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Climate Finance and Policy Group (D-GESS)

The Role of State Investment Banks for Renewable Energy Technologies in OECD Countries

Paul Waidelich, Bjarne Steffen

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European Commission

Agenda

1. Introduction and motivation
2. Hypothesis development
3. Data
4. Methodology
5. Results
6. Conclusion

Introduction and motivation

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Key characteristics of SIBs:

1) Publicly capitalized
(≠ private investment banks)

2) Independent day-to-day operations
(≠ public funds or mere loan programs)

3) Domestic focus of activities
(≠ export banks or development finance)

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- State investment banks (SIBs) increasingly used for renewable energy (RE) financing
- But: State-owned banks with well-known deficiencies (La Porta et al., 2022; Berger et al., 2005; Carvalho, 2014)
- No empirical assessments if SIBs' actual financing behavior lives up to the literature's recommendations

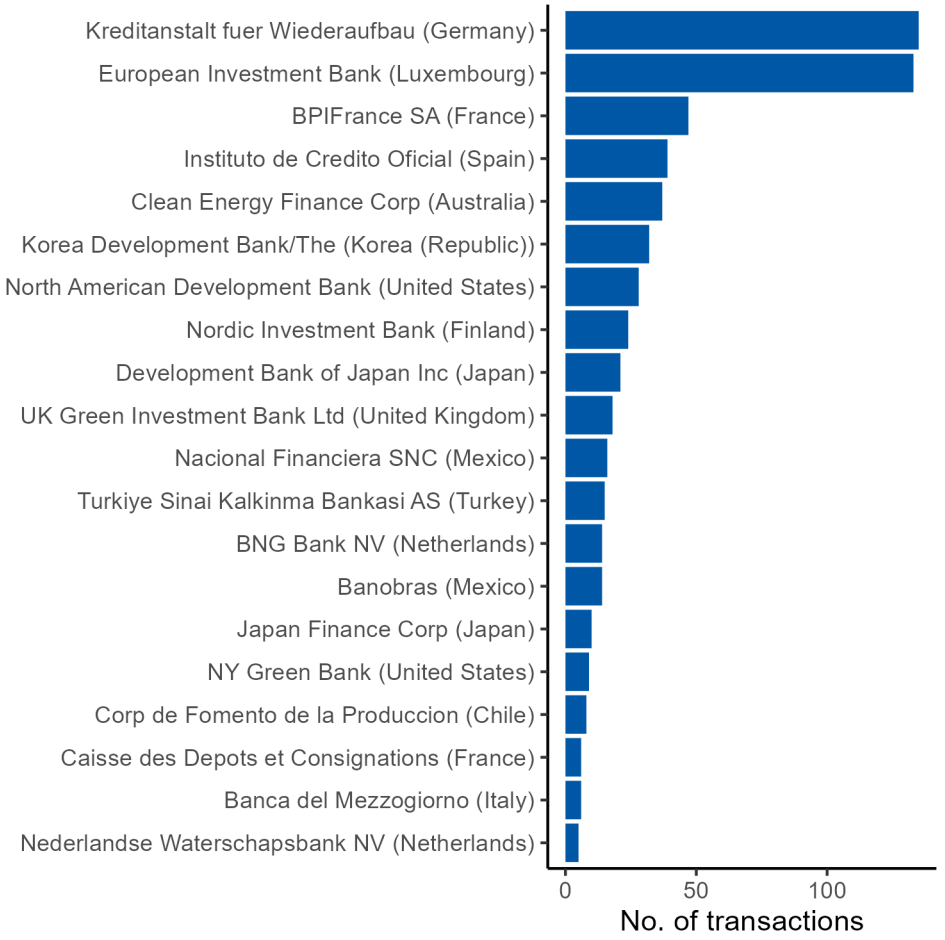
Research question: "*How does the financing behavior of SIBs with respect to RE technologies differ from that of private banks, and is that compatible with their intended role?*"

Hypothesis development (based on what SIBs *should* do)

- SIBs can provide financing to high-risk projects that, despite societal benefits, are not viable at the market rate
  - SIBs are state-backed in case of financial distress (Kornai et al., 2003)
  - Lower return expectations compared to private banks
- Technology is key determinant of RE project risk (Steffen, 2020), but technology risk decreases as deployment ramps up (Egli et al., 2018), hence SIBs should counter the maturity lifecycle (Waidelich et al., 2023; Torres & Zeidan, 2016)
  - **Hypothesis 1**: SIBs more likely to finance projects using higher-risk RE technologies
  - **Hypothesis 2**: SIBs more likely to finance projects if technology deployment is still low ("immature markets")
- Smaller deals imply higher transaction costs, making them less attractive for private banks and more likely to face limited credit access (Beck & Demirguc-Kunt, 2006; Iyer et al., 2014; Barbera et al., 2022)
  - **Hypothesis 3**: SIBs more likely to finance deals with smaller ticket sizes
- SIBs are supposed to mobilize the private sector co-financiers by vetting projects and signaling their commercial viability (OECD, 2016; Geddes et al., 2018), but risk of merely replacing private lenders remains
  - **Hypothesis 4**: SIBs more likely to engage in deals with more private sector lenders

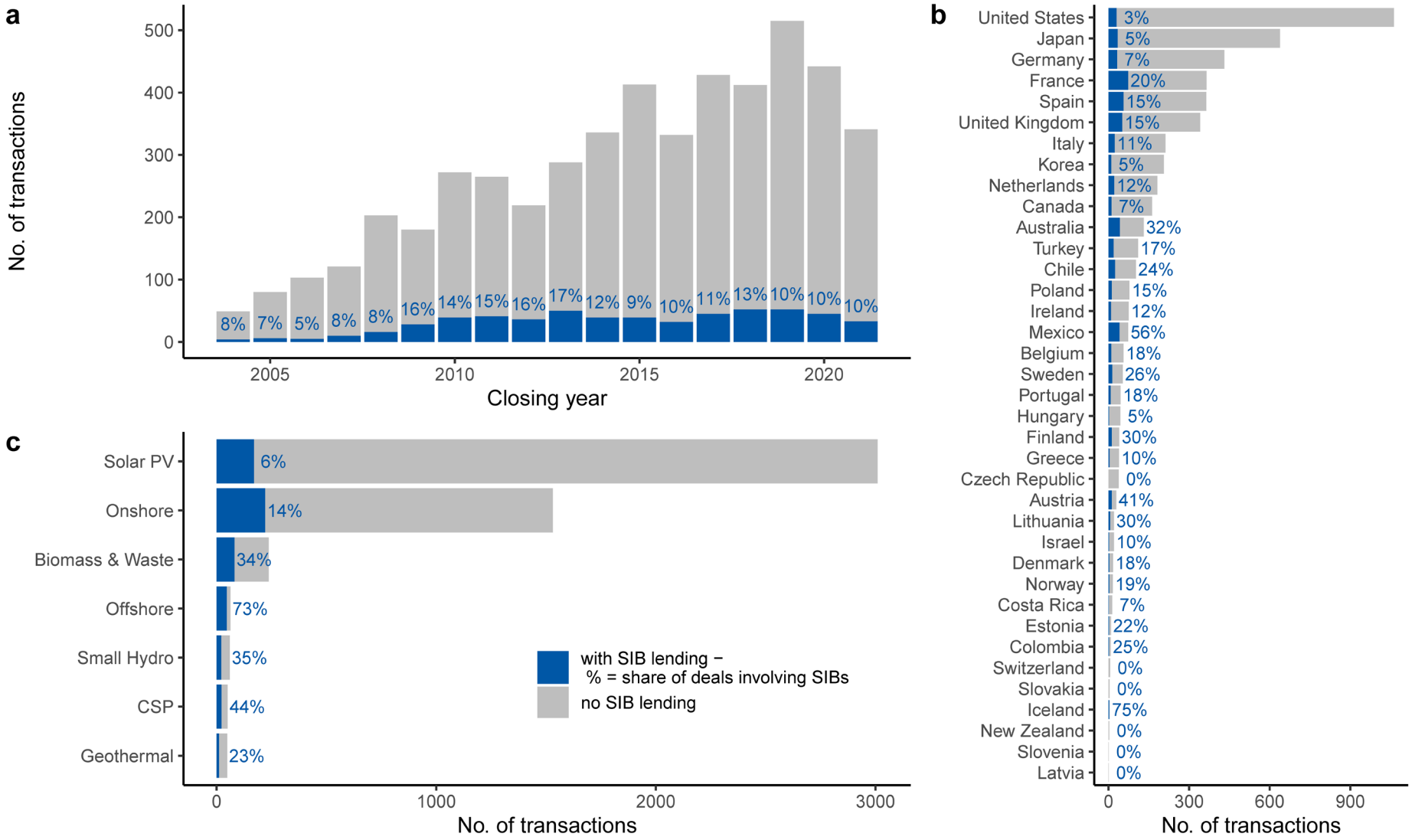
Data

- **Sample**: $N = 4{,}999$ debt financing deals for new-build RE projects in OECD countries that closed between 2004-2021 (source: Bloomberg NEF)
- **SIB whitelist**:
  1. All institutions from Global Database on Public Development Banks and Development Financing Institutions
     i) based in an OECD countries,
     ii) with a domestic scope of operations, and
     iii) a mandate that is either flexible or covers (domestic) RE
  2. Add further OECD-based institutions discussed in the extant SIB literature (OECD, 2017; Macfarlane and Mazzucato, 2018; Geddes et al., 2018; Degl'Innocenti et al., 2022) if they meet criteria above
  3. Add all SIB subsidiaries that are classified as financial sector companies in BNEF and active as RE lenders
- Resulting in 32 SIBs providing debt on 572 deals in our sample



Note: SIBs with less than five in-sample RE deals are not displayed

Sample overview



Methodology

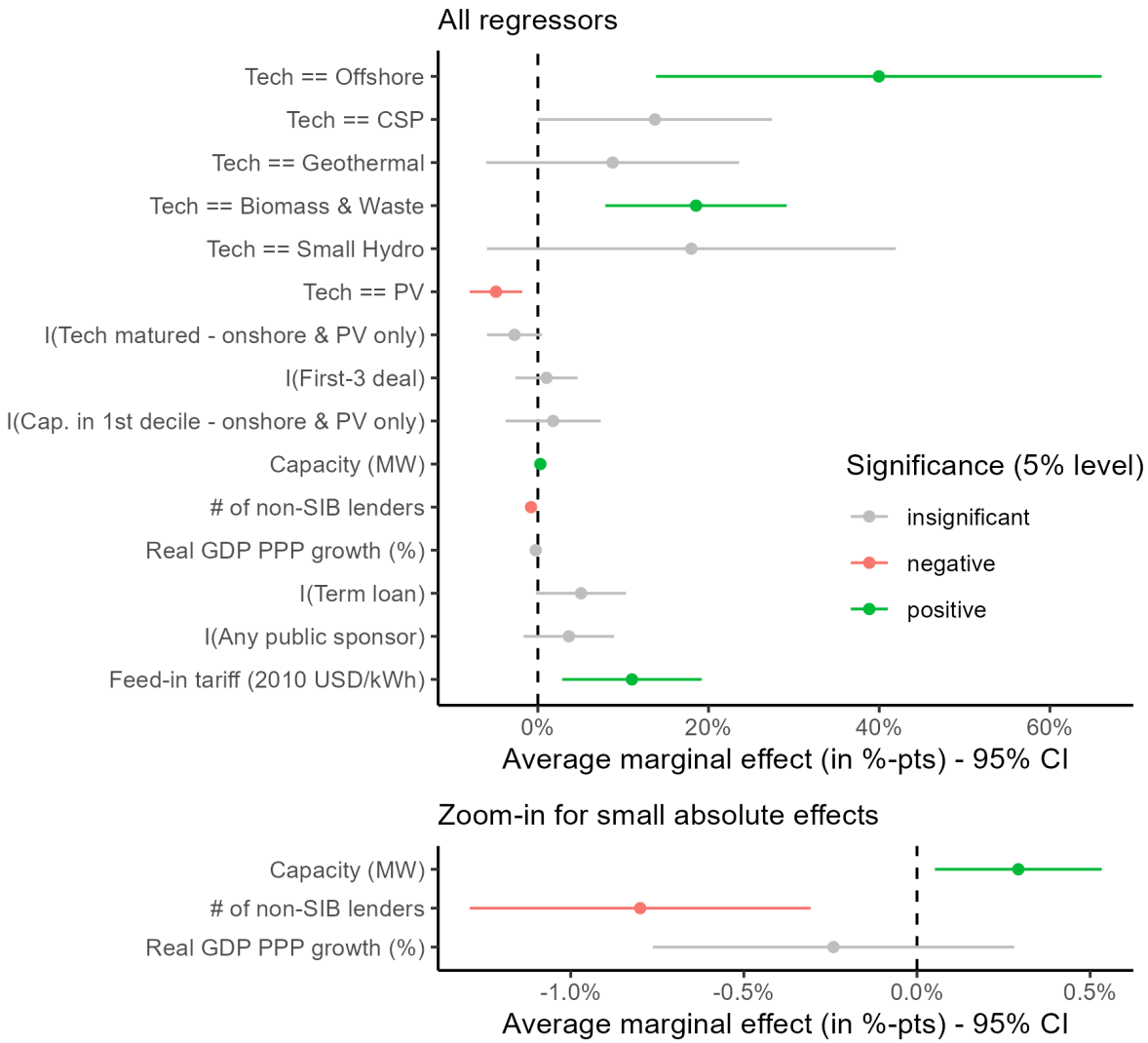
- **Model:** Two-way fixed effect logit model based on dummy Y_{icta}, which indicates whether deal i in country c closing in year t financing technology a involved at least one SIB lender:

$$logit(Y_{icta}) = \beta_0 Tech_a + \beta_1 I(Tech\ matured)_{cta} + \beta_2 I(First3\ deal)_{ica} + \beta_3 \ln(Capacity_i) + \beta_4\ \mathrm{I}(Cap.in\ 1st\ decile)_{ita} + \beta_5 NonSIB\ lenders_i + X'_{icta}\gamma + \alpha_c + \delta_t + \varepsilon_{icta}$$

Regressors	Hypothesis (expected sign)	Definition
$Tech_a$	H1: Higher-risk tech (+)	Technology dummy (low-risk baseline = onshore wind)
$I(Tech\ matured)_{cta}$	H2: Immature markets (-)	Does technology account for at least 10% of nat. capacity following IRENA (2023) and defined for onshore wind & solar PV only
$I(First3\ deal)_{ica}$	H2: Immature markets (+)	Does deal feature among first three «market-opening» debt deals for country & technology?
$\ln(Capacity_i)$	H3: Smaller-scale deals (-)	Total generation capacity financed by the deal (in MW), log-transformed
$\mathrm{I}(Capacity\ in\ 1st\ decile)_{ita}$	H3: Smaller-scale deals (+)	Does the deal capacity fall into 1st decile for same technology and closing year?
$NonSIB\ lenders_i$	H4: Lender mobilization (+)	# of lenders on a deal that are not SIBs

- **Control variables in X**: i) real GDP growth in %, ii) real, technology-specific feed-in tariff in USD/kWh, iii) term loan dummy, and iv) dummy for project sponsors involving a public sector entity

Main results (marginal effects & logit coefficients)



	I(SIB lending)			
	(1)	(2)	(3)	(4)
(Intercept)	-5.09***			
	(0.472)			
I(First-3 deal)	1.17***	1.01***	0.128	0.111
	(0.144)	(0.171)	(0.225)	(0.223)
ln(Capacity in MW)	0.528***	0.568***	0.474***	0.481***
	(0.053)	(0.056)	(0.060)	(0.060)
I(Cap. in 1st decile - onshore & PV only)	0.084	0.216	0.221	0.220
	(0.306)	(0.337)	(0.308)	(0.306)
# of non-SIB lenders	-0.039*	-0.007	-0.104***	-0.104***
	(0.019)	(0.019)	(0.029)	(0.030)
Real GDP PPP growth (%)	-0.029	-0.040	-0.031	-0.029
	(0.021)	(0.030)	(0.035)	(0.036)
Feed-in tariff (2010 USD/kWh)	0.651*	0.036	1.43***	1.27**
	(0.302)	(0.449)	(0.435)	(0.481)
I(Any public sponsor)	0.831***	0.555*	0.427†	0.433†
	(0.200)	(0.222)	(0.258)	(0.262)
I(Term loan)	1.33***	0.693*	0.788**	0.729**
	(0.268)	(0.275)	(0.274)	(0.262)
Tech = Biomass&Waste			1.45***	1.57***
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Tech = PV			-0.686***	-0.395†
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I(Tech matured) × Tech = Onshore				0.038
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Country FEs		Yes	Yes	Yes
Closing year FEs		Yes	Yes	Yes
Observations	4,841	4,797	4,797	4,797
Pseudo R^2	0.111	0.208	0.261	0.264
BIC	3,125.4	3,166.1	3,044.0	3,043.7

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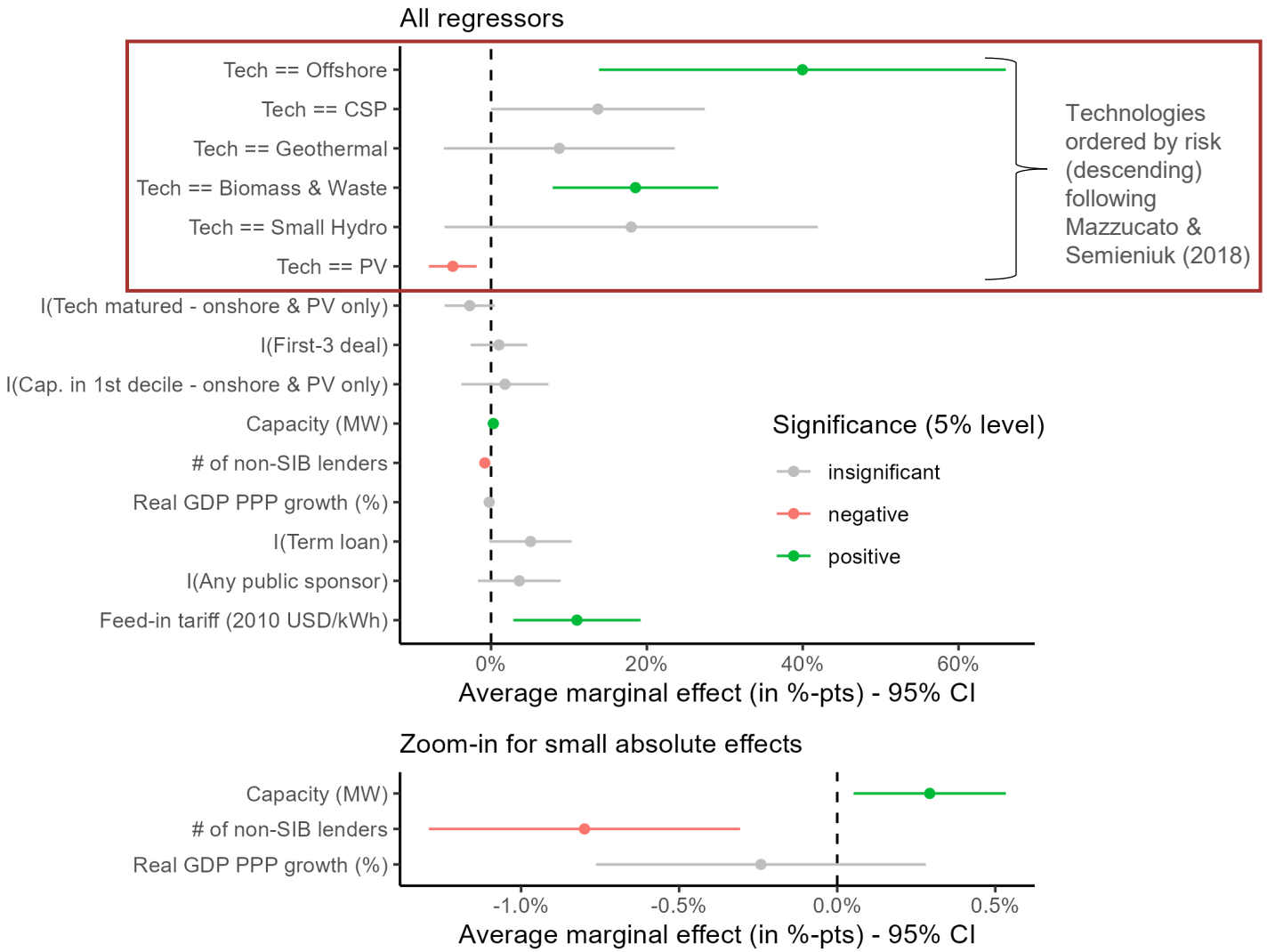

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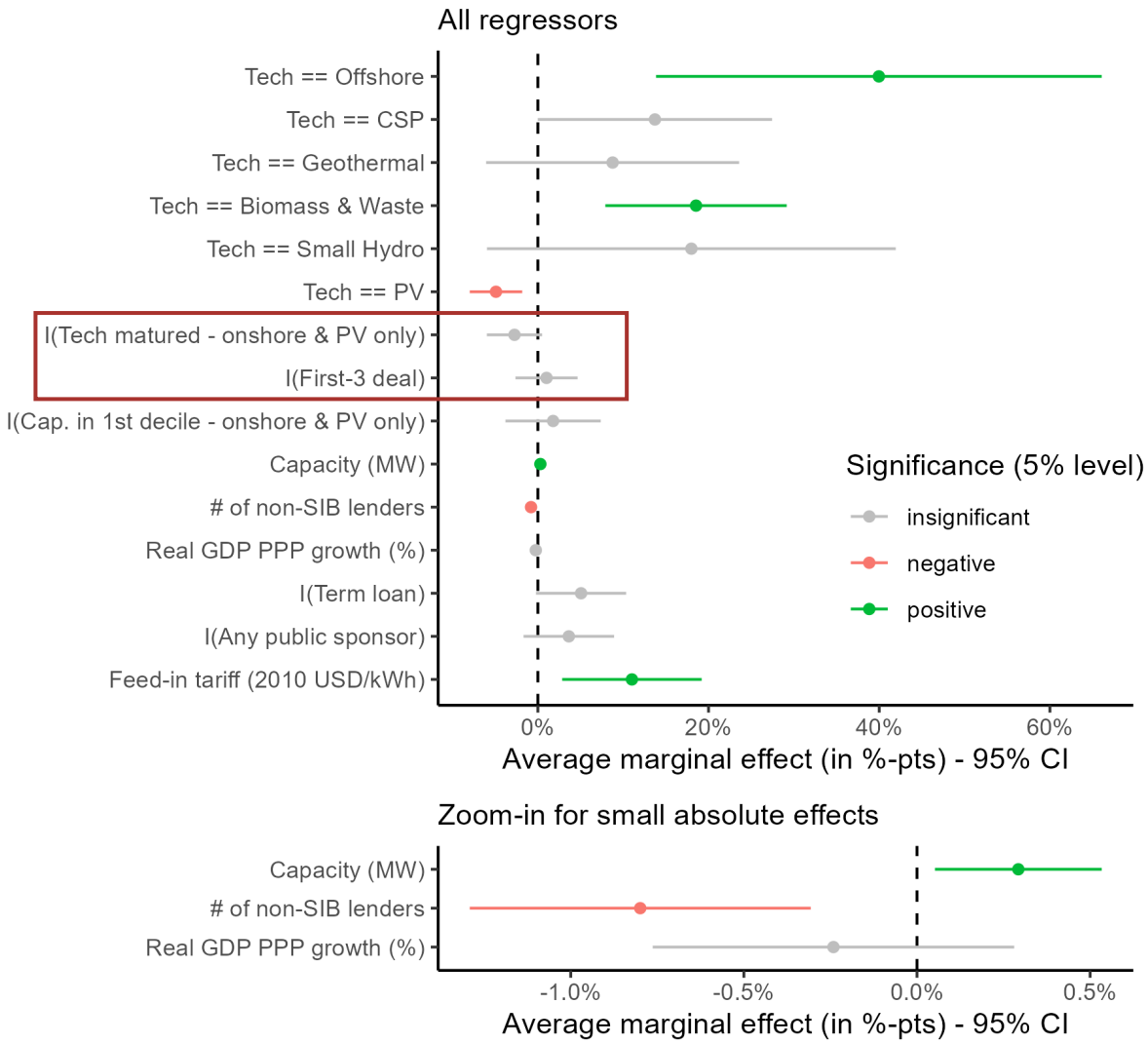

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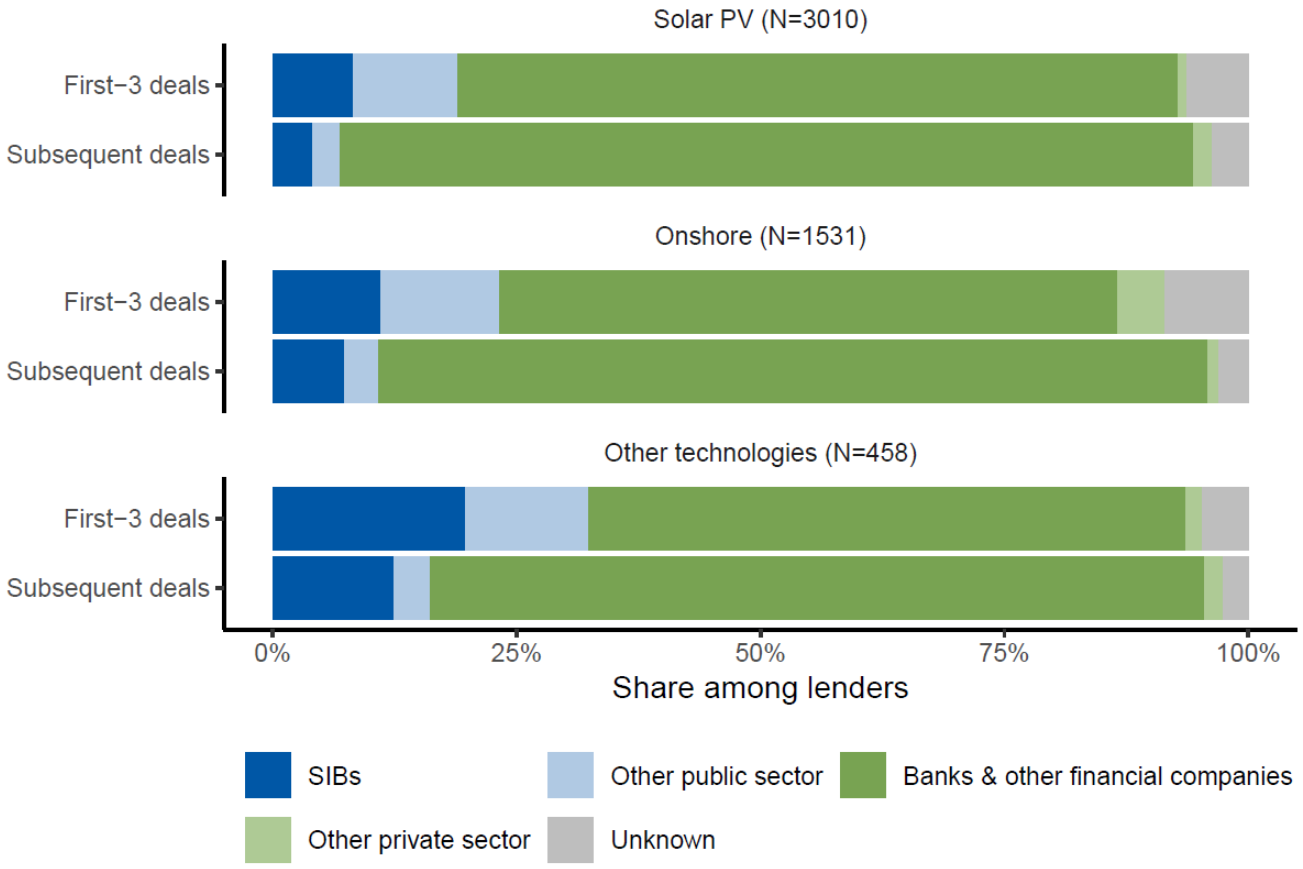
Who provides debt to novel technologies in a country?

- SIBs do feature a lot in first debt financing deals for novel technology in a country
- However, debt on these deals still primarily provided by private banks
- Notably, other public sector entities (ministries, government agencies and, in Latin American OECD countries, development banks) seem to target such market-opening deals much more strongly



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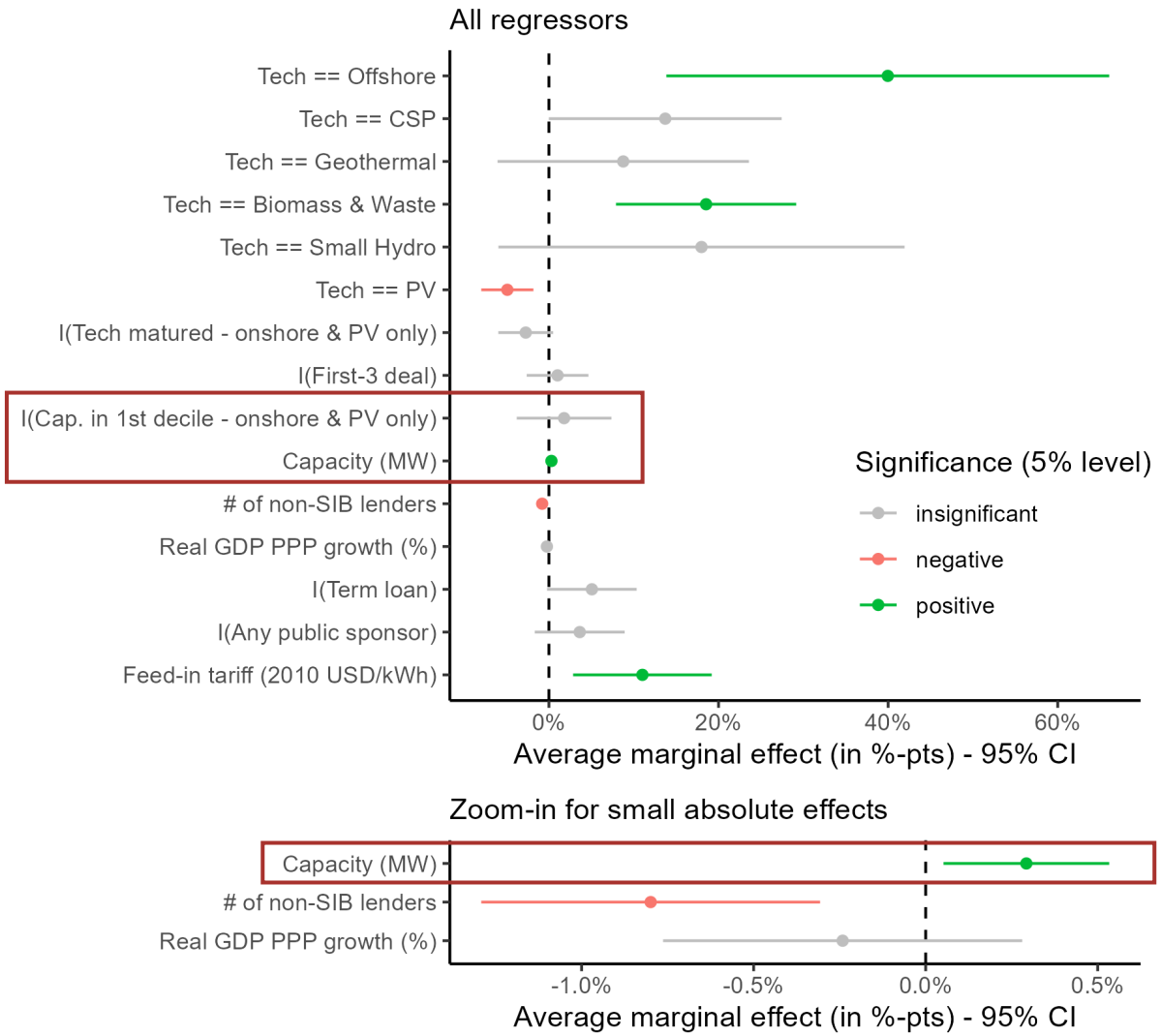

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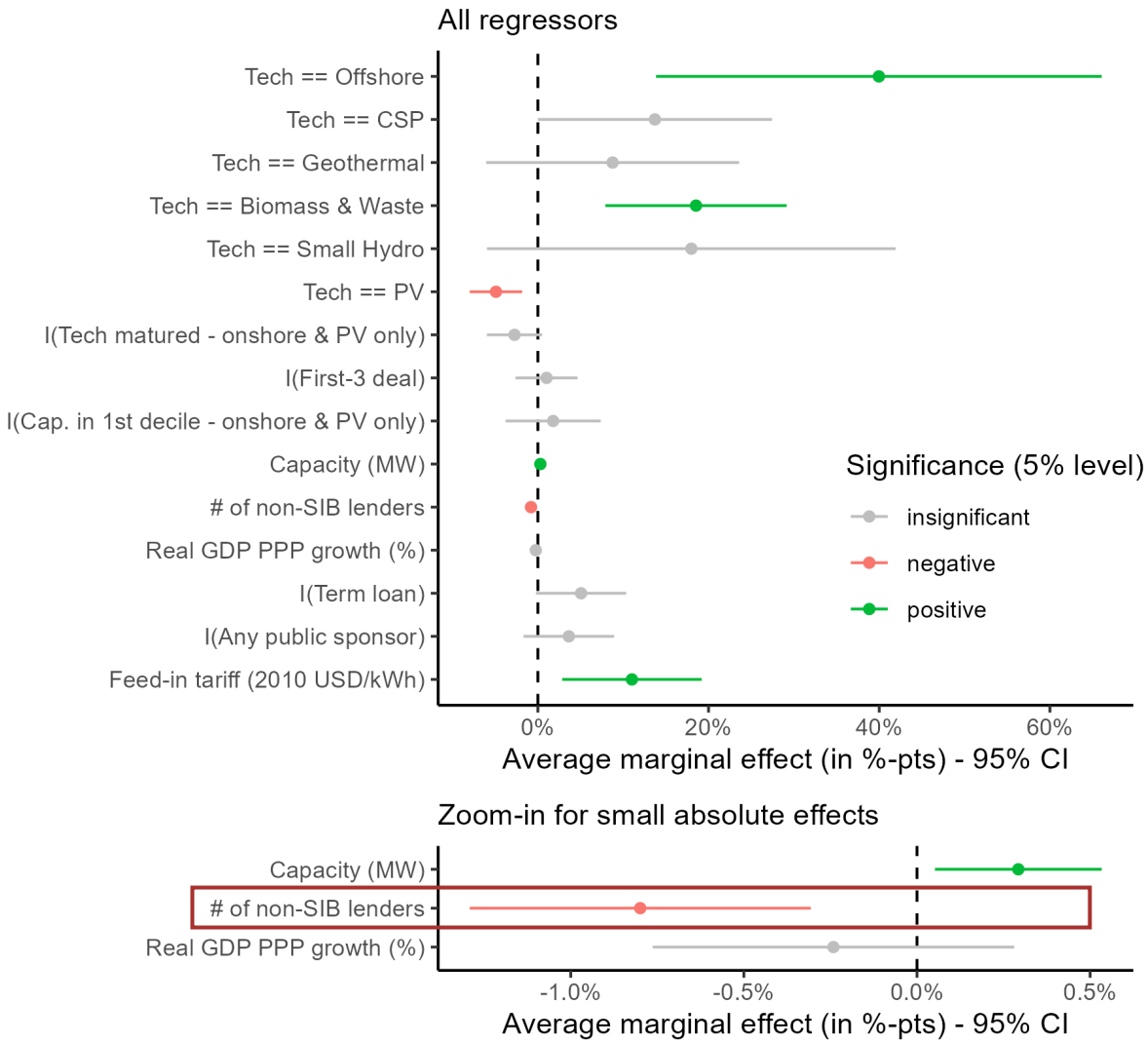

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Follow-up on lender mobilization

- Issue with using full sample for mobilization hypothesis: zero non-SIB lenders (SIB as sole lender) perfectly predicts SIB financing → spurious negative correlation
- Re-running regression on a sample without these deals (= predicting SIB *co-lending*) leads to positive association, albeit not consistently across robustness checks
- SIB as sole lenders more likely for projects sponsored by public sector entities (primarily utilities)

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	(1)	(2)	(3)
(Intercept)	-6.47***		
	(0.489)		
I(First-3 deal)	0.941***	0.164	0.160
	(0.148)	(0.267)	(0.265)
ln(Capacity in MW)	0.517***	0.535***	0.537***
	(0.062)	(0.081)	(0.082)
I(Cap. in 1st decile - onshore & PV only)	0.305	0.432	0.430
	(0.377)	(0.374)	(0.375)
# of non-SIB lenders	0.102***	0.066†	0.066†
	(0.020)	(0.035)	(0.035)
Real GDP PPP growth (%)	-0.019	-0.009	-0.008
	(0.022)	(0.036)	(0.036)
Feed-in tariff (2010 USD/kWh)	1.00**	1.87***	1.80**
	(0.361)	(0.538)	(0.578)
I(Any public sponsor)	0.558***	0.142	0.148
	(0.164)	(0.253)	(0.257)
I(Term loan)	2.02***	1.32***	1.29***
	(0.301)	(0.299)	(0.284)
Tech = Biomass&Waste		1.15***	1.19***
		(0.295)	(0.304)
Tech = PV		-1.03***	-0.903**
		(0.188)	(0.278)
Tech = SmallHydro		1.06	1.10
		(0.675)	(0.678)
Tech = CSP		0.459	0.577
		(0.485)	(0.541)
Tech = Offshore		1.21†	1.26†
		(0.633)	(0.648)
Tech = Geothermal		0.680	0.706
		(0.499)	(0.510)
I(Tech matured - onshore & PV only)		-0.479*	
		(0.200)	
I(Tech matured) × Tech = Onshore			-0.314
			(0.326)
I(Tech matured) × Tech = PV			-0.704**
			(0.219)
Country FEs		Yes	Yes
Closing year FEs		Yes	Yes
Observations	4,664	4,600	4,600
Pseudo R^2	0.138	0.284	0.284
BIC	2,321.9	2,354.8	2,362.1

Clustered (Closing year) standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, † : 0.1*

Conclusion and implications

- SIBs are key debt provider for RE, targeting higher-risk technologies (particularly offshore wind & biomass) and withdrawing from solar PV as markets mature
- No clear evidence that SIBs are more active on first debt financing deals → “first-mover” roles rather taken by other public sector entities (exception: German KfW)
- SIBs favor larger over smaller RE deals, potentially due to profitability concerns or politically influenced decisions
- Some (non-robust) evidence that SIBs mobilize co-lenders, but possibility of crowding out remains
- Policymakers should emphasize moving early into novel technologies and deliberately targeting small-scale deals
- Caveats:
  - Results cannot be interpreted causally (but are aligned with empirical finance papers claiming causality)
  - No consideration of mandate differences between SIBs
  - No systematic comparison with other ways of providing public financing, such as loan programs or export credit agencies

Overall findings:

H1: Higher-risk technologies	✓
H2: Immature markets	✓
H3: Smaller-scale deals	✗
H4: Lender mobilization	?

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Appendix

Literature review (individual papers)

- Empirical papers on energy policy explore public financing for RE, but they do not consider specific institutions
  - Polzin et al. 2015: Inconclusive effect of public direct investment on installed RE capacity in OECD countries estimated via fixed effects regression
  - Cardenas-Rodriguez et al. 2015: Mixed effect of public on private RE financing estimated via simultaneous equation Tobit model using BNEF data
  - Deleidi et al. 2020: Positive impact of public direct investment on private RE investment for 15 OECD countries + India & China; effect size larger than for feed-in tariffs
- Finance literature investigates public financial institutions' role, but it does not consider energy (technologies)
  - Gurara et al. 2020: Presence of multilateral development banks increase loan pricing, maturity and propensity to service high-risk countries
  - Broccolini et al. 2021: Participation of multilateral development banks increases bank syndicate sizes, private financing, and tenors
  - Degl'Innocenti et al. 2022: Development banks reduce syndicate concentration (= risk), particularly in times of financial turmoil and for green industries

Overview of regressors (in-detail)

Regressors	Hypothesis (expected sign)	Definition	Source
$Tech_a$	H1: Higher-risk tech (+)	Technology dummy (baseline = onshore wind)	BNEF
$I(Tech\ matured)_{cta}$	H2: Lower maturity (+)	Does technology account for at least 10% of nat. capacity following IRENA (2023) - applied only to onshore wind & solar PV	BNEF
$I(First3\ deal)_{ica}$	H2: Lower maturity (+)	Does deal feature among first three debt deals for country & tech?	BNEF
$\ln(Capacity_i)$	H3: Smaller deal size (+)	Total generation capacity financed by the deal (in MW)	BNEF
$\mathrm{I}(Capacity\ in\ 1st\ decile)_{ita}$	H3: Smaller deal size (+)	Does the deal capacity fall into 1st decile of all deals for same technology closing in the same year?	BNEF
$\#\ of\ nonSIB\ lenders_i$	H4: Larger syndicate size (+)	# of lenders on a deal that are not SIBs	BNEF
$Real\ GDP\ growth_{ct}$	None (control)	Annual real GDP growth (PPP-adjusted) of the deal's country (in %)	WB WDI
FIT_{cta}	None (control)	Technology-specific real feed-in tariff (in 2010 USD/kWh)	OECD
$I(Any\ public\ sponsor)_i$	None (control)	Is the deal sponsored by at least one public sector entity (or a subsidiary of one)?	BNEF
$I(Term\ loan)_i$	None (control)	Does the deal involve a term loan (= SIBs most frequent financing instrument)?	BNEF

Summary statistics

Statistic	N	Mean	St. Dev.	Min	Median	Max
I(SIB lending)	4,999	0.114	0.318	0	0	1
Closing year	4,999	2014.803	4.430	2004	2015	2021
Capacity (MW)	4,987	51.275	102.341	0.2	14.0	1,467.0
I(Cap. in 1st decile - onshore & PV only)	4,999	0.094	0.292	0	0	1
# of non-SIB lenders	4,999	1.746	1.937	0	1	29
# of sponsors	4,999	1.217	0.598	1	1	8
I(First-3 deal)	4,999	0.052	0.223	0	0	1
I(Term loan)	4,999	0.906	0.292	0	1	1
I(Any public sponsor)	4,874	0.056	0.230	0	0	1
I(Tech matured - onshore & PV only)	4,999	0.316	0.465	0	0	1
Feed-in tariff (2010 USD/kWh)	4,977	0.109	0.164	0.000	0.011	0.812
Real GDP PPP growth (%)	4,999	1.524	3.127	−14.839	2.005	25.176
CCPI Overall Score (0-100)	4,873	47.540	13.068	18.596	49.470	76.620
Long-term interest rate (%)	4,873	2.169	1.904	−0.511	2.064	22.497
Country Bank Z-score	4,999	18.694	8.728	0.017	16.603	43.060
Gov. expenditures (% of GDP)	4,999	18.774	3.445	10.336	19.412	26.732
Primary balance (% of GDP)	4,999	−2.481	3.499	−29.896	−2.242	15.461

Categorical variables denoted by I(...)

Group means and simple t-tests

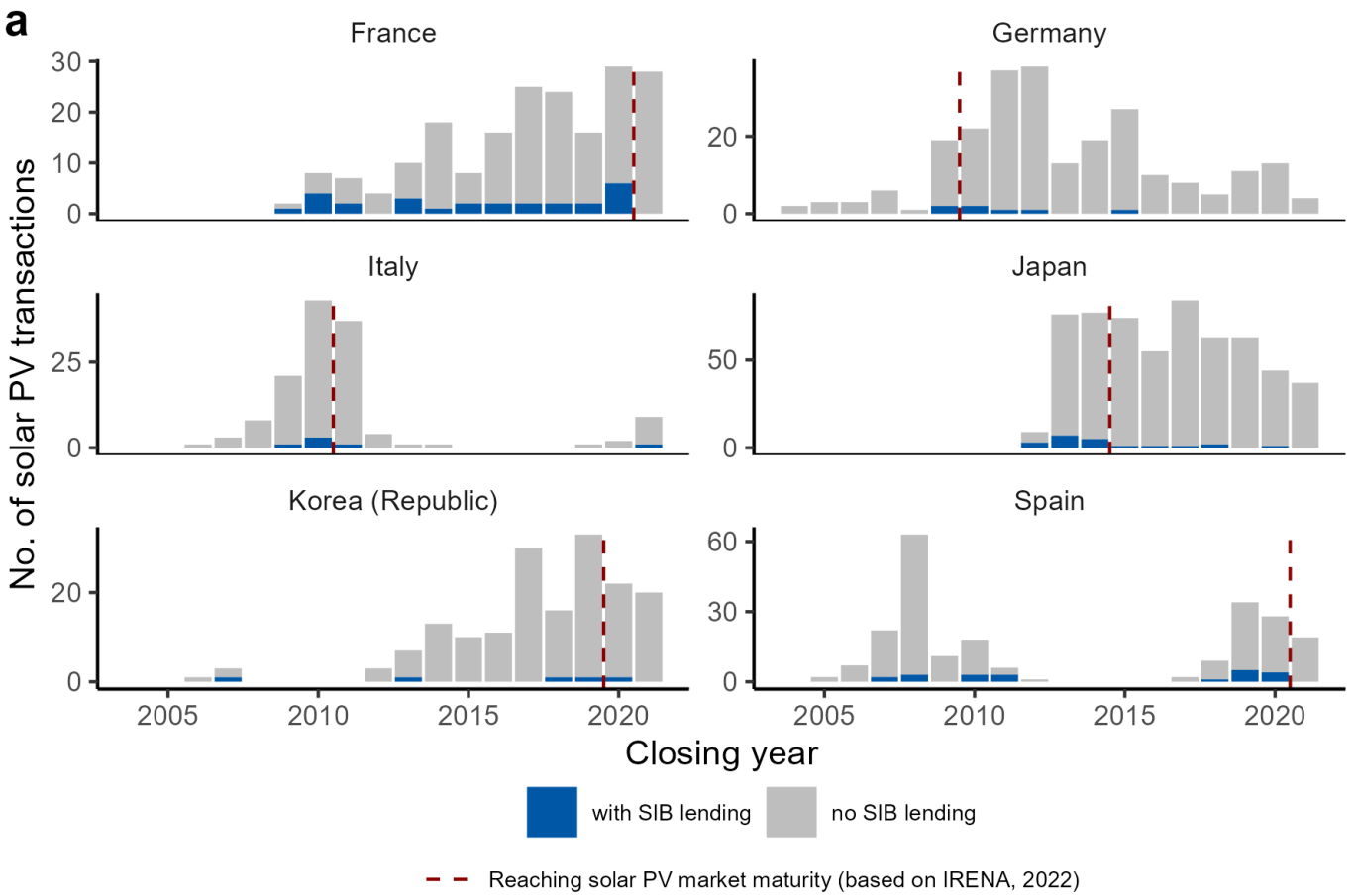
Variables	w/ SIB lending mean (s.e.)	w/o SIB lending mean (s.e.)	Diff.	t-stat
Closing year	2014.6 (4.2)	2014.8 (4.5)	-0.184	-0.99
Capacity (MW)	102.9 (152.9)	44.6 (91.8)	58.3	8.89
I(Cap. in 1st decile - onshore & PV only)	0.033 (0.18)	0.1 (0.3)	-0.0691	-7.88
# of non-SIB lenders	2.2 (3.5)	1.7 (1.6)	0.558	3.71
# of sponsors	1.5 (0.89)	1.2 (0.54)	0.272	7.15
I(First-3 deal)	0.13 (0.33)	0.043 (0.2)	0.0849	5.94
I(Term loan)	0.96 (0.2)	0.9 (0.3)	0.0612	6.52
I(Any public sponsor)	0.13 (0.34)	0.046 (0.21)	0.0834	5.7
I(Tech matured - onshore & PV only)	0.21 (0.41)	0.33 (0.47)	-0.122	-6.64
Feed-in tariff (2010 USD/kWh)	0.1 (0.15)	0.11 (0.17)	-0.0103	-1.5
Real GDP PPP growth (%)	1.3 (3.2)	1.5 (3.1)	-0.202	-1.41
CCPI Overall Score (0-100)	52.1 (11.1)	47 (13.2)	5.15	9.95
Long-term interest rate (%)	2.7 (2.3)	2.1 (1.8)	0.571	5.52
Country Bank Z-score	16.4 (7)	19 (8.9)	-2.6	-8.1
Gov. expenditures (% of GDP)	19.4 (3.8)	18.7 (3.4)	0.745	4.43
Primary balance (% of GDP)	-2.2 (3.4)	-2.5 (3.5)	0.356	2.37
Observations	572	4,427		

Alternative specifications for ticket size effects

	I(SIB lending)			
	(1)	(2)	(3)	(4)
Tech = Biomass&Waste	1.38***	1.49***	1.27**	1.39**
	(0.280)	(0.287)	(0.417)	(0.424)
Tech = PV	-0.949***	-0.683**	-1.32***	-1.07***
	(0.172)	(0.231)	(0.139)	(0.204)
Tech = SmallHydro	1.19†	1.26†	1.07	1.15
	(0.662)	(0.665)	(0.713)	(0.721)
Tech = CSP	1.17**	1.38**	1.46**	1.69**
	(0.417)	(0.463)	(0.489)	(0.527)
Tech = Offshore	2.46***	2.59***	3.32***	3.45***
	(0.671)	(0.682)	(0.843)	(0.850)
Tech = Geothermal	0.727	0.807	0.529	0.614
	(0.555)	(0.562)	(0.678)	(0.686)
I(Tech matured - onshore & PV only)	-0.329		-0.352	
	(0.234)		(0.221)	
I(Tech matured) × Tech = Onshore		0.048		0.0006
		(0.331)		(0.317)
I(Tech matured) × Tech = PV		-0.775**		-0.774***
		(0.271)		(0.233)
I(First-3 deal)	0.112	0.096	0.028	0.011
	(0.227)	(0.225)	(0.242)	(0.241)
Capacity (MW)	0.008***	0.008***		
	(0.001)	(0.001)		
Capacity (MW) square	-5.88×10^{-6}***	-5.98×10^{-6}***		
	(1.39×10^{-6})	(1.42×10^{-6})		
I(Cap. in 1st decile)	-0.426†	-0.435†		
	(0.237)	(0.237)		
Capacity decile = 1			-0.688*	-0.688*
			(0.303)	(0.297)
Capacity decile = 2			-0.320	-0.309
			(0.342)	(0.346)
Capacity decile = 3			-0.495	-0.485
			(0.317)	(0.314)
Capacity decile = 4			-0.492†	-0.484†
			(0.282)	(0.280)
Capacity decile = 5			-0.266	-0.235
			(0.400)	(0.398)
Capacity decile = 7			0.195	0.193
			(0.299)	(0.289)
Capacity decile = 8			0.276	0.305
			(0.322)	(0.320)
Capacity decile = 9			0.802***	0.813***
			(0.217)	(0.216)
Capacity decile = 10			1.30***	1.31***
			(0.224)	(0.224)
Further controls of main specification	Yes	Yes	Yes	Yes
Country FEs	Yes	Yes	Yes	Yes
Closing year FEs	Yes	Yes	Yes	Yes
Observations	4,797	4,797	4,797	4,797
Pseudo R^2	0.256	0.258	0.258	0.260
BIC	3,072.2	3,073.1	3,115.5	3,117.4

Clustered (Closing year) standard-errors in parentheses
All capacity decile dummies are applied only to onshore wind and solar PV
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05, †: 0.1*

Maturity patterns for solar PV deals in main OECD markets



- Lower probability of SIB financing not driven by increased activity of private sector (# of deals decreases)
- Depending on mandate, SIBs either shift PV financing abroad to less mature markets (KfW, EIB) or withdraw (DBJ)

Overview of robustness checks

- Re. market maturity:
  - Apply market maturity dummy to all RE technologies (instead of only large-N technologies onshore wind & solar PV)
  - Use technology's share in installed capacity instead of binary 10% threshold
  - Separate solar PV fixed effects for early- and later-stage solar PV (Mazzucato & Semieniuk, 2018)
- Re. first-3 deals: use first 1, 5, 10 and 25 deals instead
- Additional controls from the literature (government surplus, government expenditures in % of GDP, banking sector z-score to measure distress, long-term interest rate, # of project sponsors, Climate Change Performance Index) – all insignificant
- More stringent fixed effects (technology & country-year, technology-year & country)
- Alternative standard errors clustered at country instead of year level
- Bias-corrected estimator by Fernández-Val & Weidner (2016) & discarding fixed effects groups with < 25 obs. to mitigate potential incidental parameter problem
- SIB loan share as alternative dependent variable (estimated via fractional logit by Papke & Wooldridge, 1996)
- Omit observations with lenders "Not reported" (instead of treating them as no-SIB deals)