



FEEDING GREEN IDEAS: RISK FINANCE IN THE *CLEANTECH* SECTOR

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Motivation

- Start-ups are the engine for green growth and breakthrough innovations – complementary to “greening goliaths”
- Not much is known about financing of these firms
- Anecdotal and survey evidence about challenges of traditional private equity financing in cleantech (Ghosh and Nanda, 2010; Hargadon and Kenney, 2011; Burer and Wuestenhagen, 2010)
- What is the role of policy?
- Do patents play a role?
 - Contribute to growing evidence on role of patents for equity financing (e.g. Haussler, Harhoff and Mueller, 2012; Parris and Demirel, 2010)



What this paper does

- Detailed cross-country (commercial) dataset on “high-growth financing” deals in the *cleantech* sector, over the period 2005-2010
- Information on “environmental” policies over the same period for 26 countries
- PATSTAT: information on patent applications
- We describe trends across sectors and countries
- We identify micro– and macro-level correlates of high growth financing, focusing on:
 - national level supply-push policies, such as public R&D, and deployment policies, such as regulations, standards, and fiscal incentives
 - prior patenting activity of the company seeking finance: not only quantity but also quality of firms’ patents
 - Control for concentration of patenting activity at the local level (NUTS3)



What this paper does not do

- Causality
 - but we try to compare “like with like” with the information we have: we build a “control group” of cleantech firms (actively) seeking equity financing
- We do not have extensive information on firm characteristics
- We only have policy measures relative to renewable energy
 - Robustness: we limit our results to “clean” energy generation
- Evidence on factors driving equity financing opportunities rather than entrepreneurial activity.
- We do not look at the impact of equity finance on firms’ outcomes



What do we mean by “cleantech”

Primary industry	Secondary industry
agriculture	aquaculture; land management; natural pesticides
air & environment	cleanup/safety; emissions control; monitoring/compliance; trading & offsets;
energy efficiency	advanced packaging; buildings; lighting; monitoring/compliance;
energy generation	biofuels; geothermal; hydro/marine; solar; wind
energy infrastructure	management; transmission
energy storage	advanced batteries; fuel cells; hybrid systems
Manufacturing; industrial	monitoring & control; smart production
materials	bio; chemical; glass; nano;
recycling & waste	recycling; waste treatment
transportation	fuels; logistics; structures; vehicles
water & wastewater	bio; cleanup/safety; glass; wastewater treatment; water conservation; water treatment



Challenges for high growth financing in Cleantech

High	<p>Project Finance/Existing firms</p> <ul style="list-style-type: none">• Wind farms• Utility-scale solar• First-generation biofuel refineries• manufacturing of solar cells using established technologies	<p>Hard to Fund (“Valley of Death”)</p> <ul style="list-style-type: none">• First commercial plants for unproven technologies• Advanced biofuel refineries• Offshore wind farms• Carbon sequestration
Capital intensity	<p>Bank Debt/ Existing firms</p> <ul style="list-style-type: none">• Wind and solar component of proven technologies• Internal combustion engines• Insulation/building materials• Energy efficiency services	<p>Venture Capital</p> <ul style="list-style-type: none">• Energy efficiency software• Lightning• Electric drive trains• Fuel cells / Power storage• Wind and solar components of unproven technologies
Low	Low	High

Technology risk

Source: Ghosh and Nanda, 2010

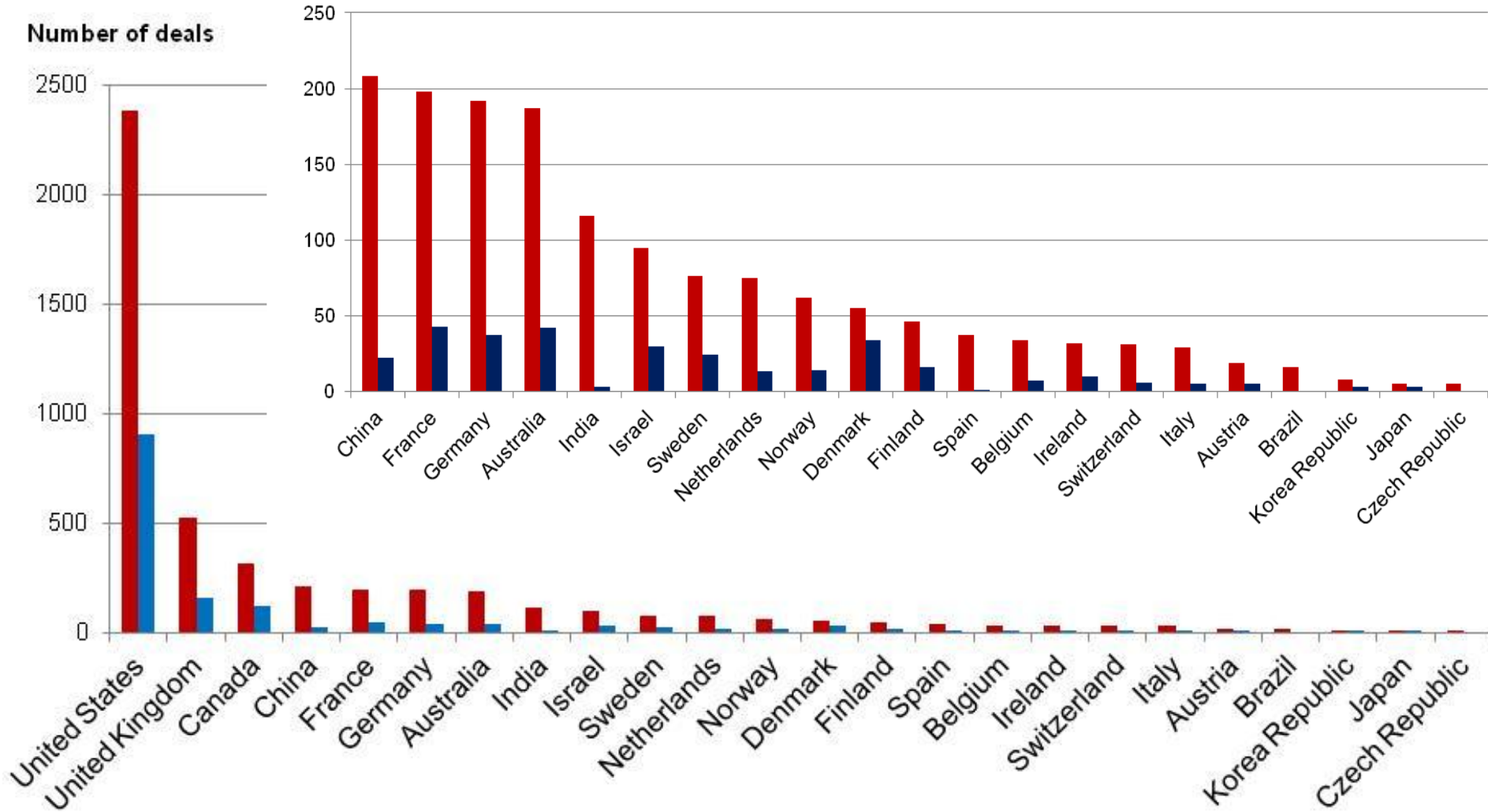


Number of deals across countries

Number of deals

All deals Deals with patents

Number of deals





The role of government

Government can play a role in different phases of the financing for high growth enterprises in Cleantech, through:

- **Technology push policies:** e.g. university and national laboratory funding; grants; prizes etc.
- **Demand-pull or deployment policies:** e.g. feed-in tariffs; renewables portfolio standards; public procurement and fiscal incentives
 - Create a market for cleantech goods and services
 - Minimise policy uncertainty



Deployment policies: a taxonomy

- 3 groups:
 - **Regulation short term:** feed-in tariffs, public bidding
 - **Regulation investments:** portfolio quotas, tradable renewable certificates
 - **Public incentives:** loans, grants, guarantees, fiscal incentives, etc.



The data: financing

- Deal-level dataset from Cleantech.com
- Information on
 - detailed (e.g. name and website) but not extensive information on companies funded and investors/VC firms (e.g. location)
 - Amount invested and date of the deal
 - Stage of the investment
- Complemented with the list of companies (unsuccessfully) looking for funding
- It covers 72 different countries over the time period from 1999 to July 2011
- Extensive cleaning, complementing and checking of information in-house
- The analysis is restricted to the period 2005-10 and to 26 OECD and BRIICS countries
 - 4792 observations: 3007 deals, 1785 seekers.



The data: financing/2

Name	Adventus Intellectual Property Inc.	Aegis Petro
Primary industry	Air & Environment	Water & Wastewater
Secondary industry	Air & Environment, Cleanup/Safety, Remediation	Oil and Gas, Wastewater Treatment, Water & Wastewater
One sentence description	Developer of a variety of bioremediation technologies.	Provider of oilfield wastewater treatment services
Website	http://www.adventus.us	http://www.aegis-petro.com/
Address	1345 Fewster Drive	3rd Fl., Alley 647, #15 Weihai Road
City	Mississauga	Shanghai
Country	Canada	China
Deal date	2Q2004	8/19/2011
Amount	\$1,440,000	\$10,000,000
Inv. Stage	Follow-On	Series A
Investors [linked table]	VentureLink Funds, Covington Group of Funds	Matrix Partners, iFirst Capital, Draper Fisher Jurvetson



The data: patenting

- Cleantech companies matched with Patent information from Patstat using a name matching algorithm
 - We restrict to patents filed at WIPO under the PCT convention
 - We add indicators of patent characteristics (scope, family size, closeness to science) from Squicciarini, Criscuolo and Dernis (2011)
 - Regional level patent information (Regpat) matched by geocoding the companies addresses



The data: Patent Quality measures

- **Patent scope:** the technological breadth of patents is an important characteristics in determining its value. Generally, broad patents are more valuable; but to the extent that the commercialization of the invention appears difficult to define, a too general patent may be valued less by potential investors.
- **Backward citations:** each patent is required to cite all previous patents or scientific literature on which it relies on. A high number of backward citations may reflect the incremental nature of the patents. It may also implies that it is “well protected” from possible litigations.
- **Family size:** a patent family is a group of patents filed for at different patent offices but referring to the same invention. The size of the family is therefore positively correlated with the value of the patents, since it is a proxy for the applicants’ efforts in protecting the invention internationally

(see Squicciarini et al., 2011 and 2012)



The data: policies

Broad information on supply-push and deployment policies:

- supply side measure: Government R&D expenditure (source: OECD, MSTI)
- deployment policies: Renewables policies (source: REN21, checked with Pew Trusts Reports, IEA, OECD, etc.)



Regression Analysis

- Data are analysed along two different dimensions:

→ at **country-industry level**, to explore the determinants on the flow of investments:

$$\text{Financing}_{sct} = f(\text{Regulation_Policies}_{ct}, \text{Gov_R\&D}_{ct-2}, \text{Seekers}_{sct}, X_{ct}, D_t, D_s)$$

→ at **deal level**: probability of a company to be funded and relative amount

$$\text{Financing}_{irsct} = f(\text{Pats}_{it}, \text{Pat_Quality}_{it}, \text{Regio_Pats}_{rt}, \text{Regulation_Policies}_{ct}, \text{Gov_R\&D}_{ct-2}, X_{ct}, D_t, D_s, D_i)$$

$$\text{Financing}_{irsct} = f(\text{Pats}_{it}, \text{Pat_Quality}_{it}, \text{Regio_Pats}_{rt}, D_{st}, D_{ct})$$

Note: i=investment stage; c=country; s=sector; r=region; t=year. The matrix X includes GDP p.c., stock mkt. size, days to start a business.



Results: probability of funding, policies

	Full sample		Seed & first stage		Follow-on	
Patent Dummy	0.249***		0.288***		0.165***	
	(0.022)		(0.025)		(0.021)	
Number of patents		0.044***		0.073***		0.027***
		(0.005)		(0.007)		(0.005)
Regulation Short Term	0.137***	0.133***	0.119*	0.113*	0.071**	0.067**
	(0.047)	(0.045)	(0.065)	(0.065)	(0.028)	(0.027)
Regulation Investment	0.151***	0.145***	0.148***	0.143***	0.123***	0.112***
	(0.030)	(0.029)	(0.050)	(0.051)	(0.020)	(0.020)
Incentives	-0.031*	-0.031*	-0.058**	-0.060**	-0.005	-0.006
	(0.017)	(0.016)	(0.029)	(0.029)	(0.012)	(0.012)
Govt R&D	0.438	0.420	0.115	0.117	0.310*	0.281*
	(0.330)	(0.320)	(0.468)	(0.479)	(0.168)	(0.161)
Obs.	4,515	4,515	1,566	1,566	1,525	1,525

Notes: errors clustered at country level. Reported coefficients are marginal effects. Dummies for year*sector and investment stage included in all regressions.



Results: probability of funding, patent quality

Sample	Full sample				Early stage	follow-on	
Number of patents	0.024*** (0.005)	0.027*** (0.006)	0.020*** (0.005)	0.035*** (0.004)	0.011*** (0.003)	0.008 (0.005)	0.006 (0.006)
Family size	0.020*** (0.002)				0.013*** (0.002)	0.006 (0.003)	0.009** (0.004)
Patent scope		0.044*** (0.008)			-0.017 (0.012)	-0.017 (0.015)	0.002 (0.011)
Backward Citations			0.022*** (0.002)		0.016*** (0.003)	0.031*** (0.008)	0.006** (0.003)
Share of NPL citations				0.274*** (0.078)	0.215*** (0.071)	0.233*** (0.064)	0.134* (0.075)
Observations	4,515	4,515	4,515	4,515	4,515	1,566	1,525

Notes: Notes: errors clustered at country level. Reported coefficients are marginal effects. Dummies for year*sector and investment stage included in all regressions. **Regression also include policy variables.**



Results: amount of funding, policies

	Full sample		Seed & first stage		Follow-on		Energy efficiency		Energy generation	
Patent Dummy	3.842***		1.999***		5.019***		2.991***		5.045***	
	(0.220)		(0.536)		(1.234)		(0.405)		(1.491)	
Number of patents		0.401***		0.404***		0.518***		0.363***		0.745***
		(0.022)		(0.031)		(0.142)		(0.101)		(0.050)
Regulation Short Term	0.920***	0.948***	0.823***	0.776***	0.263	0.565	0.433	0.582	0.991*	1.038*
	(0.080)	(0.077)	(0.279)	(0.277)	(0.908)	(0.938)	(0.627)	(0.651)	(0.535)	(0.532)
Regulation Investment	0.957***	0.998***	0.714***	0.662***	0.870	1.039	0.107	0.163	0.916**	0.815**
	(0.082)	(0.080)	(0.167)	(0.166)	(0.830)	(0.828)	(0.435)	(0.461)	(0.408)	(0.380)
Incentives	0.108***	0.081***	-0.178	-0.171	0.659	0.599	0.190	0.131	-0.205	-0.226
	(0.027)	(0.025)	(0.157)	(0.149)	(0.568)	(0.554)	(0.180)	(0.214)	(0.478)	(0.443)
Govt R&D	9.922***	9.390***	3.168**	2.885*	21.799***	20.986***	6.046**	4.140	14.826***	14.352***
	(0.687)	(0.640)	(1.557)	(1.613)	(6.334)	(6.347)	(2.587)	(2.641)	(2.753)	(2.597)
Obs.	4,526	4,526	1,582	1,582	1,609	1,609	717	717	1,653	1,653

Notes: errors clustered at country level. Reported coefficients are marginal effects. Dummies for year*sector and investment stage included in all regressions.



Results: amount of funding, patent quality

Sample	Full sample					Early stage	follow-on
Number of patents	0.310*** (0.027)	0.297*** (0.028)	0.262*** (0.028)	0.357*** (0.028)	0.222*** (0.046)	0.308*** (0.021)	0.324** (0.145)
Family size	0.204*** (0.026)				0.117*** (0.039)	0.019 (0.016)	0.113 (0.075)
Patent scope		0.565*** (0.087)			-0.138 (0.117)	-0.135** (0.065)	0.146 (0.242)
Bwd. citations			0.262*** (0.033)		0.181*** (0.052)	0.162*** (0.048)	0.148* (0.084)
Share of NPL citations				1.896*** (0.557)	0.622 (0.714)	0.713** (0.335)	0.323 (1.372)
Observations	4,526	4,526	4,526	4,526	4,526	1,582	1,609

Notes: errors clustered at country level. Reported coefficients are marginal effects. Dummies for year*sector and investment stage included in all regressions. **Regressions also include policy variables.**



Robustness

- Country/industry level
 - Excluding US
 - Alternative classifications of policies
 - Limit the analysis to the “energy generation” industry
- Deal level
 - Excluding US
 - Alternative classifications of policies
 - Control for Regional Patenting activity
 - Limit the analysis to the “energy generation” industry
 - Restricting the sample to deals where at least one investor is based in a different country than the funded firm
 - include country-year and industry-year dummies
 - Adding country*sector*year dummies in the patent quality regression



Conclusions: The role of patents

- Cleantech companies that patent are more likely to receive financing. This might reflect:
 - Importance of patents as signal/certification mechanisms or/and
 - Patents as collateral
- This highlights:
 - the importance of improving IPR policies to make patenting more efficient and less costly
 - The need for making easier for companies to signal their innovative capacity
- Family size and Closeness to science of firms' patent portfolio is associated with a higher probability of being financed.



Conclusions: policies

- Supply push policies positively correlated with financing: government R&D is an important correlate of amount of private equity financing at the micro and macro level.
- Deployment policies aimed at creating a market (both in the short and in the long term) are associated with higher levels of equity financing in the cleantech sector
- No significant correlation between fiscal incentives and private funding: too much uncertainty and volatility?



Thank you for your attention

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BACK UP SLIDES



Deployment policies, details

Feed-in tariffs set a fixed price at which power producers can sell renewable power into the electric power network. Countries can offer a fixed tariff or provide fixed premiums added to market – or cost related tariffs. Some provide both.

Renewable portfolio standards or quotas (RPS) require that a minimum percentage of generation sold or capacity installed be provided by renewable energy. Obligated Utilities are required to ensure that the target is met, either through their generation, power purchase from other producers, or direct sales from third parties to the utility's customers.

Public competitive bidding means that public authorities organise tenders for a given quota of renewable supplies or capacity, and remunerate winning bids at prices that are typically above standard market levels.

Tradable renewable certificates represent the certified generation of units of renewable energy. They allow trading of renewable energy obligations among consumers and/or producers, and in some markets like the United States allow anyone to purchase separately the green power “attributes” of renewable energy.

Public investments, loans or financing are public policies aimed at directly acquiring renewable power generators, or at providing ad-hoc subsidised financing for private investors.

Capital subsidies, consumer grants or rebates are one-time payments by the government or utility to cover a percentage of the capital cost of an investment, such as a solar hot water system or rooftop solar PV system.

Investment or other tax credits allow full or partial deduction from tax obligations or income for investments in renewable energy.

Sales tax, energy tax, excise tax or vat reduction are fiscal policy tools providing consumption tax exemptions or reductions on the sale of renewable energy and equipments.

Energy production payments or tax credits provide investors or owners of qualifying property with an annual tax credit or a payment based on the amount of electricity generated by that facility.

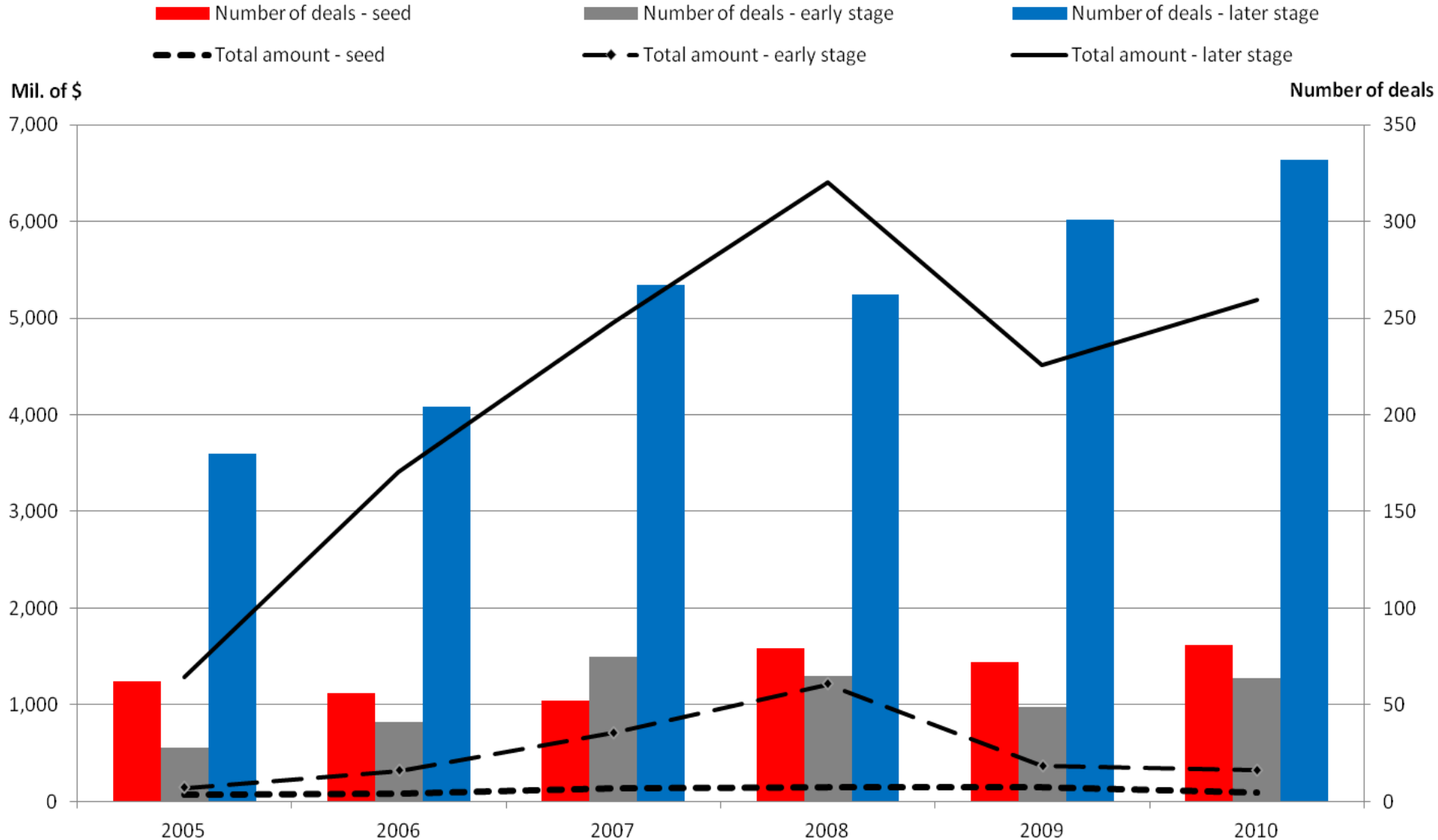


Deployment policies: a taxonomy

- 3 groups:
 - Regulation short term: feed-in tariffs, public bidding
 - Regulation investments: portfolio quotas, tradable renewable certificates
 - Public incentives: public investments, loans, grants, guarantees, fiscal incentives, etc.
- Alternative dimensions:
 - Regulation vs. Public finance
 - Price vs. quantity
 - Technological discretionality vs. neutrality
 - Operational (short-term) vs. investments

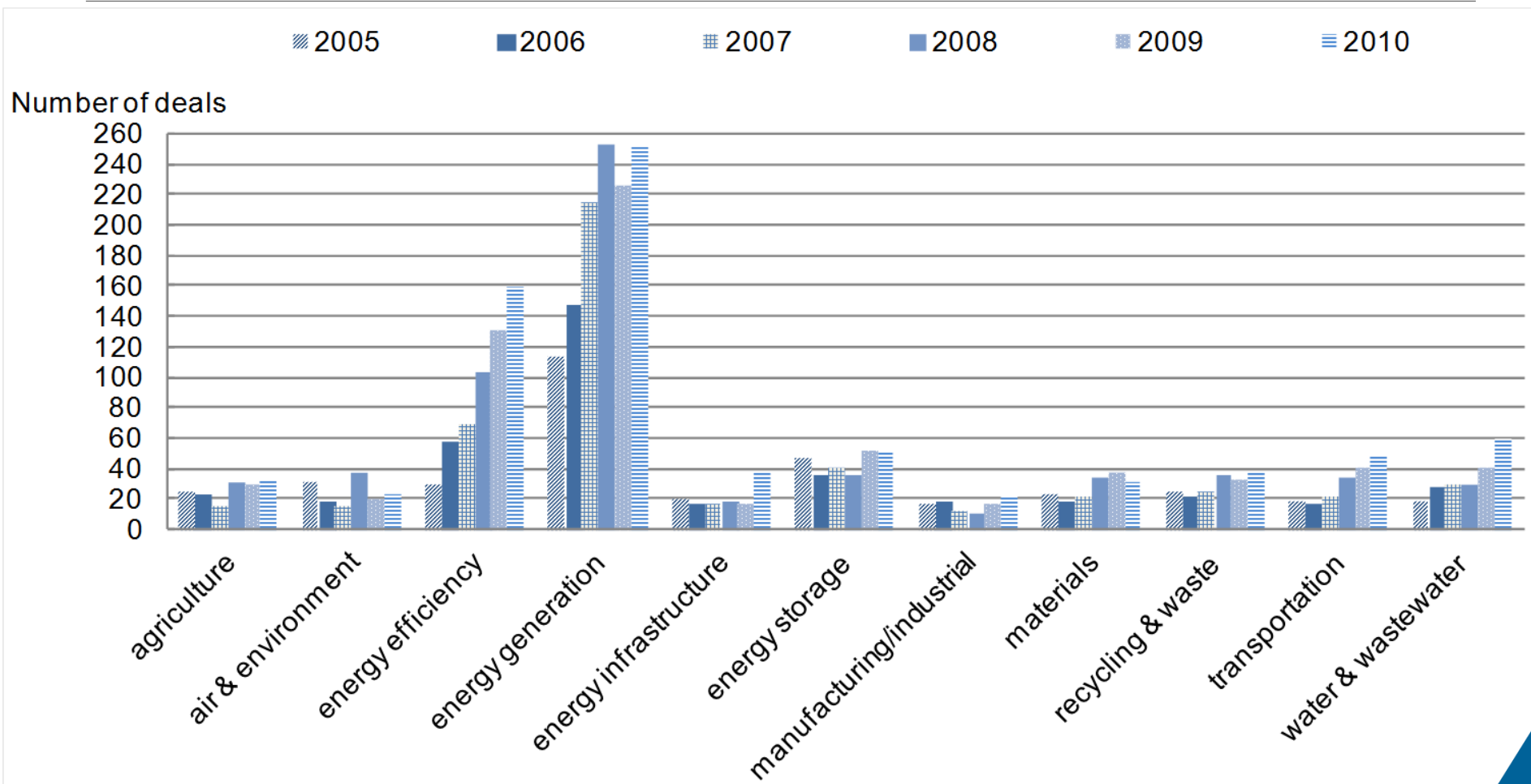


Number and size of deals by stage





Number of deals by primary industry and year





Patenting: seekers and financed firms at different financing stages

	Seekers				Financed			
	No patents	1 patents	2 or more patents	Total	No patents	1 patents	2 or more patents	Total
seed	415	26	27	468	408	54	94	502
	88.7%	5.6%	5.8%		81.3%	10.8%	18.7%	
first round	698	40	34	772	313	51	102	415
	90.4%	5.2%	4.4%		75.4%	12.3%	24.6%	
follow-on	278	22	22	322	1292	180	741	2033
	86.3%	6.8%	6.8%		63.6%	8.9%	36.4%	
private equity	17		1	18	237	9	40	277
	94.4%	0.0%	5.6%		85.6%	3.2%	14.4%	
other	552	43	35	630	833	114	307	1140
	87.6%	6.8%	5.6%		73.1%	10.0%	26.9%	
Total	1960	131	119	2210	3083	408	1284	4367
	88.7%	5.9%	5.4%		70.6%	9.3%	20.1%	



Patenting: seekers and financed firms in different sectors

Industry	Seekers			Financed		
	No patent	with patents	total	No patent	with patents	total
agriculture	71	6	77	134	76	210
air & environment	104	20	124	157	68	225
energy efficiency	280	34	314	469	223	692
energy generation	735	98	833	1141	349	1490
energy infrastructure	55	4	59	133	60	193
energy storage	79	7	86	214	158	372
manufacturing/ industrial	96	8	104	88	53	141
materials	91	13	104	128	128	256
non-cleantech focused	14	2	16	5	1	6
recycling & waste	87	10	97	216	45	261
transportation	200	23	223	179	58	237
water & wastewater	148	25	173	219	65	284
Grand Total	1960	250	2210	3083	1284	4367



Results: deployment and supply policies

	Prob (Funding)>0	Mil. \$ funding	Prob (Funding)>0 seed-FS	Mil. \$ funding Seed-FS	Prob (Funding)>0 follow-on	Mil. \$ funding follow-on
Regulation Short Term	0.086***	0.028	0.089**	27.083***	0.752	8.172**
	(0.026)	(0.034)	(0.037)	(6.443)	(0.730)	(3.361)
Regulation Investment	0.085***	-0.006	0.146***	25.194***	-0.221	10.582***
	(0.025)	(0.045)	(0.046)	(5.907)	(0.684)	(3.336)
Incentives	-0.005	-0.031	0.002	5.172*	-0.194	2.413
	(0.014)	(0.027)	(0.030)	(2.831)	(0.458)	(1.813)
Govt R&D	0.649***	0.665**	0.738**	137.694***	15.563**	44.301**
	(0.201)	(0.335)	(0.306)	(35.180)	(7.436)	(21.036)
Observations	629	629	629	629	629	629
Model	Probit	Tobit	Probit	Tobit	Probit	Tobit

Notes: errors clustered at country level. Reported coefficients are marginal effects. Country-level controls and Year and Sector FEs included in all regressions.



Patent Quality measures

- **Patent scope:** the technological breadth of patents is an important characteristics in determining its value. Generally, broad patents are more valuable; on the other side, to the extent that the commercialization of the invention appears difficult to define, a too general patent may be valued less by potential investors. The index is calculated as the number of distinct 4-digit subclasses of the International Patent Classification (IPC) the patent is allocated to.
- **Backward citations:** each patent is required to cite all previous patents or scientific literature on which it relies on. A high number of backward citations may reflect the incremental nature of the patents. It may also implies that it is “well protected” from possible litigations.
- **Family size:** a patent family is a group of patents filed for at different patent offices but referring to the same invention. The size of the family is therefore positively correlated with the value of the patents, since it is a proxy of the applicants’ efforts in protecting the invention internationally