Climate Policy, Financial Frictions, and Transition Risk

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March 2022

Climate change is a growing threat to the Earth and our well-being

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Ambitious climate action needed to achieve the goal of the Paris Agreement

Gradual carbon tax increase suggested by Integrated Assessment Models (e.g. DICE) likely insu cient to achieve 2 C goal

- The nancial sector matters a great deal for real economic activity
- Credit market frictions (e.g., moral hazard, costly defaults)
- Climate-policy-induced \transition risk"(Carney `15, ECB `19, IMF `19)
  - Financial intermediaries exposed to climate-policy-relevant sectors
  - Risk of asset stranding in carbon-intensive sectors
  - Environmental factors in macroprudential regulation
  - Risk of a recession from aggressive climate policy

- Growing call for central bankers to consider climate in policy design
  - \At a time when the Intergovernmental Panel on Climate Change is warning of the potential catastrophic and irreversible damage in icted by a changing climate, we need a leader at the helm [of the Fed] that will take bold and decisive action to eliminate climate risk."
- Biden administration Executive Order on climate-related nancial risk (May 2021)
- Federal Reserve Financial Stability Climate Committee (announced March 2021)
- ECB Climate stress tests

(courtesy of Matt Darling via Twitter @besttrousers)

- Beyond the transition, nancial frictions can a ect the e cient design of climate policy
  - Two ine ciencies (climate and nancial) two instruments needed
  - Or, second best
- Long run (steady state) and business cycles

Could a sudden and ambitious climate policy create transition risk?

- Can macroprudential policies alleviate this risk?

How do financial frictions affect the efficient design of climate policy in the long-run and over business cycles?

- Can financial regulation address the climate externality?

DSGE model

Two sources of market failure

- Pollution externality
  - Brown and green producers
- Financial friction between banks and households (Gertler & Kiyotaki 2010)
  - Credit to the economy limited by banks' net worth

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- Two sources of market failure
  - Pollution externality
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    - Credit to the economy limited by banks' net worth
- Two policy instruments
  - Climate: emissions tax
  - Macroprudential: taxes/subsidies on banks' assets
    - Could be uniform or di erentiated (di erent for green vs. brown)
- TFP shocks (RBC)

Two sets of simulations

- Transition: unexpected implementation of high carbon tax
  - Does the tax cause macroeconomic instability (recession) with nancial frictions?
  - Can macroprudential policies alleviate the risk?
- Long run and business cycles: steady state and TFP uctuations
  - E cient design of climate and/or macroprudential policy (Ramsey problem)
  - First- and second-best policies

- Transition
  - Financial frictions plus climate policy can lead to recession
  - Macroprudential policy can alleviate the risk
- Long run and business cycles
  - Financial frictions a ect steady state and cyclical properties of e cient carbon tax
  - Macroprudential policies alone (even di erentiated) not very e ective at addressing climate externality

Environmental DSGE (E-DSGE) models:

Fischer & Springborn (2011), Heutel (2012), Annicchiarico & Di Dio (2015), Dissou & Karnizova (2016), Chan (2020), Gibson & Heutel (2020)

DSGE models with nancial sector:

Gertler & Karadi (2010), Gertler & Kiyotaki (2011), Gertler et al. (2012), Aoki et al. (2018), among others

Stranded assets, transition risk, nancial policies:

van der Ploeg & Rezai (2019, 2020), Rozenberg et al. (2020), Ramelli et al. (2019), Carattini & Sen (2019)

Other E-DSGE models with nancial frictions:

Diluiso et al. (2021), Benmir & Roman (2020), Ferrari and Nispi Landi (2020)

Our paper:

- Looks at transition AND long-run/business cycles
- Ramsey-e cient policy design (externality from pollution, endogenous emissions tax)
- But, no monetary policy/price stickiness

- Households, banks, government, and non- nancial rms (`green', `brown', nal, capital)

- 2 sources of ine ciencies: pollution externality from brown rms; nancial friction from banks

- 2 policies: climate policy (emissions tax), macroprudential policy (tax/subsidy to banks assets)

- A continuum of identical households of measure unity
- Fraction 1 of members are workers, and fractionare bankers
- Workers supply labor; return the wages to the HH
- Bankers manage nancial intermediaries (banks); transfer dividends to the HH

A representative household chooses C_t, L_t^b, L_t^g, D_t to maximize

$$E_0 \left\{ \sum_{t=0}^{\infty} {}^{t} \frac{1}{1} \left(C_t \; \$ \; \frac{\left[\left(L_t^b\right)^{1+ {}_L} + \left(L_t^g\right)^{1+ {}_L} \right]^{\frac{1+}{1+ {}_L}}}{1+} \right)^{1} \right\} ;$$

subject to

$$C_t + D_t = w_t^b L_t^b + w_t^g L_t^g + R_{t-1} D_{t-1} + {}_t + {}_t + T_t :$$

Agency problem between a bank and its depositors (Gertler & Kiyotaki 2010)

The banker can divert a fraction of assets for personal bene t

The depositors will lend as long as a banker does not have incentives to misbehave

The amount of capital limited by banks' net worth

Bank j combines its own net worth $N_{j;t}$ and deposits $D_{j;t}$ to buy nancial claims on rms ($S^g_{j;t}$, $S^b_{j;t}$)

Bank's balance sheet:

$$(1 + {}_t^{b})Q_t^b S_{j;t}^b + (1 + {}_t^{g})Q_t^g S_{j;t}^g + {}_{j;t} = D_{j;t} + N_{j;t}:$$

${}_{j;t}(\ )$ - small quadratic asset management costs (helps pin down steady state portfolio).

- An agency problem between a bank and its depositors (Gertler and Karadi 2011, Gertler and Kiyotaki 2010)
- The bank can divert the fraction of total assets for its personal bene t
- Depositors can force the bank into bankruptcy and recover (1   ) fraction of assets
- The depositors will lend as long as a banker does not have incentives to run away:

$$\underbrace{V_{j,t}}_{\text{cost}} \qquad \underbrace{Q_t^b S_{j,t}^b + Q_t^g S_{j,t}^g}_{\text{bene t}} :$$

Denote by $R^b_{k;t+1}$ and $R^g_{k;t+1}$ the returns on brown and green assets

The evolution of net worth:

$$N_{j;t+1} = R^b_{k;t+1} Q^b_t S^b_{j;t} + R^g_{k;t+1} Q^g_t S^g_{j;t} \quad R_t D_{j;t}$$

Exogenous bank exit i.i.d. probability 1

Upon exit a banker transfers its retained earnings to the household

Continuation (or franchise) value at the end of period t,

$$V_{j;t} = E_t \left\{ \sum_{e=t+1}^{1} (1 \quad) \quad ^{e \ t \ 1} M_{t;e} N_{j;e} \right\}$$

The bank solves

$$V_{j,t} = \max_{S^b_{j,t}, S^g_{j,t}} E_t \{ [(1 \quad) M_{t,t+1} N_{j,t+1} + \quad M_{t,t+1} V_{j,t+1}] \} ;$$

subject to the balance sheet constraint, IC, the evolution of net worth

Value function linear in bank's net worth $\Rightarrow$ easy aggregation of the banking sector

When banks are nancially constrained:

$$Q_t^b K_t^b + Q_t^g K_t^g = \frac{'_t}{\;} N_t\,;$$

where' $_t$ is marginal shadow value of net worth

- This is the key equation capturing the nancial friction
- Capital in the economy is constrained by banks' net worth
- Shocks to the economy get ampli ed through uctuations in banks' equity capital
- Bankers do not internalize this e ect and thus the equilibrium is ine cient
    - analogous to a second externality

Production technology, $i = \{b, g\}$

$$Y_t^i = [1 - d(X_t)] A_t \left(K_{t-1}^i\right)^{\alpha^i} \left(L_t^i\right)^{1-\alpha^i}; \quad 0 < \alpha^i < 1$$

Damage function $d(X_t)$ increasing in pollution stock X_t

Firms do not internalize pollution externality

Emissions are a by-product of `brown' production

$$e_t = (1 \quad {}_t) \quad Y_t^b$$

Pollution stock evolves according to

$$X_t = \quad {}_X X_{t \quad 1} + e_t + e^{row}$$

Cost of emissions abatement $_t$

$$Z_t = \quad {}_1 \quad {}_t{}^2 Y_t^b$$

Standard RBC parameters

Financial frictions parameters (target bank leverage ratio, credit spreads)

Environmental parameters (damage function, abatement cost function, etc.)

- Calibrated based on DICE model

Parameter values

Two sets of simulations/results

- Transition risk { Exogenous climate policy shock
- Ramsey-e cient rst- and second-best policies:
  - Deterministic steady-state
  - Business cycles (TFP shocks)

- Unexpected introduction of a \$ 31 per ton tax on CO_2
  - Our (Ramsey) e cient tax
  - Roughly equal to DICE, IMF recommendations, SCC
- Start in baseline (no tax) steady state, hit with tax in period 5
- Compare model with and without nancial frictions

- Instead of switch from brown to green, nancial frictions lock up both types of capital
- Carbon tax can cause a recession, and the recession is worse with nancial frictions

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- Can macroprudential policy alleviate these risks?
  - Reduce banks' exposure to brown assets
  - A tax on `brown' & subsidy to `green' assets
  - Lowers banks' ss exposure to brown from 40% (baseline) to 33%
- Compare transition dynamics with and without macroprudential policies

Macroprudential policies reduce the extent of the transition risk

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Alternate assumptions on timing, magnitude can a ect quantitative results

- No longer transition, now steady state and uctuations around it
- The Ramsey problem:

$$\max_{\{\text{allocations}\},\{\text{instruments}\}} E_0 \sum_{t=0}^{\infty} {}^{t} U(C_t; L_t^b; L_t^g);$$

subject to competitive equilibrium conditions.

- Instruments (not all are available in each simulation):
  - Emissions tax - ${}_t^e$
  - Taxes or subsidies on banks' assets ${}_t^b$; ${}_t^g$
    - Could be uniform or di erentiated
- First, look at steady state

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- Without nancial frictions, emissions tax alone yields rst best
- With nancial frictions, need emissions tax and macroprudential tax for rst best
- Second-best policies
  - Emissions tax alone
    - Emissions close to rst-best level
    - Output still too low
  - Macroprudential policies alone
    - Output closer to rst-best level
    - Emissions even higher than no-policy
    - Even with di erentiated macroprudential policies
- Sensitivity Analysis

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- Now, look at dynamic/cyclical properties
- Impulse response functions after one-time negative TFP innovation
- First, consider just emissions tax (no macroprudential policies), with and without nancial frictions
- Second, consider di erent policy combinations, under nancial frictions

- Emissions tax much more cyclical with nancial frictions
- The regulator cuts the emissions tax more aggressively to mitigate the fall in banks' net worth and credit supply
- Procyclicality of emissions is thus dampened; emissions actually increases initially after shock

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- Next, consider macroprudential policies too (uniform or di erentiated)
  - Only uniform macroprudential policy (second best)
  - Only di erentiated macroprudential policy (second best)
  - Uniform macroprudential policy and emissions tax (rst best)

- Most outcomes similar (cyclical response) under rst best or second best
- Exception: emissions much more procyclical under second best, without emissions tax
- No di erent between uniform and di erentiated second-best macroprudential policies
  - Macroprudential policy not e ective at responding to climate externality over the business cycle

Alternate emissions calibration

- Can abrupt climate policy trigger nancial instability risk?
  - Unfortunately, yes. But, macroprudential policies, by improving the nancial sector's resilience, can mitigate this risk
- E cient design of climate and macroprudential policy in the long run and over business cycles
  - Macroprudential policies alone do poorly at addressing the climate externality
  - Carbon policy (emissions taxes) needed too

Thank you!
Merci!

Portfolio composition (the share of green assets, s_t^g):

$$s_t^g = \frac{E_t \left\{ _{t+1} \left[R^g_{k,t+1} \quad R^b_{k,t+1} \quad _t^g \quad _t^b \; R_t \right] \right\}}{E_t \left[\; _{t+1} R_t \right]} + \bar{s}^g$$

Aggregate banking sector net worth:

$$N_t = \left[\sum_{i=\{g,bg\}} R^i_{k,t} Q^i_{t-1} K^i_{t-1} \quad R_{t-1} D_{t-1} \right] + \sum_{i=\{g,bg\}} Q^i_{t-1} K^i_{t-1} :$$

Demand for labor:

$$w_t^b = \quad 1 \qquad {}^b \; \frac{Y_t^b}{L_t^b} \; p_t^b \qquad {}_1 \;\; {}_t{}^2 \qquad {}_t^e (1 \qquad {}_t) \qquad Y_t^b \qquad {}^1$$

Emissions abatement:

$${}_t^e = \quad Y_t^b \quad {}^1 \qquad {}_1 \;\; {}_2 \;\; {}_t{}^2 \;\; {}^1$$

State-contingent gross return on brown capital:

$$R_{k;t}^b = \frac{{}^b \frac{Y_t^b}{K_{t-1}^b} \Big[p_t^b \qquad {}_1 \;\; {}_t{}^2 \qquad {}_t^e (1 \qquad {}_t) \qquad Y_t^b \qquad {}^1 \Big] + \quad 1 \qquad {}^b \quad Q_t^b}{Q_{t-1}^b}$$

Table. Calibration

	0:995	Discount factor
	2	Risk aversion
	1	Frisch elasticity of labor hours
$	8:3849	Labor disutility
L	1	Intrasectoral CES of labor hours
g	0:33	Capital share in `green' prod.
b	0:35	Capital share in `brown' prod.
b; g	0:025	Capital depreciation rate
b; g	10	Investment adjustment cost
A	0:95	Persistence of aggregate TFP shocks
A	0:007	Std. dev. of innovations to TFP

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Table. Calibration

1	0:0335	Abatement cost function parameters
2	2:6	
d_0	0:0076	Damage function parameters
d_1	1:52e 5	
d_2	3:71e 8	
X	0:9965	Pollution decay
	1	Emissions elasticity parameter
e^{row}	3:1499	Emissions in the ROW
Y	2	CES between `green' and `brown' outputs
b	0:3326	Share of `brown' output
	0:3409	Fraction of divertable assets
	0:972	Bankers' survival rate
	0:003	Proportional transfer to new bankers
	10^{4}	Banks' portfolio management cost
$\bar{s}^g$	0:60	Portfolio share of green assets

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Table A1. Deterministic steady state: additional variables

	No financial frictions		Financial frictions				
	No policy	^{e}	No policy	^{e}	$^{b} = {}^{g}$	^{b} & ^{g}	^{e} & $^{b} = {}^{g}$
Consumption	1.082	1.093	1.038	1.046	1.075	1.075	1.093
Green output	0.850	0.862	0.795	0.804	0.840	0.845	0.862
Brown output	0.676	0.675	0.630	0.629	0.668	0.663	0.675
Green investment	0.254	0.257	0.221	0.223	0.248	0.251	0.257
Brown investment	0.170	0.168	0.147	0.146	0.166	0.163	0.168
Labor in green prod.	0.272	0.273	0.263	0.264	0.270	0.271	0.273
Labor in brown prod.	0.212	0.211	0.205	0.204	0.211	0.211	0.211
Climate damages	0.053	0.047	0.052	0.047	0.053	0.053	0.047

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Note: This gure plots the second-best steady-state value of the emissions tax when varying either the banks' transfer parameter ( ) or the agency problem parameter ( ) from their base-case values of 0003 and 0:3409, respectively.

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- Calibrate emissions damage function from DICE
- Base-case calibration results in steady-state pollution stock damages of about 5% of gross output, very high carbon stock
  - Why? Using DICE, a Solow-type macro growth model, to calibrate an E-DSGE model, solved around a steady state
- Alternative calibration (still using DICE), lower discount rate, long-run temperature damages
- Yields carbon price about the same, but with lower damages and lower pollution stock

Table 2: Steady state

	No financial frictions		Financial frictions				
	No policy	Emissions tax only	No policy	Emissions tax only	Uniform macro-prudential policies only ($\tau^b = \tau^g$)	Differentiated macroprudential policies only ($\tau^b \neq \tau^g$)	Emissions tax and uniform macroprudential policies
Emissions tax ($ per ton)	0	34.5	0	27.4	0	0	34.5
Tax on brown assets (%)	–	–	0	0	-0.19	-0.14	-0.22
Tax on green assets (%)	–	–	0	0	-0.19	-0.22	-0.22
Emissions	0.729	0.443	0.674	0.445	0.720	0.714	0.443
Aggregate output	1.622	1.629	1.502	1.507	1.601	1.601	1.629
Banks' net worth	–	–	3.393	3.385	3.859	3.860	3.954
Welfare loss (% CV)	0.65	0	1.46	0.94	0.75	0.73	0

Note: This table shows the steady state values of selected variables in the economies with and without financial frictions under different policy scenarios. The units of the emissions tax are dollars per ton of CO_2, based on the calibration described in the text. Tax rates on banks' assets are in percentages. Welfare loss is in terms of compensating consumption variation relative to the first-best allocations. All other variables are in arbitrary model units.