ECONOMIC IMPLICATIONS OF THE CLIMATE PROVISIONS OF THE INFLATION REDUCTION ACT

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Key questions:

1. What are the implications of IRA for energy markets?

2. What are the macroeconomic implications of the climate provisions of IRA?

3. What are the merits of IRA’s subsidies approach relative to a carbon tax?

Approach:

- Implications for energy markets using REGEN model

- Macro impact via analytical model and FRB/US
IRA subsidizes clean energy investment

- Clean electric power generation:
  - Investment tax credit and production tax credit
  - Uncapped, expiring only after emissions targets are reached
  - Bonuses for meet labor and domestic sourcing req.

- Electric vehicles and residential appliances:
  - $7500 tax credit subject to sourcing/income req.

- Carbon capture and clean fuels:
  - Larger financial incentives allowing for fossil fuel CCS (45Q)
  - Tax credit for clean hydrogen (45V)

Fiscal cost: climate provisions scored at $392 bn over 10 years
50% INCREASE IN CLEAN ENERGY INVESTMENT DUE TO IRA

- REGEN is an industry equilibrium model to project power investment and prices
- REGEN projection conservative relative to other modeling
IRA lowers carbon emissions by 7 pp

Emissions relative to 2005 levels
PROJECTIONS OF HIGHER FISCAL COST

COMPARISON OF REGEN AND JCT/CBO SCORE

Total Undiscounted Fiscal Cost (billion $)

- Direct
- Other Tax Credits
- Transport
- 45V
- 45Q
- PTC
- ITC

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<tbody>
<tr>
<td>2031</td>
<td>$0</td>
<td>$500</td>
<td>$1,000</td>
<td>$1,500</td>
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<td></td>
<td></td>
<td>$1,000</td>
<td>$1,500</td>
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IRA raises possibility of negative electricity prices

- Wholesale price could turn negative up to 20% of hours
- More modest projected declines in retail prices of 2.2% by 2030
CLIMATE PROVISIONS EXPAND POTENTIAL . . .

\[ p_c (1 - \tau_c) (r + \delta_c) = (p_e + \tau_p) G_c'(K_c) \]

\[ p_e = F_e(E, \bar{N}) \]

\[ E = G_c(K_c) \]
. . . BUT RAISE DEMAND IN THE SHORT-RUN

Transition path:

▶ Energy investment increases immediately, while output is fixed

▶ Consumption falls and real interest rates rise

▶ Crowding out extends to fossil fuel and non-energy capital

Bottlenecks:

▶ Bottlenecks constrain initial investment, slow transition

▶ Bottlenecks may raise fiscal cost under ITC
  ▶ PTC proportional to *real* investment but ITC proportional to *nominal* investment

▶ Increases in price of capital but lower path for real interest rate
MACRO IMPACTS ARE LIKELY MODEST

<table>
<thead>
<tr>
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<th>Nominal, 2018-2022 averages</th>
<th>REGEN IRA impact, 10-year avg</th>
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<tbody>
<tr>
<td></td>
<td>$ bn</td>
<td>% of BFI</td>
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<tr>
<td>Gross domestic product</td>
<td>22350</td>
<td></td>
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<tr>
<td>Nonresidential fixed investment</td>
<td>2974</td>
<td>13.3</td>
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<tr>
<td>Structures</td>
<td>633</td>
<td>21.3</td>
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<tr>
<td>Electric power structures (BEA estimate)</td>
<td>79</td>
<td>2.7</td>
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<tr>
<td>Equipment</td>
<td>1199</td>
<td>40.3</td>
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<tr>
<td>Electrical transmission, distribution, and industrial apparatus</td>
<td>52</td>
<td>1.8</td>
</tr>
<tr>
<td>Electrical equipment, n.e.c</td>
<td>9</td>
<td>0.3</td>
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- Substantial structures investment but modest in aggregate
- FRB/US finds demand effects result in small increases in output, employment, core inflation initially
  - Headline inflation falls due to lower retail electricity prices
- Important limitations to FRB/US modeling:
  - Lack of detailed electricity or energy market in FRB/US
  - Combined effects of IIJA, IRA, and CHIPS Act
Higher rates negatively impact clean energy generation

- LCOE for clean energy more sensitive to changes in interest rates
- Large construction cost increases over pandemic: structures up 20%, power plant equipment up 13% and transmission up 27%
OPTIMAL POLICY LEAVES CLEAN ENERGY MARGIN UNDISTORTED

Capital choice under subsidies/tax:

\[ p^c_t = \frac{1}{1 + r_t} \left[ \left( p^e_{t+1} + \tau^p_{t+1} \right) G'_c \left( K^c_{t+1} \right) + p^c_{t+1} \left( 1 - \delta_c \right) \right] \]

\[ p^f_t = \frac{1}{1 + r_t} \left[ \left( p^e_{t+1} - \tau^f_{t+1} \right) G'_f \left( K^f_{t+1} \right) + p^f_{t+1} \left( 1 - \delta_f \right) \right] \]

Planner’s allocation:

\[ p^c_t = \frac{1}{1 + r_t} \left[ p^e_{t+1} G'_c \left( K^c_{t+1} \right) + p^c_{t+1} \left( 1 - \delta_c \right) \right] \]

\[ p^f_t = \frac{1}{1 + r_t} \left[ p^e_{t+1} G'_f \left( K^f_{t+1} \right) + p^f_{t+1} \left( 1 - \delta_f \right) \right] - \mu_{t+1} G'_f \left( K^f_{t+1} \right) \]

- REGEN finds abatement cost $83 per ton under IRA v. $12 per ton by 2030 under emissions equivalent carbon tax
CLEAN ENERGY SUBSIDIES JUSTIFIED UNDER LEARNING-BY-DOING

Modeling learning-by-doing:

- Price of clean energy capital is a decreasing function of level of installed capital

- Increasing returns to scale or credit constraints would give rise to similar effects

Optimal subsidy with learning-by-doing or increasing returns:

$$p(K^c_t) = \frac{1}{1 + r_t} \left[ p^e_{t+1} G'_c (K^c_{t+1}) + p(K^c_{t+1}) (1 - \delta_c) - \underbrace{p' (K_{t+1}) I^c_t}_{\text{time-varying ITC/PTC}} \right]$$
Key Takeaways

1. What are the implications of IRA for energy markets?
   ▶ 50% increase in renewable power generation with $800 bn in fiscal expenditures over 10 years
   ▶ Possibility of very low or negative wholesale electricity prices

2. What are the macroeconomic implications of the climate provisions of IRA?
   ▶ Long-run supply side benefits from lower electricity prices
   ▶ Higher interest rates and upstream costs could negatively impact clean energy investment

3. What are the merits of IRA’s subsidy approach relative to a carbon tax?
   ▶ Optimal policy favors carbon tax over subsidy approach
   ▶ Subsidies justified with learning-by-doing externalities or increasing returns to scale
Additional Slides
MACROECONOMIC FRAMEWORK

Model setup:

\[ V (K_0) = \max_{C_t, K_{t+1}} \sum_{t=0}^{\infty} \beta^t u (C_t) \]

subject to \[ C_t + (1 - \tau_t^c) p_t^c I_t^c = \left( p_t^e + \tau_t^p \right) G (K_t^c) - T_t + W_t \tilde{N} \]

\[ K_{t+1}^c = I_t^c + (1 - \delta_c) K_t^c \]

\[ p_t^e = F_e (G (K_t^c), \tilde{N}) \]

Extension with fossil fuel investment:

\[ C_t + p_t^c (1 - \tau_c) I_t^c + p_t^f I_t^f = \left( p_t^e + \tau_p \right) G_c (K_t^c) + \left( p_t^e - \tau_f \right) G \left( K_t^f \right) \]

\[ K_{t+1}^c = I_t^c + (1 - \delta_c) K_t^c \]

\[ K_{t+1}^f = I_t^f + \left( 1 - \delta_f \right) K_t^f \]
Planner’s problem:

\[ V(K_0, Q_0) = \max_{C_t, K_{t+1}^c, K_{t+1}^f} \sum_{t=0}^{\infty} \beta^t [u(C_t) - D(Q_t)] \]

\[ C_t + p_t^c I_t^c + p_t^f I_t^f = F(E_t, \bar{N}) \]

\[ Q_{t+1} = Q_t + \kappa E_t^f \]

Labor requirements and domestic sourcing:

- Modeled as two technologies: \( p_c^{\text{high}} > p_c^{\text{low}} \), but firms choose technology that has lowest after-tax user cost:

\[ p_c^{\text{high}} \left(1 - \tau_c^{\text{high}}\right) \leq p_c^{\text{low}} \left(1 - \tau_c^{\text{low}}\right) \]

- Domestic sourcing may slow transition depending on cost difference between domestic and foreign technology
TAX v. SUBSIDY DISTRIBUTIONAL CONSIDERATIONS

- Concerns that carbon tax disproportionately impacts poorer households

- A carbon tax/dividend welfare improving for bottom half if energy consumption increasing in absolute terms
Small macroeconomic impacts in FRB/US

Macroeconomic Effects of Funds Rate Perturbation (VAR Expectations)

- Federal Funds Rate
- 10-Year Treasury Yield
- Unemployment Rate
- Inflation Rate (4-Quarter)

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# Carbon Tax Delivers Lower Abatement Costs

<table>
<thead>
<tr>
<th>Metric (units)</th>
<th>2021</th>
<th>IRA Scenario</th>
<th>CO₂ Equivalent</th>
<th>Difference (p.p.)</th>
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<tr>
<td></td>
<td></td>
<td>2030</td>
<td>2035</td>
<td>2030</td>
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<tr>
<td><strong>Generation Share (%)</strong></td>
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<tr>
<td>Coal</td>
<td>22%</td>
<td>11%</td>
<td>8%</td>
<td>7%</td>
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<tr>
<td>Coal CCS</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
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<tr>
<td>Gas</td>
<td>39%</td>
<td>20%</td>
<td>18%</td>
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<tr>
<td>Gas CCS</td>
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<td>Other</td>
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<td>9%</td>
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<td>Nuclear</td>
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<td>Hydro</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
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<td>Wind and Solar</td>
<td>13%</td>
<td>33%</td>
<td>41%</td>
<td>28%</td>
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<td><strong>CO₂ Emissions (% Reduction from 2005)</strong></td>
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<td>Generation Price ($/MWh)</td>
<td>N/A</td>
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<td>$52</td>
<td>$65</td>
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<td>Abatement Cost ($/t-CO₂)</td>
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<td>$12</td>
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