Asset Overhang and Technological Change

(previous title: Banking barriers to the green economy)

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

- "In 2015 *"Montauk Credit Union"* was placed under conservatorship… it had one third of its loan book to taxicab operators that had been struggling to reimburse their credit lines since the entry of *Uber"*

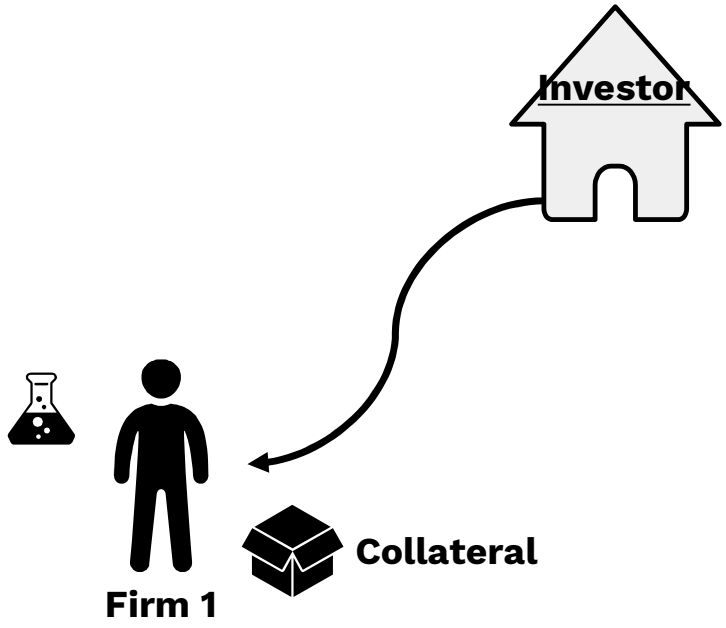
- Financiers may face **"asset overhang"**: a financier's reduced incentive to fund a firm's profitable innovation due to negative externalities imposed on that financier's legacy positions

Research questions

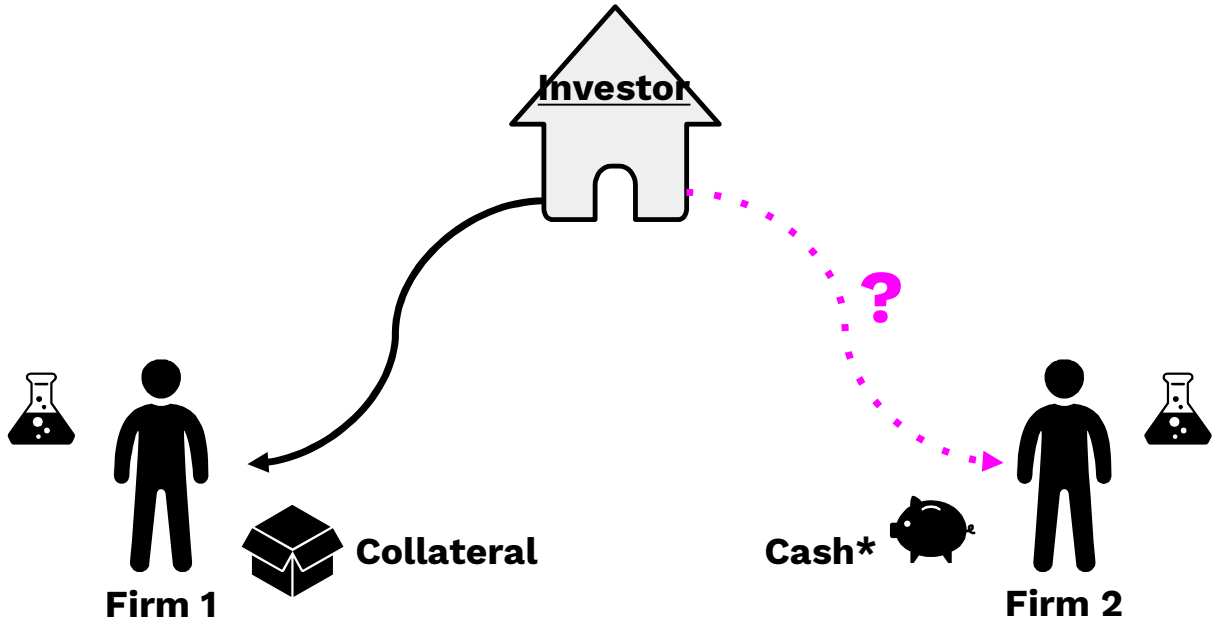
- Does investors' "asset overhang" hamper the financing of technological change?
  - What is role of "heterogeneity in asset overhang across the population of investors" (market structure)?

- Empirical application: financing of climate change technology
  - Interesting case as it combines (i) large threats of disruptive environmental innovation *and* (ii) strong exposures across the population of investors toward brown industries (ECB, 2019)

Intuition



Intuition



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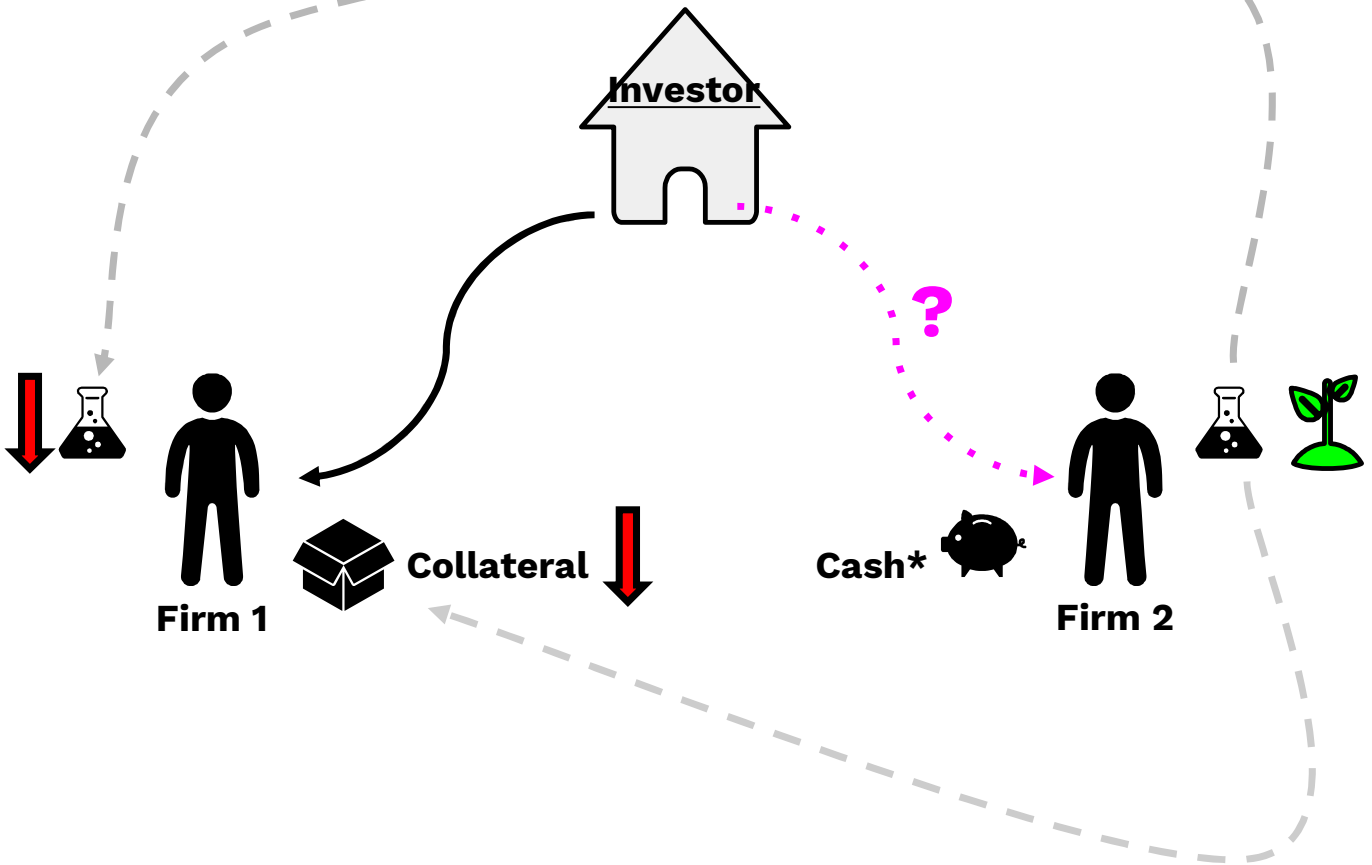


Preview of findings

1. Theory: “asset overhang” hinders financing (and thus entry) of technological innovations
   - Individually: investors internalise the cost on their portfolio and demand compensation which increases rationing of new projects
   - Collectively: “market structure of asset overhang faced by population of investors” determines the extent of the barriers

   ⇒ greater rationing of technological change when intermediary system’s asset overhang is high and homogeneous across investor population

2. Empirical application to climate change:
   1. Evidence on green externalities and legacy positions at risk
      - Green innovation and diffusion negatively impacts brown firms’ performance and collateral
      - Banks’ perspective reflects these in PD and collateral valuation
   2. Empirical analysis on credit rationing of green projects
      - Extensive margin:
        - Green innovators are 5p.p. more likely to be rationed when banking system has a common average asset overhang; effect largely muted when some banks have no asset overhang
        - Bank with lowest asset overhang 13 p.p. more likely to “break the barrier”
      - Intensive margin: changes in the “lowest asset overhang” drives credit availability

1. Theory

Model

Holmstrom & Tirole (1997) **extended**

Project from firm 2 with cash **A**
- Investment **I**
- Return **Z**
- $\mathbf{P_H}$ if effort
- $\mathbf{P_L}$ if shirks with **B**

(here focus on **collateral**)

Loan to firm 2?

$$P_H Z - I > 0 > P_L Z + B - I$$

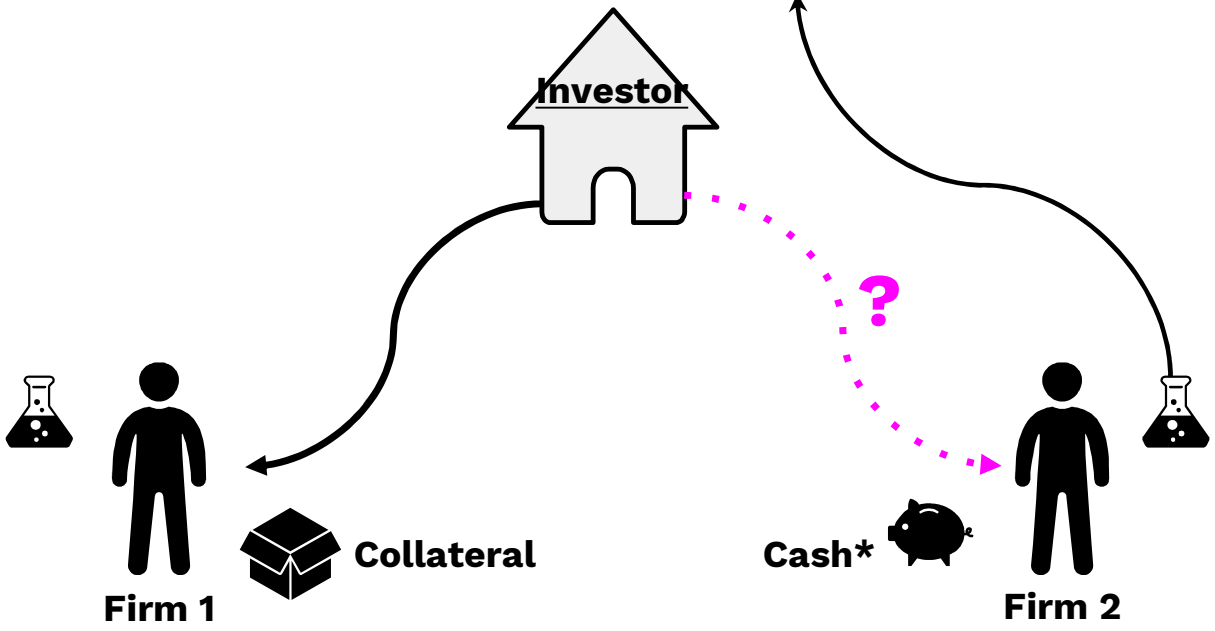
Lending decision

- Incentive compatibility

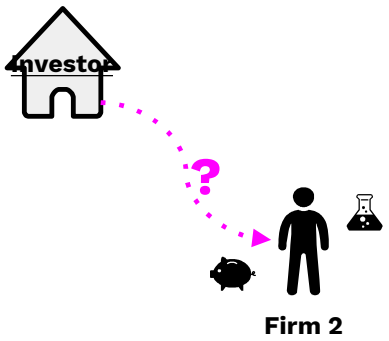
$$Z_E \geq B/(\Delta P)$$

- Individual rationality

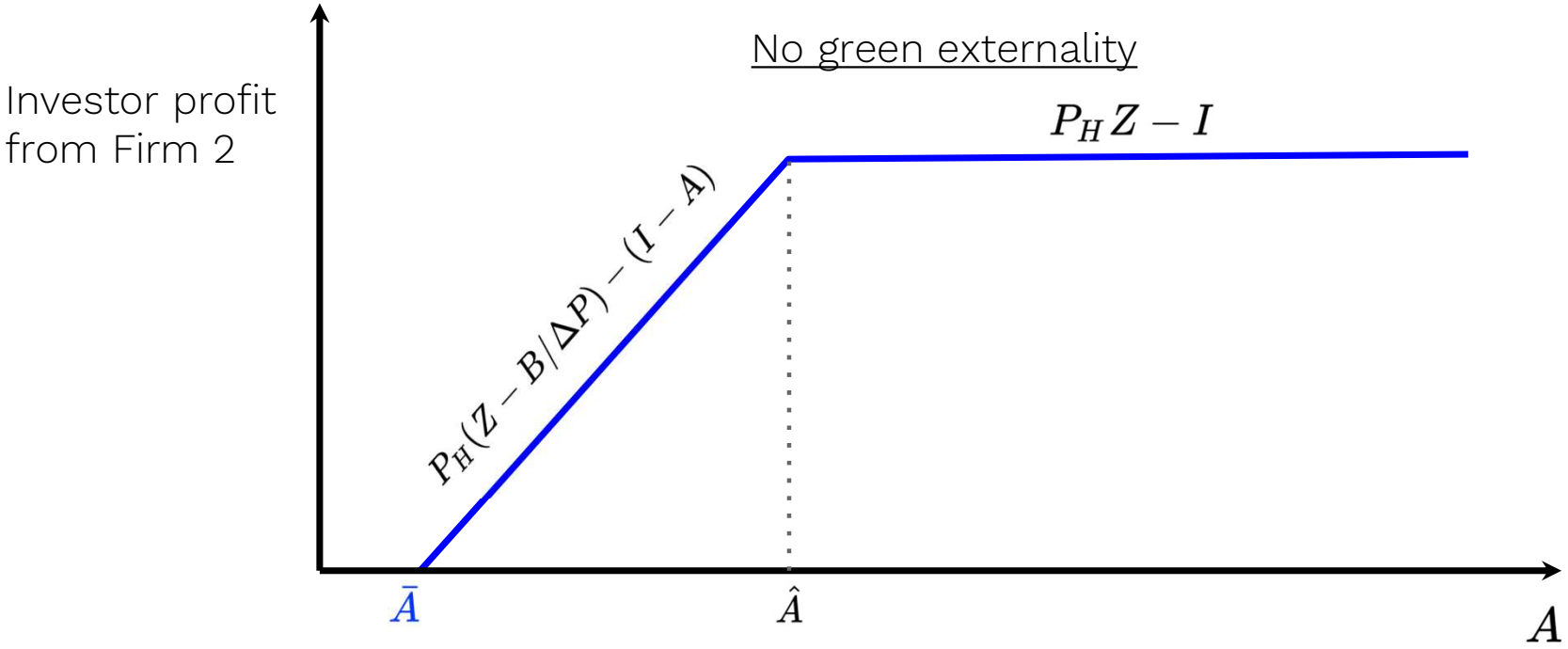
$$Z_E \geq A/P_H$$



Rationing



Monopoly Investor



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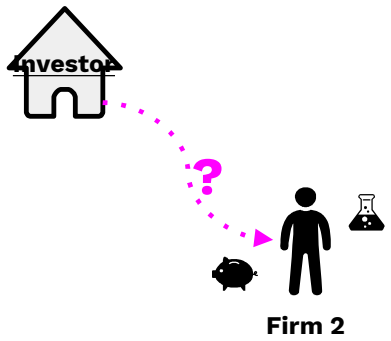

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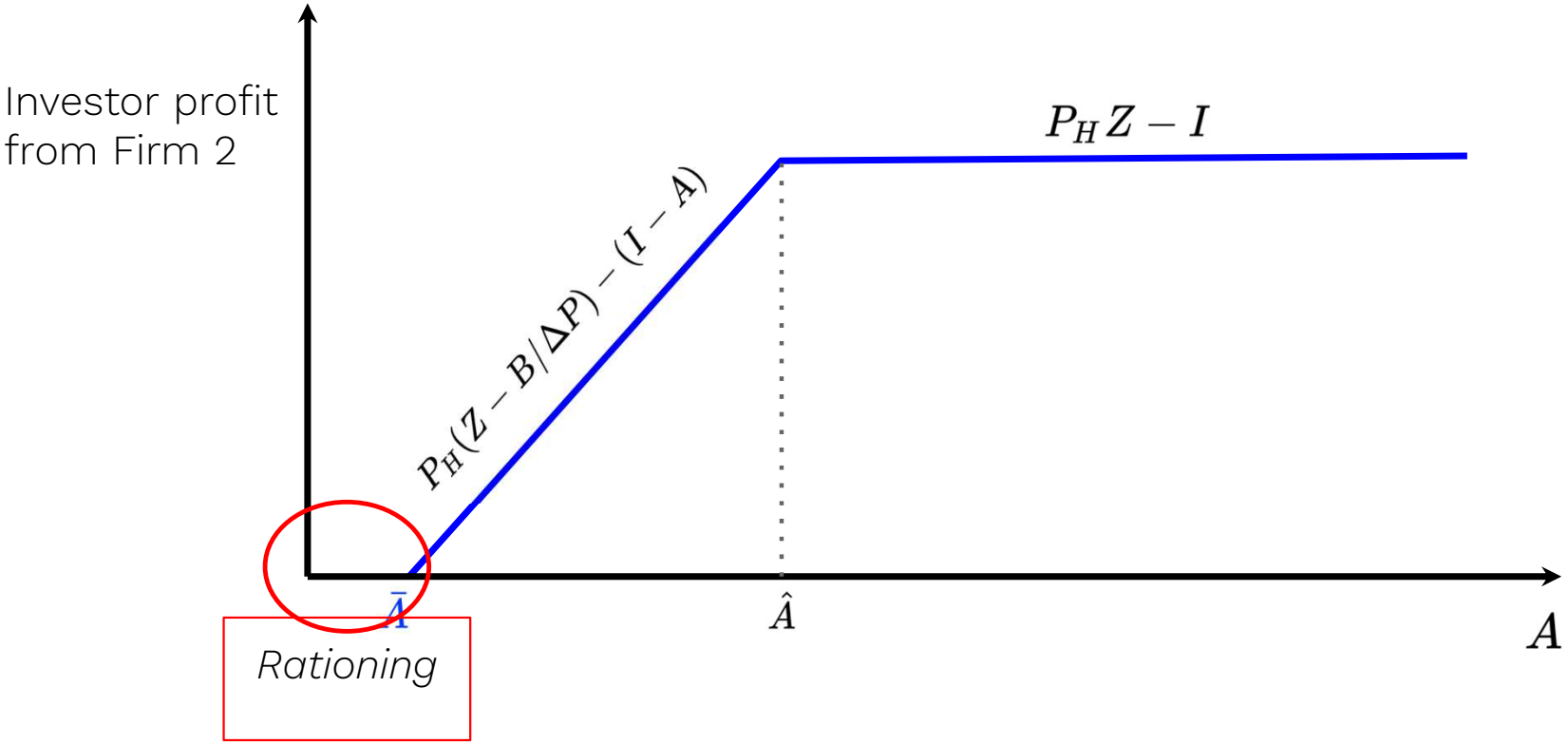

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Lending decision

- Incentive compatibility

$$Z_E \geq B/(\Delta P)$$

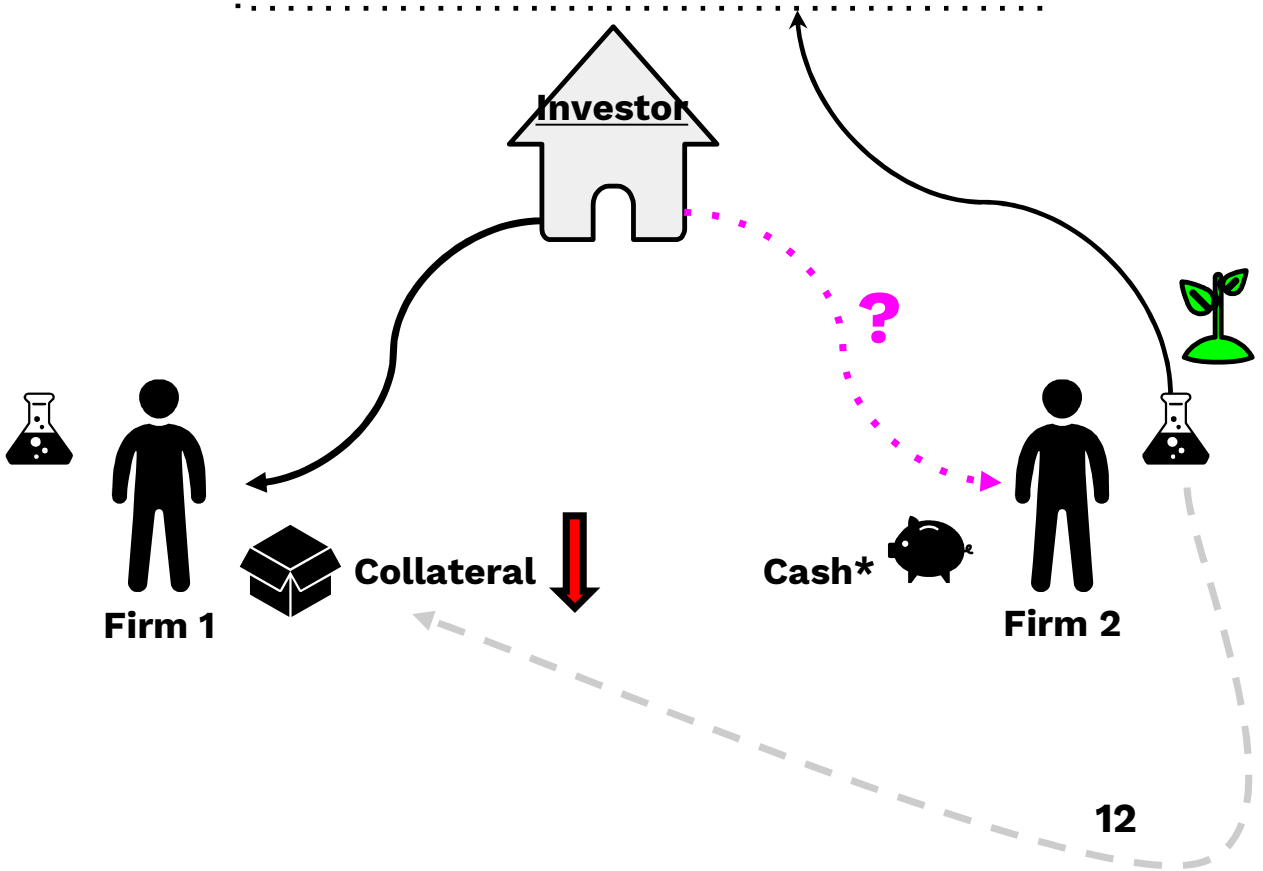
- Individual rationality

$$Z_E \geq A/P_H$$

Externality on Firm 1

- Collateral value drop

$$\Delta C > 0$$



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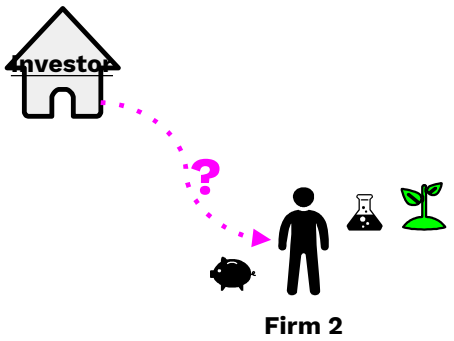

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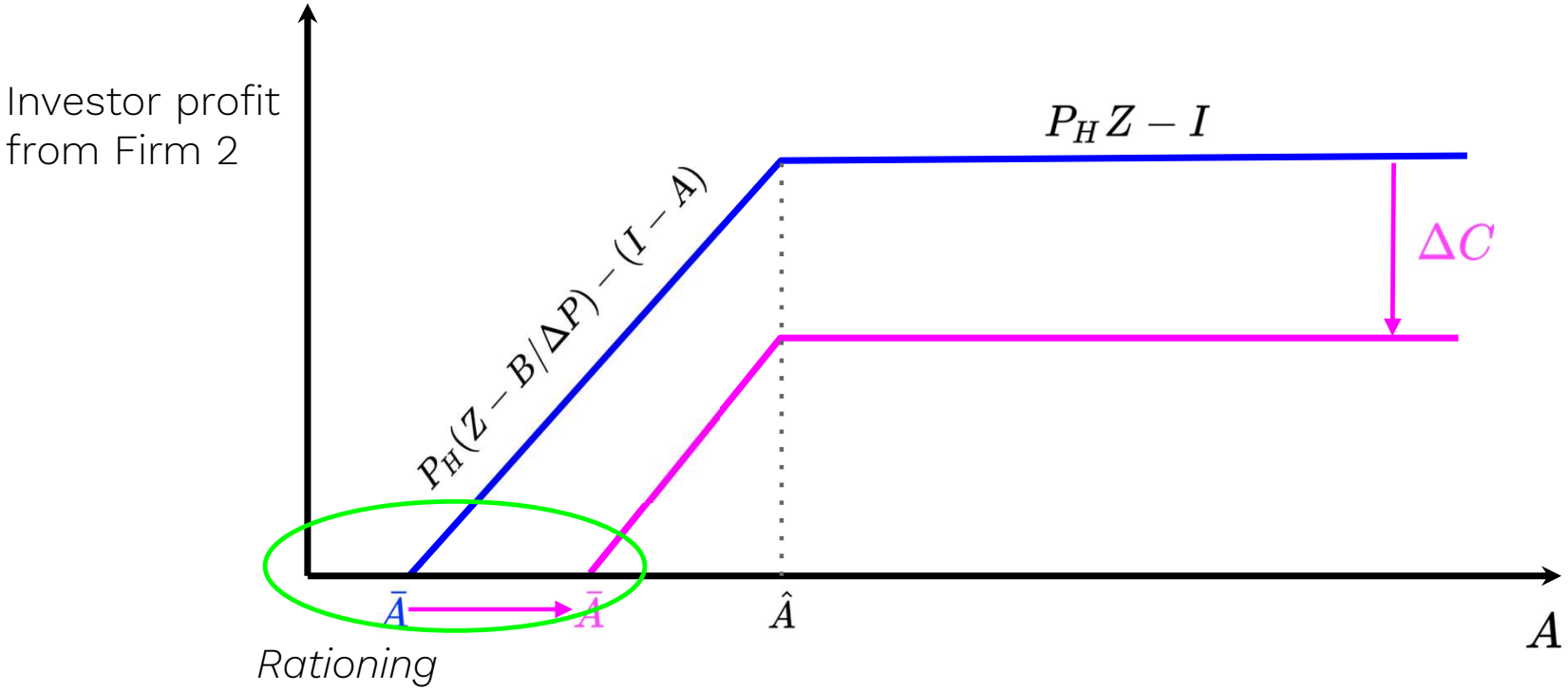
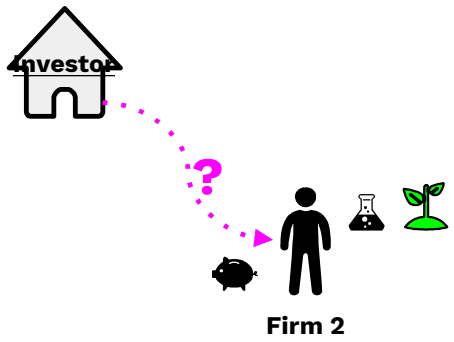


Complete rationing if ΔC is large



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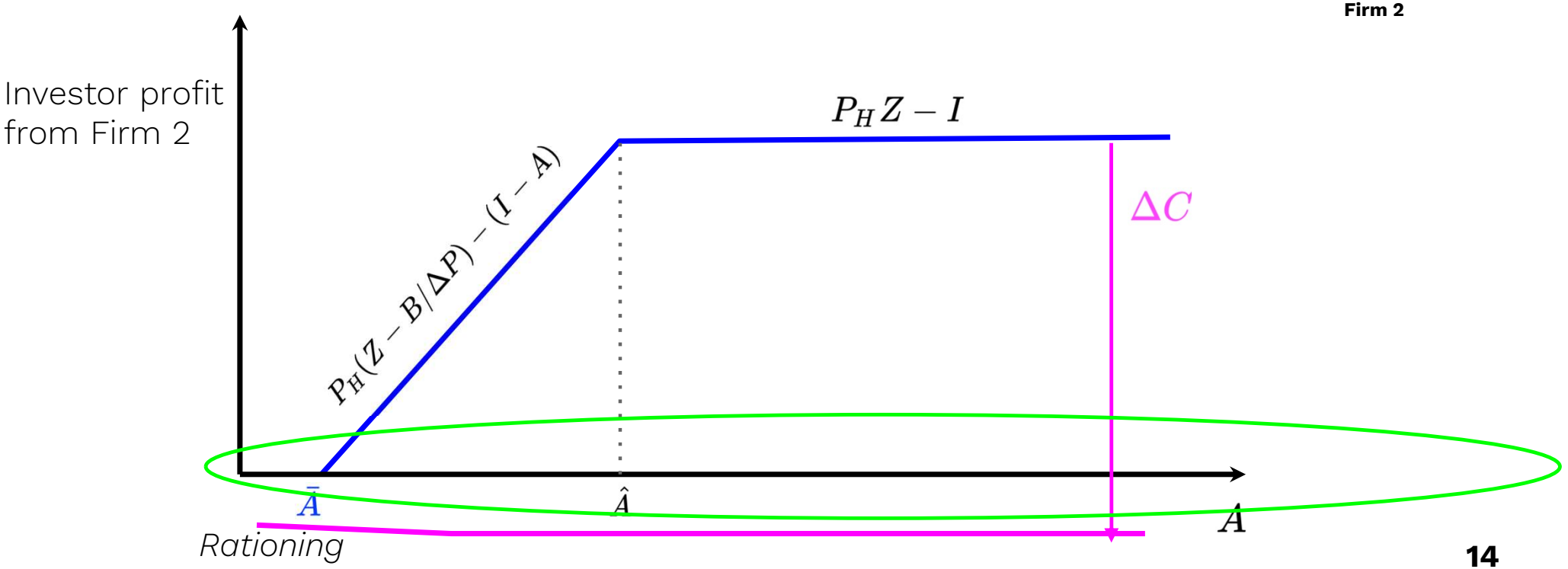

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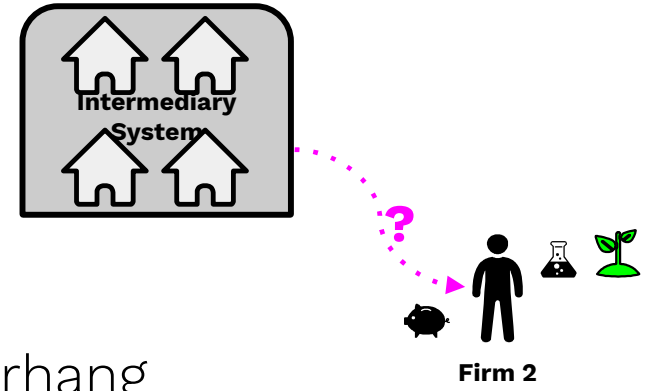
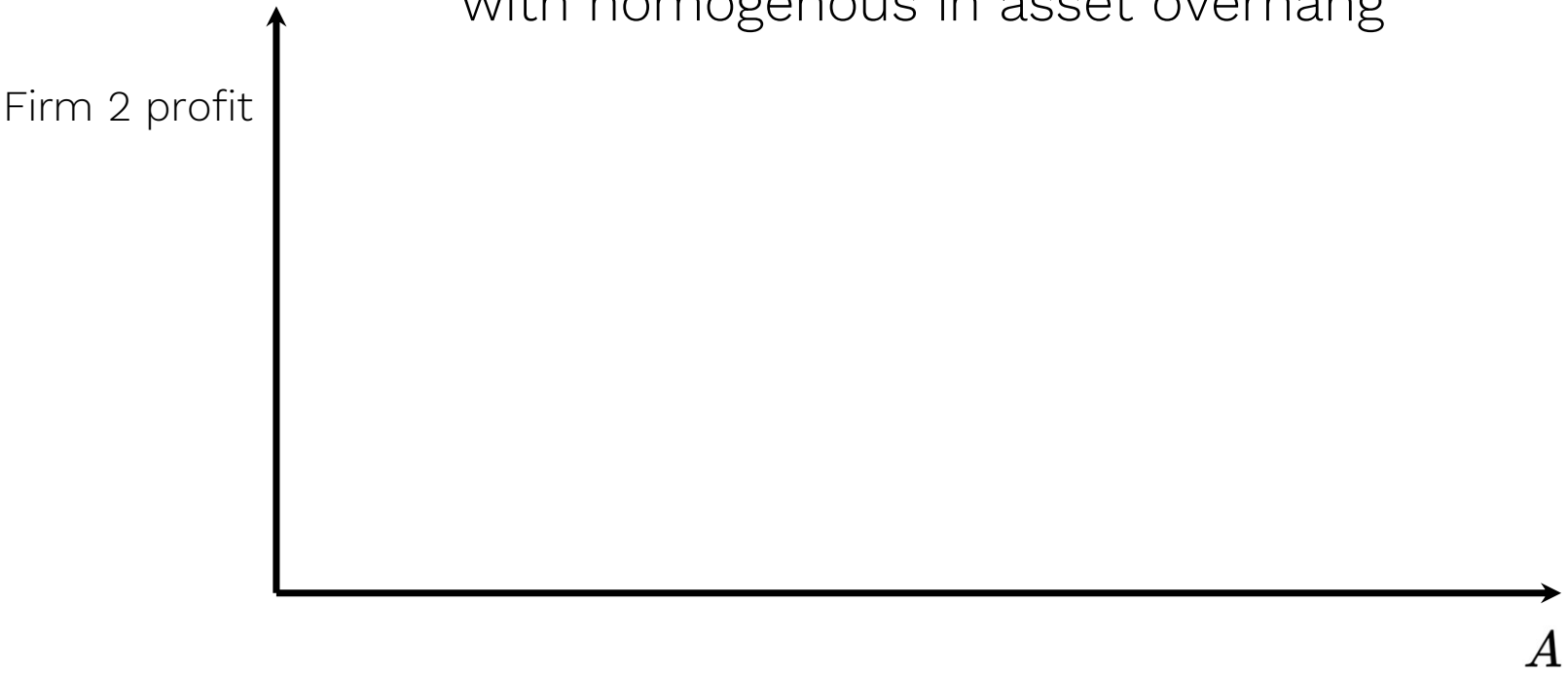


Competitive investors
with homogenous in asset overhang



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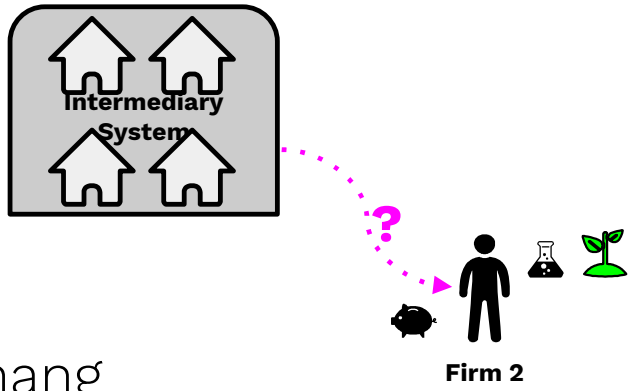

Competitive investors
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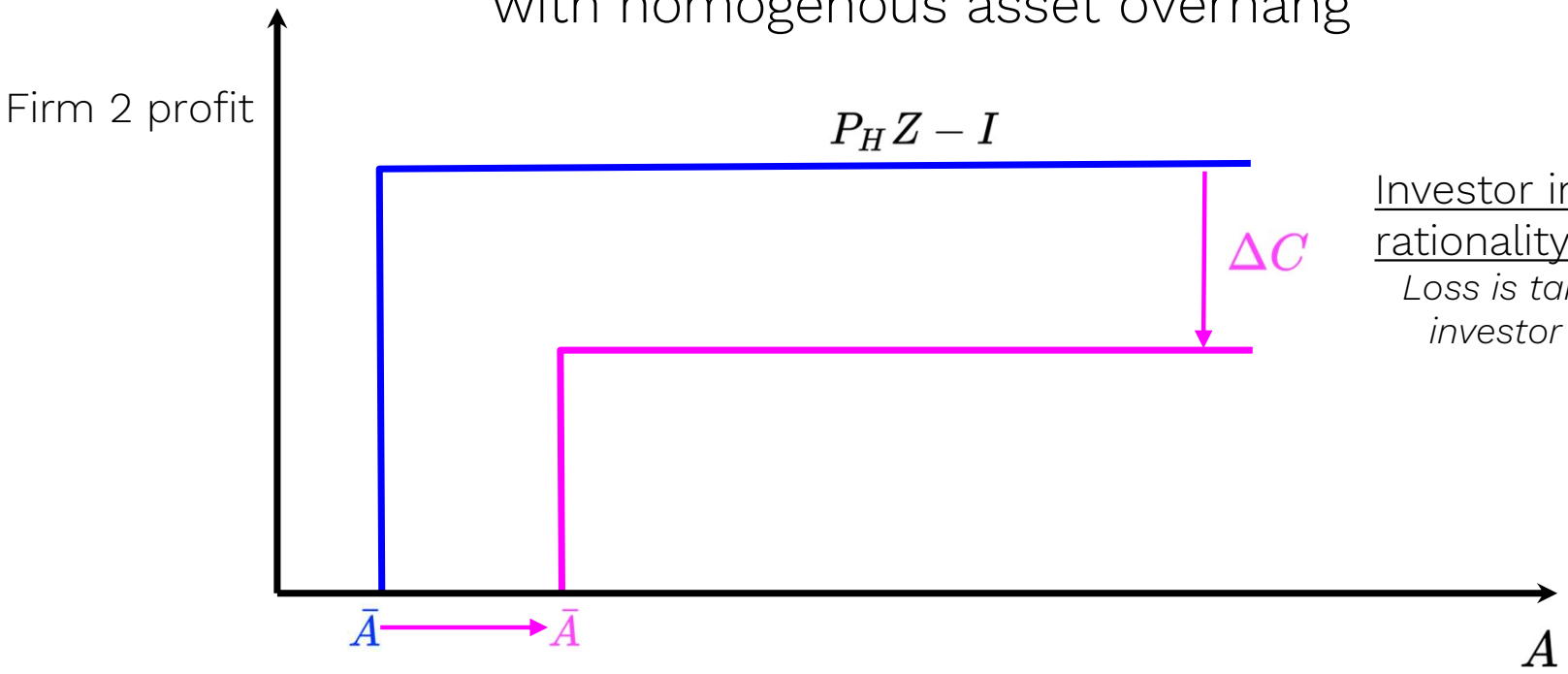
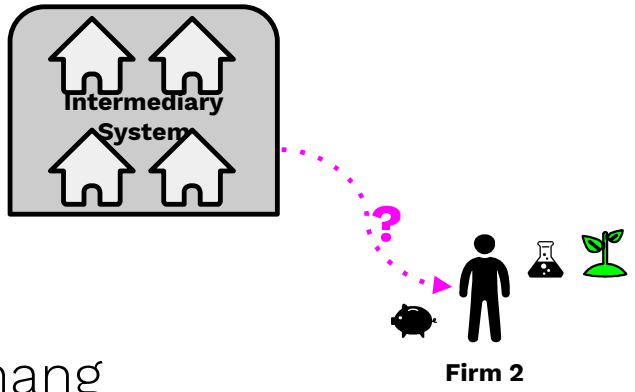


Investor individual rationality

Loss is taken by Firm 2 and investor is compensated

Rationing



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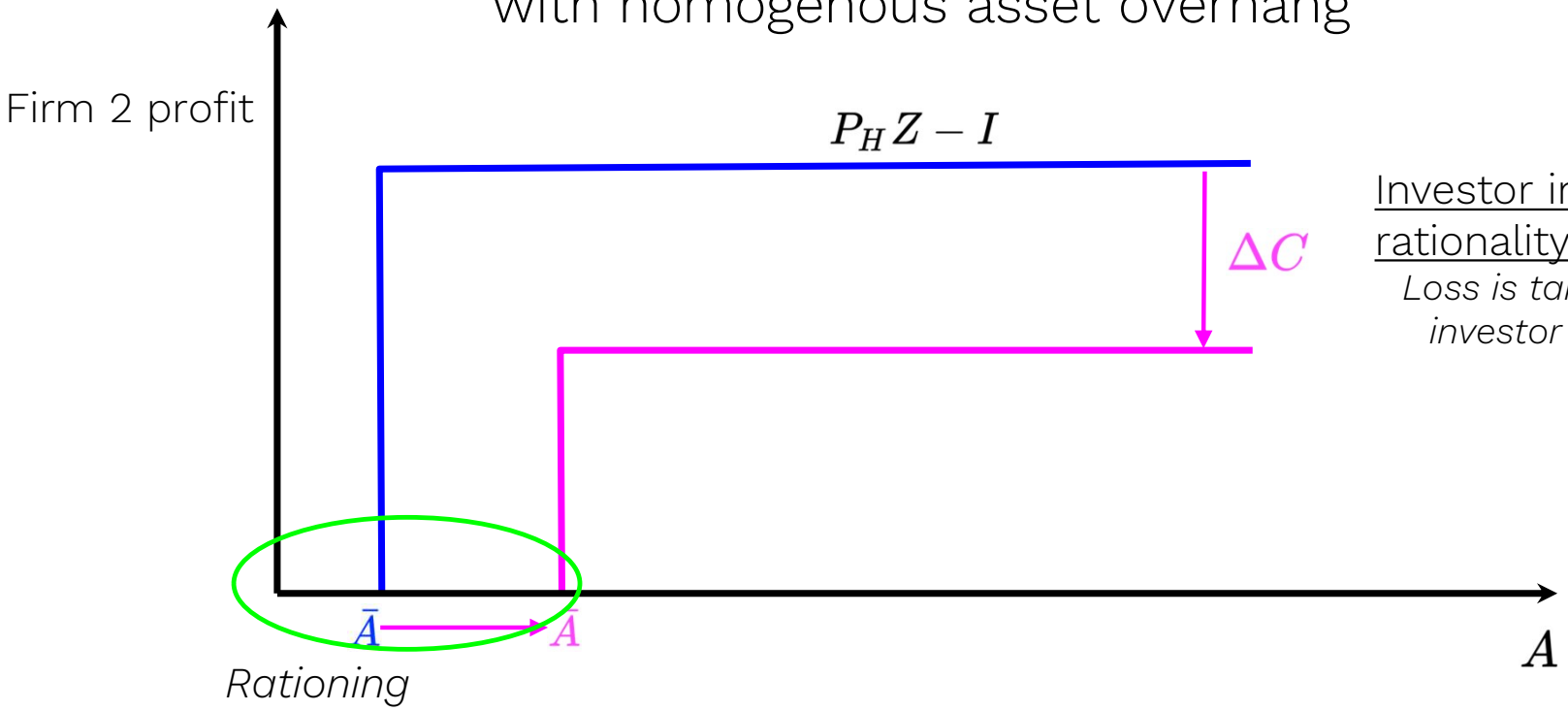

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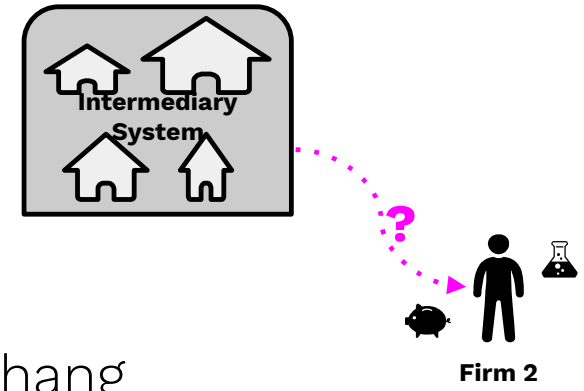
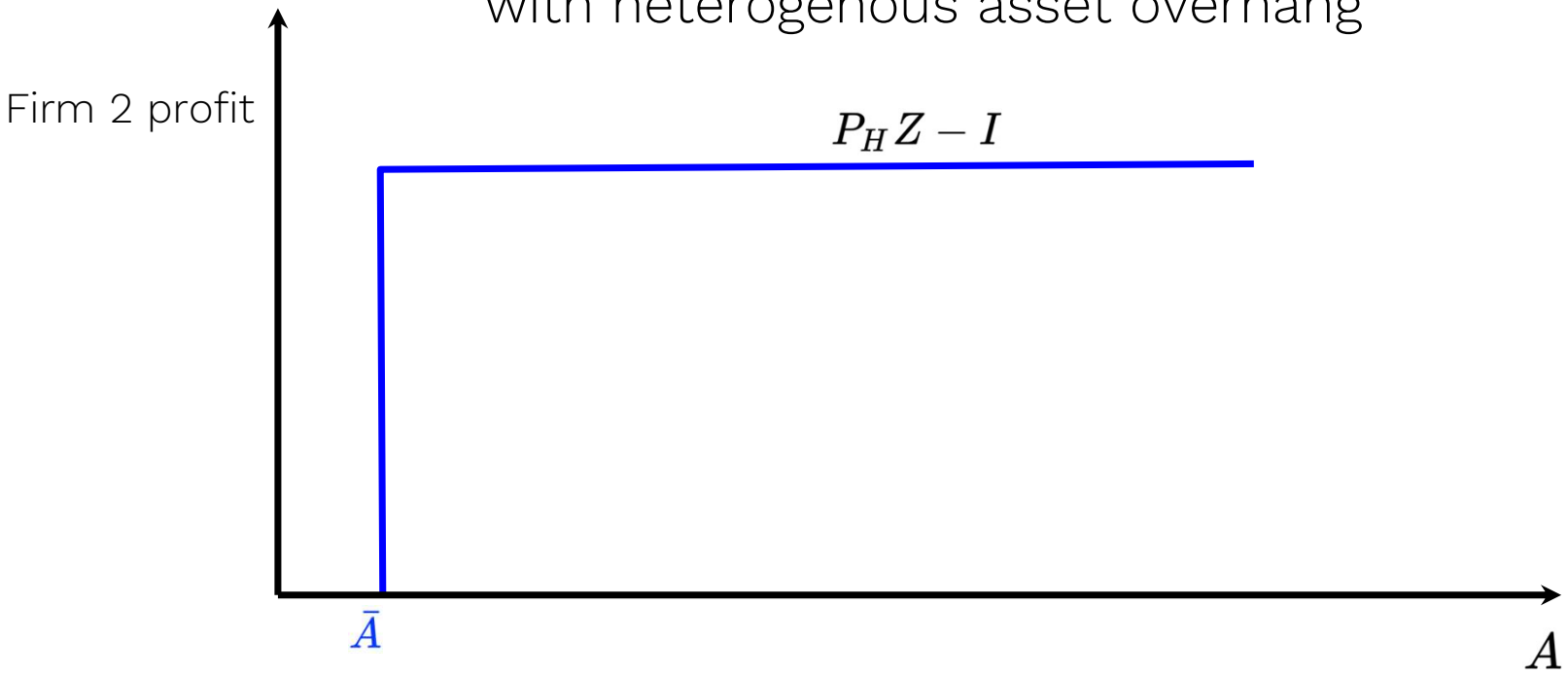
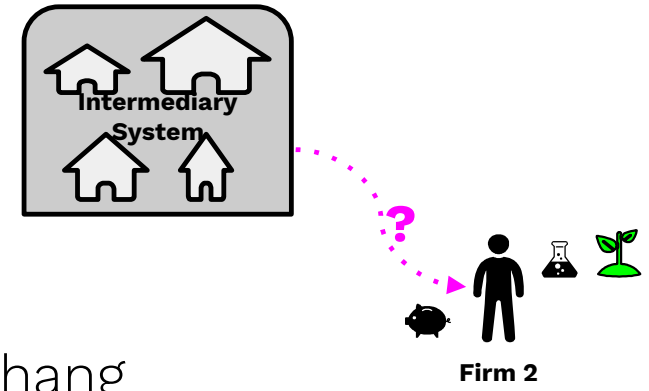


Competitive investors
with heterogenous asset overhang



Rationing



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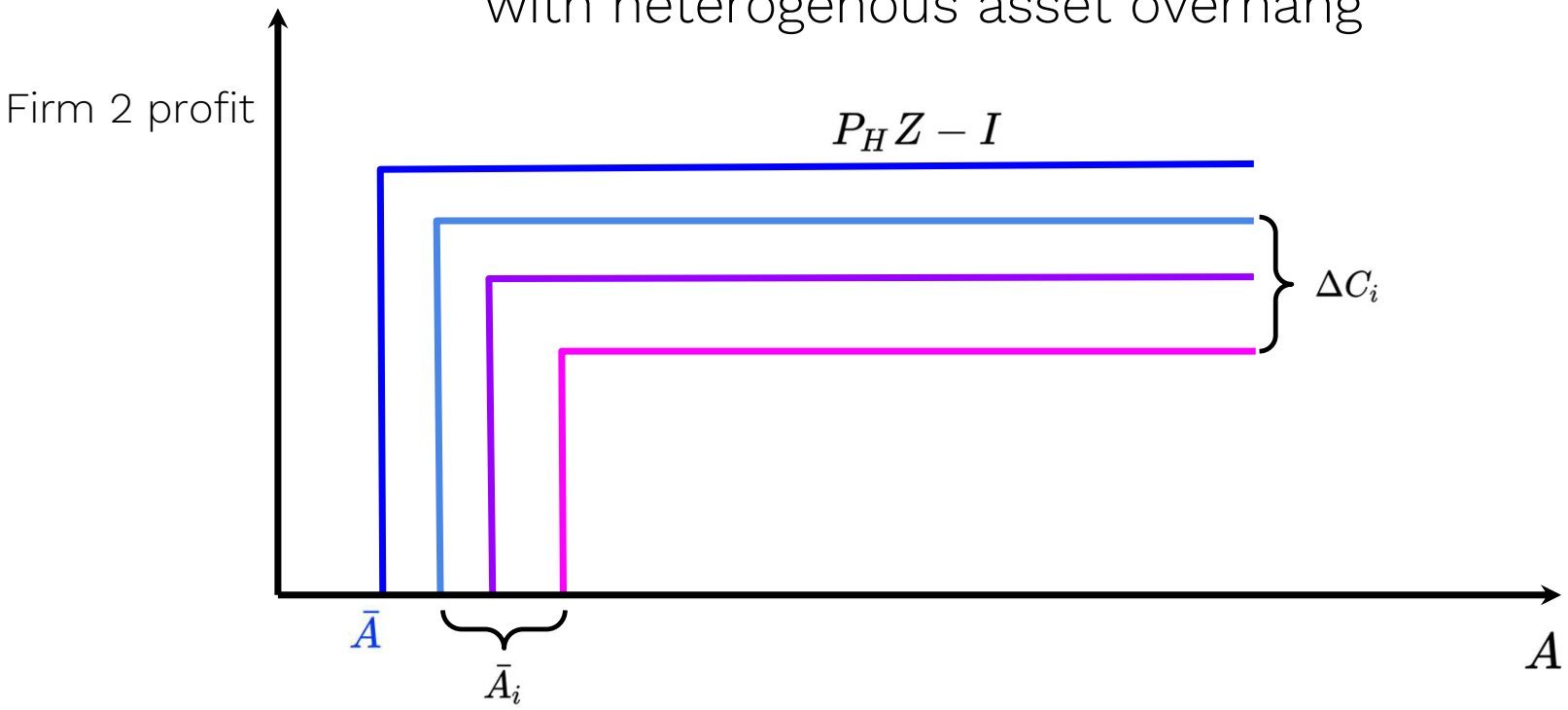

Rationing

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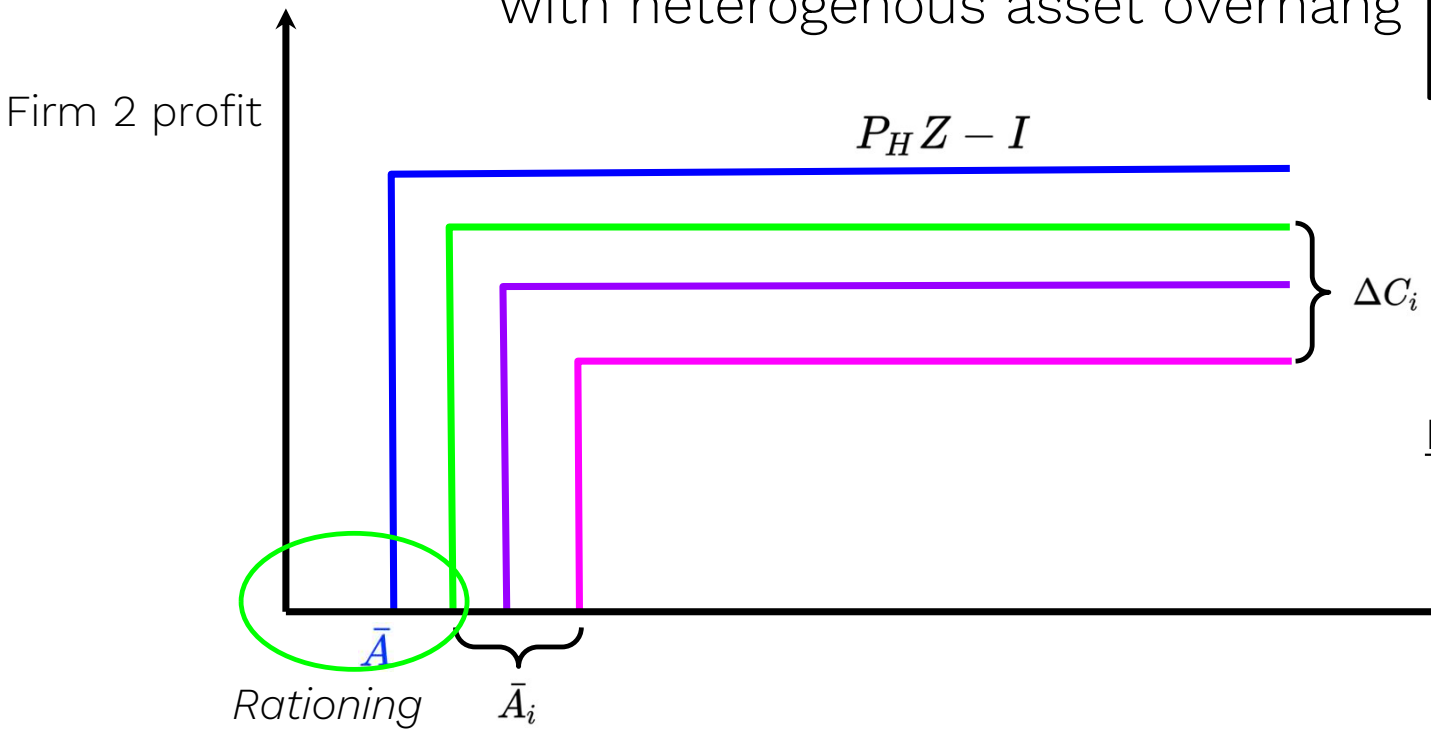


Proposition
Rationing if
$min\{\Delta C_i\} > 0$

Lowest legacy positions

Empirical predictions. Armed with our theoretical results, we can formulate testable predictions.

1. "Legacy effect": An increase in exposures to the negative externality should lead to more rationing.

2. "Market structure effect": An increase in heterogeneity of exposures to the negative externality should lead to less rationing.

2. Empirical application: financing of green projects

Measuring green externalities

Combine different data sets from Belgium (bank based economy)

- PATSTAT (patents – product and process innovation) from EPO

- SBS (structural business survey): firms' share of green sales and investments for period 2008-2018: covering 80% of aggregate sales and 60% of aggregate employment

- business-to-business transactions: VAT transactions across all firms – input and output tables at firm level (Dewachter, Tielens and Vanhove)

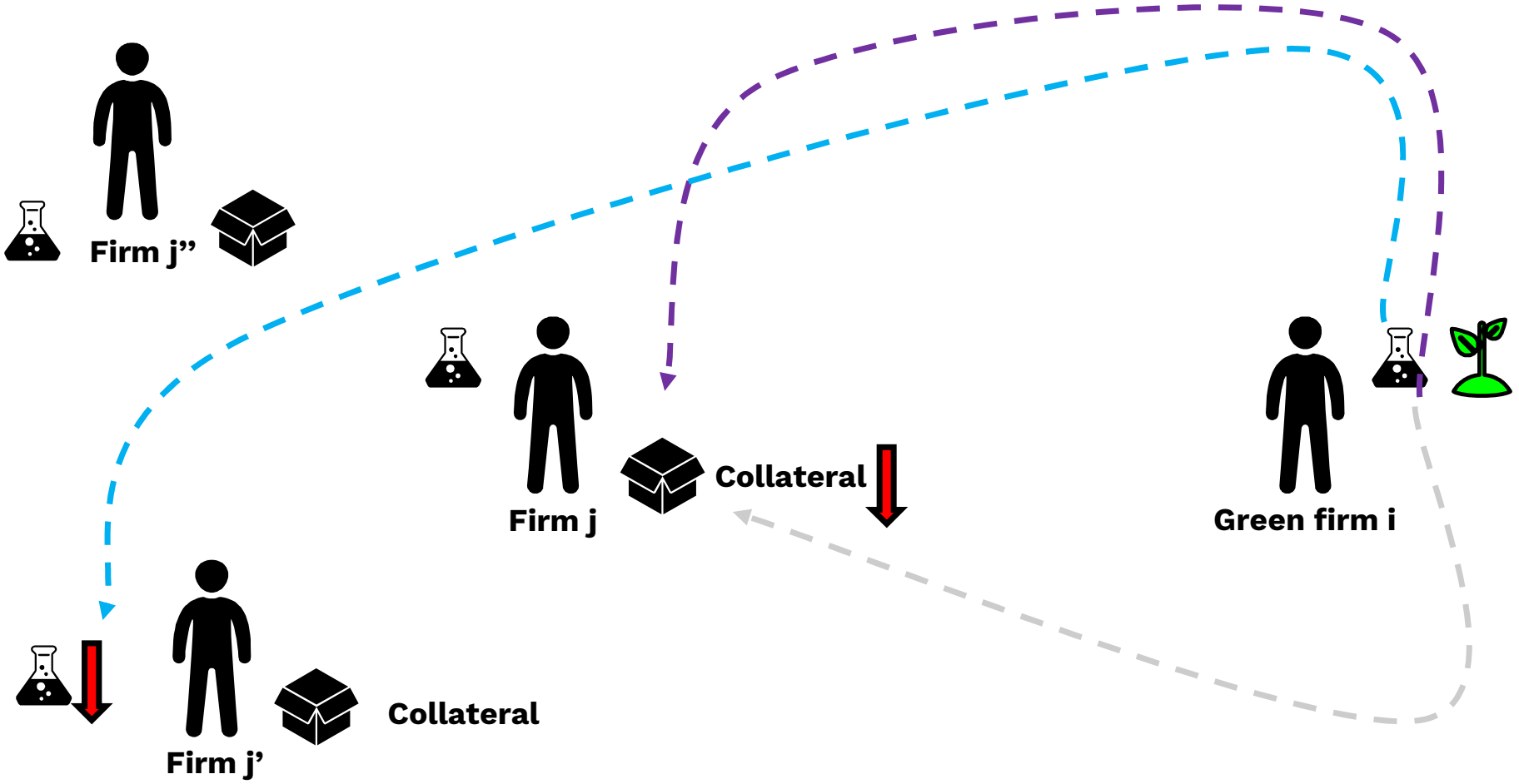
- credit registry data: bank-firm level credit exposures (e.g., De Jonghe et al., RoF, 2020) including collateral information (and market valuations, from 2018 onwards)

- firm balance sheet data

2. Measuring green externalities

Do green activities generate negative spillovers on brown firms' performance?

Do green activities generate negative spillovers on brown firms' asset value (i.e., collateral)?



2. Measuring green externalities

- *Identifying green activities*

  - ***Green innovation*** *relates to the development of new green technology*
  - ***Green diffusion*** *relates to the dissemination of incumbent green technology*

2. Measuring green externalities

- Definition 3.2 (Green innovation). *Green innovation is of two types:*
  - ***Green process innovation*** *embodies a more environmentally friendly way to produce an existing good.*
  - ***Green product innovation*** *delivers novel goods/services that either reduce environmental pressures or are designed to be cleaner and more resource efficient when operated than conventional products*

- Employing PATSTAT data (as in de Haas and Popov, 2019), we sort between process and product innovations by extracting the full texts of the universe of green patents awarded by the EPO (similar to Bena et al, JFE forth) and using dictionary as in Banholzer et al., 2019)
  - Green process innovator =1 if it has patented at least one green process innovation.
  - Green product innovator = 1 if it has patented at least one green product innovation.
  - Green innovator if at least one of these activities

Definition 3.3 (Green diffusion). *Green diffusion is of two types*

- ***Green adoption*** *entails the investment in environmental capital goods that embody clean technologies and/or end-of-pipe technologies.*
- ***Green provision*** *entails the selling of goods and/or services that either reduce environmental pressures or are designed to be cleaner and more resource efficient when operated than conventional products.*

Employing the Structural Business Survey (SBS; available at NBB):

- Green adopter = 1 if it reports a non-zero fraction of green fixed capital investments, zero otherwise
- Green provider = 1 if it reports a non-zero fraction of green sales, zero otherwise
- Green diffusor= 1 if at least one of these activities

Sample:

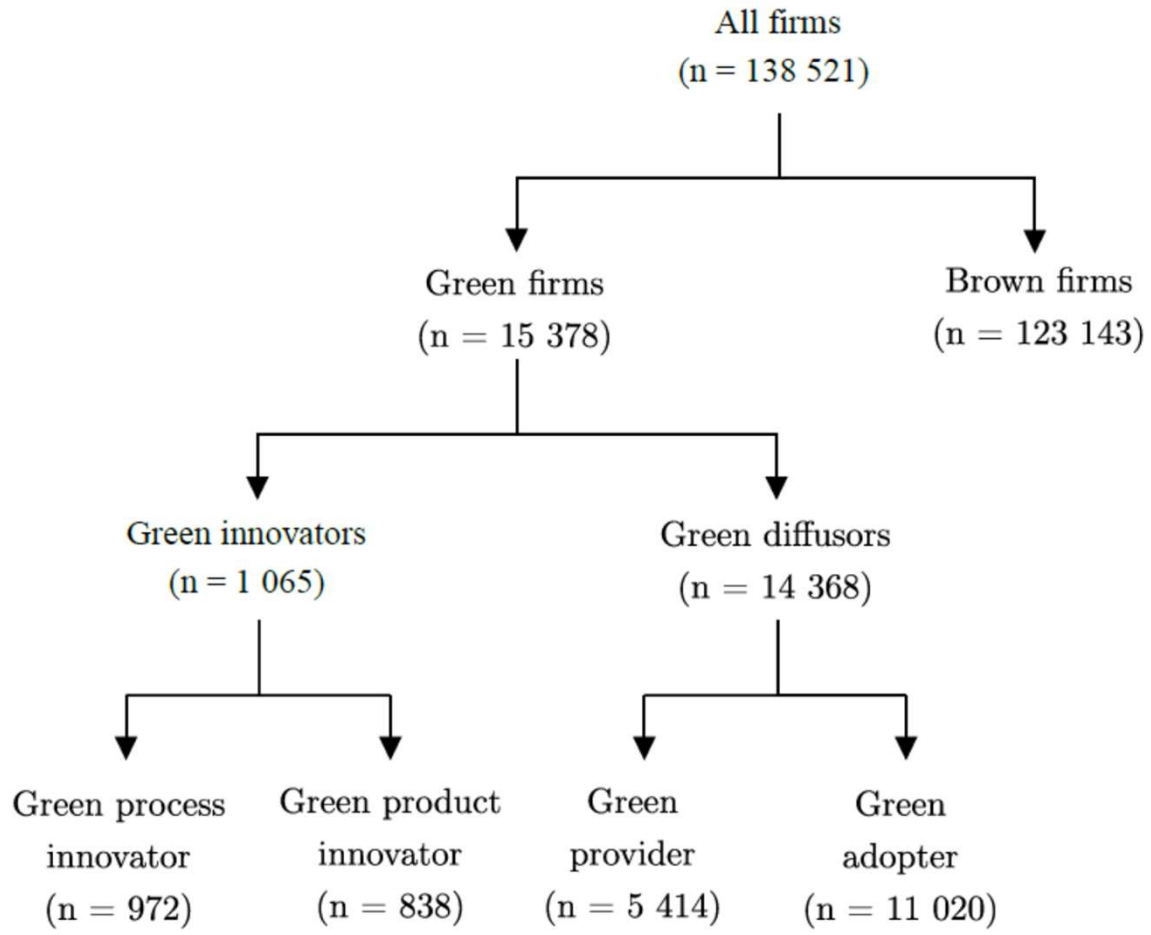
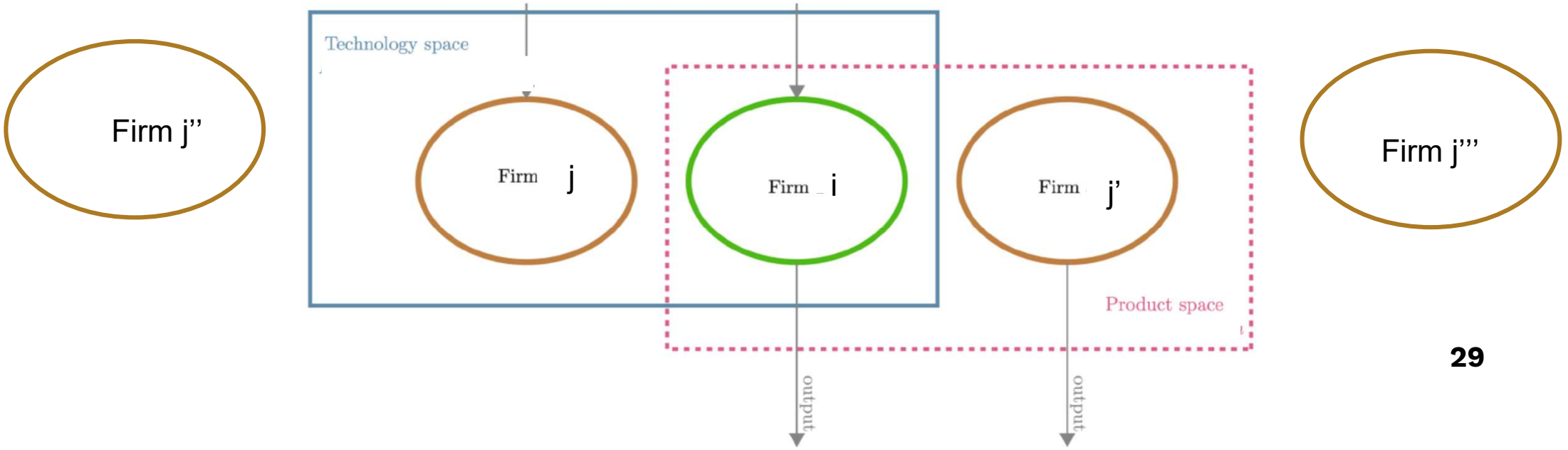


Figure 3: Incidence of various green activities by Belgian non-financial firms.

Do green activities generate negative effects on brown firms?

- *Identifying affected brown firms: following the innovation literature (e.g., Bloom et al., Ectra 2013), we construct indicators of closeness in economic space (technology space and product space), relying upon the business-to-business transaction dataset based upon VAT filings*



Do green activities generate externalities on brown firms?

- *Performance decline:*

1. Change in sales to households: $\Delta \ln (\text{HH sales}_{it})$
2. Change in sales to corporate customers: $\Delta \ln (\text{B2B sales}_{it})$
3. Change in number of corporate customers: $\Delta \ln (\text{B2B customers}_{it})$
4. Loss of corporate customers to green competitors: Lost B2B_{it}

- *Asset Pledgeability :*

1. Exceptional writedowns: Writedowns_{it}
2. Liquidation losses: $\text{Liquidation loss}_{it}$

2. Summary of empirical analysis

Table 5: ESTABLISHED EXTERNALITIES

SPACE ($\mathcal{S}$)	GREEN ACTIVITY ($\mathcal{A}$): INNOVATION	
	Product Innovation	Process Innovation
Product space	Performance: ↓	Performance: ↓
	Pledgeability: ∅	Pledgeability: ∅
Technology space	Performance: ∅	Performance: ∅
	Pledgeability: ∅	Pledgeability: ↓
	GREEN ACTIVITY ($\mathcal{A}$): DIFFUSION	
	Green providing	Green adopting
Product space	Performance: ↓	Performance: ↓
	Pledgeability: ∅	Pledgeability: ∅
Technology space	Performance: ∅	Performance: ∅
	Pledgeability: ∅	Pledgeability: ↓

- Banks perspective:

- Product space: Higher probability of an upward revision of default probabilities and book additional provisions
- Technology space: process innovation and green adoption drives down the value of physical assets that are pledged

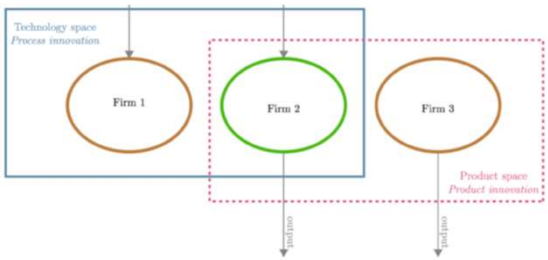
3. Impact of (structure of) banks' asset overhang on credit rationing.

- Extensive margin
- Extensive margin: who breaks the barrier
- Intensive margin

Asset overhang of banks

- For every green firm i, we have identified the set of impacted brown firms

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



- For every i and bank b, we construct bank b's legacy position employing data from the credit registry and the exposures to the brown firms j.

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

- **Legacy effect**: median across banks:

$$f_1(\boldsymbol{\theta}_{it}^{\mathcal{A}}) = Med(\boldsymbol{\theta}_{it}^{\mathcal{A}}))$$

- **Market structure effect**: minimum across all banks

$$f_2(\boldsymbol{\theta}_{it}^{\mathcal{A}}) = Min(\boldsymbol{\theta}_{it}^{\mathcal{A}}))$$

Asset overhang of banks

- **Legacy effect**: median across banks: $f_1(\theta_{it}^{\mathcal{A}}) = Med(\theta_{it}^{\mathcal{A}}))$
- **Market structure effect**: minimum across all banks $f_2(\theta_{it}^{\mathcal{A}}) = Min(\theta_{it}^{\mathcal{A}}))$

$$Borrower_{it} = \beta_1 \times \mathcal{A} + \beta_2 \times Med(\theta_{it-1}^{\mathcal{A}}) + \beta_3 \times Min(\theta_{it-1}^{\mathcal{A}}) + \boldsymbol{\zeta}' \boldsymbol{z}_{it-1} + \varepsilon_{it} \quad (3)$$

where $Borrower_{it}$ equals 1 when firm i has a positive exposures in the credit registry at t, zero otherwise. $\mathcal{A} = \{Green_i, Innovator_i, Diffusor_i\}$ is a dummy variable indicating whether the firm engages in a particular activity.

- Hypotheses:
  - $\beta_2 < 0$: the larger the banking system's legacy positions, the less likely green firms get loans from the banking system
  - $\beta_3 < 0$ the larger the "lowest" asset overhang, the less likely green firms get credit

Extensive Margin: LPM

Greater banking system legacy positions at risk: more green firm rationing

- Legacy effect: innovators 5.9pp more likely to be rationed when median legacy compared to absence of legacy; diffusors: 0.5 pp

Greater minimum legacy position at risk, more green firm rationing

- **Market structure effect:**

For innovators: a 0.5sd reduction in the lowest asset overhang implies 5.3 pp more likely getting bank loans; 0.5 pp for diffusors

Table 8: RATIONING EXTENSIVE MARGIN: BASELINE RESULTS

Dependent variable: $Borrower_{it}$				
	(1)	(2)	(3)	(4)
Estimation sample:	Brown Firms + Green Firms	Brown Firms + Green Firms	Brown Firms + Green Firms	Brown Firms + Green Firms
$Green_i$	−0.026***	−0.024***		
	(0.004)	(0.002)		
Green innovator$_i$			−0.035**	−0.042***
			(0.015)	(0.014)
Green diffusor$_i$			−0.027***	−0.025***
			(0.002)	(0.002)
$Med(\theta_{it-1}^{A=\text{Green}})$		−0.212***		
		(0.068)		
$Min(\theta_{it-1}^{A=\text{Green}})$		−0.997***		
		(0.251)		
$Med(\theta_{it-1}^{A=\text{Innovator}})$				−7.517***
				(2.794)
$Min(\theta_{it-1}^{A=\text{Innovator}})$				−10.274**
				(4.713)
$Med(\theta_{it-1}^{A=\text{Diffusor}})$				−0.186***
				(0.042)
$Min(\theta_{it-1}^{A=\text{Diffusor}})$				−0.941***
				(0.184)
Controls	Y	Y	Y	Y
Sector FE × Time FE	Y	Y	Y	Y
Location FE × Time FE	Y	Y	Y	Y
Cluster	Firm	Firm	Firm	Firm
# Clusters	90749	90749	90749	90749
# Observations	502067	502067	502067	502067
Adj. R^2	0.164	0.164	0.164	0.161

Extensive margin: Who breaks the barrier? LPM

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

- $\iota_t(b = \arg\min_b(\theta^{\mathcal{A}}_{it-1}))$ is a dummy variable equal to one when the bank has the lowest legacy position, zero otherwise
- $\iota_t(b = \arg\max_b(\theta^{\mathcal{A}}_{it-1}))$ is a dummy variable equal to one when the bank has the largest legacy position, zero otherwise Is a dummy

$\beta > 0$ 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

Extensive margin: Who breaks the barrier?

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

Table 13: RATIONING EXTENSIVE MARGIN: WHO IS BREAKING THE BARRIER?

	Dependent variable: Borrower_{ibt}					
	(1)	(2)	(3)	(4)	(5)	(6)
Estimation sample:	$\text{Green}_i = 1$		$\text{Innovation}_i = 1$		$\text{Diffusor}_i = 1$	
$\theta_{ibt-1}^{A=\text{Green}}$	-0.721^{***}	-0.940^{***}				
	(0.160)	(0.146)				
$\iota_t(b = \arg\min_b(\theta_{it-1}^{A=\text{Green}}))$		0.130^{***}				
		(0.024)				
$\iota_t(b = \arg\max_b(\theta_{it-1}^{A=\text{Green}}))$		-0.016				
		(0.020)				
$\theta_{ibt-1}^{A=\text{Innovation}}$			-2.620	-8.143		
			(2.490)	(5.022)		
$\iota_t(b = \arg\min_b(\theta_{it-1}^{A=\text{Innovation}}))$				0.262^{***}		
				(0.090)		
$\iota_t(b = \arg\max_b(\theta_{it-1}^{A=\text{Innovation}}))$				0.065		
				(0.130)		
$\theta_{ibt-1}^{A=\text{Diffusion}}$					-0.725^{***}	-0.935^{***}
					(0.159)	(0.146)
$\iota_t(b = \arg\min_b(\theta_{it-1}^{A=\text{Diffusion}}))$						0.130^{***}
						(0.024)
$\iota_t(b = \arg\max_b(\theta_{it-1}^{A=\text{Diffusion}}))$						-0.011
						(0.020)
Sector FE × Time FE	4-digit	4-digit	1-digit	1-digit	4-digit	4-digit
Location FE × Time FE	Y	Y	Y	Y	Y	Y
Cluster	Y	Y	Y	Y	Y	Y
# Clusters	871	871	26	26	859	859
# Observations	4434	4434	122	122	4339	4339
Adj. R^2	0.154	0.168	0.229	0.285	0.154	0.168

Intensive margin

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

Increases in the minimum asset overhang are associated with less credit expansion at green firms.

	(1)	(2)	(3)
Estimation sample:	Green	Innovators	Diffusors
$\Delta\theta_{ibt-1}^{\mathcal{A}=\text{Green}}$	0.120		
	(0.147)		
$\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Green}})$	−0.060***		
	(0.010)		
$\Delta\theta_{ibt-1}^{\mathcal{A}=\text{Innovator}}$		−1.792	
		(1.748)	
$\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Innovator}})$		−0.141**	
		(0.068)	
$\Delta\theta_{ibt-1}^{\mathcal{A}=\text{Diffusor}}$			−0.006
			(0.302)
$\Delta Min(\boldsymbol{\theta}_{it-1}^{\mathcal{A}=\text{Diffusor}})$			−0.062***
			(0.010)
$\mathcal{A}$: Green			
Δ Market structure effect	-0.061		
$\mathcal{A}$: Innovator			
Δ Market structure effect		-0.037	
$\mathcal{A}$: Diffusor			
Δ Market structure effect			-0.061
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	Firm	Firm	Firm
# Clusters	10533	300	10143
# Observations	120238	3262	117012
Adj. R^2	0.003	0.002	0.004

Policy discussion

Promote investors' incentives to finance entry and diffusion of green activities

Policies

1. Alternative banking models
   - Entry of legacy free banks
2. Funding sources
   - Develop alternative financing sources to green projects
3. Collateral policies
   - Promote green insensitive collateral ($\Delta C = 0$)
4. Macroprudential tools
   - Brown legacy penalty ($\Delta M > \Delta C$)

Market structure effect

Weakest asset overhang sets the rationing barrier for entire banking system

↧

Entry of a single legacy-free bank transforms aggregate provision of credit directed to disruptive innovation and diffusion beyond her own credit capacity

Conclusion

- Asset overhang may induce investors to bar the financing of technological change (i.e., entry of green technology)
  - Influence of market structure of asset overhang

- Empirical evidence showing that green innovation is detrimental to brown firms' operations and asset pledgeability; Banks increases their PDs of brown firms

- Empirical evidence suggesting that banks' legacy positions and its distribution are important drivers of access to bank finance for green firms both at extensive and intensive margin.

Thank you!

Comments welcome @

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