Asset Overhang
&
Technological Change

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Technological change is not always in an investor's best interest

Technological change is not always in an investor's best interest

Investor

Firm 1

Collateral

Technological change is not always in an investor's best interest
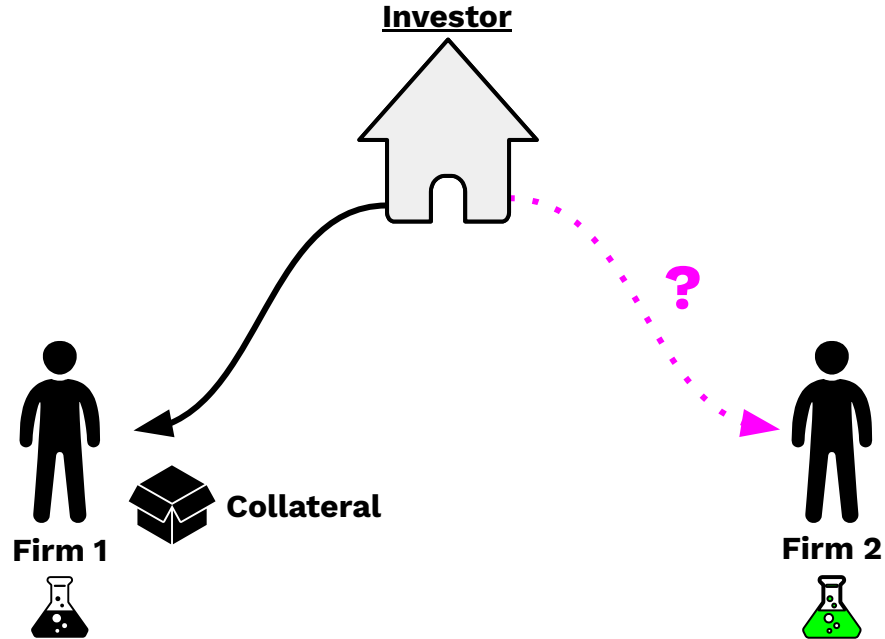

Investor

Firm 1

Collateral

Firm 2

4

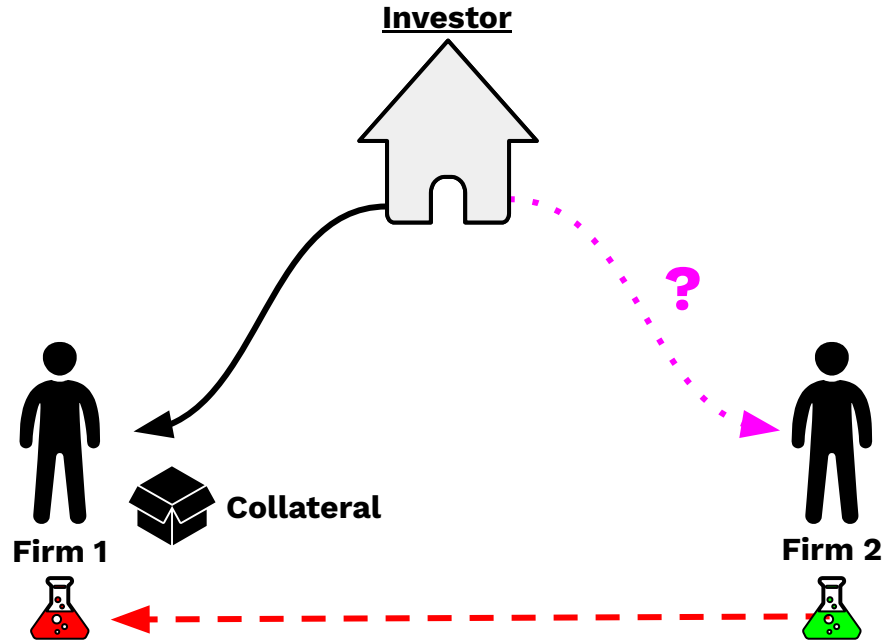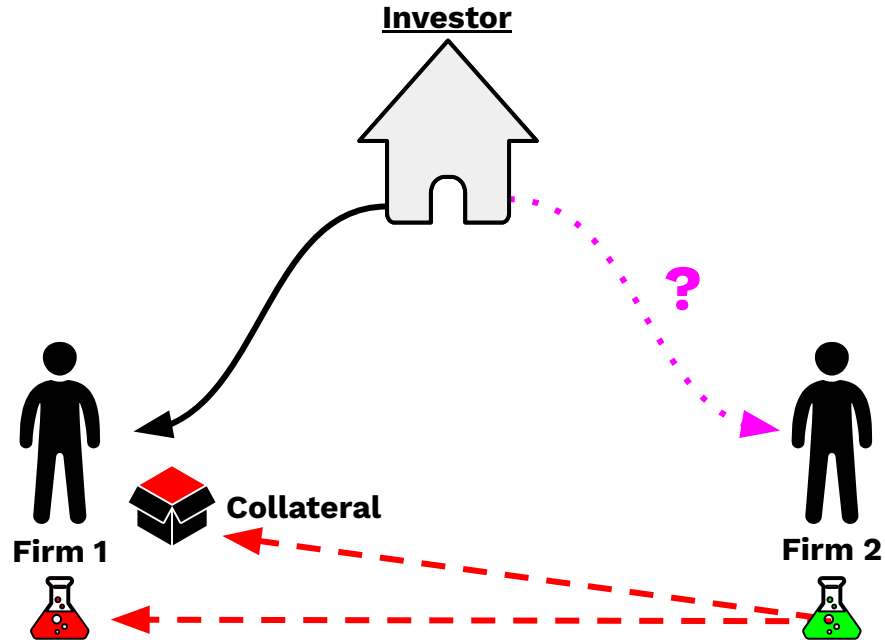# Technological change is not always in an investor's best interest

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Technological change is not always in an investor's best interest

Investor

?

Firm 1

Collateral

Firm 2

6

Technological change is not always in an investor's best interest

Investor

Asset overhang

Collateral

Firm 1

Firm 2

*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

Investor

*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*

Asset overhang

Collateral

Firm 1

Firm 2

Technological change

8

This paper

Investor

*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*

Asset overhang

Firm 1

Collateral

?

Firm 2

Technological change

9

Preview

1. <u>Theory</u>

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. <u>Empirical application to climate change</u>

Financing the green tech transition: <u>innovation</u> and <u>diffusion</u>

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

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Theory

Model

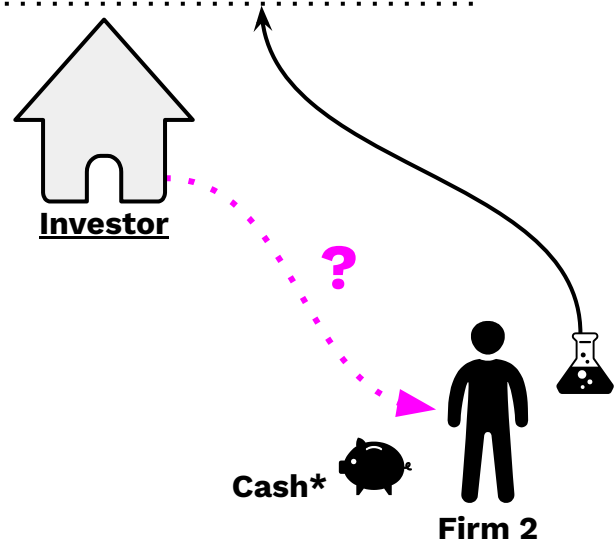Holmstrom & Tirole (1997) **extended**

(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
$$Z_{1E} \geq A/P_H$$

Project from firm 2 with cash **A**
- Investment **I**
- Return **Z**
- P_H if effort
- P_L if shirks with **B**

Investor

?

Cash*

Firm 2

12

Model <small>Holmstrom & Tirole (1997) **extended**</small>

Project from firm 2 with cash **A**
- Investment **I**
- Return **Z**
- P_H if effort
- P_L if shirks with **B**

(here focus on **collateral**)

Loan to firm 2?
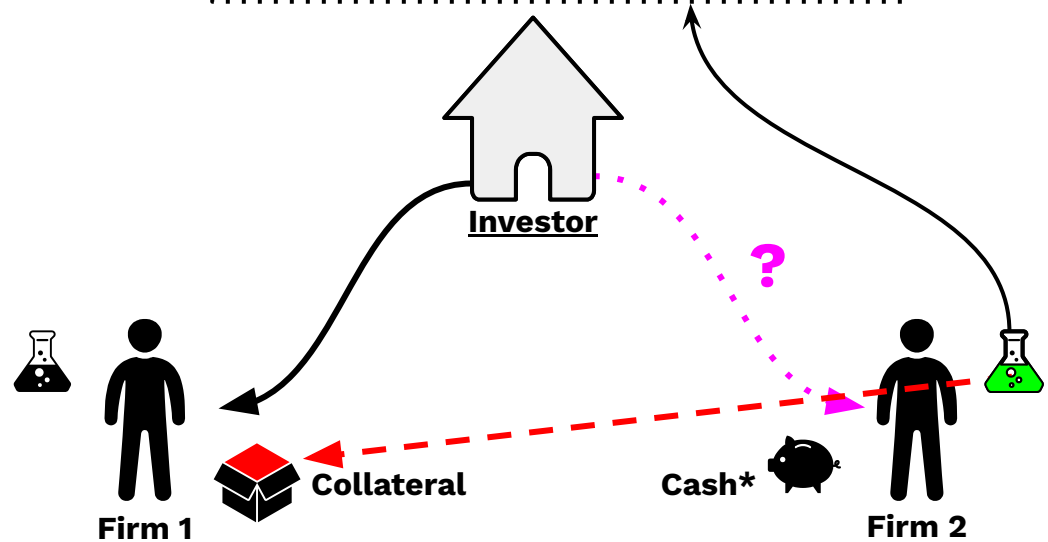
$$P_H Z - I > 0 > P_L Z + B - I$$

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**
$$\Delta C > 0$$

Investor

?

Collateral

Cash*

Firm 1

Firm 2

Rationing

Monopoly investor

No spillover

Investor profit from Firm 2

$$P_H Z - I$$

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

$\bar{A}$

$\hat{A}$

A

Rationing

Rationing

Monopoly investor

With technological spillover

Investor profit from Firm 2

$P_H Z - I$

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

ΔC

$\bar{A}$ $\bar{A}$ $\hat{A}$

A

Rationing

15
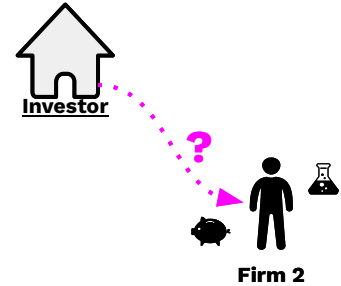
Rationing

Monopoly investor

Investor
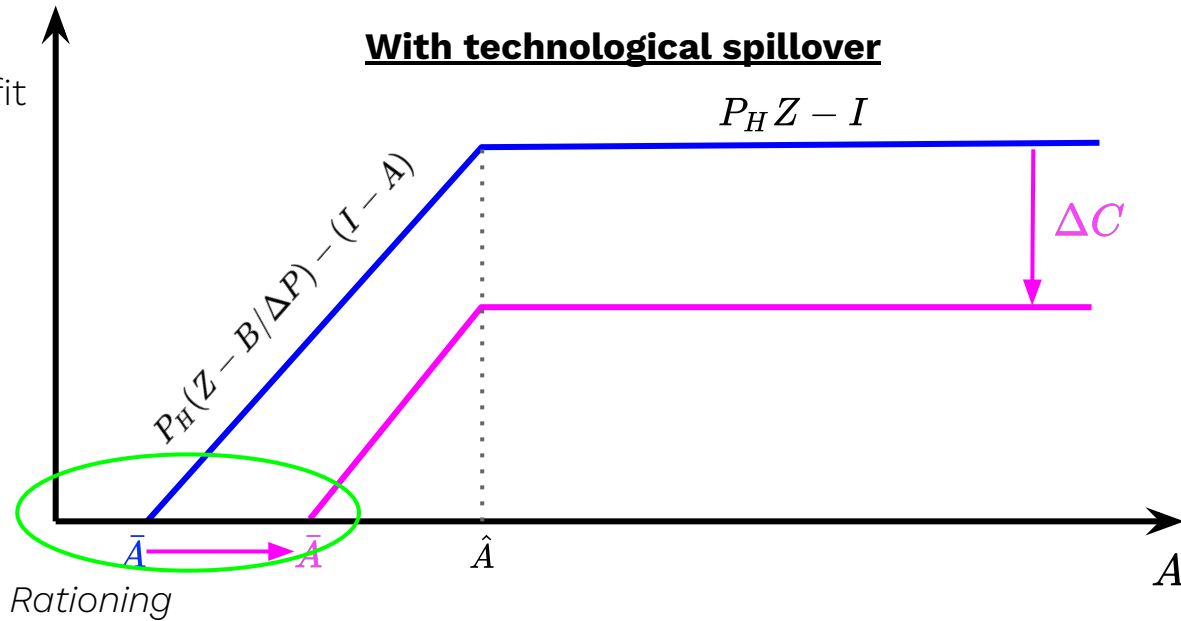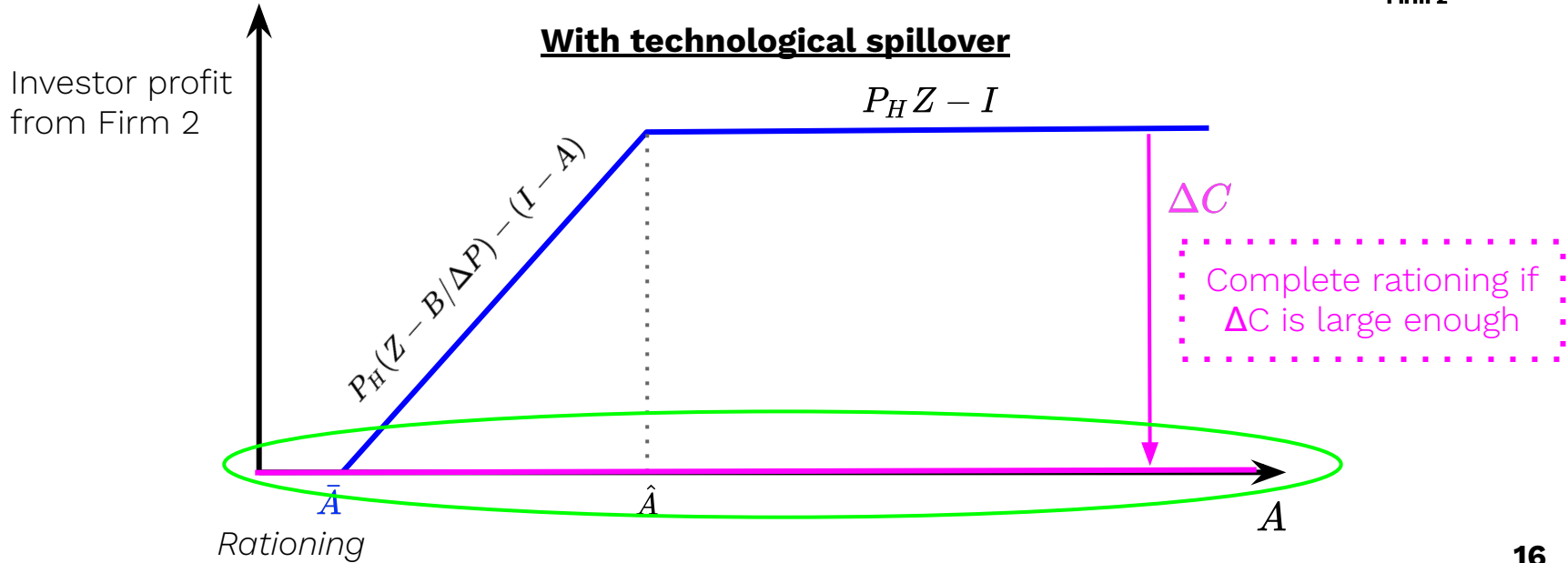
Firm 2

With technological spillover

$P_H Z - I$

Investor profit
from Firm 2

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

ΔC

Complete rationing if
ΔC is large enough

$\bar{A}$

$\hat{A}$

A

Rationing

Rationing

Competitive financial system
Homogenous asset overhang

Firm 2 profit

A

Rationing

Competitive financial system
Homogenous asset overhang

Financial System

Firm 2

Firm 2 profit

$P_H Z - I$

ΔC
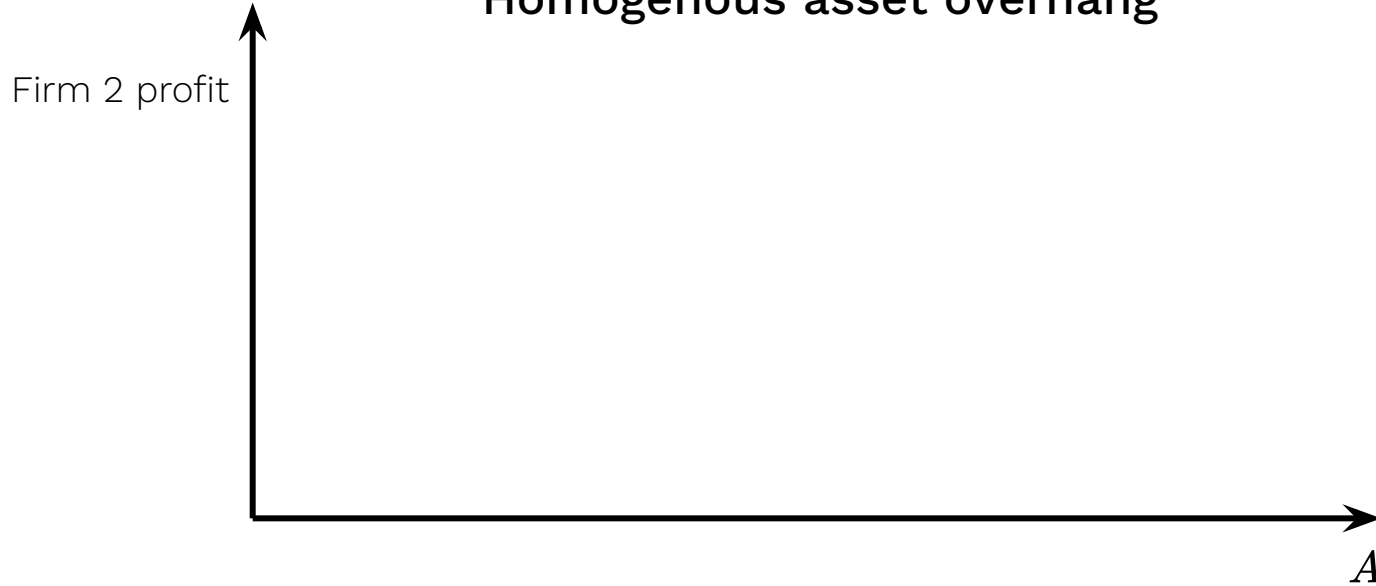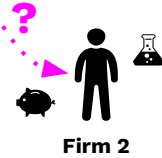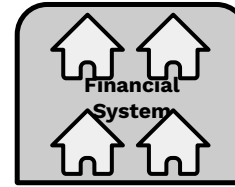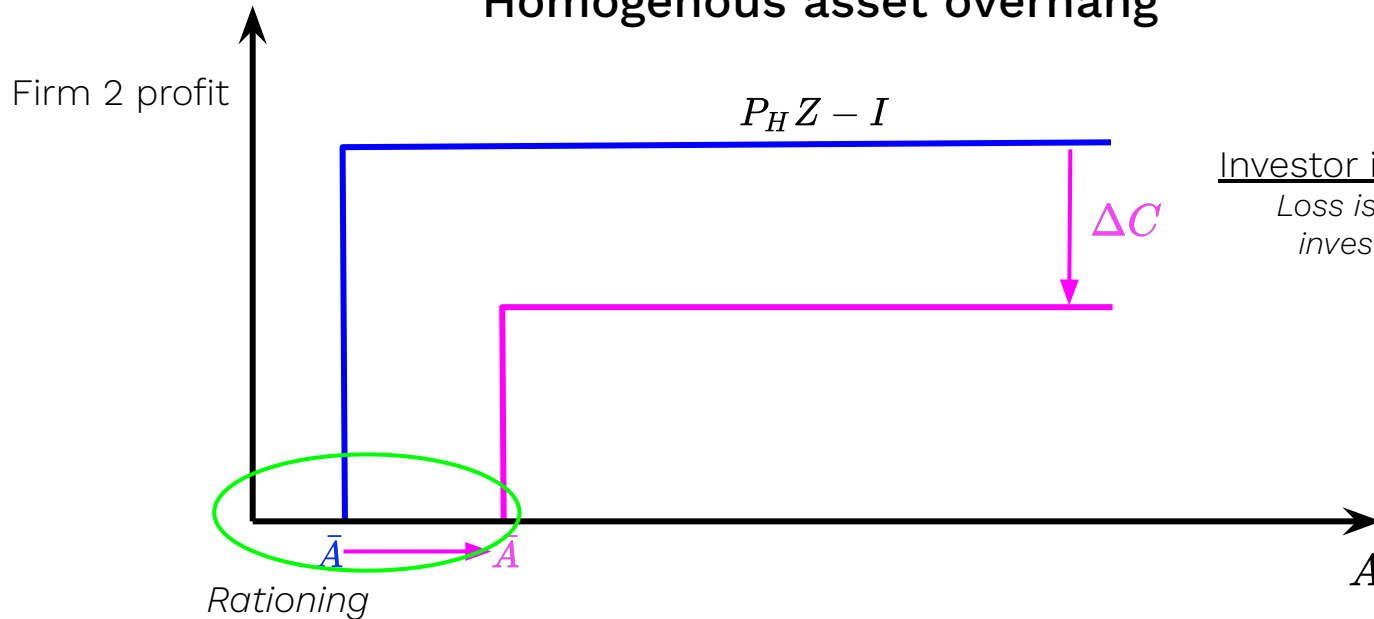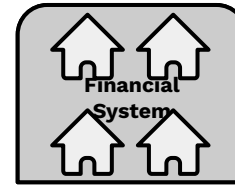
<u>Investor individual rationality</u>
*Loss is taken by Firm 2 and
investor is compensated*
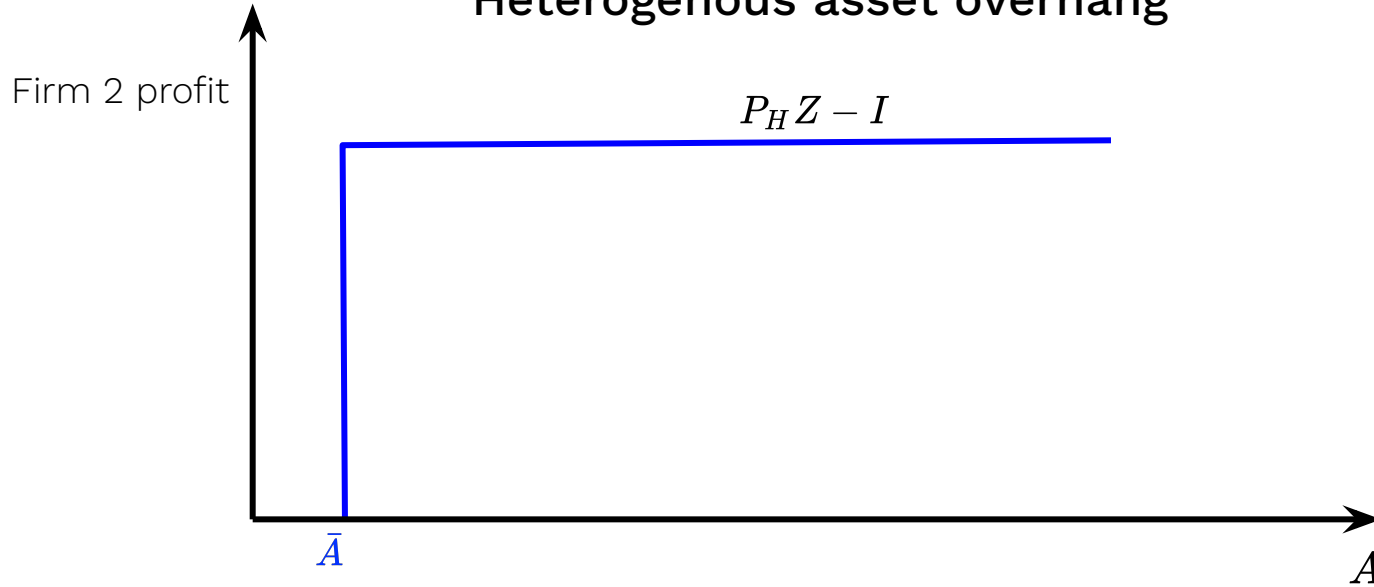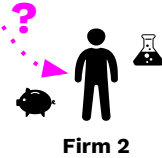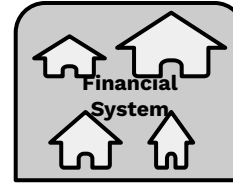
$\bar{A}$ $\bar{A}$

A

Rationing

Rationing

Competitive financial system
Heterogenous asset overhang

Firm 2 profit

$P_H Z - I$

$\bar{A}$

A

Rationing

Competitive financial system
Heterogenous asset overhang

Firm 2 profit

$P_H Z - I$

ΔC_i

$\bar{A}$

$\bar{A}_i$

A
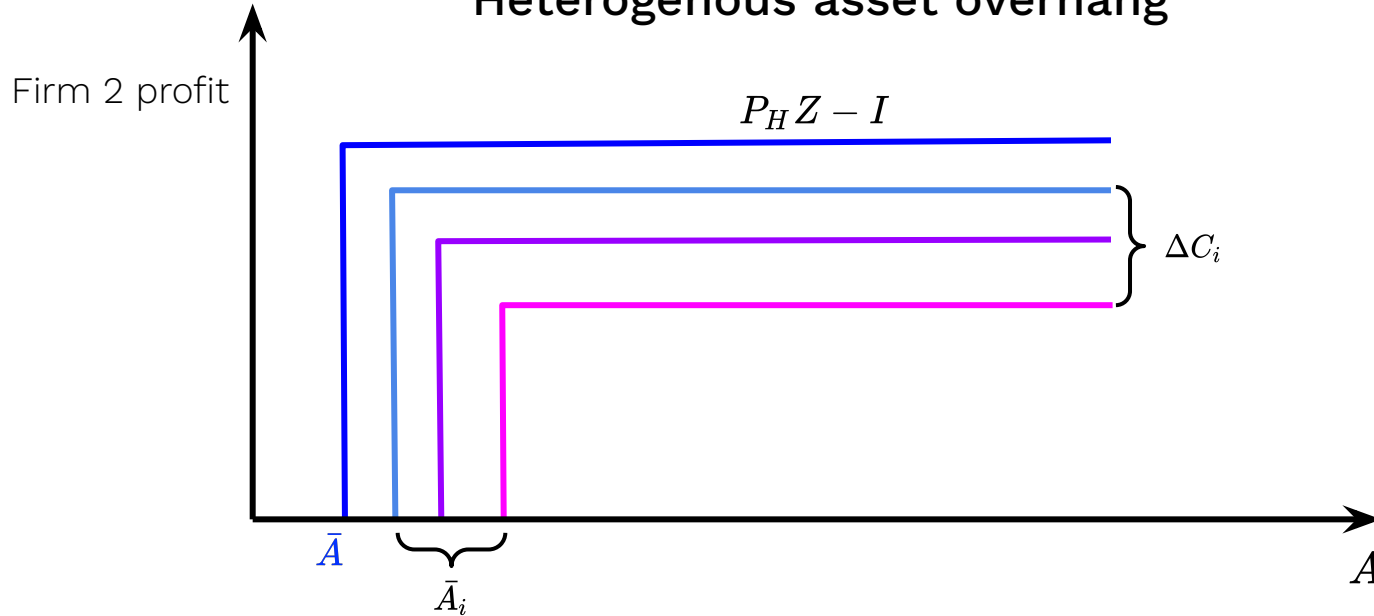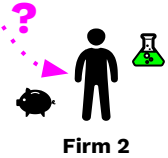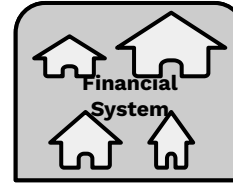
Rationing

Competitive financial system
Heterogenous asset overhang
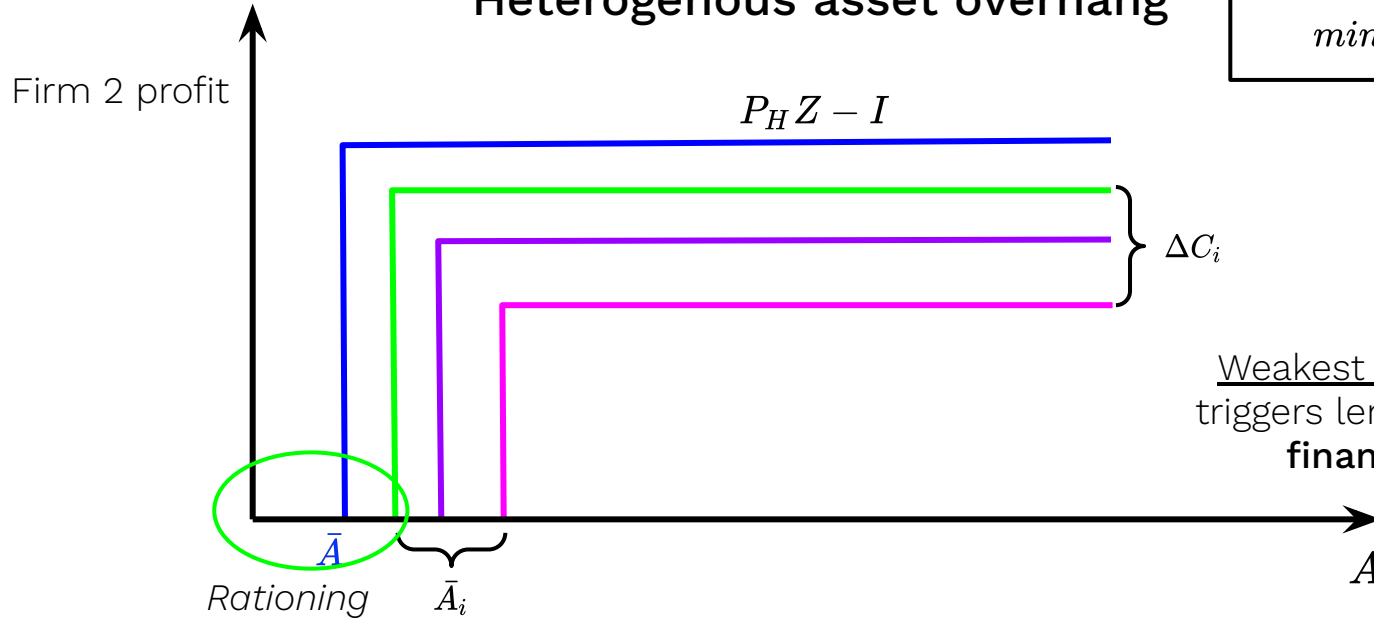
Proposition
Rationing if
$$min\{\Delta C_i\} > 0$$

Firm 2 profit

$P_H Z - I$

ΔC_i

$\bar{A}$

Rationing

$\bar{A}_i$

A

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 → $q(D-C)$ 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?

Green firm

Firm j

Collateral

Performance

Firm j'

No spillover

Firm j''
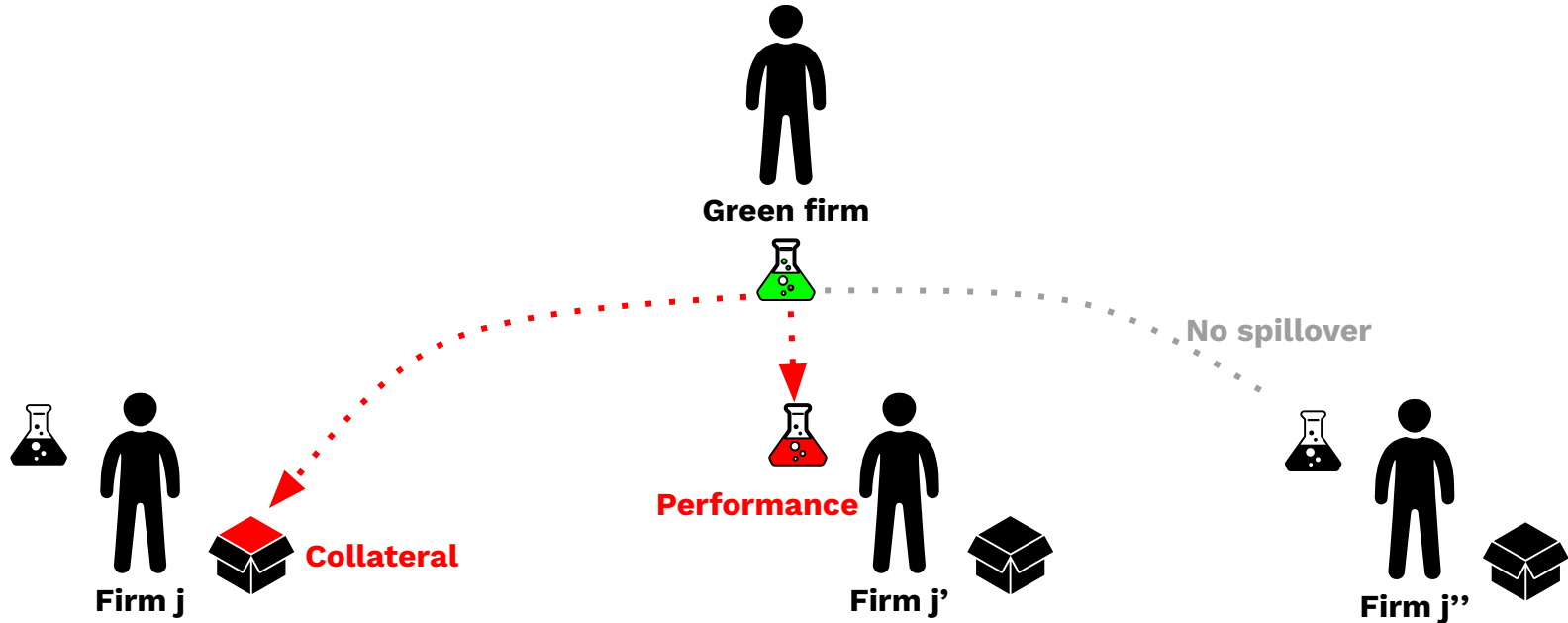
Externalities

Innovation		Diffusion	
Green Product	**Green Process**	**Green Provision**	**Green Adoption**

Externalities

Space	Innovation		Diffusion	
	Green Product	Green Process	Green Provision	Green Adoption
Product space				
Technology space				

Externalities

Space	Innovation				Diffusion			
	Green Product		**Green Process**		**Green Provision**		**Green Adoption**	
Product space	Performance	?	Performance	?	Performance	?	Performance	?
	Collateral	?	Collateral	?	Collateral	?	Collateral	?
Technology space	Performance	?	Performance	?	Performance	?	Performance	?
	Collateral	?	Collateral	?	Collateral	?	Collateral	?

Externalities **Data sources**

Space	Innovation				Diffusion			
	Green Product		**Green Process**		**Green Provision**		**Green Adoption**	
Product space	Performance	?	Performance	?	Performance	?	Performance	?
	Collateral	?	Collateral	?	Collateral	?	Collateral	?
Technology space	Performance	?	Performance	?	Performance	?	Performance	?
	Collateral	?	Collateral	?	Collateral	?	Collateral	?

Patents (PATSTAT)

Structural Business Survey

VAT transactions

Annual accounts, Credit registry, Bank balance-sheet

Externalities

	Firm performance		Tangible asset pledgeability	
	$\Delta \ln (\text{HH sales}_{it})$	$\Delta \ln (\text{B2B sales}_{it})$	Writedowns$_{it}$	Liquidation loss$_{it}$
	(1)	(2)	(3)	(4)
$\overline{\Delta d(i,t)}^{\mathcal{A}=\text{product innovation}}_{\mathcal{S}=\text{product space}}$	−0.067*** (0.005)	−0.022*** (0.003)	−0.029 (0.168)	0.722 (2.372)
$\overline{\Delta d(i,t)}^{\mathcal{A}=\text{process innovation}}_{\mathcal{S}=\text{product space}}$	−0.021*** (0.003)	−0.004* (0.002)	−0.077 (0.137)	−0.677 (1.580)
$\overline{\Delta d(i,t)}^{\mathcal{A}=\text{product innovation}}_{\mathcal{S}=\text{technology space}}$	0.000 (0.003)	0.001 (0.002)	0.000 (0.029)	−0.314 (0.180)
$\overline{\Delta d(i,t)}^{\mathcal{A}=\text{process innovation}}_{\mathcal{S}=\text{technology space}}$	0.003 (0.003)	−0.002 (0.002)	0.208** (0.092)	0.352* (0.180)
Controls	Y	Y	Y	Y
Sector × Time FE	4 digit	4 digit	3 digit	3 digit
Location × Time FE	Y	Y	Y	Y
Firm FE	Y	Y	N	N
Cluster-level	Firm	Firm	Firm	Firm
# Observations	428180	526016	76397	33625
$Adj.\ R^2$	0.159	0.101	0.024	0.129

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Externalities

Space	Innovation				Diffusion				
	Green Product		**Green Process**		**Green Provision**		**Green Adoption**		
Product space	Performance	↓	Performance	↓	Performance	↓	Performance	↓	$qR_B > 0$
	Pledgeability	∅	Pledgeability	∅	Pledgeability	∅	Pledgeability	∅	
Technology space	Performance	∅	Performance	∅	Performance	∅	Performance	∅	
	Pledgeability	∅	Pledgeability	↓	Pledgeability	∅	Pledgeability	↓	$\Delta C > 0$

Step 2: What is the impact of asset overhang?

Step 2: What is the impact of asset overhang?

Green firm

Financial System

(banks)

?

?

No spillover

Performance

Collateral
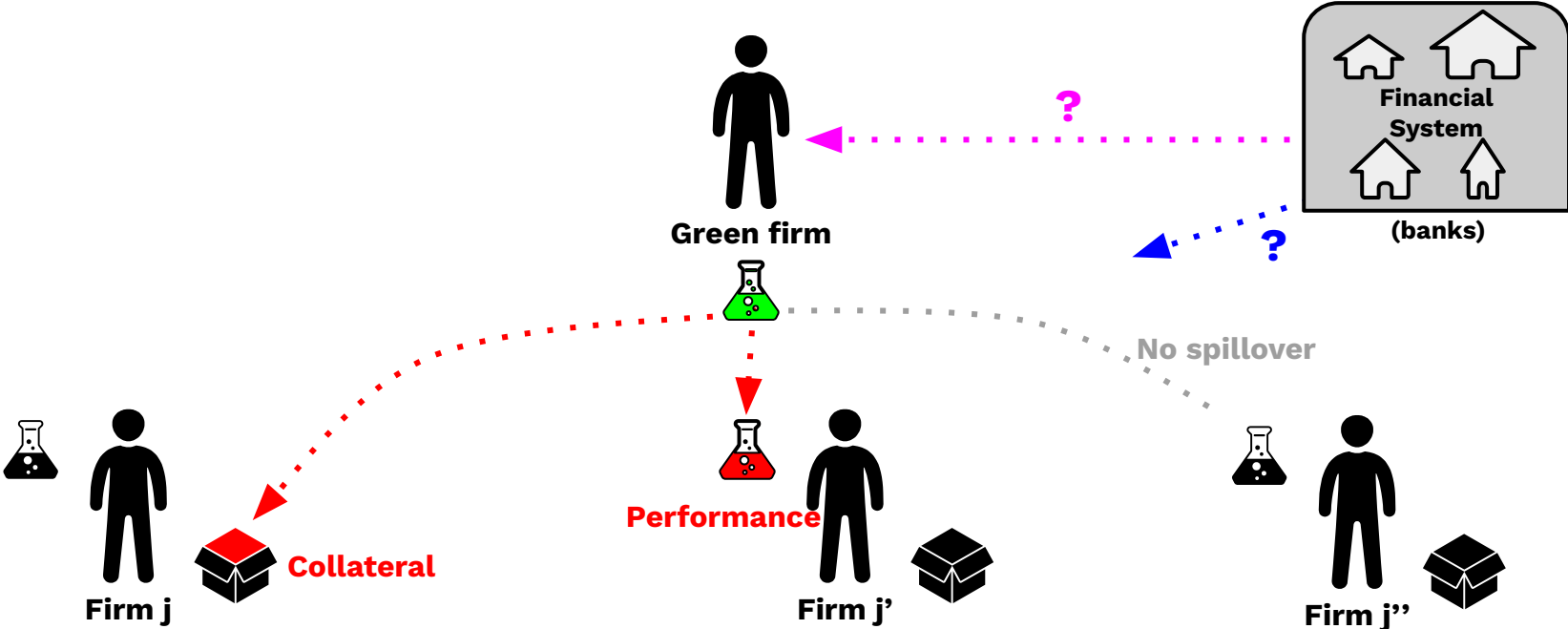
Firm j

Firm j'

Firm j''

Asset overhang values

Firms impacted by green activity from firm *i*

$$\mathcal{I}_{it}^{\mathcal{A}} \cdots\cdots\cdots\cdots\cdots \mathcal{A} = \{Green_i, Innovator_i, Diffusor_i\}$$

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

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

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

Financial system at risk from green firm *i*

$$\boldsymbol{\theta}_{it}^{\mathcal{A}} = (\theta_{ibt}^{\mathcal{A}})$$

Extensive margin

$$Borrower_{it} = \beta_1 \times \mathcal{A} + \beta_2 \times Med(\boldsymbol{\theta}^{\mathcal{A}}_{it-1}) + \beta_3 \times Min(\boldsymbol{\theta}^{\mathcal{A}}_{it-1}) + \boldsymbol{\zeta}' \boldsymbol{z}_{it-1} + \varepsilon_{it}$$

Legacy effect

Market structure effect

= 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

	Dependent variable: Borrower$_{it}$			
	(1)	(2)	(3)	(4)
Green$_i$	−3.162***	−3.082***		
	(0.337)	(0.351)		
Green innovation$_i$			−1.135	−1.288
			(2.022)	(1.086)
Green diffusion$_i$			−3.300***	−3.231***
			(0.337)	(0.221)
$Med(\boldsymbol{\theta}_{it-1}^{A=\text{Green}})$		−1.397*		
		(0.863)		
$Min(\boldsymbol{\theta}_{it-1}^{A=\text{Green}})$		−3.179**		
		(1.428)		
$Med(\boldsymbol{\theta}_{it-1}^{A=\text{Green innovation}})$				−11.314**
				(5.453)
$Min(\boldsymbol{\theta}_{it-1}^{A=\text{Green innovation}})$				−19.343**
				(8.631)
$Med(\boldsymbol{\theta}_{it-1}^{A=\text{Green diffusion}})$				−1.394*
				(0.787)
$Min(\boldsymbol{\theta}_{it-1}^{A=\text{Green diffusion}})$				−3.086**
				(1.281)
$\mathcal{A}$: Green				
Legacy effect		−1.008		
Market structure effect		−1.318		
$\mathcal{A}$: Green innovation				
Legacy effect				−4.369
Market structure effect				−5.292
$\mathcal{A}$: Green diffusion				
Legacy effect				−1.006
Market structure effect				−1.280
Controls	Y	Y	Y	Y
Sector × Time FE	4 digit	4 digit	4 digit	4 digit
Location × Time FE	Y	Y	Y	Y
Cluster-level	Firm	Firm	Firm	Firm
# Observations	654689	654689	654689	654689
Adj. R^2	0.185	0.185	0.185	0.185

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 (ΔC = 0)
   - Develop alternative financing sources to disruptive projects (green)
2. **Collateral policies**
   - Promote tech insensitive collateral (ΔC = 0)
3. **Macroprudential tools**
   - Brown legacy penalty (ΔM > ΔC)
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

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Framework

- Green activity (Hall, 2004)
  - Innovation
    - Product
    - Process
  - Diffusion
    - Adoption
    - Provision
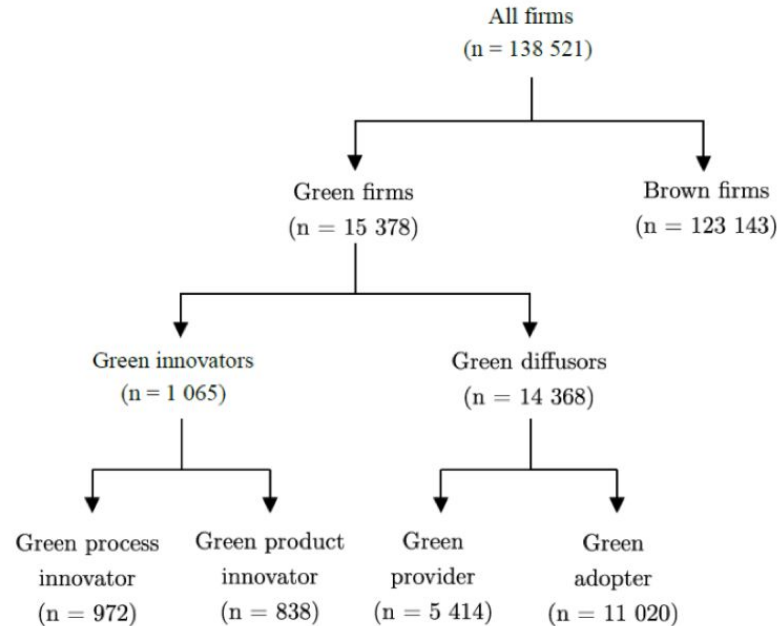
Figure 3: Incidence of various green activities by Belgian non-financial firms.

Framework

- Green activity (Hall, 2004)

- Economic spaces (Bloom, 2013)
  - Product space
    - Output closeness
  - Technology space
    - Input closeness

Technology Space

Firm 1

Firm 2

Firm 3

Product Space

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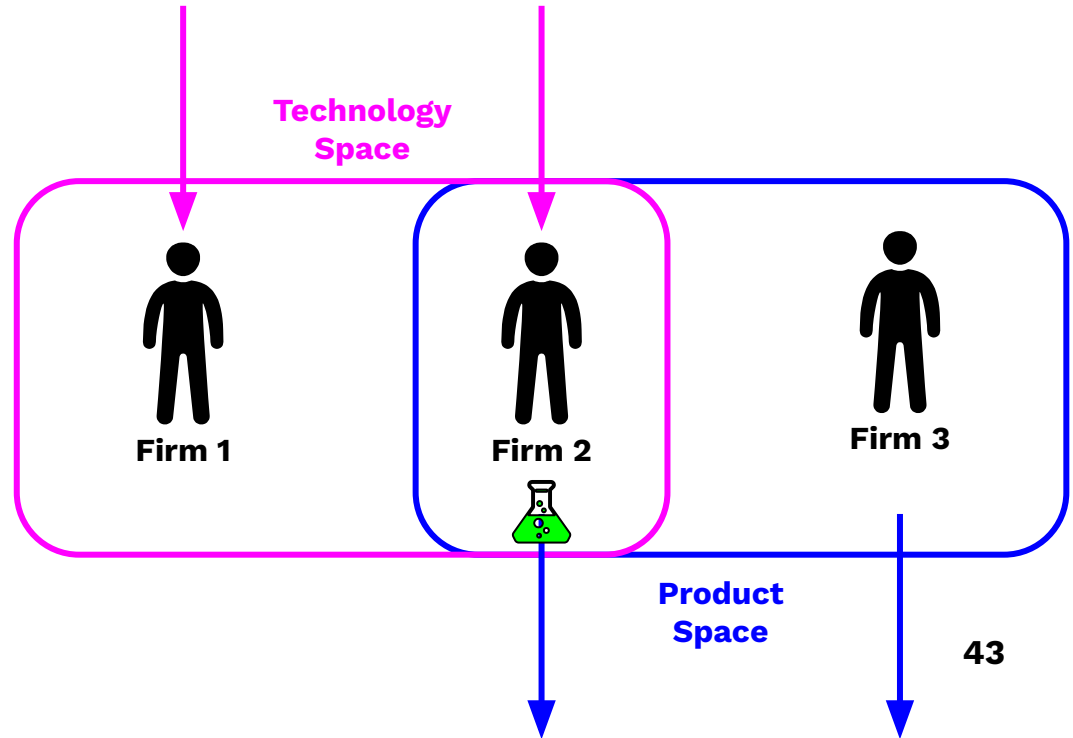
Framework

- Green activity (Hall, 2004)

- Economic spaces (Bloom, 2013)

- Green impact
  - Performance decline
    - Δ HH sales
    - Δ 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

Airplanes

Inputs   Inputs

Maersk   DHL Aviation   Brussels Airlines

Product space
DHL Aviation

Technology space
DHL Aviation

Shipment service   Outputs   Outputs

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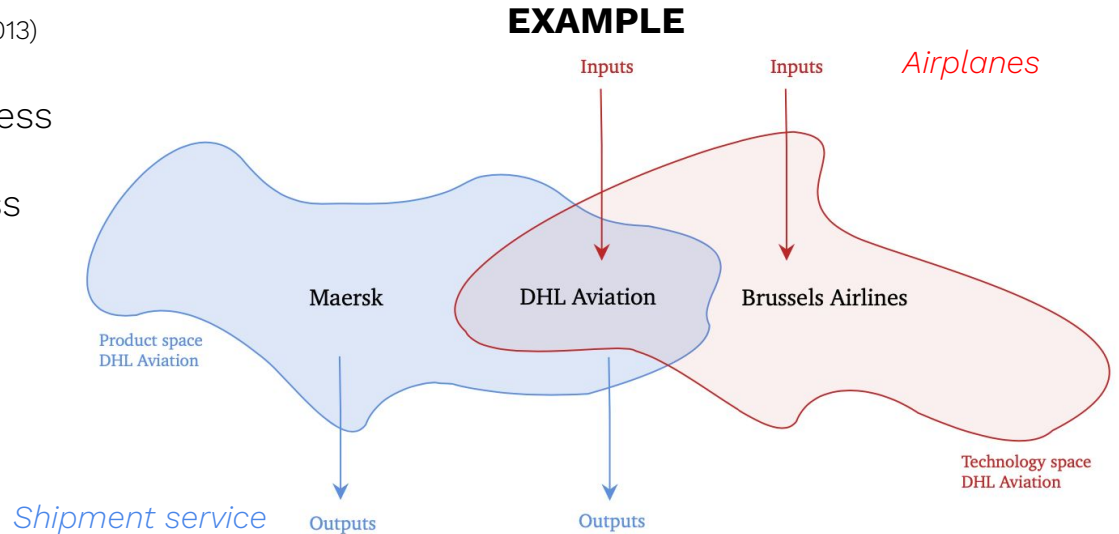
Externalities

	Innovation			
Space	**Green Product**		**Green Process**	
Product space	Performance	↓	Performance	↓ $qR_B > 0$
	Pledgeability	∅	Pledgeability	∅
Technology space	Performance	∅	Performance	∅
	Pledgeability	∅	Pledgeability	↓ $\Delta C > 0$

*Same results for **diffusion***

Breaking the barrier

$$Borrower_{ibt} = \alpha \times \theta^{\mathcal{A}}_{ibt-1} + \beta \times \iota_t(b = \arg\min_b(\boldsymbol{\theta}^{\mathcal{A}}_{it-1})) + \gamma \times \iota_t(b = \arg\max_b(\boldsymbol{\theta}^{\mathcal{A}}_{it-1})) + \varepsilon_{ibt}$$

= 1 if firm i has credit from bank b at t

= 1 if bank b has the lowest overhang at t-1

= 1 if bank b has the largest overhang at t-1

Interpretation

- **β > 0** suggests it is the bank with the lowest asset overhang that breaks the barrier

- **γ > 0** suggests it is the bank with the largest asset overhang that breaks the barrier

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Breaking the barrier

Bank with lowest
asset overhang
is more likely
to break the barrier

	Dependent variable: Borrower$_{ibt}$		
	(1)	(2)	(3)
Estimation sample:	Green$_i = 1$	Green innovation$_i = 1$	Green diffusion$_i = 1$
$\theta_{ibt-1}^{\mathcal{A}=\text{Green}}$	-49.527^{***}		
	(15.079)		
$\iota_t(b = \arg\min_b(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green}}))$	8.362^{***}		
	(1.126)		
$\iota_t(b = \arg\max_b(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green}}))$	-7.114^{***}		
	(1.610)		
$\theta_{ibt-1}^{\mathcal{A}=\text{Green innovation}}$		-380.730^{***}	
		(131.150)	
$\iota_t(b = \arg\min_b(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green innovation}}))$		21.675^{**}	
		(10.637)	
$\iota_t(b = \arg\max_b(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green innovation}}))$		9.438	
		(6.763)	
$\theta_{ibt-1}^{\mathcal{A}=\text{Green diffusion}}$			-48.995^{***}
			(14.955)
$\iota_t(b = \arg\min_b(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green diffusion}}))$			8.272^{***}
			(1.071)
$\iota_t(b = \arg\max_b(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green diffusion}}))$			-6.969^{***}
			(1.555)
Sector × Time FE	Y	Y	Y
Location × Time FE	4-digit	1-digit	4-digit
Cluster	Y	Y	Y
# Observations	6960	175	6825
Adj. R^2	0.105	0.339	0.102

Intensive margin

$$\Delta ln(Credit_{ibt}) = \alpha \times \Delta\theta_{ibt-1}^{\mathcal{A}=\text{Green}} + \beta \times \underline{\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green}})} + \gamma_{bt} + \gamma_{gt} + \varepsilon_{ibt}$$

Decrease in the lowest asset overhang are associated with more credit expansion towards green firms.

	Dependent variable: $\Delta \ln(\text{Credit}_{ibt})$		
	(1)	(2)	(3)
Estimation sample:	$\text{Green}_i = 1$	$\text{Green innovation}_i = 1$	$\text{Green diffusion}_i = 1$
$\Delta\theta_{ibt-1}^{\mathcal{A}=\text{Green}}$	2.724		
	(1.816)		
$\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green}})$	−5.302*		
	(3.213)		
$\Delta\theta_{ibt-1}^{\mathcal{A}=\text{Green innovation}}$		−7.989	
		(10.129)	
$\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green innovation}})$		−28.004*	
		(17.181)	
$\Delta\theta_{ibt-1}^{\mathcal{A}=\text{Green diffusion}}$			2.957
			(1.839)
$\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green diffusion}})$			−5.894*
			(3.247)
$\mathcal{A}$: Green			
Δ Market structure effect	-0.045		
$\mathcal{A}$: Innovator			
Δ Market structure effect		-0.111	
$\mathcal{A}$: Diffusor			
Δ Market structure effect			-0.050
Controls	Y	Y	Y
Bank × Time FE	Y	Y	Y
Loc. ×Sect. × Size × Time FE	Y	Y	Y
Location	Region	Region	Region
Assets	Decile	Decile	Decile
Sector	3 digits	2 digits	3 digits
Cluster	Bank	Bank	Bank
# Observations	108235	978	107618
Adj. R^2	0.037	0.029	0.037

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