



# FINANCING GREEN INNOVATION AND INFRASTRUCTURE

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## Five principles of innovation-inducing environmental policy design

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- Ambitious - how high is the price of not inventing and adopting “clean” innovation
- Flexibility – does the policy induce search across all options
- Incidence – does the policy “hit” the policy objective directly
- Depth – does it provide incentives across whole range of outcomes
- Predictability – can the investor foresee future likely policy context

Source: Johnstone, N., I. Haščić and M. Kalamova (2010), "Environmental Policy Design Characteristics and Technological Innovation: Evidence from Patent Data", *OECD Environment Working Papers*, No. 16, OECD Publishing (Paris: OECD)



# The key role of policy settings at different stages of financing

## Industry-country level tobit (Amount of funding in CleanTech)

Sample	Early stage	Follow-on	Other stages
Regulation price	1.346*	4.691	30.628***
	-0.776	-4.673	-10.044
Regulation quantity	1.890*	17.819***	45.102***
	-0.974	-6.369	-13.3
Sale tax reductions	0.353	5.328	2.691
	-0.787	-4.684	-11.909
Fiscal incentives	-4.399***	-9.002	-31.005
	-1.587	-9.574	-20.845
Gov. R&D as % GDP	16.293***	93.573***	388.111***
	-5.876	-31.943	-82.973

Criscuolo, C. and C. Menon (2014), "Environmental Policies and Risk Finance in the Green Sector: Cross-country Evidence", *OECD Science, Technology and Industry Working Papers*, No. 2014/01, OECD Publishing, Paris.

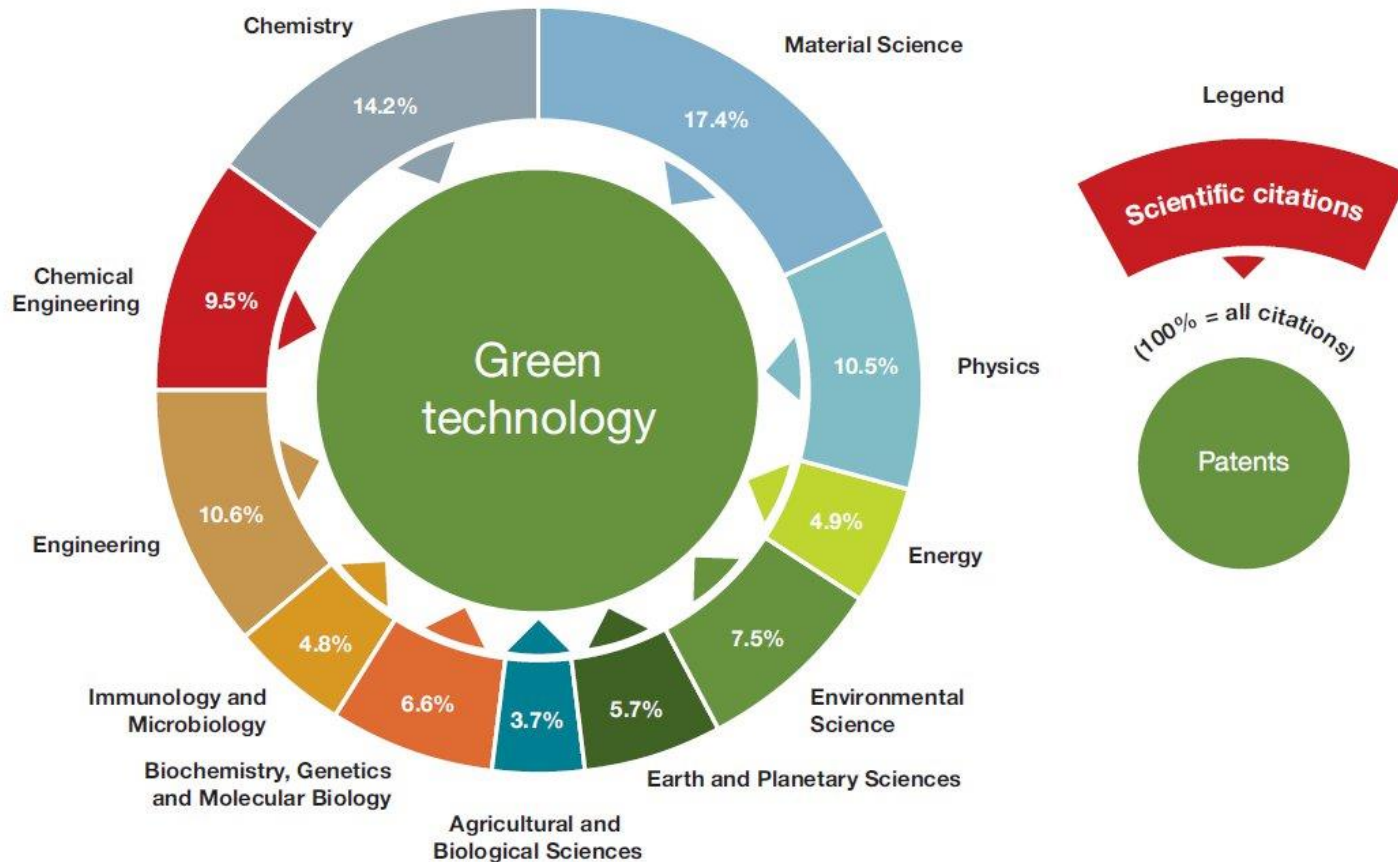
DOI: <http://dx.doi.org/10.1787/5jz6wn918j37-en>



# But what is meant by “green innovation” - standing on the shoulders of a “diverse” basket of giants

## The innovation-science link in selected green technologies

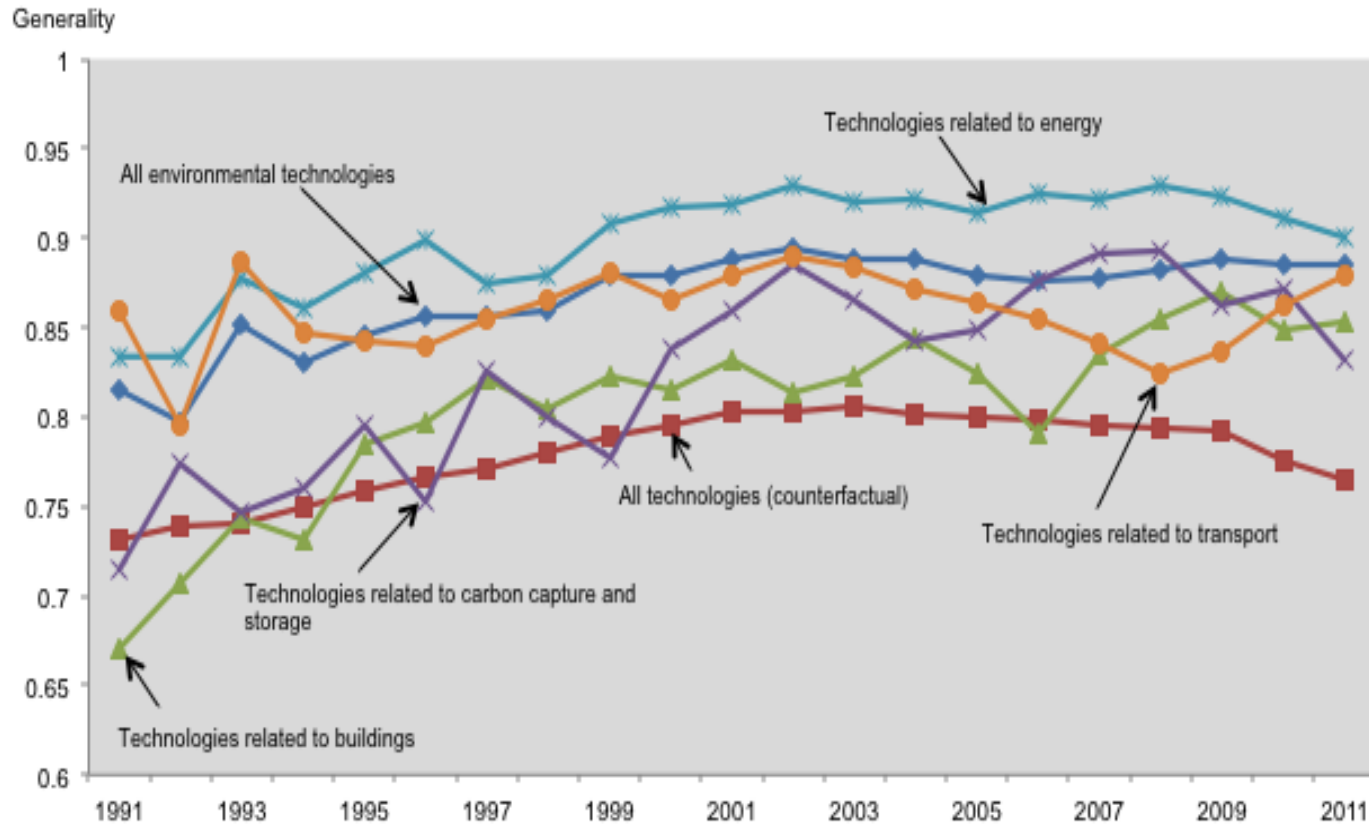
Patent-science link via citations, 2000-07



Source: OECD (2010), *Measuring Innovation – A New Perspective*, based on Scopus Custom Data, Elsevier, July 2009; OECD, Patent Database, January 2010; and EPO, Worldwide Patent Statistical Database, September 2009.



....and are increasingly the shoulders for innovation in many fields (measure of diffusion across fields)



Source: Egli, F., N. Johnstone and C. Menon (2015), "Identifying and inducing breakthrough inventions: An application related to climate change mitigation", *OECD Science, Technology and Industry Working Papers*, No. 2015/04, OECD Publishing, Paris.

DOI: <http://dx.doi.org/10.1787/5js03zd40n37-en>



# The Positive Implications of Generality and Radicalness for Attracting Risk Finance.....

Dependent variable:	Risk finance 2001-2010 (logs)
Industrial generality	18.82*** (2.837)
Radicalness	25.60*** (9.689)
Closeness to science	32.67*** (9.927)
Family size	1.738*** (0.512)
Maturity	0.973 (2.366)
Patent apps. 1990-2000	2.453*** (0.391)
No. of backward cits.	0.937 (1.090)

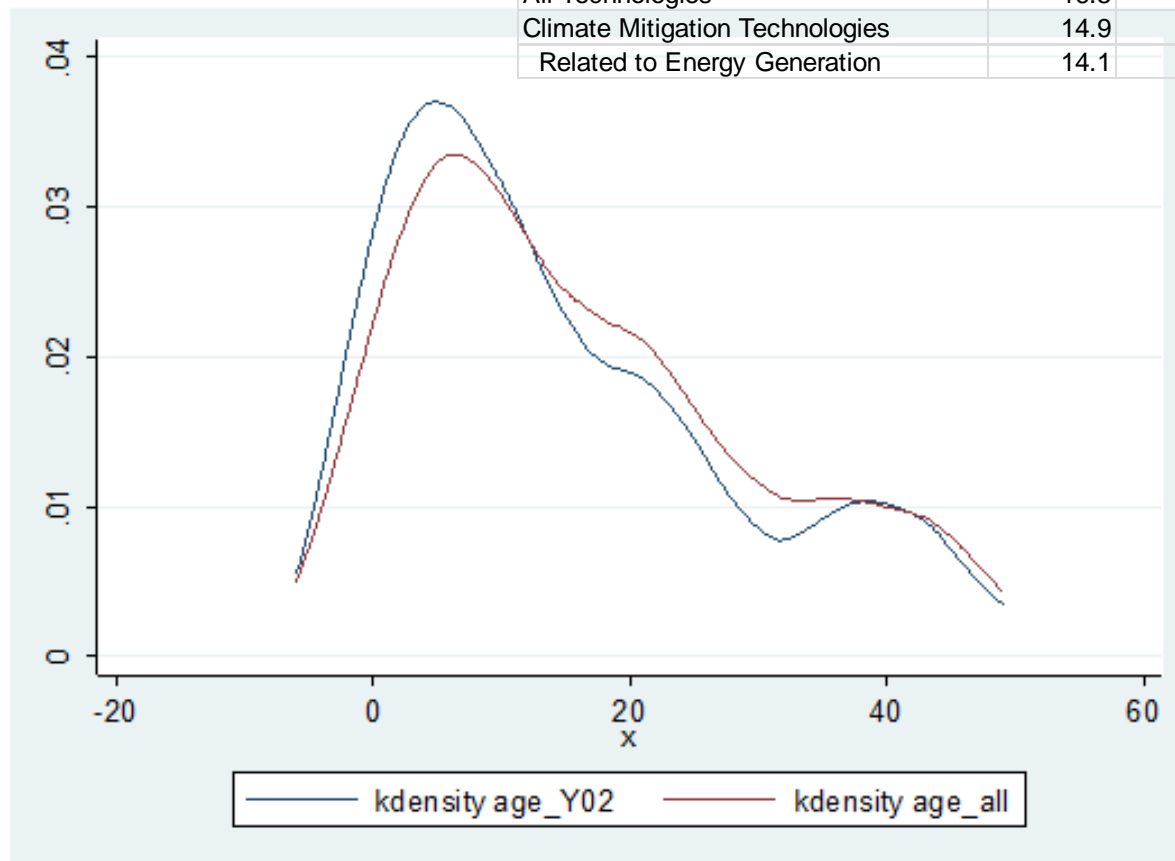
Note: All regressions are estimated with Least Squares (LS) and are weighted by the no. of patents in the period 1990-2000 in the CPC category. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Source: Egli, F., N. Johnstone and C. Menon (2015), "Identifying and inducing breakthrough inventions: An application related to climate change mitigation", *OECD Science, Technology and Industry Working Papers*, No. 2015/04, OECD Publishing, Paris. DOI: <http://dx.doi.org/10.1787/5js03zd40n37-en>



# Perhaps more “who” than “what” - the importance of “start ups” for innovation in climate mitigation

## Firm Age of Patenting Firms for Climate Mitigation Technologies (Y02) and Technologies in General)

	Mean Age	Median Age
All Technologies	16.5	13
Climate Mitigation Technologies	14.9	11
Related to Energy Generation	14.1	10





# The special challenge of green infrastructure - the “quadruple” market failure

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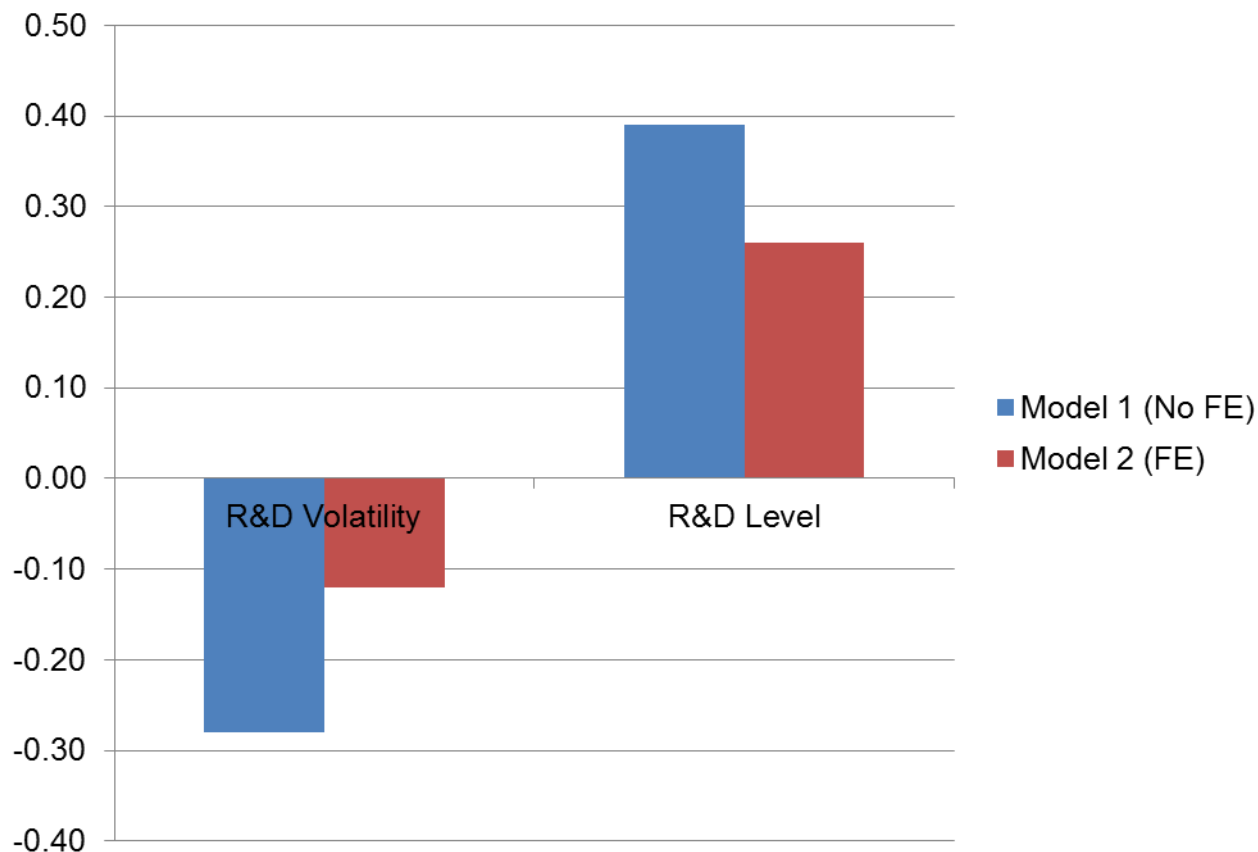
- The tale of (as many as) four market failures for some “environmental” innovations and investment.
  1. Environmental
  2. Knowledge
  3. Imperfect Competition
  4. Financial market failures
- Arguably in the case of “green” infrastructure all four are present. Think transport, energy, etc....
- Low-carbon energy pathways are dependent upon investment in complementary and long-lived infrastructures
  - Complex co-ordination game (energy, transport, ICT) and,
  - Key question of predictability (long-lived and irreversible)





# The Role of Policy Predictability.....

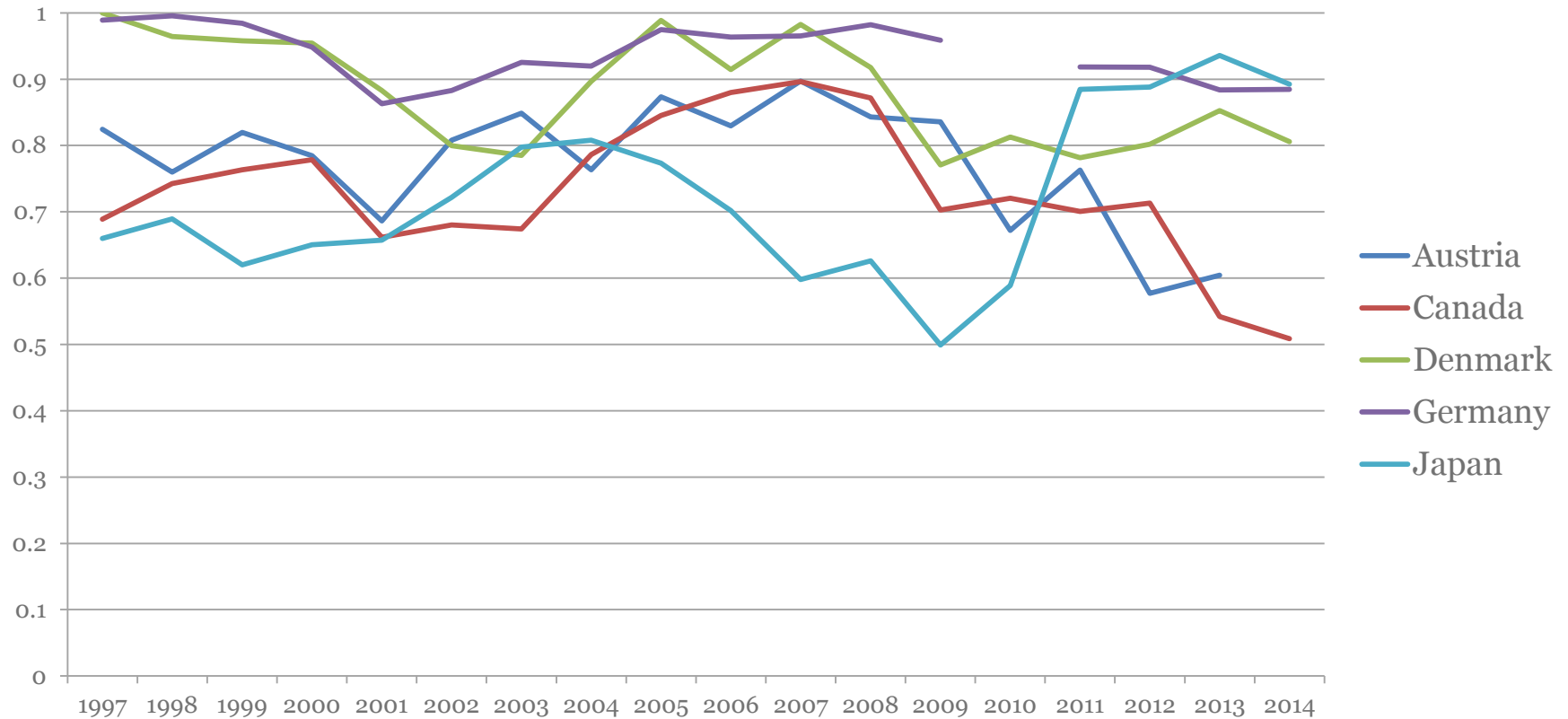
## Effect of Targeted Public R&D Volatility on Inventive Activity



*Note:* Figure shows the estimated response to a 1% increase in the level and volatility of public R&D in encouraging inventive activity in environmental technologies, measured as the number of patent applications (claimed priorities) deposited during 1975-2007 in a cross-section of OECD countries. *Source:* Kalamova, Johnstone and Hascic (2012) in V. Constantini and M. Mazzanti (eds.) *The Dynamics of Environmental and Economic Systems* (Springer, forthcoming).



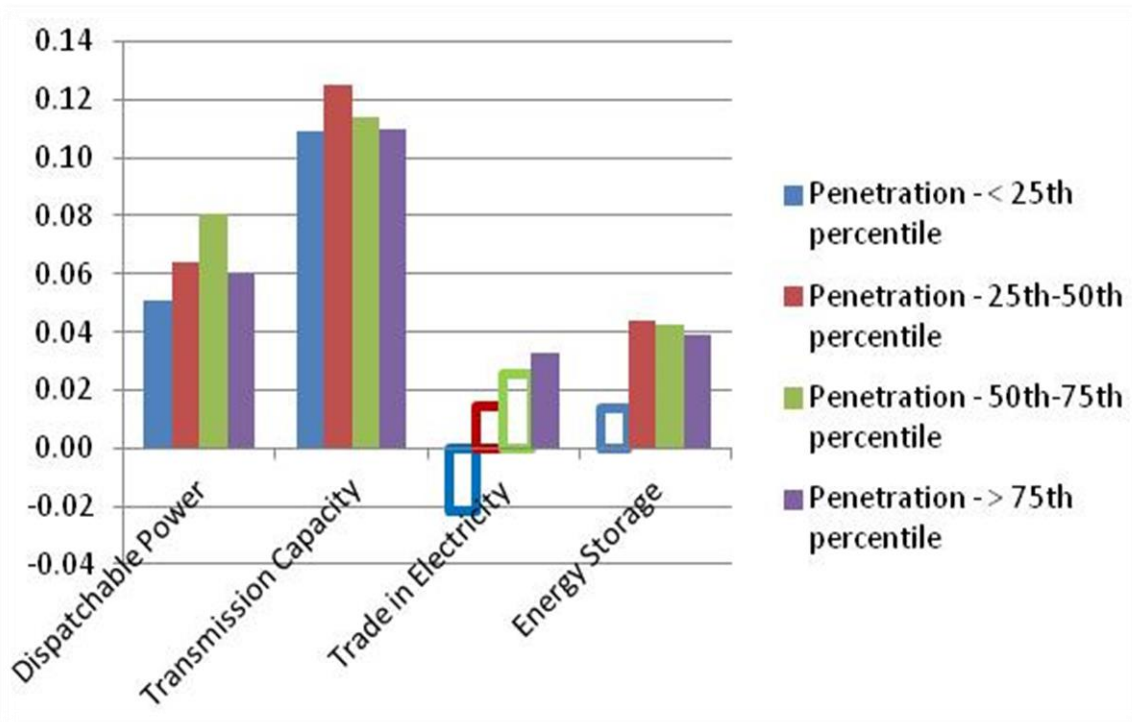
# Public R&D on Advanced Energy Storage and Advanced Grid Management and Generating Technologies (Generating as % of Total)



Johnstone, N. and I. Haščič (2013) “Increasing the Penetration of Intermittent Renewable Energy: Innovation in Energy Storage and Grid Management” in R. Fouquet (ed.) *Handbook on Energy and Climate Change*, Edward Elgar.



# The Importance of Infrastructure - Model Estimating Effective Capacity Factors of Renewable (Effects of 'Strategy' Variables)



**Although ECF mostly depends on ecological factors (wind speed), it is also significantly affected by other explanatory variables**

Benatia, D., N. Johnstone and I. Hašič (2013), "Effectiveness of Policies and Strategies to Increase the Capacity Utilisation of Intermittent Renewable Power Plants", *OECD Environment Working Papers*, No. 57, OECD Publishing, Paris. DOI: <http://dx.doi.org/10.1787/5k46jotrlnn-en>



# Conclusions

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- Policy settings influence allocation of risk finance to “green”. But:
  - Since environmental innovation can come from anywhere – premium on flexibility (and search) and direct incidence of policy measure
  - Since new firms are the vehicles through which green innovation emerges – ensure dynamic business environment
  - Since infrastructure is strongly complementary – may have been underfinanced and under-coordinated
  - The “sunk” nature of both innovation and infrastructure – places a premium on predictability (and credibility)