(Debt) Overhang: Evidence from Resource Extraction

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Ohio State University

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Debt Overhang

Myers' (1977) debt overhang is a pillar of corporate finance theory.

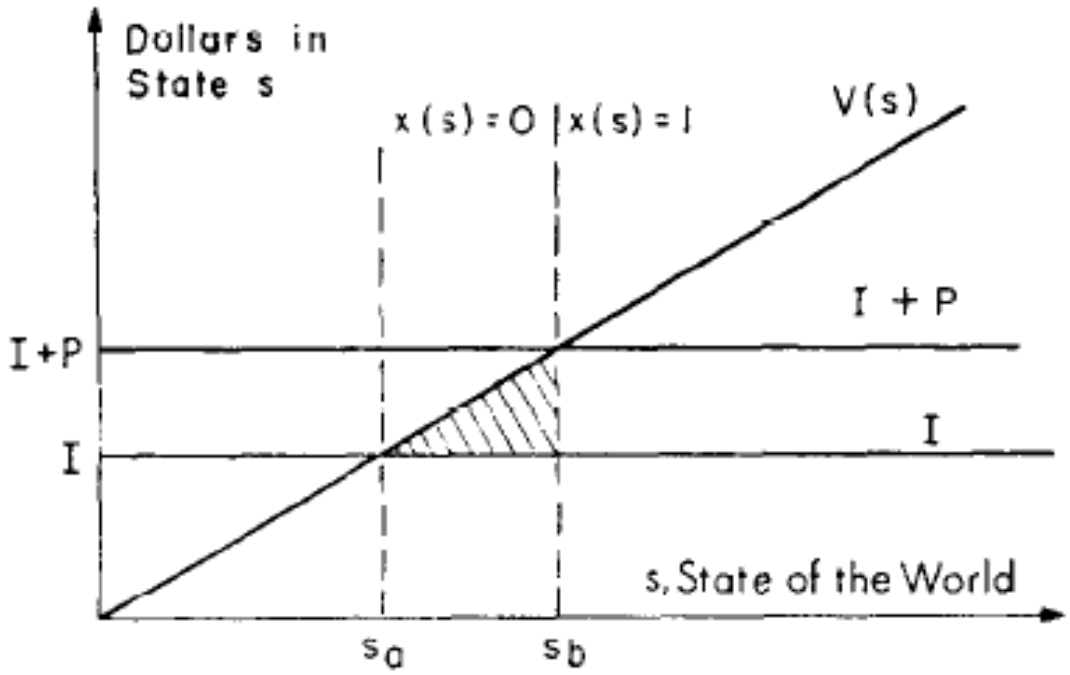

Fig. 2. The firm's investment decision with prior debt financing as a function of the state of the world, s, at the decision point.

Debt Overhang

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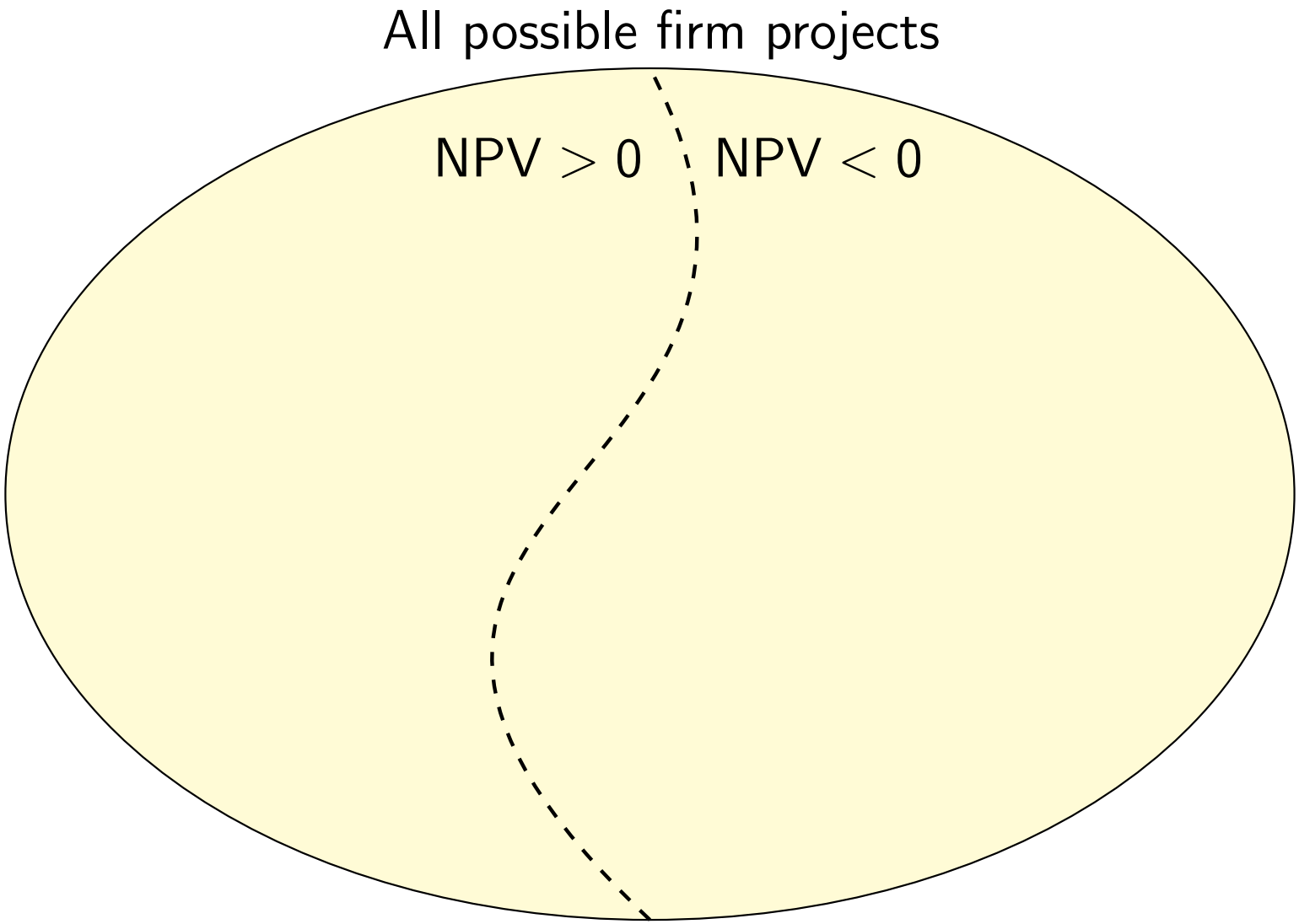

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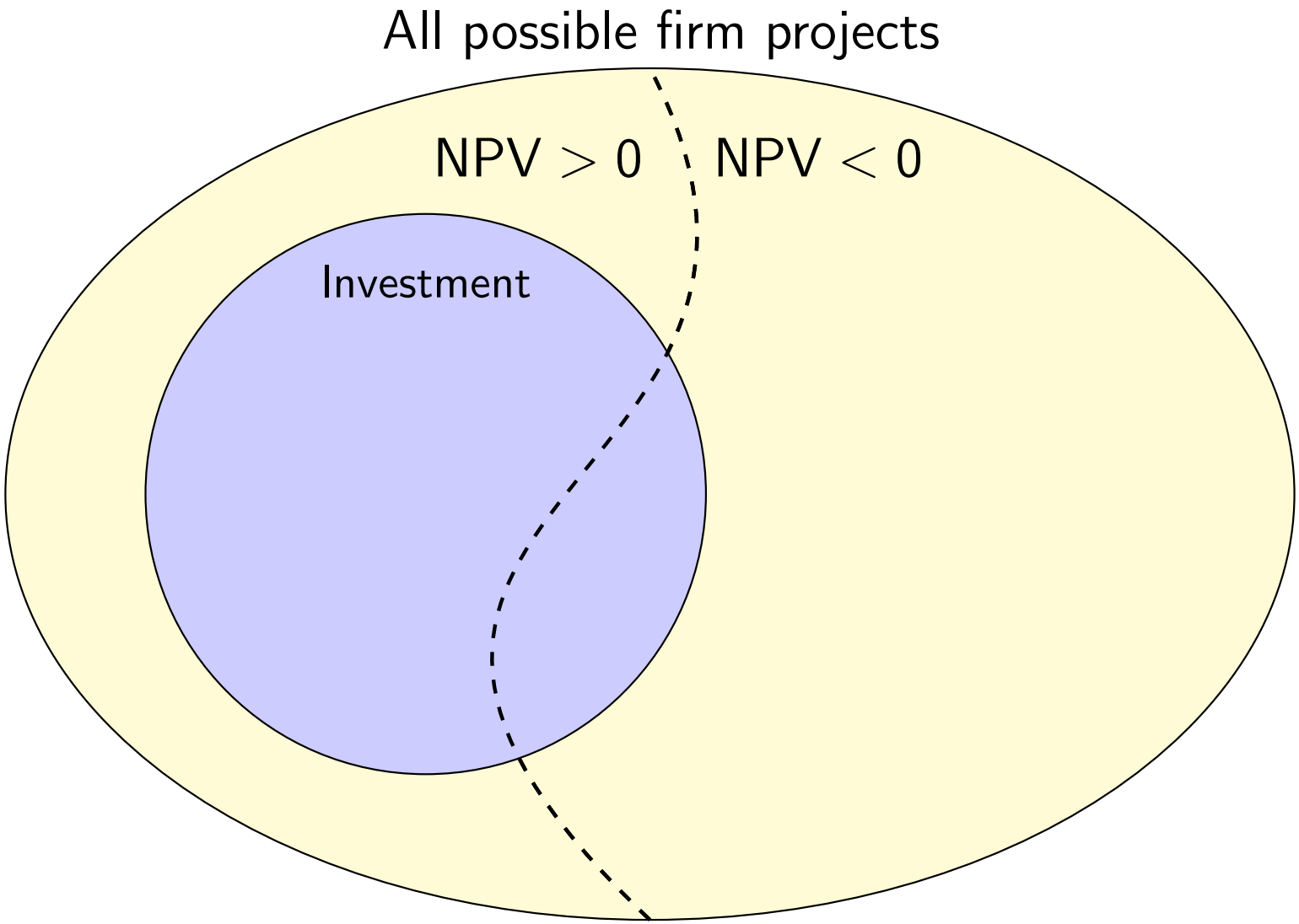

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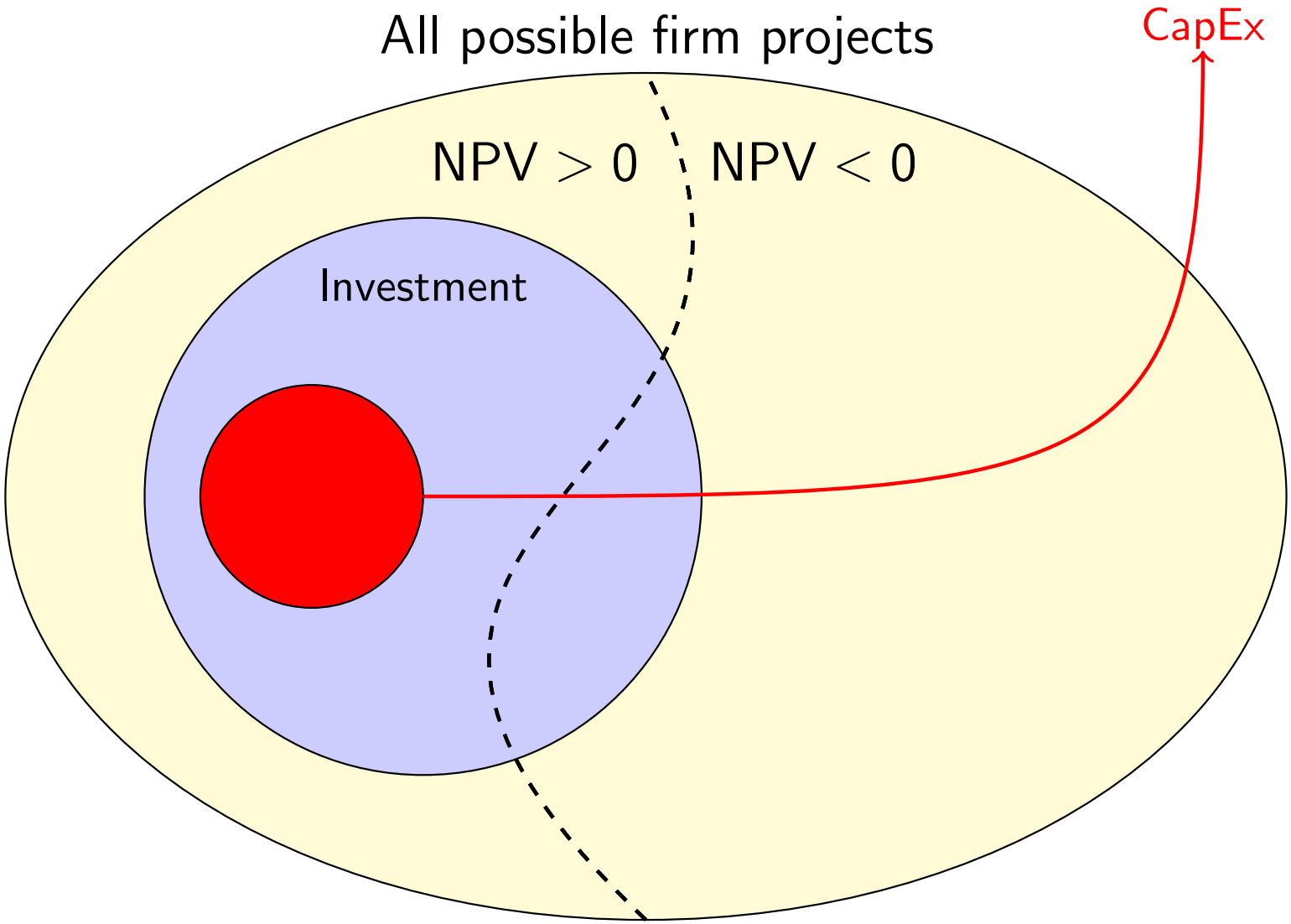

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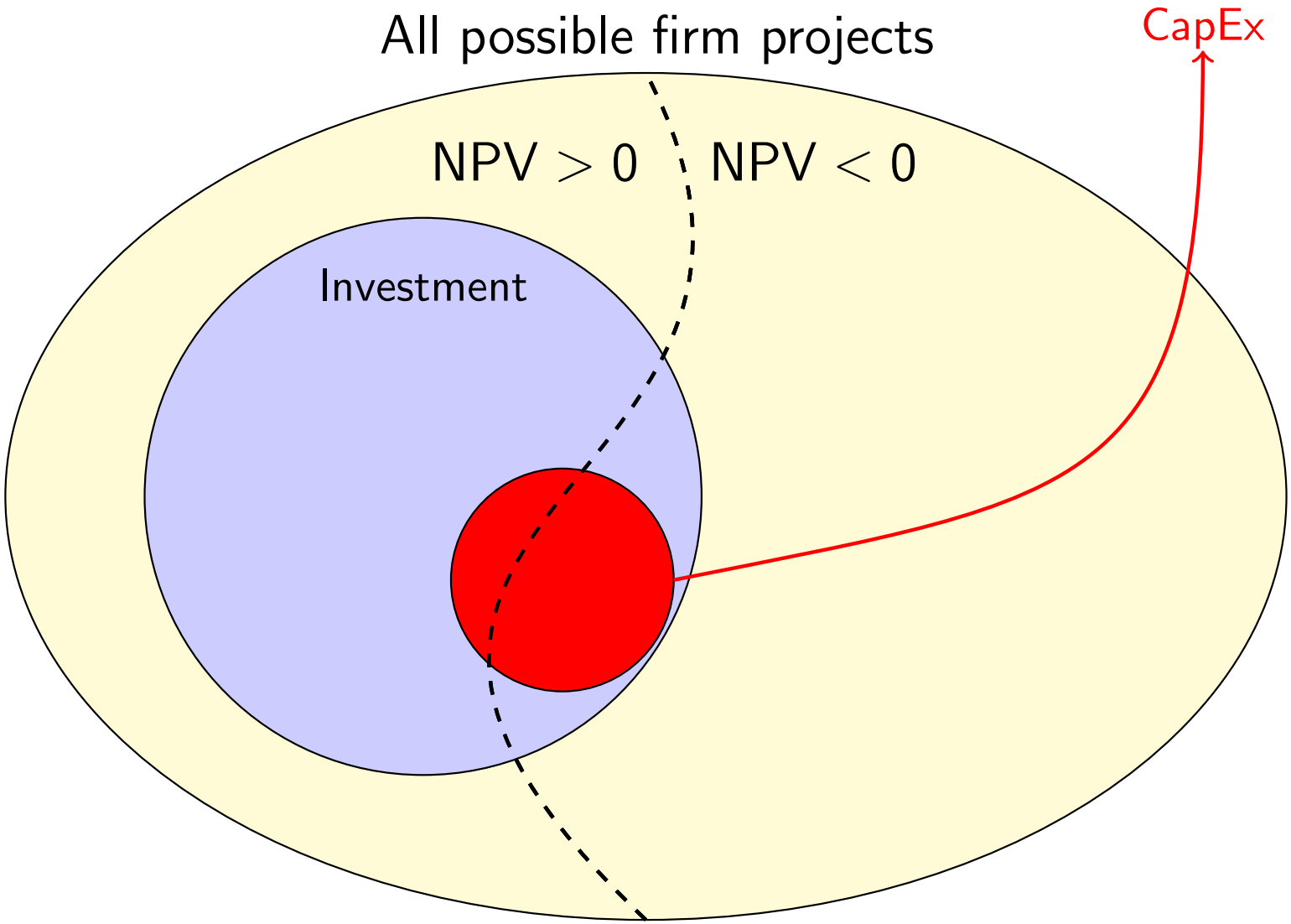

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Myers presents a number of ways to resolve the overhang problem.

- $\Rightarrow$ Renegotiation
- $\Rightarrow$ Shortening maturity
- $\Rightarrow$ Secured debt (Stulz and Johnson (1985))

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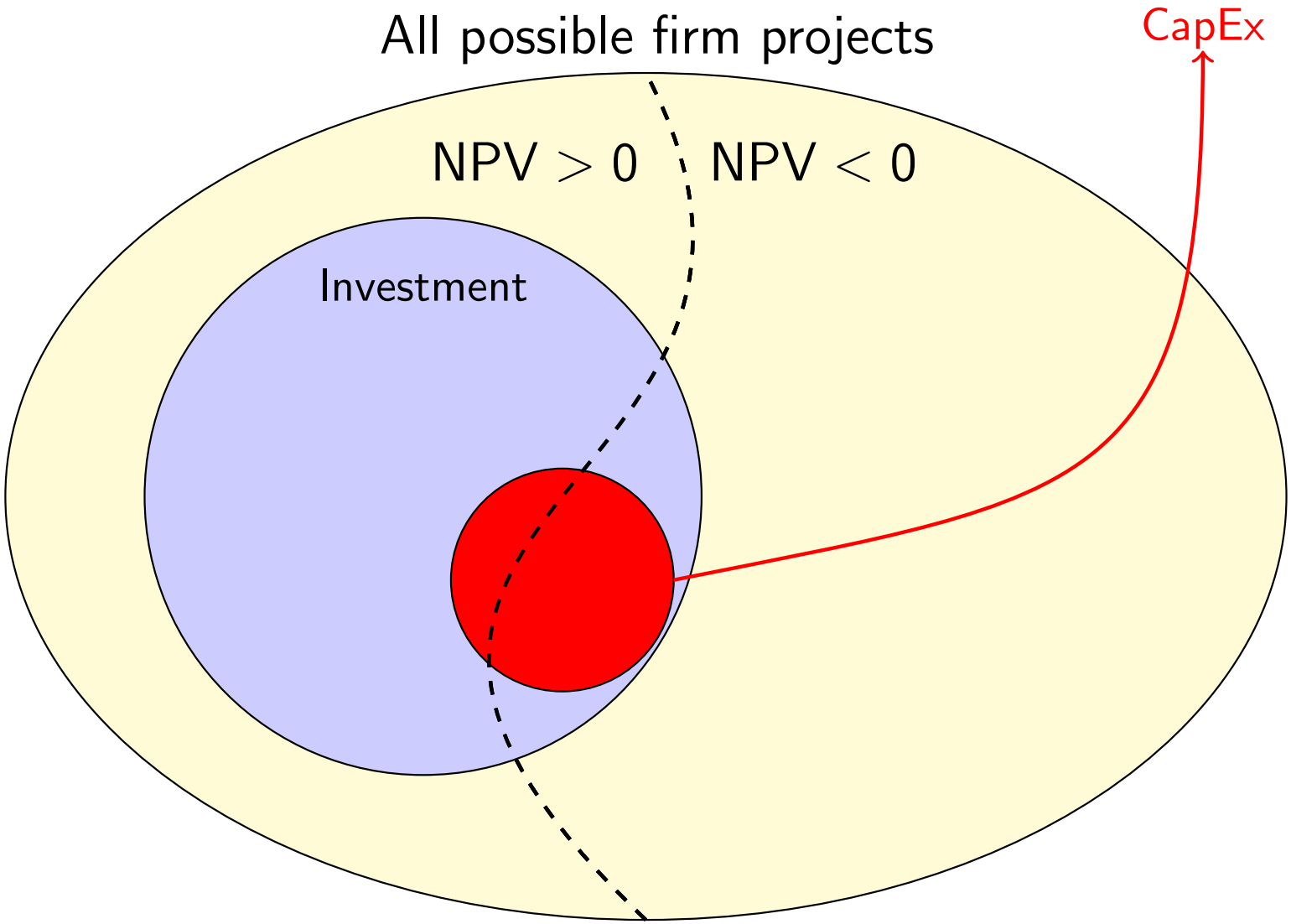

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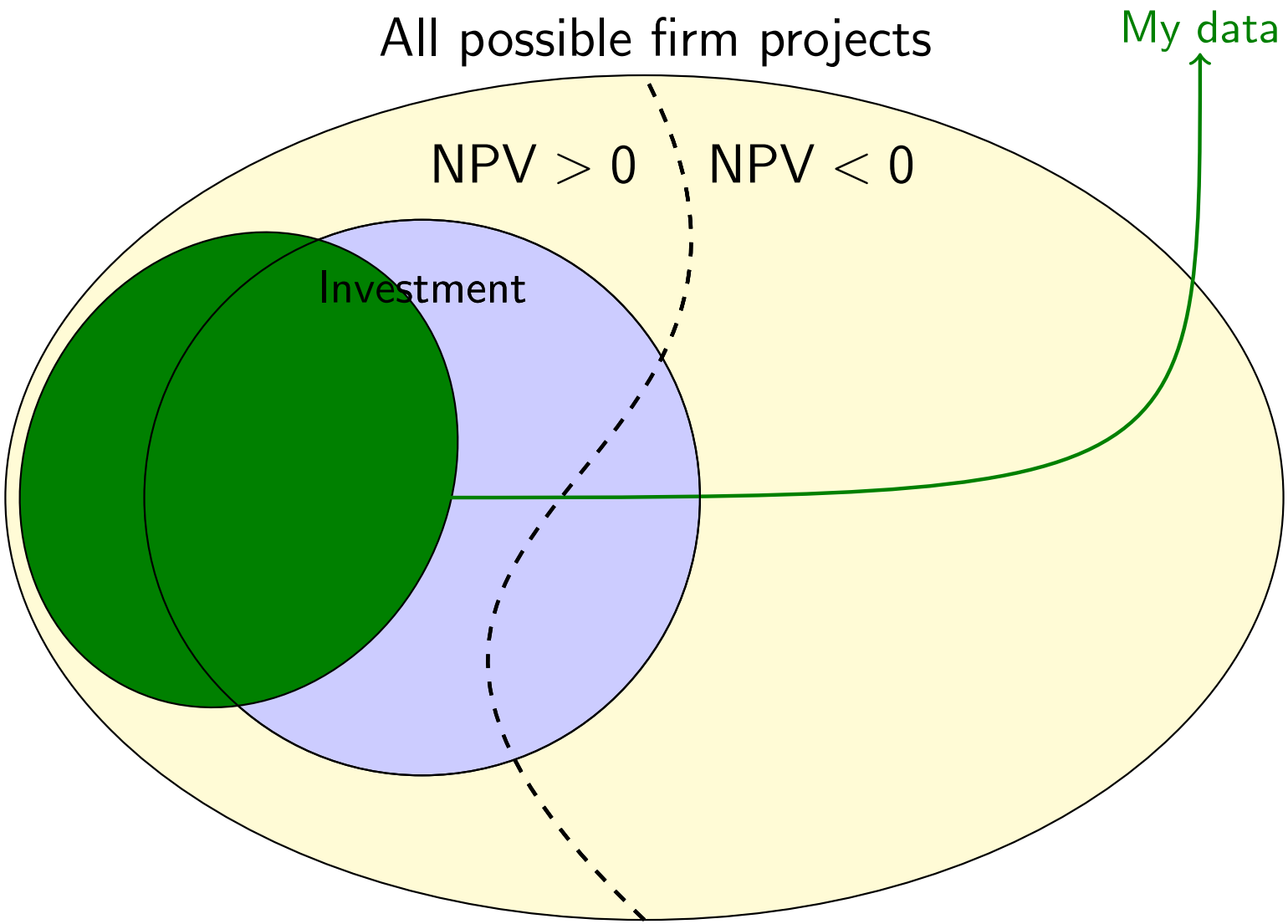

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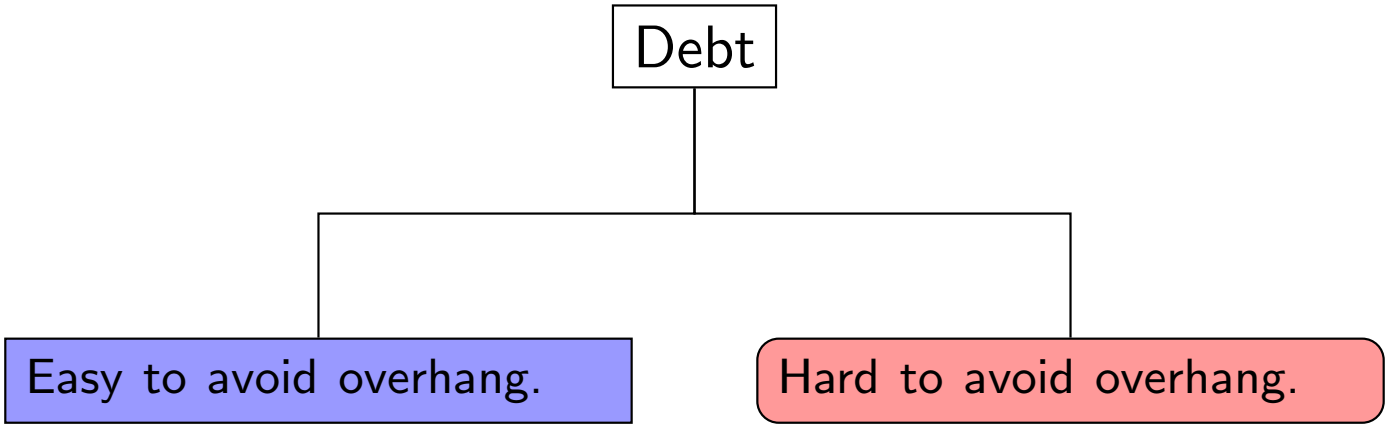

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My debt overhang regression:

$$\text{Positive NPV Investment} = \alpha + \beta_E \underbrace{\text{Debt}_E}_{\text{Easy to avoid OH.}} + \beta_H \underbrace{\text{Debt}_H}_{\text{Hard to avoid OH.}} + \beta_X X + \gamma_{i,t} + \epsilon$$

Firm Liabilities

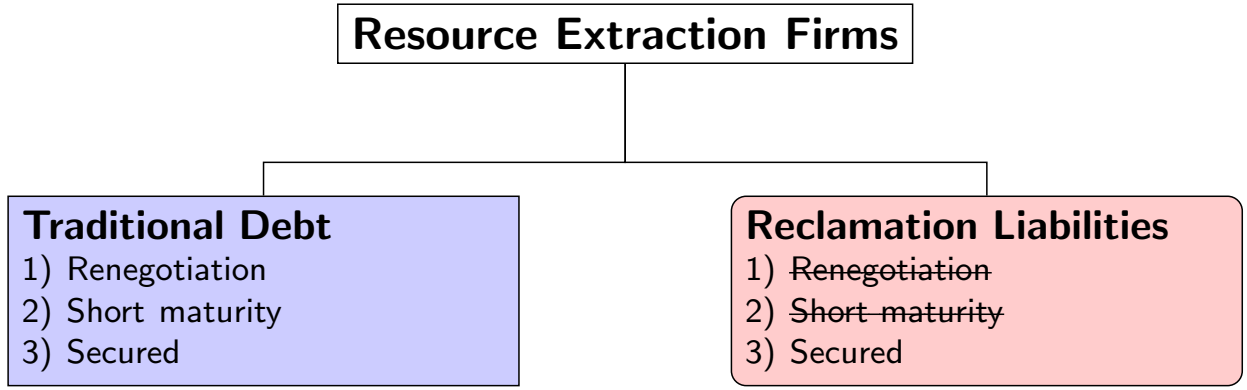
Identification Strategy

Do liabilities induce firms to:

Main takeaway

Firm Liabilities

OH contracting options



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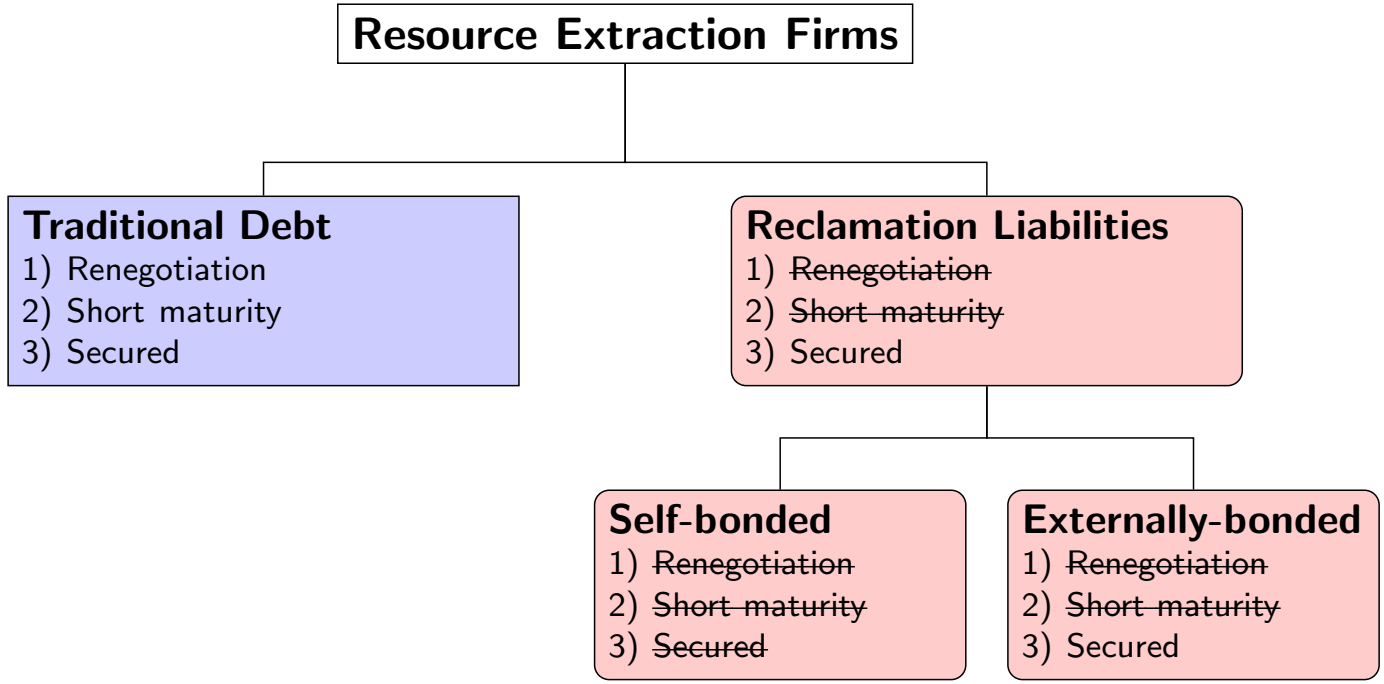

Firm Liabilities
OH contracting options

Identification Strategy
OH contracting options

Do liabilities induce firms to:
a) Forgo NPV+ mining projects?
b) Postpone NPV+ mining projects?

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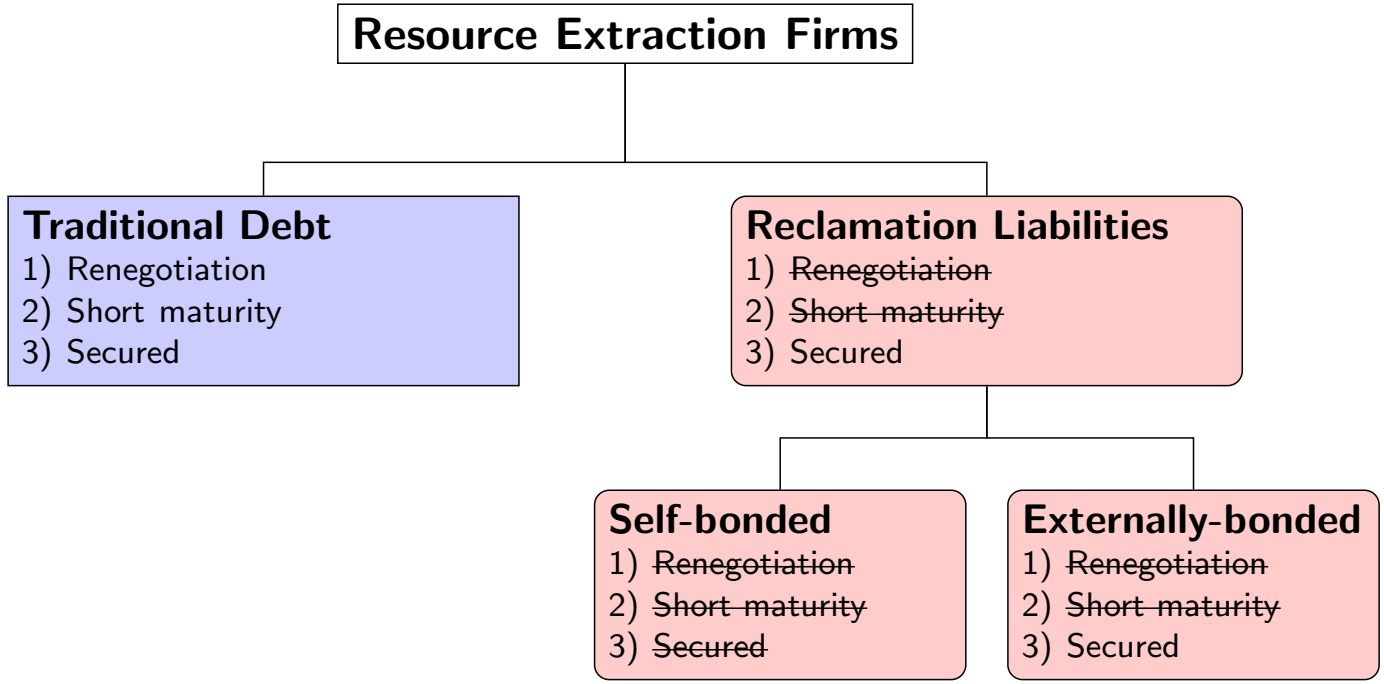

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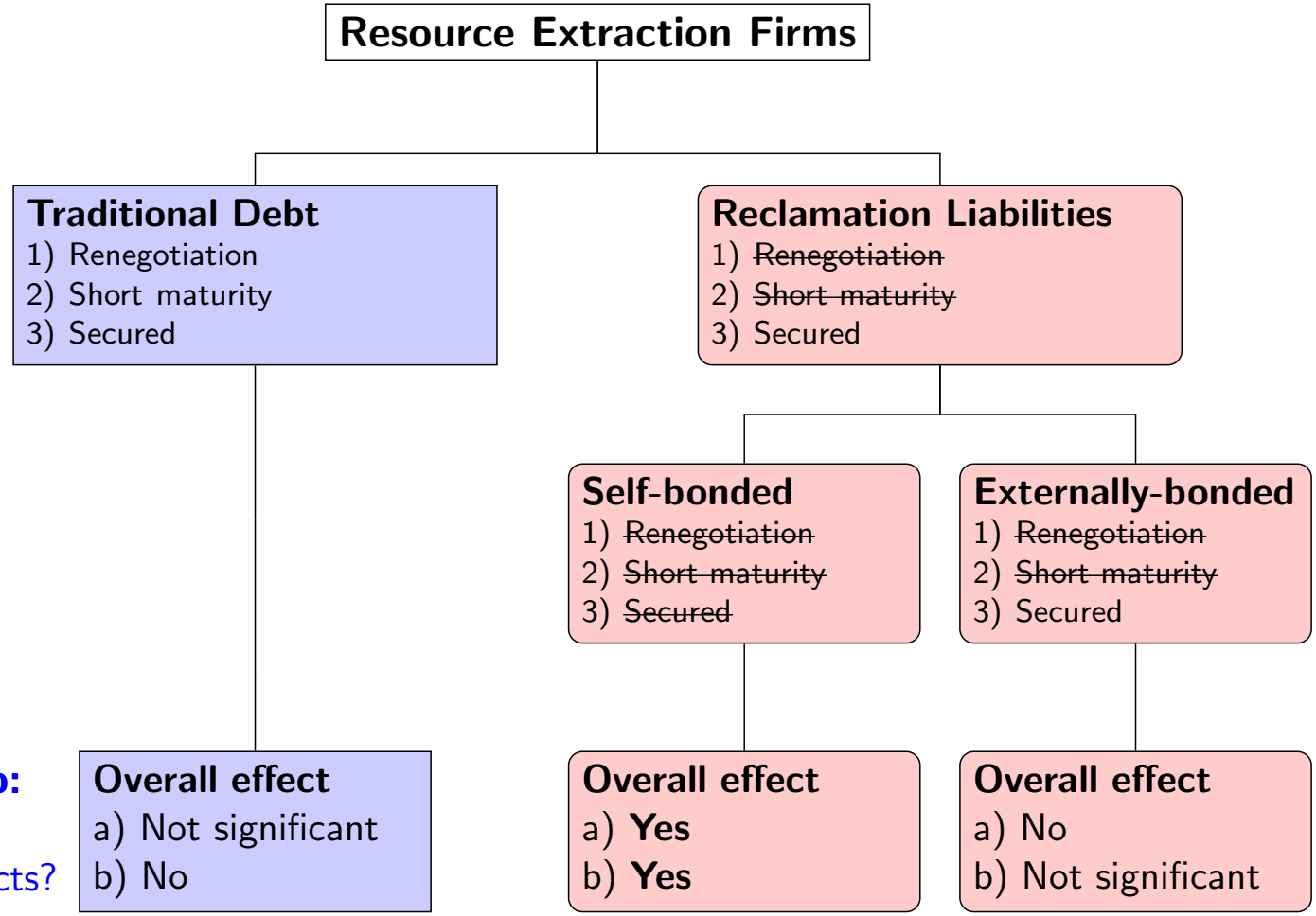

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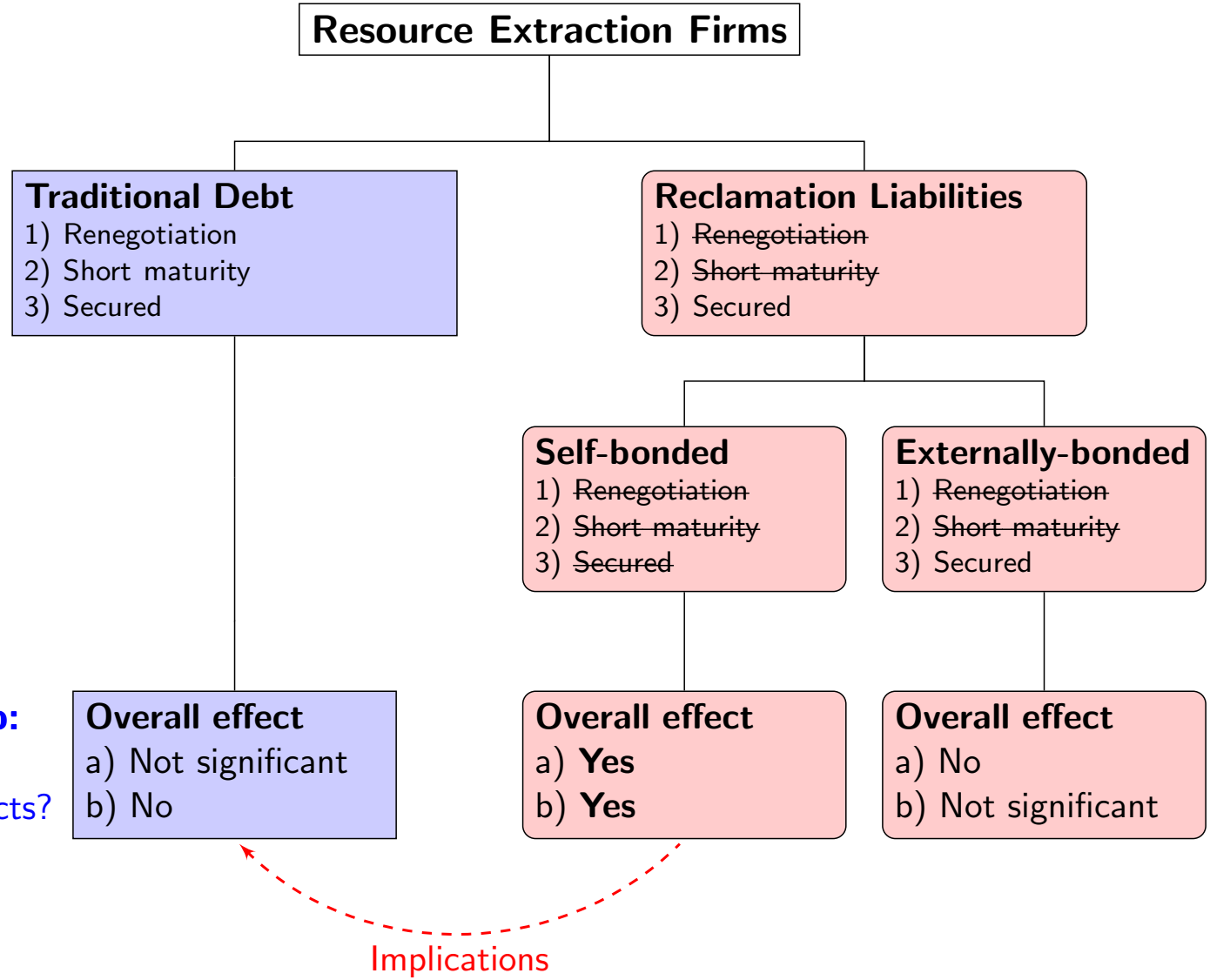

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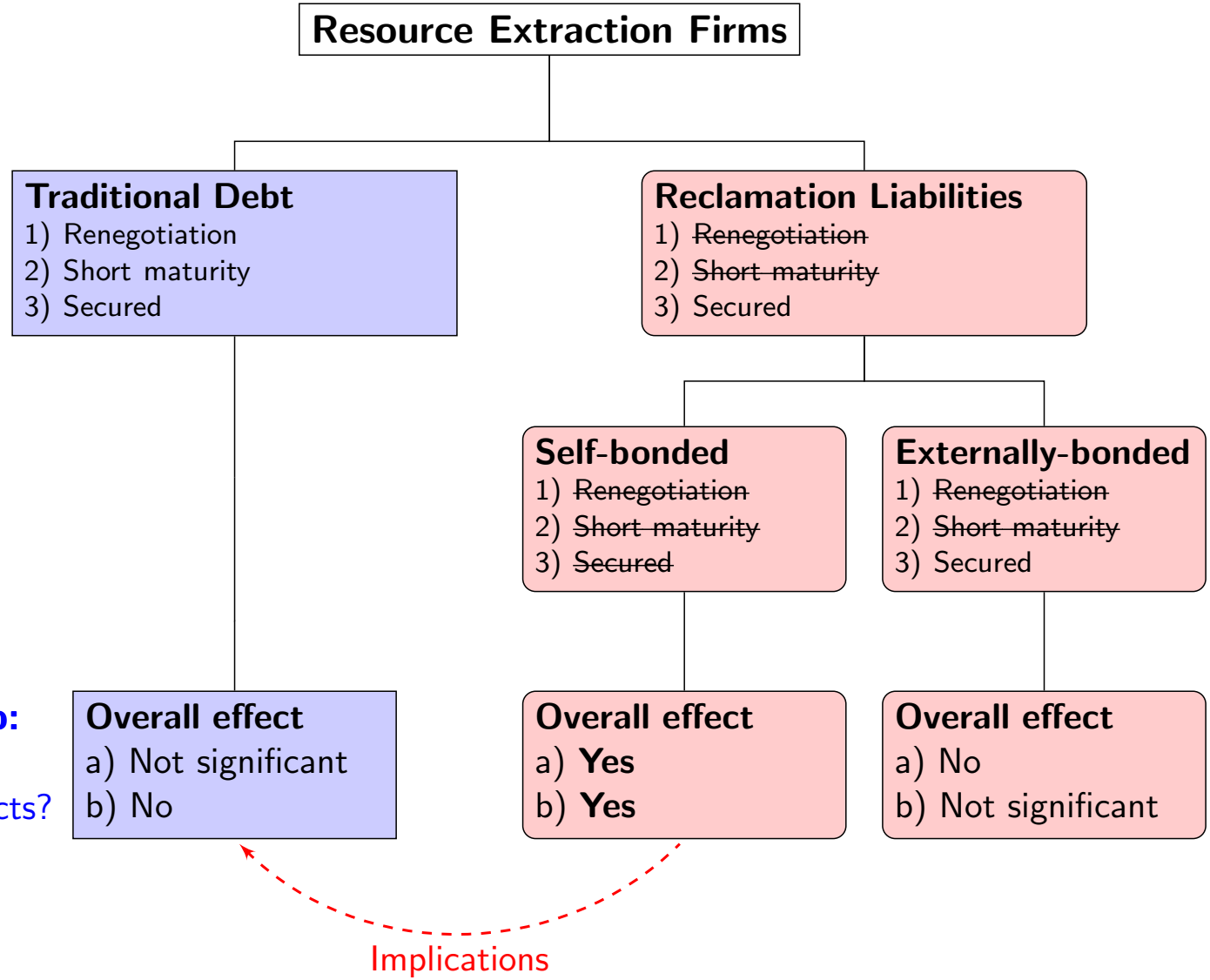

Main takeaway

The cost of debt overhang is potentially large, and where possible, effective solutions have endogenously arisen to mitigate it.

Institutional setting

Sample of mining firms listed on Toronto Stock Exchange (TSX) or the TSX Venture Exchange (TSXV) which own mines around the world.

$\Rightarrow$ National Instrument 43-101 Standards of Disclosure of Mineral Projects (NI 43-101) for Ontario Securities Commission (OSC)

- Require a series of technical reports
- Prepared by a "qualified person"
- Contains the estimated **project NPV**

Identification strategy

I exploit the cross-sectional and time-series variation in local financial assurance regulations.

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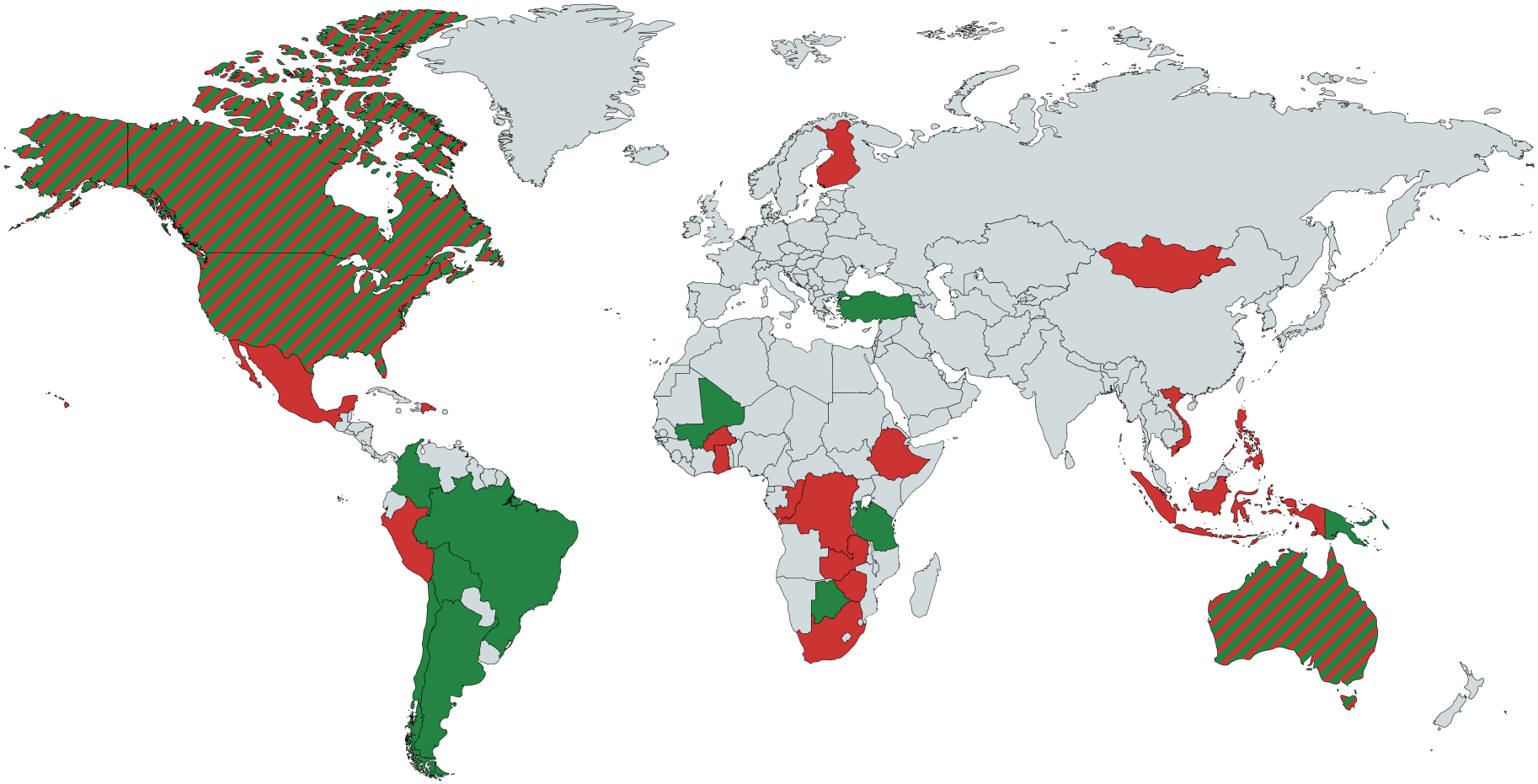

US and Canada | Mines

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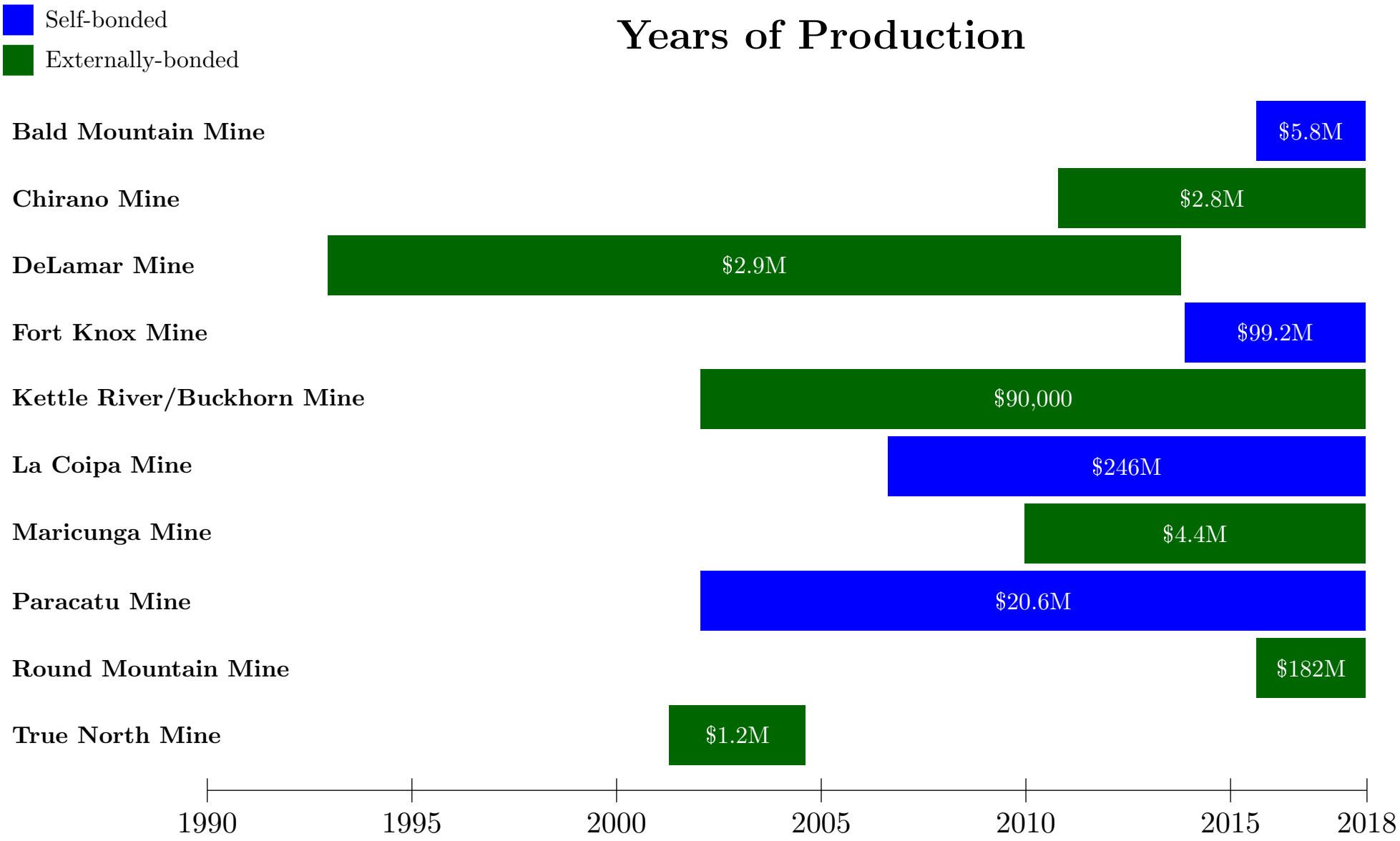
A self-bonded mine is defined as any mine that was permitted in a jurisdiction and during a time period in which self-bonds were considered an acceptable form of financial assurance.

$\Rightarrow$ If a firm can self-bond, it does self-bond.

$\Rightarrow$ All other mines defined as externally-bonded.

- Must be bonded with collateral.
- Options include surety bond, collateral bond, letter of credit.

Kinross Gold Example



Empirical Measures

Short-hand notation:

$$\text{SB}_t = \sum_{i \in \text{P,S}} E[\text{Reclamation liability}_{it}]$$

$$\text{EB}_t = \sum_{i \in \text{P,E}} E[\text{Reclamation liability}_{it}]$$

where P represents producing mines, S represents self-bonded mines, and E represents externally-bonded mines.

Empirical Measures

Measure 1

$$\text{Liability/MV} = \frac{\text{Liability}}{\text{Market value of assets}}$$

where Liability = Traditional debt (TD), SB, or EB

$\Rightarrow$ "Leverage" ratios

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Measure 2

$$\mathbb{1}_{\text{Liability} \geq NPV} = 1 \text{ if Liability} \geq \text{NPV and 0 otherwise}$$

where Liability = Traditional debt (TD), SB, or EB

$\Rightarrow$ Identifies Myers' "wedge" in baseline model

Measuring Investment

$\Rightarrow$ Discrete investment in new mineral projects.

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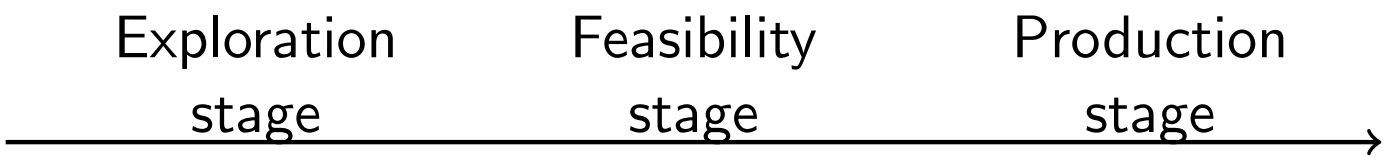

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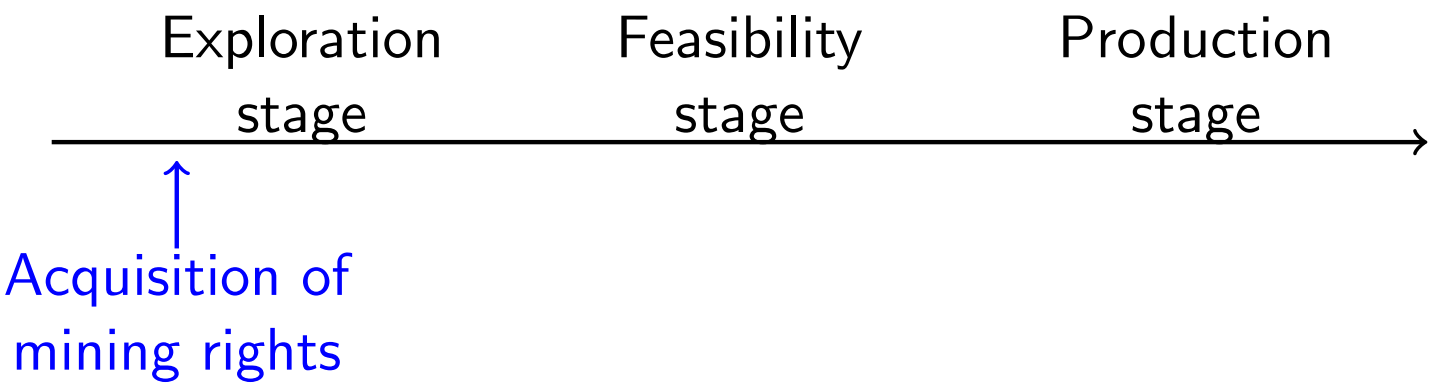

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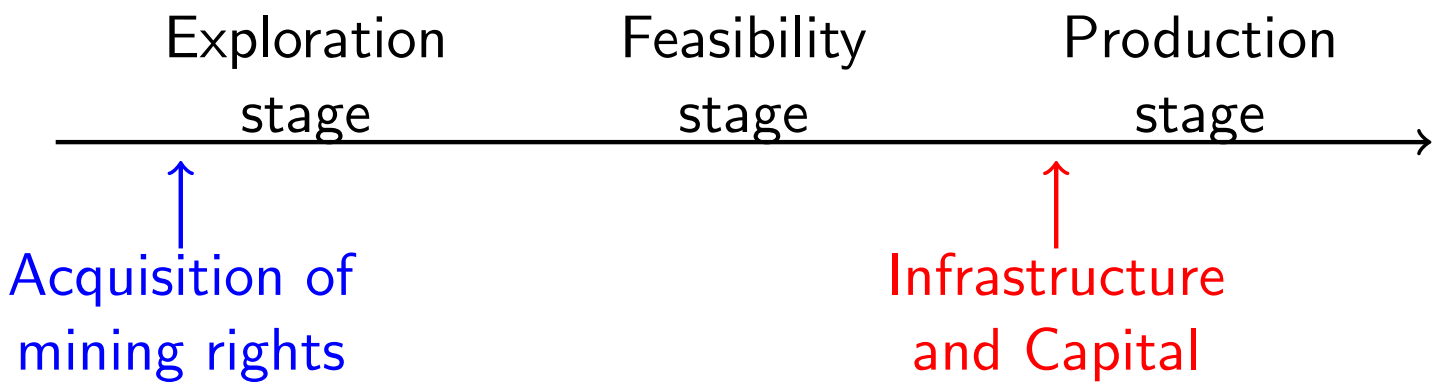

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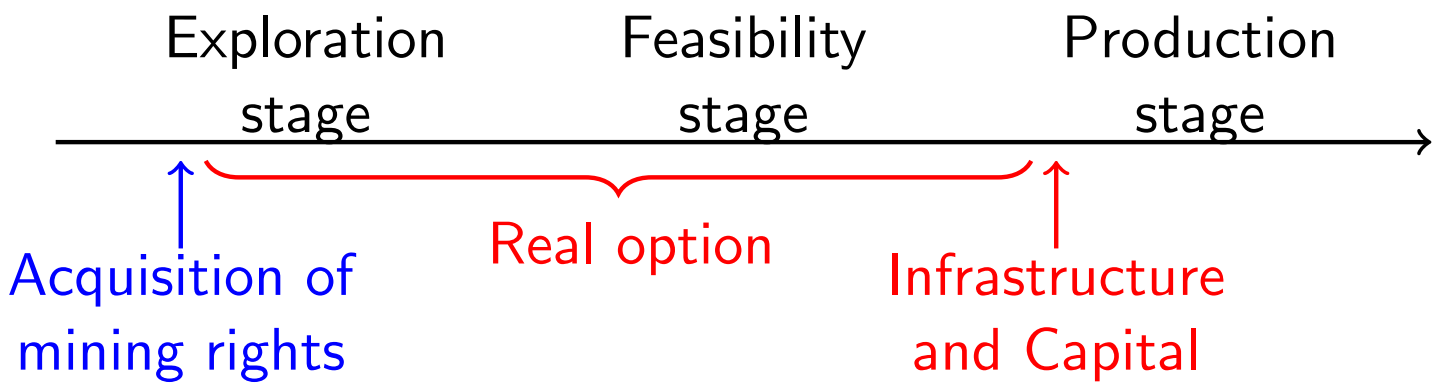

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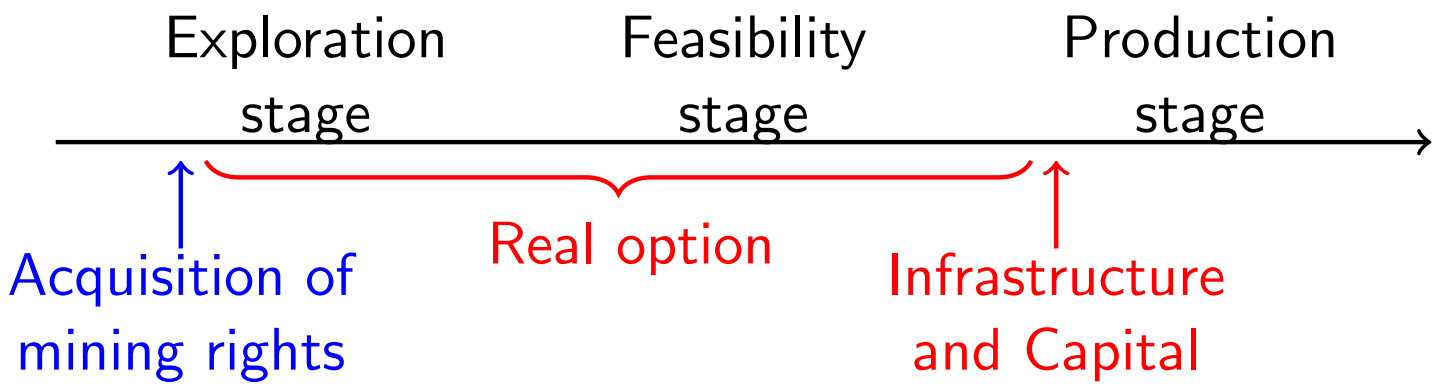

Debt overhang theory

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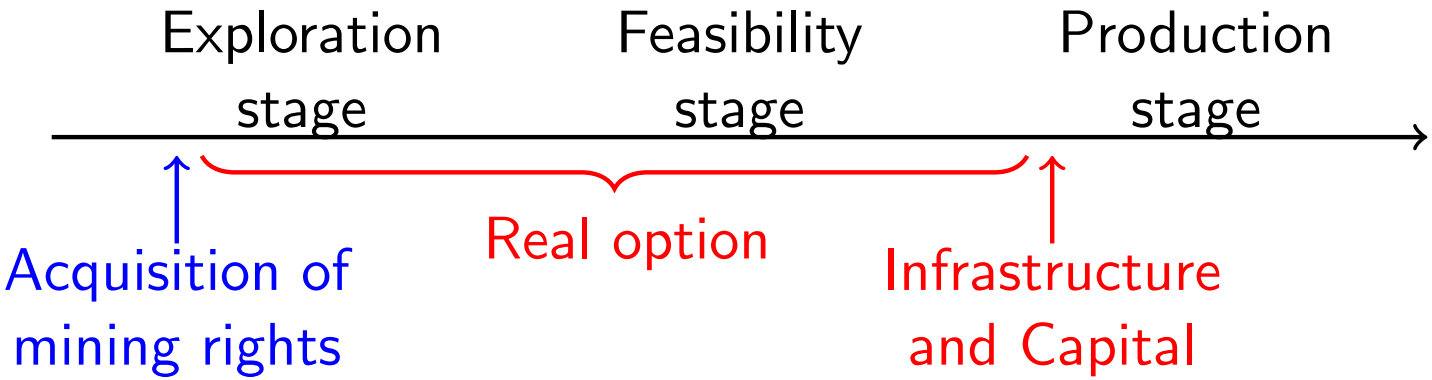

Debt overhang theory

Expiring growth options
Myers (1977)

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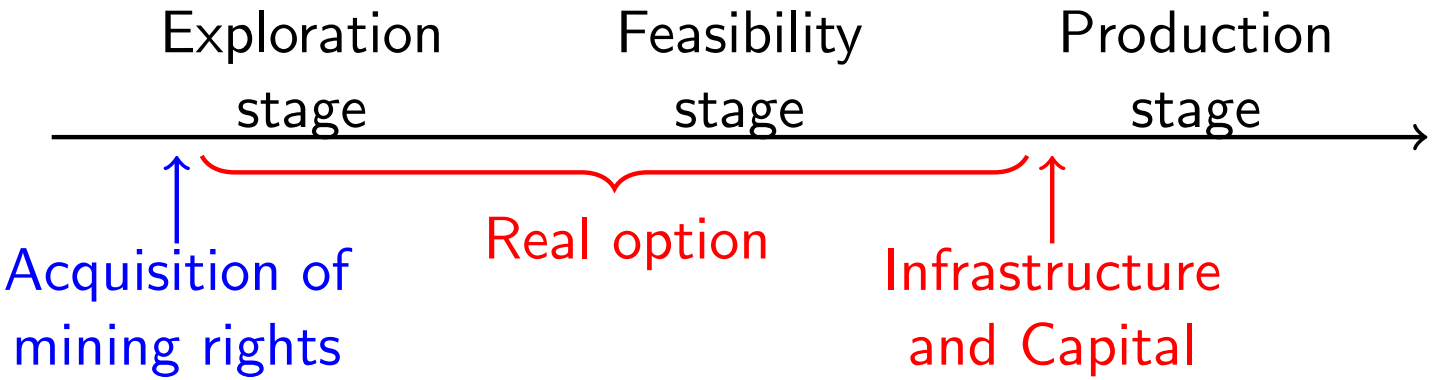

Debt overhang theory

Expiring growth options
Myers (1977)

Real options
Mello and Parsons (1992),
Mauer and Ott (2000)

Acquire new mining rights

$$\text{Acquire rights} = \alpha + \beta_L \underbrace{\textit{Liability}}_{\text{Liability/Market value of assets}} + \beta_X X + \gamma_{i,t} + \epsilon$$

Dependent variable =	Likelihood of acquiring rights to any project			Likelihood of acquiring rights to NPV+ projects		
	(1)	(2)	(3)	(4)	(5)	(6)
SB/MV	-0.030***	-0.035**	-0.005**	-0.022***	-0.025***	-0.004***
	(0.009)	(0.015)	(0.002)	(0.008)	(0.006)	(0.001)
EB/MV	0.002	0.003	0.005	0.001	0.001	0.001
	(0.003)	(0.003)	(0.004)	(0.001)	(0.001)	(0.001)
Market leverage	-0.046	-0.057*	-0.011*	-0.014	-0.027	-0.002
	(0.031)	(0.032)	(0.007)	(0.015)	(0.019)	(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls	No	Yes	Yes	No	Yes	Yes
Number of firms	790	775	775	790	775	775
Observations	7,083	6,747	6,747	7,083	6,747	6,747
R^2	0.275	0.301	0.301	0.128	0.166	0.165

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Impact is larger for traditional debt when considering all projects.

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Conditional on positive NPV projects, only SB has an impact.

Acquire new mining rights

Acquire rights = Dependent variables normalized by their mean and standard deviation. $\gamma_{i,t} + \epsilon$

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Mining Projects as Real Options

In a real options framework, Mello and Parsons (1992) and Mauer and Ott (2000) show that debt overhang arises from suboptimal operating decisions.

$\Rightarrow$ Delay (re)opening and exercising the option to expand

Project-level data

Variable	Obs.	Mean	Median	Min	Max
First estimated NPV ($Ms)	269	402.4	172	-48.9	7114.6
First estimated capital costs ($Ms)	269	535.7	223	1.2	7899.0
Discount rate used (%)	269	6.8	7.5	5	15
Estimated mine life (years)	269	14.1	11	1	50
Projects undertaken by 2016 (%)	269	0.283			
$\mathbb{1}_{SB \geq NPV}$	269	0.043	0	0	1
$\mathbb{1}_{EB \geq NPV}$	269	0.072	0	0	1
$\mathbb{1}_{TD \geq NPV}$	269	0.177	0	0	1


Canada
ALBERTA
MANITOBA
BRITISH COLUMBIA
SASKATCHEWAN
ONTARIO
QUEBEC
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
Ottawa
Montreal
SOUTH DAKOTA
WISCONSIN
MAIN
VT
OREGON
IDAHO
WYOMING
MICHIGAN
Toronto
NH
NEW YORK
Chicago
MA
IOWA
CT RI
NEBRASKA
ILLINOIS
OHIO
PENN
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UTAH
COLORADO
KANSAS
MISSOURI
WEST VIRGINIA
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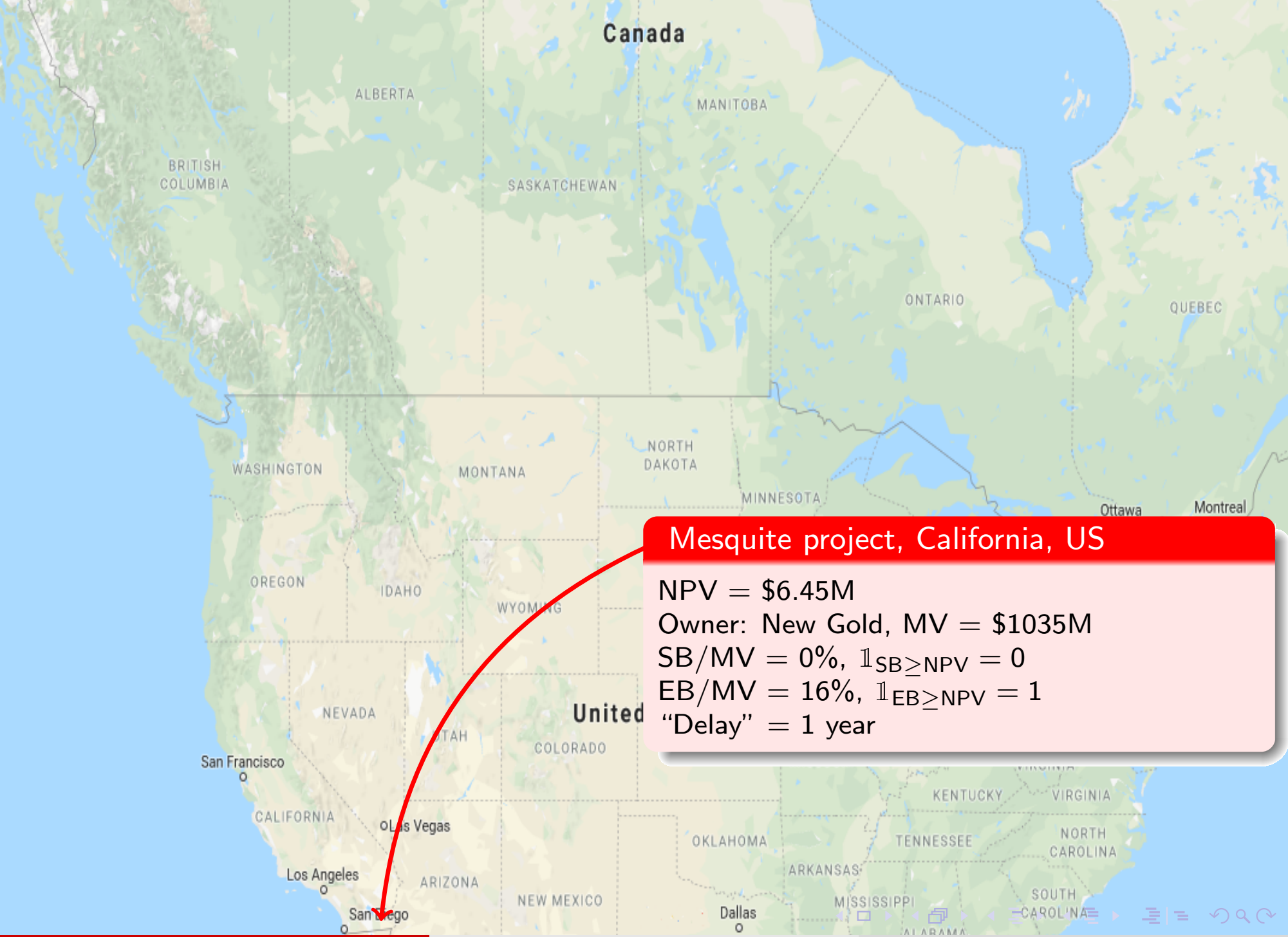

Mesquite project, California, US

NPV = \$6.45M
Owner: New Gold, MV = \$1035M
SB/MV = 0%, $\mathbb{1}_{SB \geq NPV} = 0$
EB/MV = 16%, $\mathbb{1}_{EB \geq NPV} = 1$
"Delay" = 1 year

Monument Bay project, Manitoba, CA

NPV = \$6.51M
Owner: Yamana Gold, MV = \$1677M
SB/MV = 9.6%, $\mathbb{1}_{\text{SB}\geq\text{NPV}} = 1$
EB/MV = 0.6%, $\mathbb{1}_{\text{EB}\geq\text{NPV}} = 1$
"Delay" = 4+ years

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EB/MV = 16%, $\mathbb{1}_{\text{EB}\geq\text{NPV}} = 1$
"Delay" = 1 year

Mining Projects as Real Options

$$\text{Begin construction} = \alpha + \beta_L \underbrace{\textit{Liability}}_{\text{Liability/Market value of assets}} + \beta_X X + \gamma_{i,t} + \epsilon$$

	Likelihood of beginning construction on an NPV+ project				
	(1)	(2)	(3)	(4)	(5)
SB/MV	-0.046***	-0.054***	-0.055***	-0.048**	-0.124***
	(0.014)	(0.014)	(0.016)	(0.020)	(0.024)
EB/MV	0.020	0.003	0.011	0.012	0.122
	(0.061)	(0.062)	(0.125)	(0.132)	(0.137)
Market leverage	0.010	-0.007	-0.030	-0.038	-0.070
	(0.058)	(0.056)	(0.057)	(0.060)	(0.069)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Primary mineral FE	No	No	No	Yes	Yes
Controls	None	Accounting + Project + IOS	Accounting + Project + IOS + Mineral price	Accounting + Project + IOS + Futures price	Accounting + Project + IOS + Futures price + Volatility
Number of firms	177	174	143	140	126
Observations	838	822	679	662	589
R^2	0.289	0.299	0.294	0.296	0.306

Robustness FE | Robustness permitting

Mining Projects as Real Options

$$\text{Begin construction} = \alpha + \beta_L \underbrace{\textit{Liability}}_{\text{Liability/Market value of assets}} + \beta_X X + \gamma_{i,t} + \epsilon$$

	Likelihood of beginning construction on an NPV+ project				
	(1)	(2)	(3)	(4)	(5)
SB/MV	-0.046***	-0.054***	-0.055***	-0.048**	-0.124***
	(0.014)	(0.014)	(0.016)	(0.020)	(0.024)
EB/MV	0.020	0.003	0.011	0.012	0.122
	(0.061)	(0.062)	(0.125)	(0.132)	(0.137)
Market leverage	0.010	-0.007	-0.030	-0.038	-0.070
	(0.058)	(0.056)	(0.057)	(0.060)	(0.069)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year F		Yes	Yes	Yes	Yes
Primar		No	No	Yes	Yes
Contro		Accounting + Project + IOS	Accounting + Project + IOS Mineral price	Accounting + Project + IOS + Futures price	Accounting + Project + IOS + Futures price + Volatility
Number of firms	177	174	143	140	126
Observations	838	822	679	662	589
R^2	0.289	0.299	0.294	0.296	0.306

Robust to other factors affecting the optimal trigger.

Robustness FE | Robustness permitting

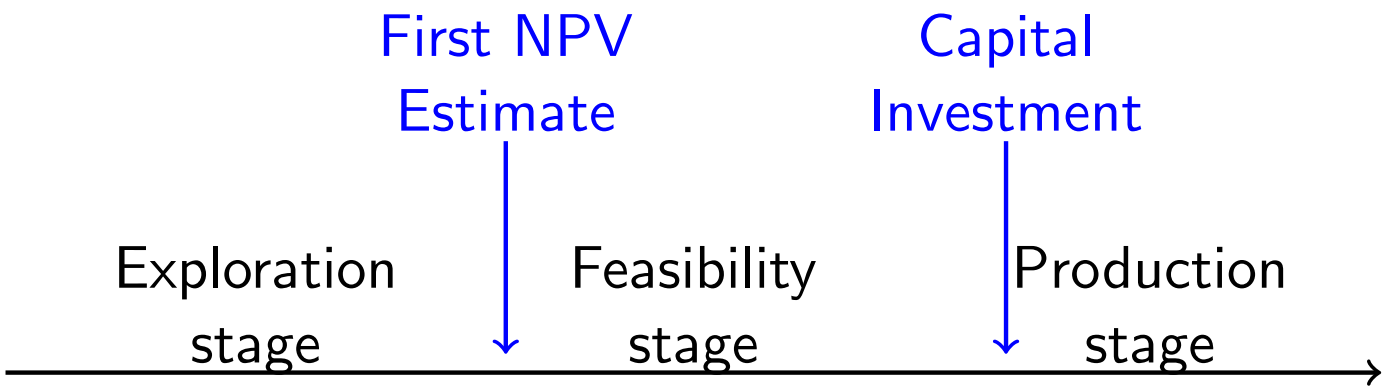
Mining Projects as Real Options

$$\text{Begin construction} = \alpha + \beta_L \underbrace{\textit{Liability}}_{\text{Indicator variable =1 if Liability} \geq \text{ Estimated NPV}} + \beta_X X + \gamma_{i,t} + \epsilon$$

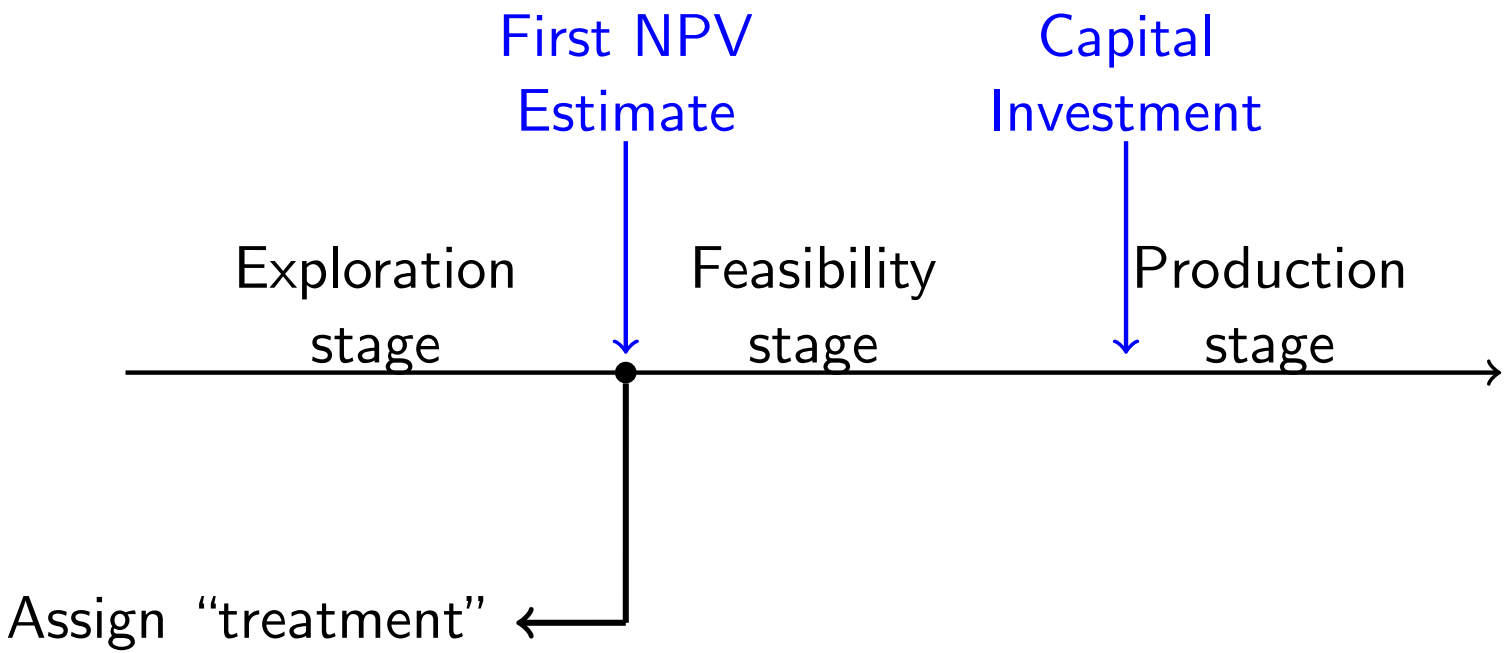
	Likelihood of beginning construction on an NPV+ project				
	(1)	(2)	(3)	(4)	(5)
$\mathbb{1}_{SB \geq NPV}$	-0.232**	-0.264**	-0.269**	-0.243**	-0.378*
	(0.116)	(0.109)	(0.106)	(0.106)	(0.222)
$\mathbb{1}_{EB \geq NPV}$	0.013	-0.019	0.001	0.024	0.046
	(0.072)	(0.082)	(0.086)	(0.097)	(0.104)
$\mathbb{1}_{TD \geq NPV}$	-0.018	-0.034	-0.028	-0.043	-0.040
	(0.066)	(0.070)	(0.071)	(0.074)	(0.075)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Primary mineral FE	No	No	No	Yes	Yes
Controls	None	Accounting + Project + IOS	Accounting + Project + IOS + Mineral price	Accounting + Project + IOS + Futures price	Accounting + Project + IOS + Futures price + Volatility
Number of firms	177	174	143	140	126
Observations	838	822	679	662	589
R^2	0.290	0.300	0.295	0.297	0.300

Robustness FE | Robustness permitting

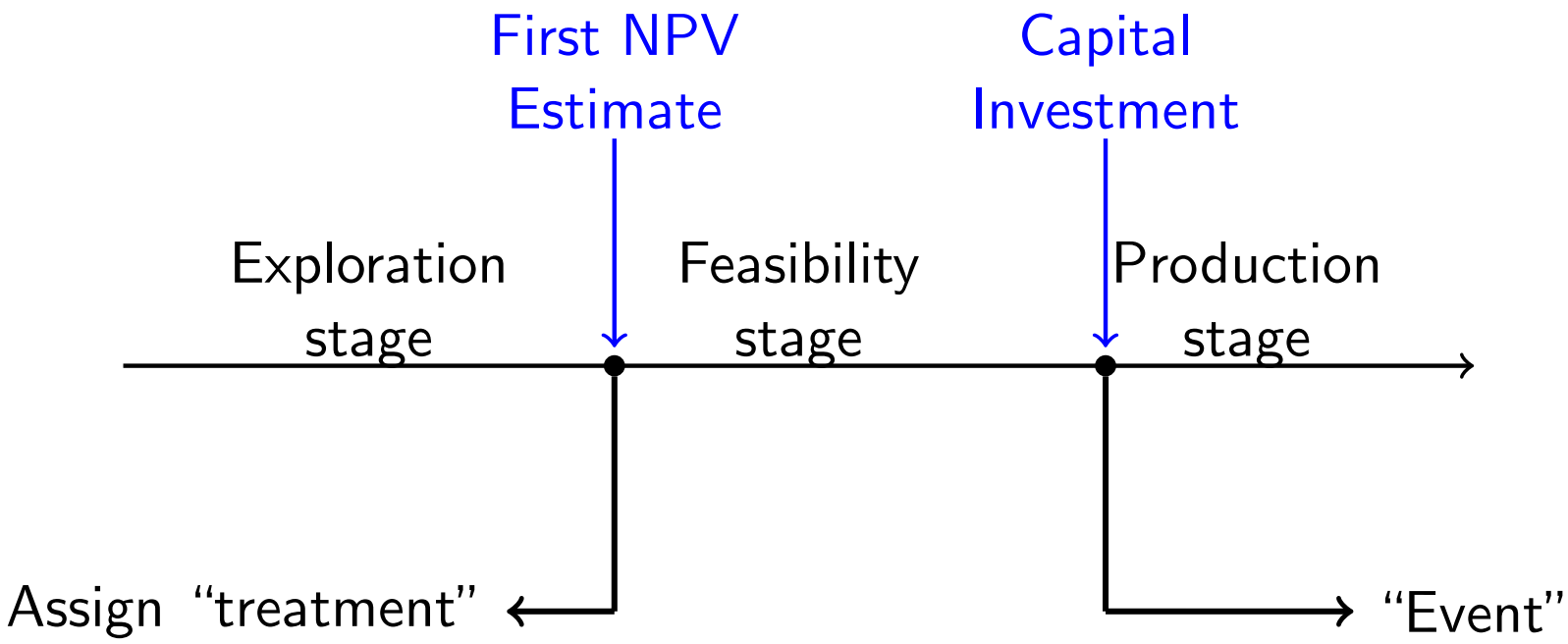
Survival Analysis



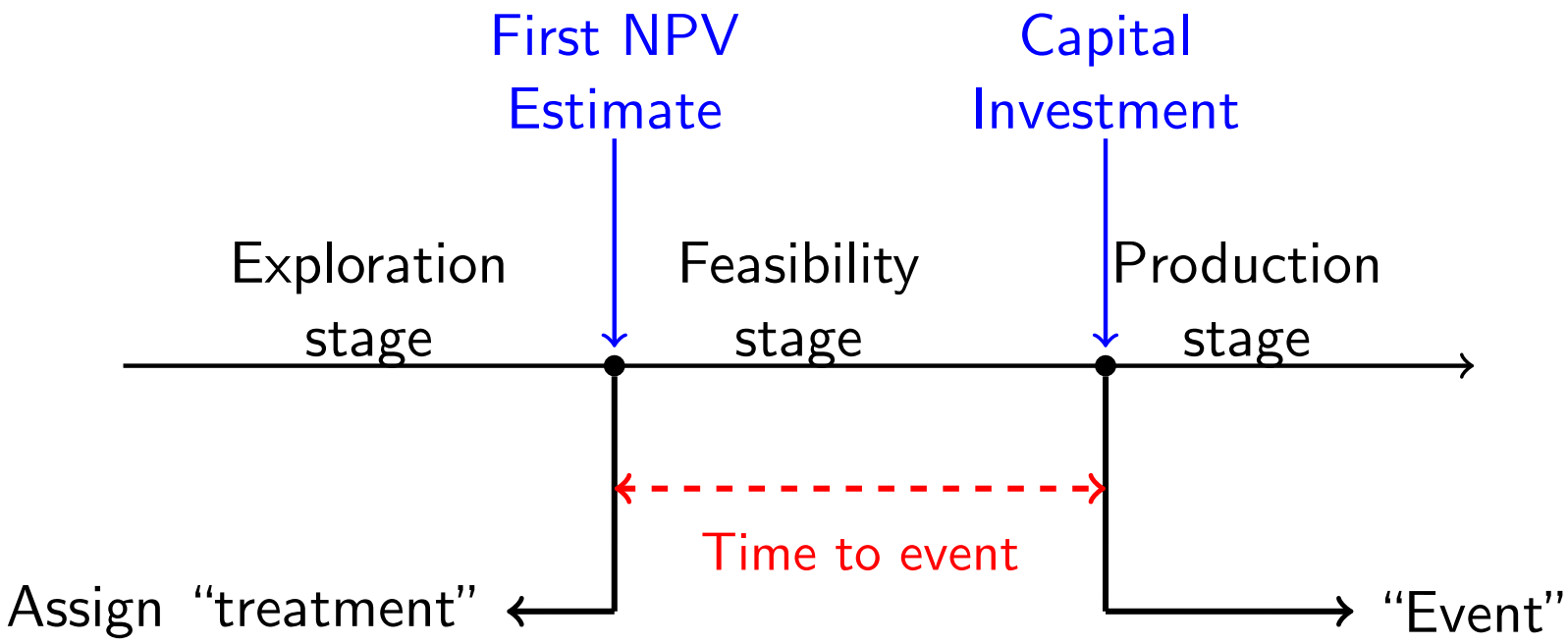
Survival Analysis

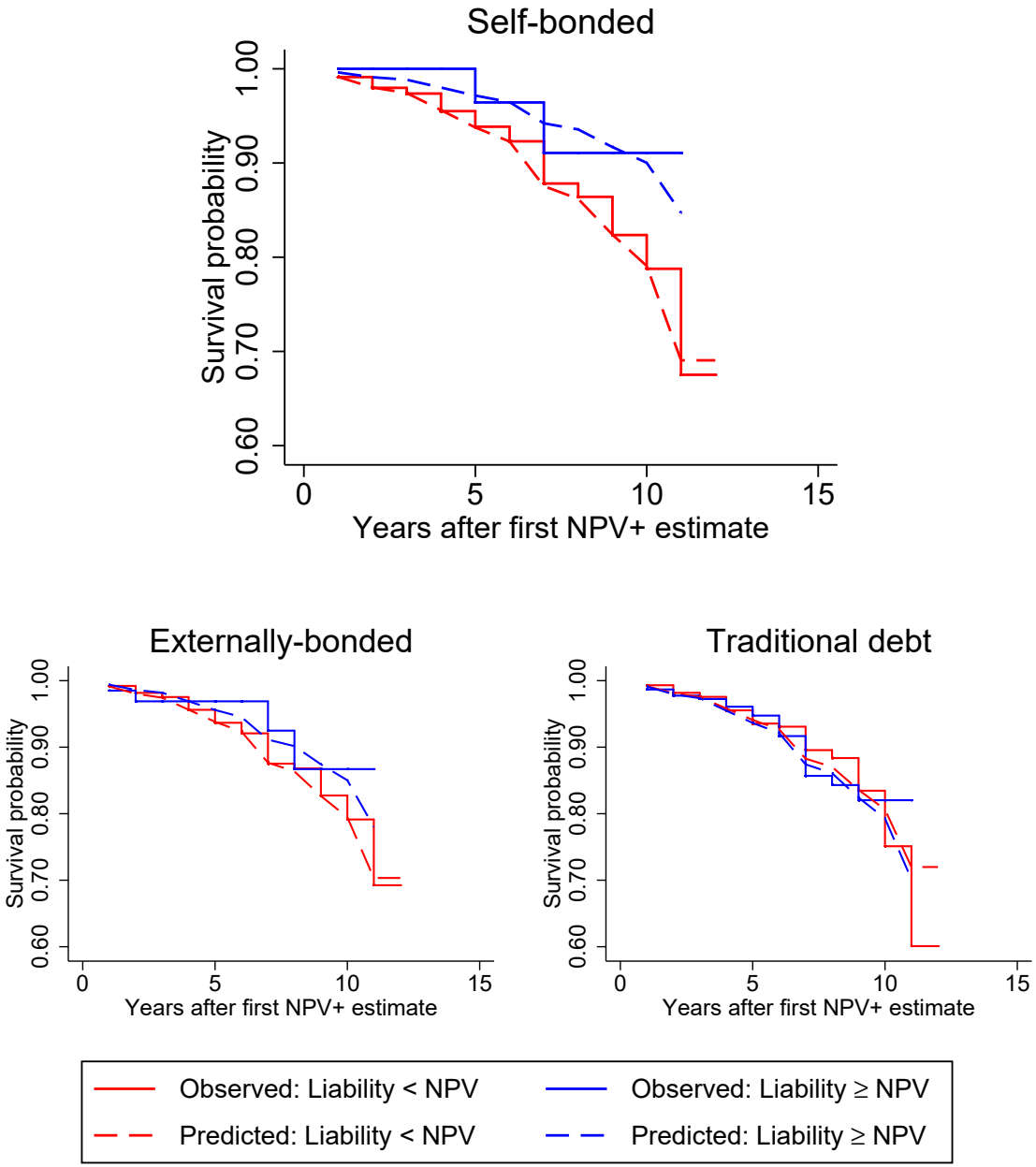


Survival Analysis



Survival Analysis




Self-bonded
Survival probability
1.00
0.90
0.80
0.70
0.60
0
5
10
15
Years after first NPV+ estimate
Externally-bonded
Traditional debt
Observed: Liability < NPV
Predicted: Liability < NPV
Observed: Liability ≥ NPV
Predicted: Liability ≥ NPV

$$\lambda_i(t|x_i) = \lambda_0(t)\exp\{\beta_L \underbrace{Liability}\}\exp\{\beta_X X\}$$

Indicator variable =1 if Liability $\geq$ Estimated NPV

	Survival analysis				
	(1)	(2)	(3)	(4)	(5)
$\mathbb{1}_{SB \geq NPV}$	0.329***	0.433**	0.467**	0.476**	0.470**
	(0.121)	(0.162)	(0.167)	(0.173)	(0.163)
$\mathbb{1}_{EB \geq NPV}$	0.709	0.800	0.864	0.889	0.643
	(0.380)	(0.447)	(0.479)	(0.496)	(0.373)
$\mathbb{1}_{LTD \geq NPV}$	0.917	0.834	0.867	0.866	0.866
	(0.289)	(0.307)	(0.314)	(0.313)	(0.315)
Year FE	Yes	Yes	Yes	Yes	Yes
Primary mineral FE	Yes	Yes	Yes	Yes	Yes
Project controls	No	Yes	Yes	Yes	Yes
Time-varying controls	None	Accounting + IOS	Accounting + IOS Mineral price	Accounting + IOS + Futures price	Accounting + IOS + Futures price + Volatility
Number of firms	191	189	158	155	144
Observations	955	944	823	811	754
Psuedo-R^2	0.108	0.126	0.113	0.114	0.125

Costs of Overhang

Firms exposed to overhang from reclamation liabilities incur:

- $\Rightarrow$ Costs of forgoing mining projects
- $\Rightarrow$ Costs of delaying mining projects

Costs of Overhang

Firms exposed to overhang from reclamation liabilities incur:

- $\Rightarrow$ Costs of forgoing mining projects $=$ 2.27% of firm value
- $\Rightarrow$ Costs of delaying mining projects $=$ 4.00% of firm value

Risky Liabilities

Dependent variable =	Acquire rights		Begin construction			
	(1)	(2)	(3)	(4)	(5)	(6)
SB/MV	-0.023***	-0.025***	-0.058***	-0.054***		
	(0.007)	(0.006)	(0.012)	(0.014)		
$\mathbb{1}_{SB \geq NPV}$					-0.414***	-0.284*
					(0.157)	(0.148)
SB/MV × downgrade period		-0.161***		-0.368**		
		(0.053)		(0.141)		
$\mathbb{1}_{SB \geq NPV}$ × downgrade period						-0.170*
						(0.097)
Downgrade period		0.002		0.005		0.028
		(0.003)		(0.020)		(0.085)
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of firms	756	775	170	174	170	174
Observations	6,361	6,747	791	822	791	822
R^2	0.133	0.167	0.312	0.300	0.312	0.302

Risky Liabilities

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	(1)	(2)	(3)	(4)	(5)	(6)
SB/MV	-0.023***	-0.025***	-0.058***	-0.054***		
	(0.007)	(0.006)	(0.012)	(0.014)		
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$\mathbb{1}_{SB \geq NPV}$ × downgrade period						-0.170*
						(0.097)
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		(0.003)		(0.020)		(0.085)
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of firms	756	775	170	174	170	174
Observations	6,361	6,747	791	822	791	822
R^2			2	0.300	0.312	0.302

Simliar results when excluding firms with investment grade bonds.

Risky Liabilities

Dependent variable =	Acquire rights		Begin construction			
	(1)	(2)	(3)	(4)	(5)	(6)
SB/MV	-0.023***	-0.025***	-0.058***	-0.054***		
	(0.007)	(0.006)	(0.012)	(0.014)		
$\mathbb{1}_{SB \geq NPV}$					-0.414***	-0.284*
					(0.157)	(0.148)
SB/MV × downgrade period		-0.161***		-0.368**		
		(0.053)		(0.141)		
$\mathbb{1}_{SB \geq NPV}$ × downgrade period						-0.170*
						(0.097)
Downgrade period		0.002		0.005		0.028
		(0.003)		(0.020)		(0.085)
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of firms	756	775	170	174	170	174
Observations	6,361	6,747	791	822	791	822
R^2	0.133	0.167	0.312	0.300	0.312	0.302

More pronounced during periods around credit downgrades.

Robustness

TSX and TSXV CapEx Replications

Dependent variable =	Capital expenditures			
	(1)	(2)	(3)	(4)
SB/MV	-0.023***	-0.022***	-0.022***	-0.021***
	(0.003)	(0.003)	(0.003)	(0.003)
EB/MV	-0.004***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Market leverage	-0.022	-0.038**	-0.028	-0.033*
	(0.017)	(0.017)	(0.017)	(0.018)
Market leverage × Tobin's Q			-0.003**	
			(0.001)	
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Accounting controls	No	Yes	Yes	Yes
Number of firms	790	775	775	764
Observations	7,029	6,697	6,697	5,904
R^2	0.354	0.387	0.388	0.415

Robustness

TSX and TSXV CapEx Replications

Dependent variable =	Capital expenditures			
	(1)	(2)	(3)	(4)
SB/MV	-0.023***	-0.022***	-0.022***	-0.021***
	(0.003)	(0.003)	(0.003)	(0.003)
EB/MV	-0.004***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Market leverage	-0.022	-0.038**	-0.028	-0.033*
	(0.017)	(0.017)	(0.017)	(0.018)
Market leverage × Tobin's Q			-0.003**	
			(0.001)	
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Accountir	No	Yes	Yes	Yes
Number of firms	790	775	775	764
Observations	7,029	6,697	6,697	5,904
R^2	0.354	0.387	0.388	0.415

Often interpreted as "debt overhang".

Robustness

U.S. Voluntary Disclosure in Annual Reports

Dependent variable =	Capital expenditures			
	(1)	(2)	(3)	(4)
SB/MV	0.080*	-0.112**		
	(0.040)	(0.043)		
EB/MV	-0.016	-0.011		
	(0.014)	(0.008)		
$\mathbb{1}_{SB \geq 0}$			-0.016***	-0.022***
			(0.004)	(0.008)
Market leverage	-0.037	-0.002	-0.040	-0.015
	(0.028)	(0.032)	(0.026)	(0.028)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Accounting Controls	No	Yes	No	Yes
Number of firms	39	39	42	42
Observations	338	338	359	359
R^2	0.621	0.680	0.629	0.682

Robustness

U.S. Mine Safety and Health Administration (MSHA)

Dependent variable =	Capital expenditures		Pr(new mine)
	(1)	(2)	(3)
# of self-bonded mines	-0.003*	-0.003*	-0.015**
	(0.002)	(0.001)	(0.006)
# of externally-bonded mines	0.003*	0.003**	0.016***
	(0.001)	(0.001)	(0.006)
Market leverage	-0.026*	-0.009	
	(0.012)	(0.012)	
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Additional Controls	No	Yes	No
Number of firms	120	120	4,983
Observations	1,453	1,453	33,876
R^2	0.559	0.585	0.238

Conclusions

Firms' traditional debt is unrelated to the propensity to postpone or forgo positive NPV mining projects.

$\Rightarrow$ Even when the same firms' leverage ratios are negatively correlated with capital expenditures

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$\Rightarrow$ Suggests that financial contracting and debt composition is important

Conclusions

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Does this imply that debt overhang is not empirically important?

$\Rightarrow$ No, liabilities with high costs of avoidance provide a benchmark result.

$\Rightarrow$ Suggests that financial contracting and debt composition is important

Overhang associated with traditional debt **does** matter, with costs up to 6.27% of firm value.

Mine reclamation

Mine reclamation is the process of restoring land that has been mined to a natural or economically usable state.

Back

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Back

Initial NPV estimate event study

Dependent variable =	CAR[0,1]	CAR[-1,1]	CAR[0,5]	CAR[0,1]	CAR[-1,1]	CAR[0,5]
	(1)	(2)	(3)	(4)	(5)	(6)
NPV/Market capitalization$_{t-1}$	0.0014***	0.0012***	0.0015***	0.0014***	0.0012***	0.0014***
	(0.0003)	(0.0002)	(0.0004)	(0.0003)	(0.0002)	(0.0004)
Constant	-0.0092	-0.0039	-0.0116	-0.0087	-0.0020	-0.0095
	(0.0085)	(0.0088)	(0.0131)	(0.0085)	(0.0088)	(0.0131)
Model	3-factor	3-factor	3-factor	5-factor	5-factor	5-factor
Primary mineral FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	141	141	141	141	141	141
R^2	0.250	0.227	0.373	0.250	0.238	0.380

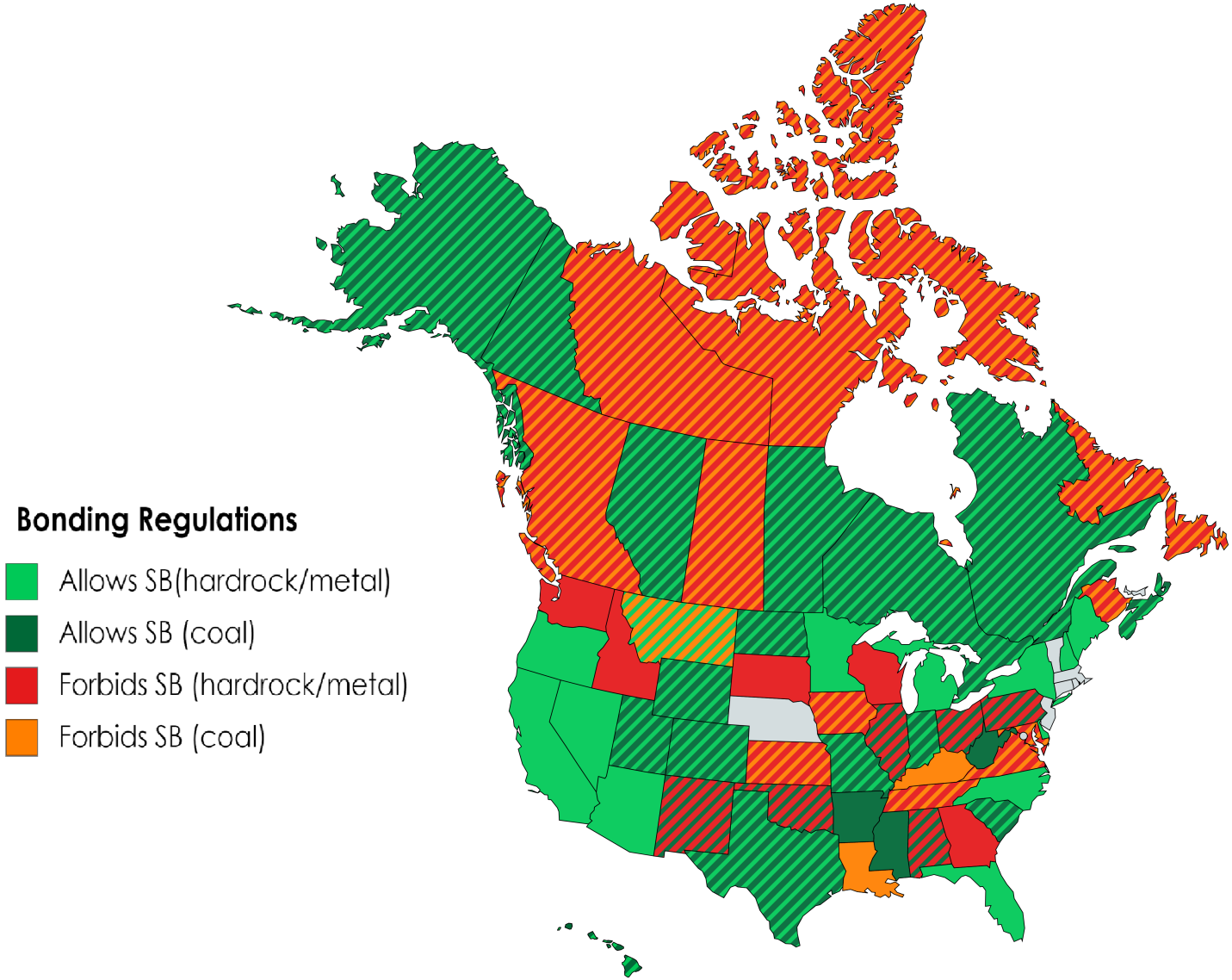
Back

Ex ante costs of financial assurance

1. Surety bond
   - ⇒ Annual premiums from 1-3.5% (Kuipers (2000)) to 5-6% (Chelimsky (1988))
   - ⇒ Collateral requirement of up to 100% (Chelimsky (1988))
2. Letter of credit
   - ⇒ Negligible premiums
   - ⇒ Collateral requirement from 120-200% (Kirschner and Grandy (2003))
3. Collateral bond
   - ⇒ Collateral requirement of 100%

Back

Bonding Regulations - US and Canada



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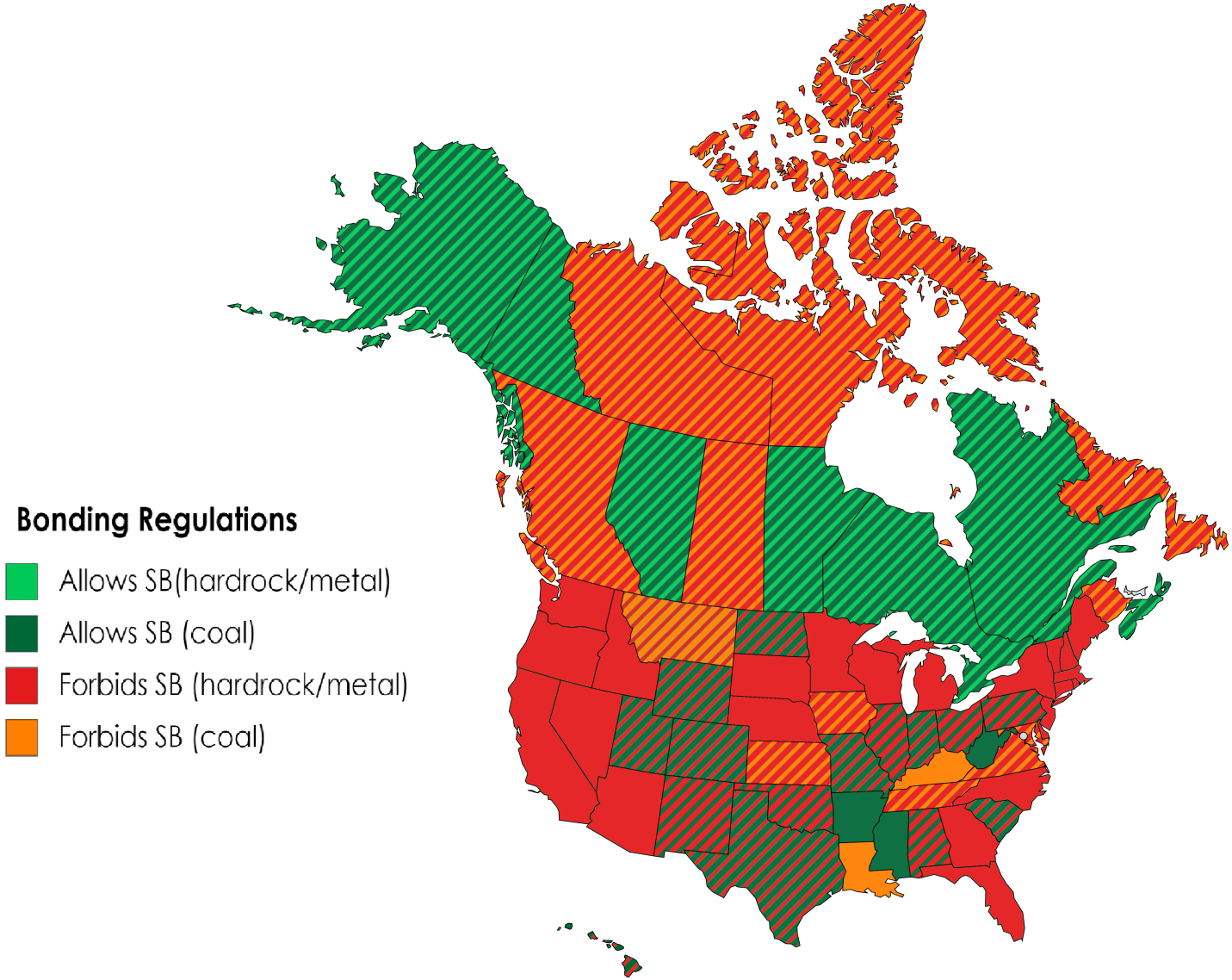
Bonding Regulations - US and Canada



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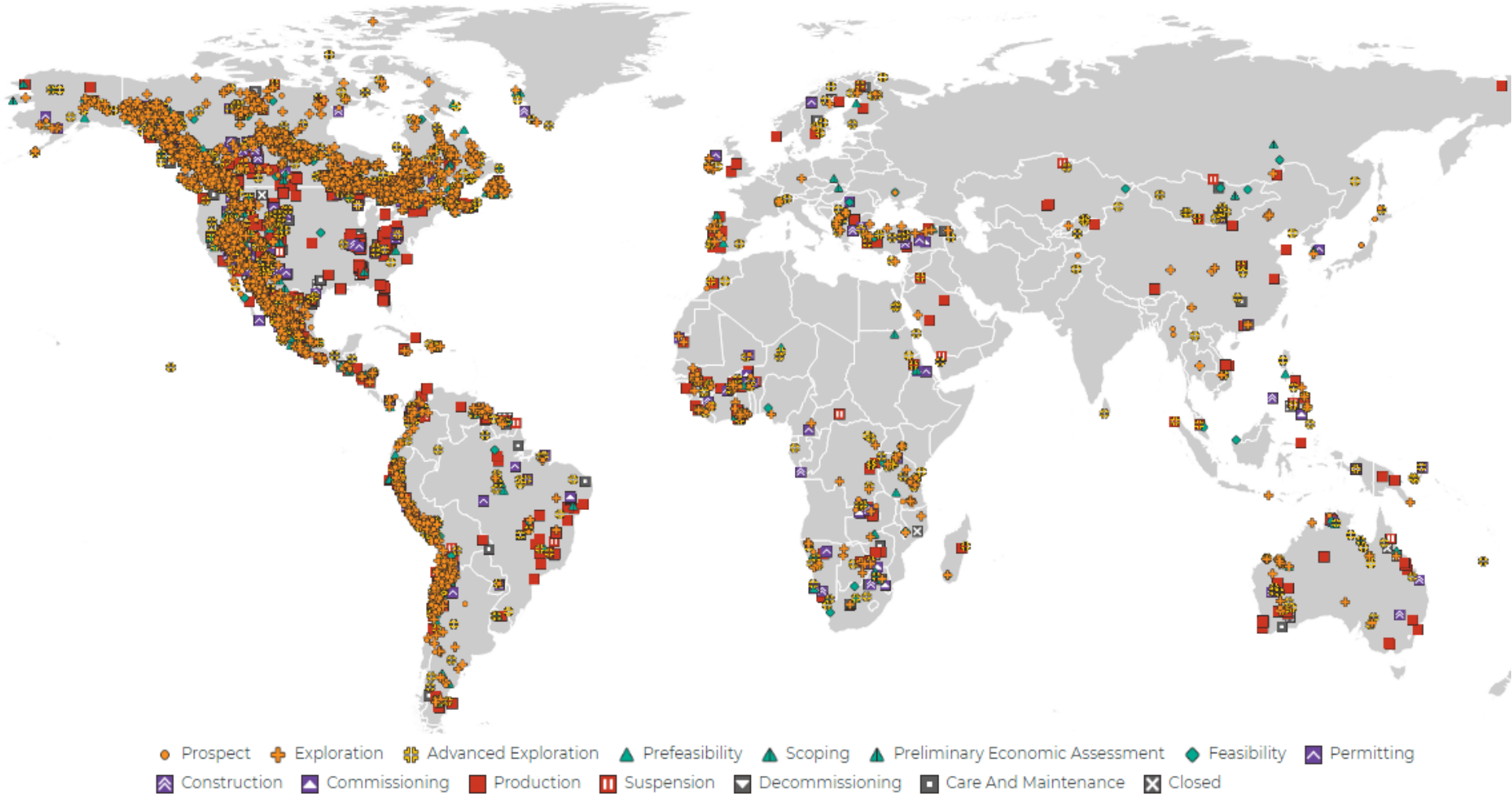
Map of Mines



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Robustness to fixed effects

Dependent variable =	Likelihood of beginning construction on an NPV+ project			
	(1)	(2)	(3)	(4)
SB/MV	-0.053***	-0.053***	-0.054***	-0.136
	(0.013)	(0.013)	(0.014)	(0.217)
EB/MV	-0.010	0.002	-0.007	0.034
	(0.059)	(0.062)	(0.060)	(0.088)
Market leverage	-0.015	-0.031	-0.003	-0.032
	(0.052)	(0.051)	(0.054)	(0.075)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No
State/Province FE	Yes	No	No	No
Country FE	No	Yes	No	No
Mine type FE	No	No	Yes	No
Primary mineral × year FE	No	No	No	Yes
Number of firms	170	173	174	165
Observations	809	820	822	755
R^2	0.371	0.330	0.315	0.375

Back

Robustness to permitting

	Likelihood of permitting an NPV+ project				
	(1)	(2)	(3)	(4)	(5)
SB/MV	-0.008	-0.009	-0.009	-0.005	-0.002
	(0.006)	(0.007)	(0.007)	(0.008)	(0.013)
EB/MV	0.019	0.011	0.035	0.014	0.027
	(0.032)	(0.033)	(0.058)	(0.067)	(0.069)
Market leverage	-0.034	-0.033	-0.043	-0.040	-0.034
	(0.046)	(0.040)	(0.040)	(0.040)	(0.043)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Primary mineral FE	No	No	No	Yes	Yes
Controls	None	Accounting + Project + IOS	Accounting + Project + IOS Mineral price	Accounting + Project + IOS + Futures price	Accounting + Project + IOS + Futures price + Volatility
Number of firms	177	174	143	140	126
Observations	838	822	679	662	589
R^2	0.198	0.209	0.222	0.233	0.240

Back

Robustness to permitting

	Likelihood of permitting an NPV+ project				
	(1)	(2)	(3)	(4)	(5)
$\mathbb{1}_{SB \geq NPV}$	-0.044	-0.009	-0.013	-0.026	-0.027
	(0.050)	(0.102)	(0.106)	(0.120)	(0.171)
$\mathbb{1}_{EB \geq NPV}$	0.006	0.021	0.031	0.029	0.053
	(0.048)	(0.055)	(0.058)	(0.061)	(0.070)
$\mathbb{1}_{TD \geq NPV}$	-0.042	-0.039	-0.035	-0.038	-0.045
	(0.036)	(0.037)	(0.037)	(0.038)	(0.040)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Primary mineral FE	No	No	No	Yes	Yes
Controls	None	Accounting + Project + IOS	Accounting + Project + IOS + Mineral price	Accounting + Project + IOS + Futures price	Accounting + Project + IOS + Futures price + Volatility
Number of firms	177	174	143	140	126
Observations	838	822	679	662	589
R^2	0.201	0.253	0.265	0.279	0.288

Back

Robustness to fixed effects

Dependent variable =	Likelihood of beginning construction on an NPV+ project			
	(5)	(6)	(7)	(8)
$\mathbb{1}_{SB \geq NPV}$	-0.445***	-0.298**	-0.230**	-0.171**
	(0.135)	(0.117)	(0.108)	(0.072)
$\mathbb{1}_{EB \geq NPV}$	0.101	-0.082	0.013	0.024
	(0.109)	(0.066)	(0.090)	(0.102)
$\mathbb{1}_{LTD \geq NPV}$	-0.060	-0.076	-0.026	-0.046
	(0.075)	(0.072)	(0.068)	(0.080)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No
State/Province FE	Yes	No	No	No
Country FE	No	Yes	No	No
Mine type FE	No	No	Yes	No
Primary mineral × year FE	No	No	No	Yes
Number of firms	170	173	174	165
Observations	813	824	826	759
R^2	0.373	0.334	0.314	0.374

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