Asset Overhang & Technological Change

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A financier’s reduced incentive to fund a firm’s profitable and innovative project due to negative externalities imposed on that financier’s legacy positions.
Technological change is not always in an investor’s best interest

An economy’s capacity to **innovate and diffuse disruptive technologies**

A financier’s reduced incentive to fund a firm’s profitable and innovative project due to negative externalities imposed on that financier’s legacy positions
This paper

A financier’s reduced incentive to fund a firm’s profitable and innovative project due to negative externalities imposed on that financier’s legacy positions.

An economy’s capacity to innovate and diffuse disruptive technologies.

Technological change

Asset overhang

Investor

Firm 1

Collateral

Firm 2
1. **Theory**

   *Asset overhang hinders financing and development of technological disruption*

   - **Findings**
     - Investors internalise the cost of the externality on their portfolio and demand compensation which increases **rationing of innovative projects**
     - The extent of the barrier is determined by the **investor market structure**
       - The higher and more homogenous is the distribution of asset overhang across the investor population, the greater is the rationing against disruptive technologies

2. **Empirical application to climate change**

   *Financing the green tech transition: innovation and diffusion*

   **Motivation:** Large threats of tech disruption to the entire pool of investors, in particular banks

   - **Findings**
     - Negative green externalities and legacy positions at risk
     - Rationing of green projects driven by asset overhang
Theory
(here focus on collateral)

**Model** Holmstrom & Tirole (1997) extended

**Loan to firm 2?**

\[ P_H Z - I > 0 > P_L Z + B - I \]

**Lending decision**

- Incentive compatibility
  \[ Z_{1E} \geq B / (\Delta P) \]

- Individual rationality
  \[ Z_{1E} \geq A / P_H \]

**Project from firm 2 with cash**
- Investment \( I \)
- Return \( Z \)
- \( P_H \) if effort
- \( P_L \) if shirks with \( B \)
Model
Holmstrom & Tirole (1997) extended

(here focus on collateral)

Loan to firm 2?

\[ P_H Z - I > 0 > P_L Z + B - I \]

Lending decision

- Incentive compatibility
  \[ Z_{1E} \geq B/(\Delta P) \]

- Individual rationality
  \[ Z_{1E} \geq A/P_H \]

Externality on Firm 1

- Collateral value drop
  \[ \Delta C > 0 \]
Rationing

Monopoly investor

Investor profit from Firm 2

Investor

Firm 2

No spillover

$P_H (Z - B/\Delta P) - (I - A) \quad \begin{array}{c}
\hat{A} \\
\hat{A}
\end{array}

P_H Z - I

Rationing

$A$
Rationing

Investor profit from Firm 2

With technological spillover

Monopoly investor
Rationing

Monopoly investor

With technological spillover

Investor profit from Firm 2

complete rationing if $\Delta C$ is large enough

$P_H Z - I$

$P_H (Z - B/\Delta P) - (I - A)$

$\Delta C$

A

Rationing
Rationing

Competitive financial system
Homogenous asset overhang

Firm 2 profit
Rationing

Competitive financial system
Homogenous asset overhang

Investor individual rationality
Loss is taken by Firm 2 and investor is compensated

$P_H Z - I$

$\Delta C$
Rationing

Competitive financial system
Heterogenous asset overhang

Firm 2 profit

\[ P_H Z - I \]

\( \bar{A} \)

\( A \)
Rationing

Competitive financial system
Heterogenous asset overhang
Rationing

Competitive financial system
Heterogenous asset overhang

\[ P_H Z - I \]

\[ \Delta C_i \]

Proposition
Rationing if
\[ \min\{\Delta C_i\} > 0 \]

Weakest legacy positions
triggers lending from entire
financial system
Discussion

Model and extensions

- Nature of collateral, types of investments, information structure
- Alternative payoffs
  - Who absorbs shock? Shock on collateral only when project fails à la Stiglitz and Weiss (1981): effect dampened but qualitatively robust
- Probability of default $\rightarrow q(D-C)$ where $q = \Delta P_H$
  - Shock to Collateral and Probability of Default: reinforcement of the effect

Empirical predictions

- **Legacy effect**
  - An increase in exposures of the financial system to the negative externality should lead to more rationing

- **Market structure effect**
  - An decrease in the lowest exposures of the financial system to the negative externality should lead to less rationing
Empirical application

Green transition
(Belgium)
Step 1: which green activities affect peers and how?
Step 1: which green activities affect peers and how?
# Externalities

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Diffusion</th>
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<tbody>
<tr>
<td>Green Product</td>
<td>Green Provision</td>
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<td>Green Process</td>
<td>Green Adoption</td>
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# Externalities

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<thead>
<tr>
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<td>Technology space</td>
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<td><strong>Product space</strong></td>
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*Collateral?*
## Externalities

**Data sources**

<table>
<thead>
<tr>
<th>VAT transactions</th>
<th>Patents (PATSTAT)</th>
<th>Structural Business Survey</th>
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<tbody>
<tr>
<td><strong>Innovation</strong></td>
<td></td>
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<td><strong>Space</strong></td>
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</table>

Annual accounts, Credit registry, Bank balance-sheet
## Externalities

### Panel A: Innovation

<table>
<thead>
<tr>
<th></th>
<th>Firm performance</th>
<th>Tangible asset pledgeability</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>( \Delta \ln (\text{HH sales}_{it}) )</td>
<td>( \Delta \ln (\text{B2B sales}_{it}) )</td>
</tr>
<tr>
<td>( \Delta d(i, t)_{S=\text{product}} )</td>
<td>( -0.067^{***} )</td>
<td>( -0.022^{***} )</td>
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<tr>
<td></td>
<td>(0.005)</td>
<td>(0.003)</td>
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<tr>
<td>( \Delta d(i, t)_{S=\text{process}} )</td>
<td>( -0.021^{***} )</td>
<td>( -0.004^{*} )</td>
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<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>( \Delta d(i, t)_{S=\text{technology}} )</td>
<td>( 0.000 )</td>
<td>( 0.001 )</td>
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<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
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<td>(0.002)</td>
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<th>( Y )</th>
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<td>3 digit</td>
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<tr>
<td>Firm FE</td>
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<td>( Y )</td>
<td>( N )</td>
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<tr>
<td>Cluster-level</td>
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<td>Firm</td>
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<td># Observations</td>
<td>428180</td>
<td>526016</td>
<td>76397</td>
<td>33625</td>
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<tr>
<td>( Adj. R^2 )</td>
<td>0.159</td>
<td>0.101</td>
<td>0.024</td>
<td>0.129</td>
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</tbody>
</table>
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<td>Pledgeability</td>
<td>Ø</td>
<td>Ø</td>
</tr>
<tr>
<td>Technology space</td>
<td>Performance</td>
<td>Ø</td>
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<tr>
<td>Pledgeability</td>
<td>Ø</td>
<td>Pledgeability</td>
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<tr>
<td>Pledgeability</td>
<td>Ø</td>
<td>Pledgeability</td>
</tr>
</tbody>
</table>

$qR_B > 0$

$\Delta C > 0$
Step 2: What is the impact of asset overhang?
Step 2: What is the impact of asset overhang?
Asset overhang values

Firms impacted by green activity from firm $i$

$$\mathcal{I}_{it}^A$$

$\mathcal{A} = \{\text{Green}_i, \text{Innovator}_i, \text{Diffusor}_i\}$

Legacy of bank $b$ at risk from green firm $i$

$$\theta_{ibt}^A = \sum_{j \in \mathcal{I}_{it}^A} c_{jbt}$$

Share of credit by bank $b$ to firm $j$ at time $t$

Financial system at risk from green firm $i$

$$\theta_{it}^A = (\theta_{ibt}^A)$$
Extensive margin

\[
Borrower_{it} = \beta_1 \times A + \beta_2 \times Med(\theta_{it-1}^A) + \beta_3 \times Min(\theta_{it-1}^A) + \zeta' z_{it-1} + \varepsilon_{it}
\]

= 1 if firm \( i \) has credit at \( t \)

From the theory

- \( \beta_2 < 0 \)
  
  The larger the banking system’s asset overhang, the less likely a green firm gets a loan

- \( \beta_3 < 0 \)
  
  The lower the weakest asset overhang, the more likely a firm gets a loan
Results

Baseline
1. Legacy effect
↓ green firm with 1 s.d. negative impact on banks is credit rationed compared to an absence of overhang
   Innovators → 4.4 pp
   Diffusors → 1.0 pp

2. Market structure effect
↓ 1 s.d. drop in the lowest overhang increases bank credit to green firm
   Innovators → 5.3 pp
   Diffusors → 1.3 pp
   ↓ Legacy effect muted

Further analysis
● Decomposition by green activity, externality, maturity, firm size, etc.
● Breaking the barrier
● Intensive margin

\[ \text{Dependent variable: Borrower}_{it} \]

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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</thead>
<tbody>
<tr>
<td>Green_{it}</td>
<td>-3.162***</td>
<td>-3.082***</td>
<td>-1.135</td>
<td>-1.288</td>
</tr>
<tr>
<td></td>
<td>(0.337)</td>
<td>(0.351)</td>
<td>(2.022)</td>
<td>(1.086)</td>
</tr>
<tr>
<td>Green innovation_{it}</td>
<td>-3.300***</td>
<td>-3.231***</td>
<td>-1.397*</td>
<td>-11.314**</td>
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<tr>
<td></td>
<td>(0.337)</td>
<td>(0.221)</td>
<td>(0.863)</td>
<td>(5.453)</td>
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<tr>
<td>M ed(θ^A=Green)_{it=1}</td>
<td></td>
<td></td>
<td>-19.343**</td>
<td>-4.369</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(8.631)</td>
<td></td>
</tr>
<tr>
<td>M in(θ^A=Green innovation)_{it=1}</td>
<td>-1.394*</td>
<td>-5.292</td>
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<tr>
<td></td>
<td>(0.787)</td>
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<tr>
<td>M ed(θ^A=Green diffusion)_{it=1}</td>
<td></td>
<td></td>
<td>-3.086**</td>
<td>-1.006</td>
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<td></td>
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<td>(1.281)</td>
<td>(1.280)</td>
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</tbody>
</table>

A : Green
   Legacy effect
   Market structure effect

A : Green innovation
   Legacy effect
   Market structure effect

A : Green diffusion
   Legacy effect
   Market structure effect

Controls
Sector × Time FE
Location × Time FE
Cluster-level
# Observations
Adj. R^2

Y Y Y Y
4 digit 4 digit 4 digit 4 digit
Firm Firm Firm Firm
654689 654689 654689 654689
0.185 0.185 0.185 0.185

36
Policy discussion

Promote investors incentives to stimulate entry and diffusion of disruptive technology (e.g. green technology)

Policies

1. Alternative models
   ○ Entry of legacy free institutions ($\Delta C = 0$)
   ○ Develop alternative financing sources to disruptive projects (green)

2. Collateral policies
   ○ Promote tech insensitive collateral ($\Delta C = 0$)

3. Macroprudential tools
   ○ Brown legacy penalty ($\Delta M > \Delta C$)

4. Other applications
   ○ Niche technologies, developing economies, public monopoly

Market structure effect

Weakest exposure sets the rationing barrier for entire financial system

Entry/presence of a single legacy-free institution transforms aggregate provision of funding directed to disruptive technologies beyond individual capacity
Conclusion

- **Asset overhang theory**: legacy may induce investors to bar the financing of technological change (i.e., entry and development of disruptive technology)
  - Key role of market structure on asset overhang

- **In the context of climate finance and the green transition**
  - Empirical evidence shows that green activity adversely affects competing firms’ operations and asset pledgeability;
  - Empirical evidence shows that banks’ legacy positions and overhang distribution are important drivers of access to bank finance for green firms both at extensive and intensive margin.

- **Policies** accounting for discrepancies in legacy exposures to technological disruption may be key to aligning incentives and re-directing funding towards otherwise profitable innovative projects
Thank you!
Empirical strategy

Step 1: Measuring green externality

- **Green technological transition**
  - Green innovation
    - Process vs Product
  - Green diffusion
    - Adoption vs Provision
- **Economic spaces**
  - Product space
  - Technology space
- **Economic impact**
  - Firm performance
  - Collateral value

Goals
1. Evidence of negative spillovers
2. Identification of channels for impact on performance and collateral
3. Framework to quantify overhang (legacy risk)

Step 2: Impact of asset overhang on technology rationing

- Extensive margin
- Matching
- Intensive margin
Empirical strategy

Step 1: Measuring green externality

- **Green technological transition**
  - Green innovation
  - Green diffusion
- **Economic spaces**
  - Product space
  - Technology space
- **Economic impact**
  - Firm performance
  - Collateral value

Step 2: Impact of asset overhang on technology rationing

- Extensive margin
- Matching
- Intensive margin

**Data sources**

- Patents (PATSTAT)
- Structural Business Survey
- VAT transactions
- Annual accounts, Credit registry
- Bank balance sheets + Credit registry
Framework

- Green activity (Hall, 2004)
  - Innovation
    - Product
    - Process
  - Diffusion
    - Adoption
    - Provision

Figure 3: Incidence of various green activities by Belgian non-financial firms.
Framework

- Green activity (Hall, 2004)
- Economic spaces (Bloom, 2013)
  - Product space
    - Output closeness
  - Technology space
    - Input closeness
Framework

- Green activity (Hall, 2004)
- Economic spaces (Bloom, 2013)
- Green impact
  - Performance decline
    - \( \Delta \) HH sales
    - \( \Delta \) B2B sales
  - Asset pledgeability
    - Writedowns
    - Liquidation losses
Framework

- Green activity (Hall, 2004)
- Economic spaces (Bloom, 2013)
  - Product space
    - Output closeness
  - Technology space
    - Input closeness

EXAMPLE

Shipment service
# Externalities

<table>
<thead>
<tr>
<th>Space</th>
<th>Green Product</th>
<th>Green Process</th>
<th>qR_B &gt; 0</th>
<th>ΔC &gt; 0</th>
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<tr>
<td><strong>Product space</strong></td>
<td>Performance</td>
<td>Performance</td>
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<tr>
<td><strong>Technology space</strong></td>
<td>Performance</td>
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</table>

Same results for *diffusion*
Breaking the barrier

\[
Borrower_{ibt} = \alpha \times \theta_{ibt-1}^A + \beta \times \nu_t(b = \arg \min_b(\theta_{it-1}^A)) + \gamma \times \nu_t(b = \arg \max_b(\theta_{it-1}^A)) + \varepsilon_{ibt}
\]

Interpretation

- **\( \beta > 0 \)** suggests it is the bank with the lowest asset overhang that breaks the barrier

- **\( \gamma > 0 \)** suggests it is the bank with the largest asset overhang that breaks the barrier
# Breaking the barrier

## Table

<table>
<thead>
<tr>
<th>Dependent variable: Borrower_{ibt}</th>
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<th>(2)</th>
<th>(3)</th>
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<tbody>
<tr>
<td><strong>Estimation sample:</strong></td>
<td>Green_{ibt-1} = 1</td>
<td>Green innovation_{ibt-1} = 1</td>
<td>Green diffusion_{ibt-1} = 1</td>
</tr>
<tr>
<td>$\theta^A_{ibt-1}$</td>
<td>$-49.527^{***}$</td>
<td>$-380.730^{***}$</td>
<td>$-48.995^{***}$</td>
</tr>
<tr>
<td></td>
<td>(15.079)</td>
<td>(131.150)</td>
<td>(14.955)</td>
</tr>
<tr>
<td>$t_t(b = \arg\min_b(\theta^A_{ibt-1} = \text{Green}))$</td>
<td>8.362***</td>
<td>21.675**</td>
<td>8.272***</td>
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<tr>
<td></td>
<td>(1.126)</td>
<td>(10.637)</td>
<td>(1.071)</td>
</tr>
<tr>
<td>$t_t(b = \arg\max_b(\theta^A_{ibt-1} = \text{Green}))$</td>
<td>-7.114***</td>
<td>9.438</td>
<td>-6.969***</td>
</tr>
<tr>
<td></td>
<td>(1.610)</td>
<td>(6.763)</td>
<td>(1.555)</td>
</tr>
</tbody>
</table>

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Bank with lowest asset overhang is more likely to break the barrier.
Decrease in the lowest asset overhang are associated with more credit expansion towards green firms.

\[
\Delta \ln(Credit_{ibt}) = \alpha \times \Delta \theta_{ibt-1}^{A=\text{Green}} + \beta \times \Delta \text{Min}(\theta_{ibt-1}^{A=\text{Green}}) + \gamma_{ibt} + \gamma_{yt} + \varepsilon_{ibt}
\]

| \(\Delta \theta_{ibt-1}^{A=\text{Green}}\) | 2.724 |  \(\text{(1.816)}\) |  \(\text{(3.213)}\) |
| \(\Delta \text{Min}(\theta_{ibt-1}^{A=\text{Green}})\) | -5.303* |  \(\text{(10.120)}\) |  \(\text{(28.004)*} \) |
| \(\Delta \theta_{ibt-1}^{A=\text{Green innovation}}\) | -7.989 |  \(\text{(10.120)}\) |  \(\text{(17.181)}\) |
| \(\Delta \text{Min}(\theta_{ibt-1}^{A=\text{Green innovation}})\) | -28.004* |  \(\text{(17.181)}\) |  \(\text{(3.247)}\) |

**: A : Green, Δ : Market structure effect**

| Controls | Bank x Time FE | \(\checkmark\) | \(\checkmark\) | \(\checkmark\) |
| Location | Region x Sect. x Size x Time FE | \(\checkmark\) | \(\checkmark\) | \(\checkmark\) |
| Sector | Digits | Digits | Digits | Digits |
| Cluster | Region | Region | Region | Region |
| # Observations | \(108,235\) | \(978\) | \(978\) | \(978\) |
| Adj. \(R^2\) | 0.0317 | 0.0319 | 0.0319 | 0.0319 |