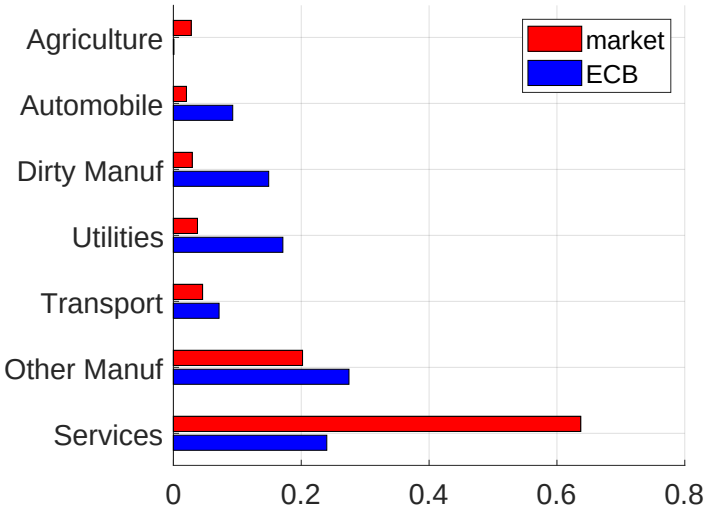
# Market portfolio shares (debt + equity) in nonfinancial sectors

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 looks more like emission shares

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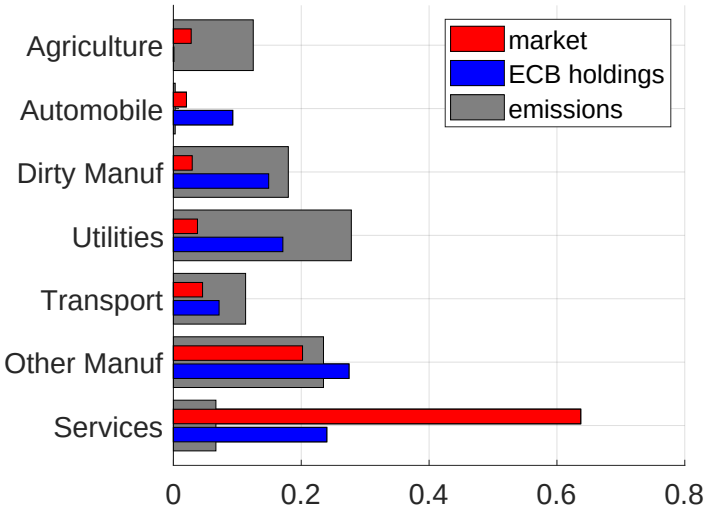

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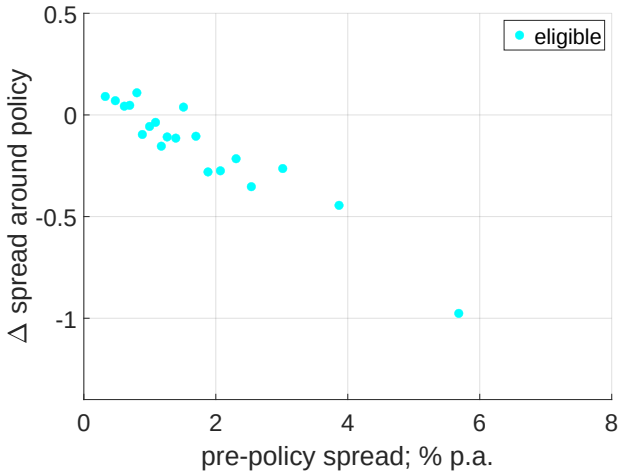
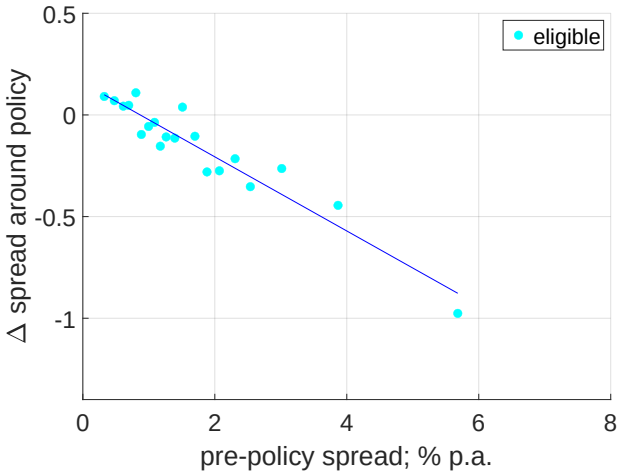
  - three measures of market portfolio, results here based on capital income from Eurostat
  - sectoral scope 1 emissions from Eurostat
- Post-announcement changes in bond spreads by group of firm
  - firm-level yields, outstandings & bond characteristics from CSDB
  - firm-level emission intensities from Urgentem

# CSPP impact on corporate bond spreads




- all eligible bonds binned into 20 groups
- spread in Feb 2016 on x-axis
- Δ spread on y-axis (median Mar-Aug – Feb)

# CSPP impact on corporate bond spreads




- regression line with negative slope: riskier bonds experience larger spread decline

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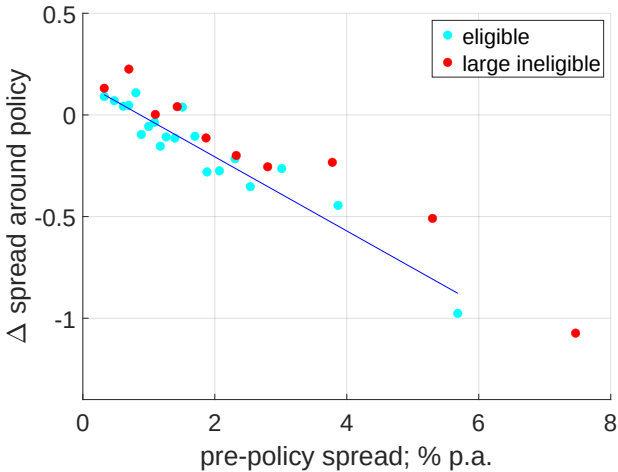
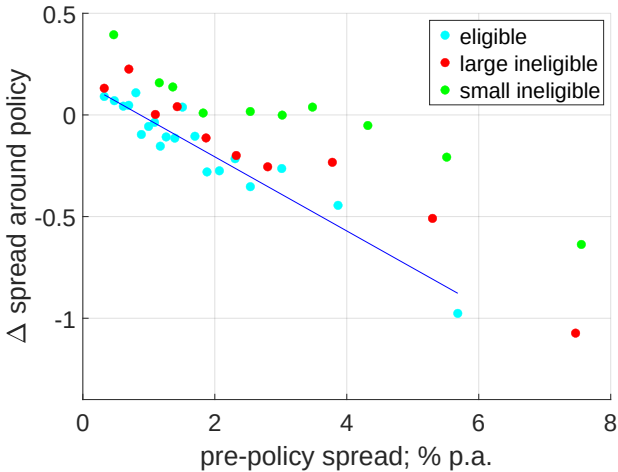


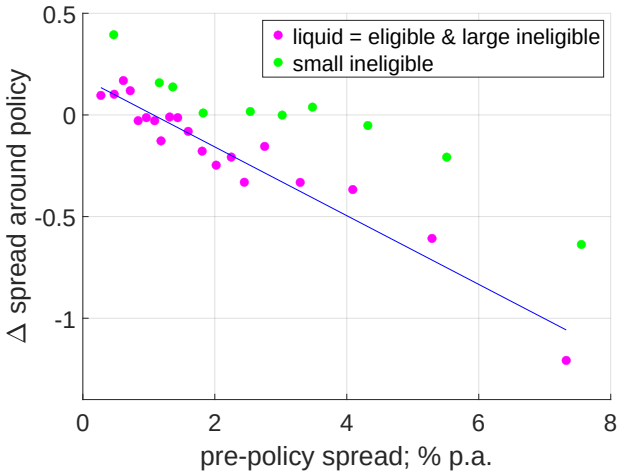

- add bins of ineligible bonds by large issuers (top 10%, issuance >800K Euros)
- very similar pattern: riskier bonds experience larger spread decline

# CSPP impact on corporate bond spreads




- add ineligible bonds by smaller issuers
- smaller impact on spreads

# CSPP impact on corporate bond spreads




- combine eligible & large ineligible =: liquid,
  = highly rated or large

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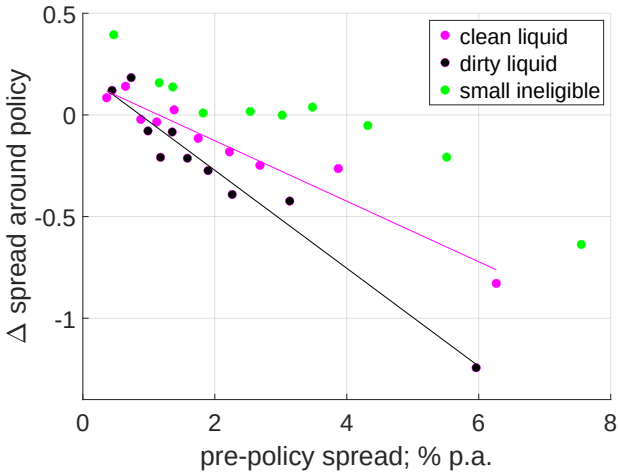


- break out "dirty" = top 10% by emission intensity
- stronger effect for dirty

# 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
  - CES aggregator over varieties within sector

- 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

- Holding assets requires resource costs (in units of final goods)
  - captures reasons why assets undesirable & pay premia (risk, illiquidity...)
  - cost is asset-specific: some assets less desirable, pay higher premia
  - could reflect household preferences or intermediation: both generate premia
- Cost depends on exposure to a vector of $F << N$ factors
  - assets with similar risk & liquidity are close substitutes
    - e.g. Begenau et al. maps bank portfolios to exposures to interest rate, credit risk: $F = 2$
    - large empirical literature on small $F$ in equities, incl liquidity
    - recent evidence on climate factor (Pastor-Stambaugh, Bolton-Kacperczyk)
  - here factor structure due to shape of cost, as in hedonic pricing model
- Per unit cost $h(\beta_t)$ of holding capital depends on private sector factor exposure $\beta_t$
  - exposure from capital $k_t^i$ described by $F \times 1$ vector $\beta^i$
  - exposure of portfolio = average exposure of individual holdings
    e.g. market portfolio with average exposure $\beta_t^* = \left(\sum_i \beta^i k_t^i\right) / K_t$
  - $h$ convex in exposure: increasing marginal cost of risk, illiquidity

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# Central bank purchase program

- CB buys portfolio of capital $k_t^{g,i}$
  - issues debt $d_t^g = \sum_i k_t^{g,i}$ to finance program; relative size $\delta_t = d_t^g / K_t$
  - CB exposure $\beta_t^g = \sum_i k_t^{g,i} \beta^i / d_t^g$ requires holding cost $h^g(\beta_t^g)\,\delta_t K_t$ , $h^g$ convex
  - CB debt has zero exposure: purchase reduces private sector exposure $\beta_t = \beta_t^* - \beta_t^g \delta_t$
  - total holding cost to society $h(\beta_t^* - \beta_t^g \delta_t) K_t + h^g(\beta_t^g)\,\delta K_t$ (constant returns!)
- Role of central bank
  - provides zero exposure (riskfree, liquid) assets, makes private sector safer
  - familiar theme from literature: CB better able to commit to repay debt than private sector as long as balance sheet sufficiently small ($h^g$ convex!)
  - real model with focus on investment & asset premia: medium run perspective
- When is QE effective?
  - frictionless benchmark: $h, h^g$ linear with same slope $\rightarrow$ "Ricardian equivalence"
  - strict convexity: zero exposure CB debt lowers total cost, more so if $h$ steeper
  - which is it? learn from effect of purchase program on premia/spreads!

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# Private Intermediaries

- Competitive firms owned by households, choose holdings of capital $k_t^i$
- Shareholder value maximization

$$\max_{k_t} \; M_{t+1}\left(\sum_i R_{t+1}^i k_t^i - h(\beta_t)\sum_i k_t^i\right) - \sum_i k_t^i$$

household discount factor $M_{t+1} = e^{-\rho}u'(C_{t+1})/u'(C_t)$

- FOCs for capital holdings from firm i

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

return on firm $i$ = discount rate + marginal holding costs

- $R^f$ return on zero-exposure assets, e.g. CB reserves

return premium = marginal holding cost difference

$$R_{t+1}^i - R_{t+1}^f = \frac{\partial h(\beta_t)}{\partial \beta_t^\top}\beta^i \text{ , with market prices of factor exposure } \pi_t = \frac{\partial h(\beta_t)}{\partial \beta_t^\top}$$

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# Firms, government & equilibrium

- Intermediate goods firms
  - hire labor at wage $w_{t+1}$, sell goods at price $p^i_{t+1}$, pay carbon tax $\tau_{t+1}$ per unit of emissions
  - maximize profits $\left(p^i_{t+1} - \tau_{t+1}\varepsilon^i_{t+1}\right) y^i_{t+1} - w_{t+1} l^i_{t+1} - R^i_{t+1} k^i_t$

  $\Rightarrow$ FOC for capital

$$R^i_{t+1} = \left(p^i_{t+1} - \tau_{t+1}\varepsilon^i_{t+1}\right) \alpha_n \frac{y^i_{t+1}}{k^i_t}$$

cost of capital = marginal product of capital net of carbon tax

- Final good firms
  - buy intermediate goods at price $p^i_{t+1}$, sell final good at price one
- Government
  - consolidated budget constraint with lump sum transfers $T_t$

$$\sum_i R^i_t k^{g,i}_{t-1} = \left(R^f_t + \tilde{h}(\beta_{t-1})\right) d_{t-1} + T_t$$

- Agents optimize and markets clear

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# What do CB purchases do?

- Combine firm & intermediary FOCs

$$\text{MPK net of carbon tax} = \underbrace{R^i}_{\text{cost of capital}} = \underbrace{R^f}_{\text{zero beta rate}} + \underbrace{\frac{\partial h(\beta_t^* - \beta_t^g \delta_t)}{\partial \beta_t^\top} \beta^i}_{\text{marginal holding cost}}$$

- Macro effect: integrate over all $i$
  - with convex $h$, private sector factor exposure increases premia, lowers investment
  - purchase program lowers exposure, factor prices, premia
  - stimulates investment as in many macro models of QE
  - some factor prices may not be affected by policy, e.g. liquidity

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- Cross sectional effects
  - firm $i$ market portfolio share $k^i/K$ lower if marginal holding cost higher
  - private sector factor exposure a source of misallocation that CB can address
  - factor structure makes QE a blunt instrument
    - CB affects individual returns only via market prices of factor exposure, no finetuning by $i$
    - affects returns *on all assets* exposed to same factors
    - including corporate bonds issued by ineligible firms
  - CB can target groups of firms with similar exposure by trading factors
    - example: green CB purchases increase market price of climate risk

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# What do CB purchases do?

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$$\text{MPK net of carbon tax} = \underbrace{R^i}_{\substack{\text{cost of} \\ \text{capital}}} = \underbrace{R^f}_{\text{zero beta rate}} + \underbrace{\frac{\partial h(\beta_t^* - \beta_t^g \delta_t)}{\partial \beta_t^\top} \beta^i}_{\text{marginal holding cost}}$$

- Cross sectional effects
  - firm $i$ market portfolio share $k^i/K$ lower if marginal holding cost higher
  - private sector factor exposure a source of misallocation that CB can address
  - factor structure makes QE a blunt instrument
    - CB affects individual returns only via market prices of factor exposure, no finetuning by $i$
    - affects returns *on all assets* exposed to same factors
    - including corporate bonds issued by ineligible firms
  - CB can target groups of firms with similar exposure by trading factors
    - example: green CB purchases increase market price of climate risk

# Understanding responses to CSPP announcement

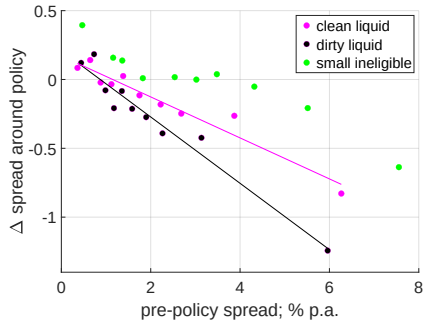
- Three factors: spreads reflect market risk, climate risk & liquidity

$$R^i - R^f = \underbrace{\pi_1 \beta_1^i}_{\text{market risk}} + \underbrace{\pi_2 \beta_2^i}_{\text{climate risk}} + \underbrace{\pi_3 \beta_3^i}_{\text{liquidity}}$$

- Groups of firms differ in factor loadings
  - liquid (eligible firms & large ineligible) firms do not load on liquidity factor
  - small ineligible firms load on liquidity, high emissions firms load on climate factor
- CB purchases lower prices of market & climate risk, affect liquidity less
- Policy response: scatter plot of spread change against spread before policy

$$\Delta R^i - \Delta R^f = (\Delta \pi_1)\beta_1^i + (\Delta \pi_2)\beta_2^i + (\Delta \pi_3)\beta_3^i$$

# Understanding responses to the CSPP announcement




- Policy response: scatter plot of spread change against spread before policy

$$\Delta R^i - \Delta R^f = (\Delta\pi_1)\beta_1^i + (\Delta\pi_2)\beta_2^i + (\Delta\pi_3)\beta_3^i$$

  - clean liquid firms on straight line with slope $-\Delta\pi_1$
  - larger response for dirty firms due to climate exposure $\beta_2^i$
  - smaller response for small firms since larger share of spread due to liquidity exposure $\beta_3$

# Market neutrality

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

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- definition: market neutral policy does not change relative costs of capital $R^i - R^j$

  $\rightarrow$ market neutral policies do not change market portfolio $k^i/K$
  - 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 factor exposures, leave $I - 1$ costs of capital unchanged

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# Optimal policy

- Optimal central bank purchase program when carbon tax is available
  - equate marginal cost of central bank to factor prices

$$\frac{\partial h}{\partial \beta}\left(\beta_t^* - \beta_t^g \delta_t\right) = \frac{\partial h^g}{\partial \beta}\left(\beta_t^g\right)$$

    $\rightarrow$ typically not neutral: helps more exposed firms more

  - equate marginal benefit of reduced private exposure to CB balance sheet cost

$$\beta_t^{g'} \frac{\partial h}{\partial \beta}\left(\beta_t^g\right) = h^g\left(\beta_t^g\right)$$

    $\rightarrow$ implies optimal size of central bank balance sheet

  - same formula as without climate externalities: policy should reflect color only if it appears as financial friction (principle of targeting)
- What if no carbon tax?
  - trading climate factor can reduce emissions by increasing dirty firms' cost of capital

# Message

- Evidence: ECB CSPP purchase program favors dirty firms
  - compare ECB bond portfolio to market portfolio of equity + debt
  - → ECB portfolio tilted towards high emission sectors
  - announcement effect on cross section of yield spreads
  - → larger drop for riskier firms, especially if liquid & dirty

- Theory: growth model with climate externalities & financial frictions
  - consistent with *factor structure* in bond premia & announcement effects of CSPPs, purchase programs lower prices for market risk & climate risk
  - if program has macro effects, it has cross-sectional effects ("market neutrality" elusive)
  - if carbon tax available, optimal program should focus on financial frictions
  - in absence of carbon tax, trading a climate risk factor can be beneficial