Climate policy uncertainty and investment behavior: Evidence from small hydropower plants

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Outline

- Background
- Hypothesis
- Modeling framework
- Preliminary results
- Further work

Background

- 2001: European Union introduces a focus on renewable energy resources. (directive 2001/77/EC)
  - Focus on electricity
- 2003: Sweden introduces a green certificate market to promote new renewable energy resources (subsidy)
- 2010: Politicians consider a common green certificate market for Norway and Sweden

Subsidy uncertainty

2003
- Initial discussion of green certificate market
- Plants constructed after 1.1.2004 will be included
- Uncertainty with respect to which plants will be included (size)

2004
- Further discussions of a common market
- If agreement is reached, a common market will open 1.1.2006

2005
- A common market is delayed until 1.1.2007

2006
- Negotiations break down and there will be no agreement
- Feed-in tariff is introduced to replace the certificate market. Support scheme will start 1.1.2008

Subsidy uncertainty

2007
- New negotiations for a common green certificate market
- Feed-in tariffs are canceled

2008
- Further discussion of a common green certificate market
- Discussions on which plants should be included

2009
- Agreement on the main principles for a common market is achieved
- If agreement is found, the common market will open 1.1.2012

2010
- Still no agreement, discussions concerning which power plants should be included in the market

Politicians have created uncertainty?

A QUOTE

- ”Our power plant may be profitable now, however, the green certificates will significantly boost profitability, so we’re waiting to see what the government has up its sleeve”

  Steinar Røhme, spokesperson for Jamtåsbekken vasskraftlag, a group of local land owners in Orkdal, the county of Sør-Trøndelag (Adresseavisen, 26. september 2009)

Research objective:

- Understand investor behavior and how subsidy uncertainty affects this behavior

Research question:

- Can a real options model, where subsidy uncertainty is included, better explain investor behavior compared to a net present value analysis?

Research Approach

- Use regression techniques to test if a model that includes subsidy uncertainty better explain investor behavior
- Three scenarios for expectations to subsidy:
  1) Uncertainty in subsidies are not included
  2) Uncertainty w.r.t. support scheme. If a market is introduced, it will be valid for power plants with construction start after 1.1.2004, but the size limit (in MW) is uncertain
  3) Uncertainty w.r.t support scheme. If a market is introduced, it will only include power plants with construction start after the given time and size limit (in MW) is uncertain

Find net present value and real options value

Use regression techniques to test for explanatory power of different subsidy regimes

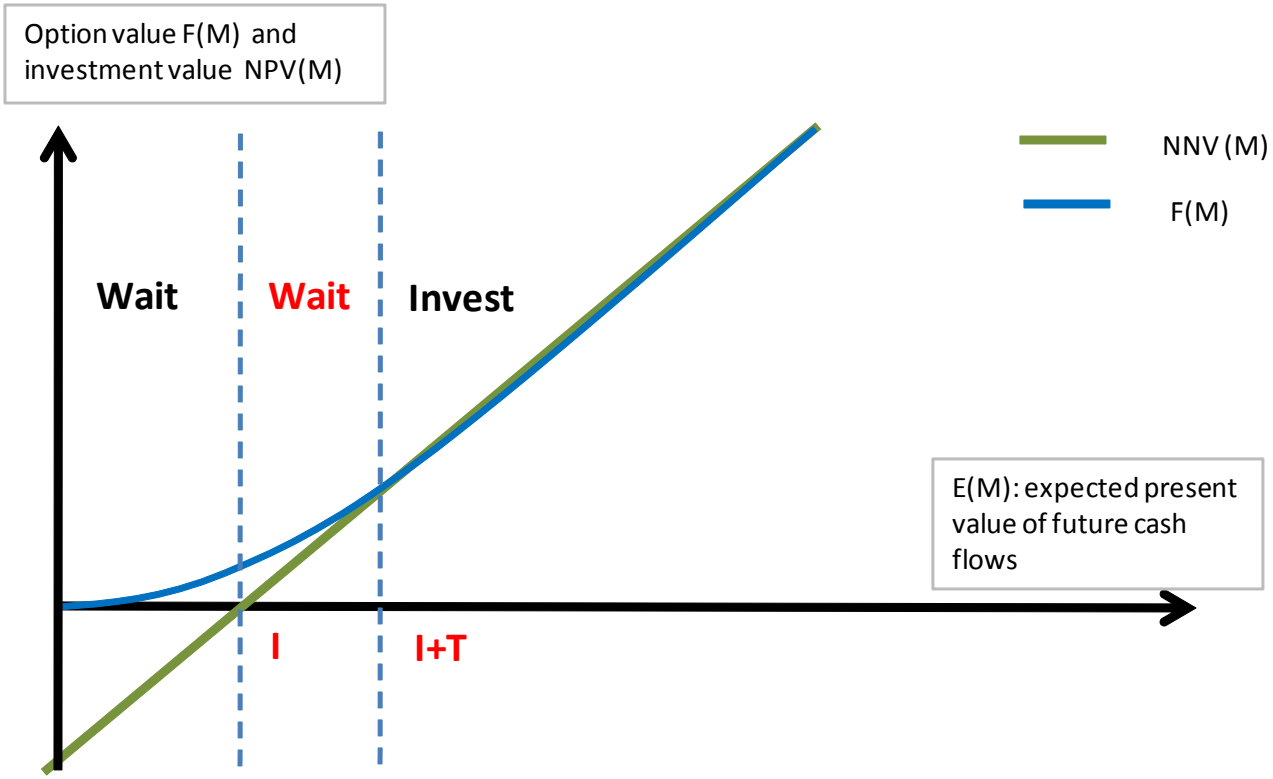
Extract results and give policy recommendations

Real options analysis versus NPV

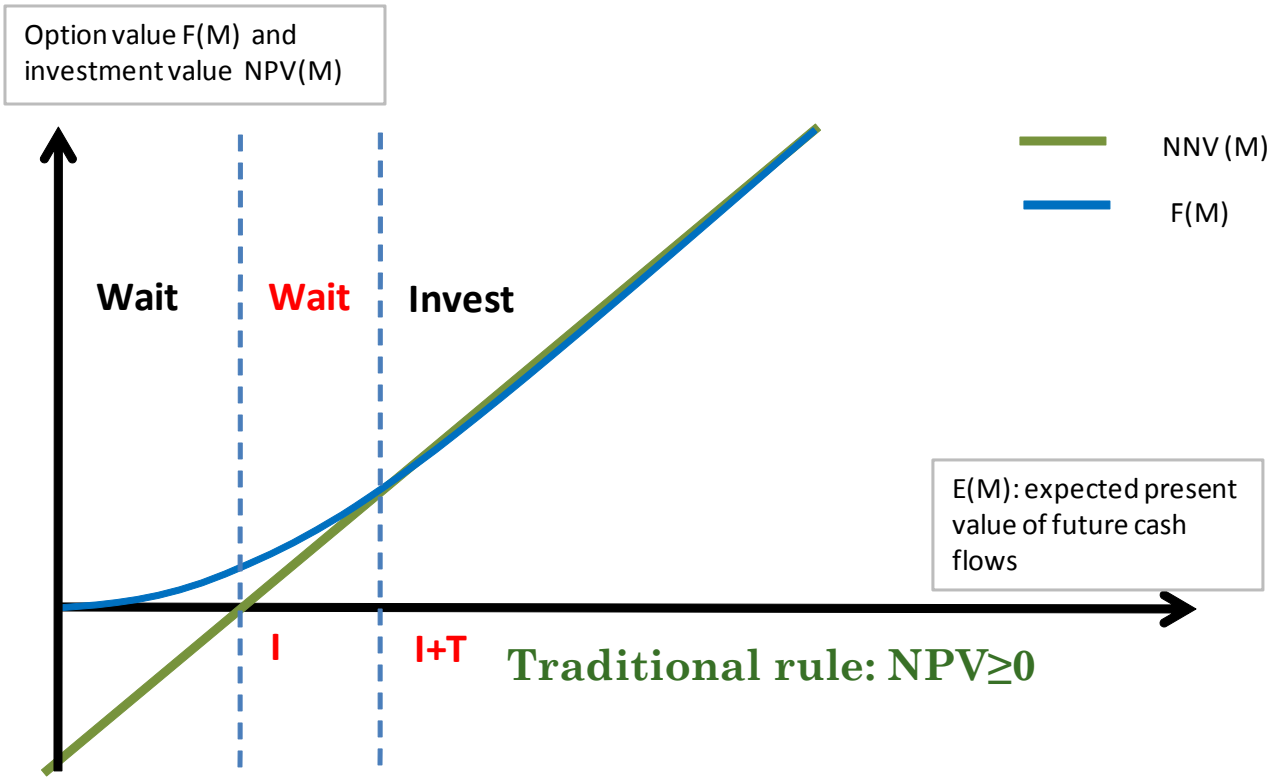
- NPV:
  - Only the most likely or representative outcomes are modeled
  - Uncertainty only included in the discount rate
  - Flexibility regarding timing is ignored
  - Easy to model
  - (Irving Fisher, The Rate of Interest, 1907)

- Real options analysis:
  - Can encounter for uncertainty in more detail
  - Investors can wait to see how the support scheme materializes
  - More complicated to model
  - (Dixit & Pindyck, Investment Under Uncertainty, 1994)

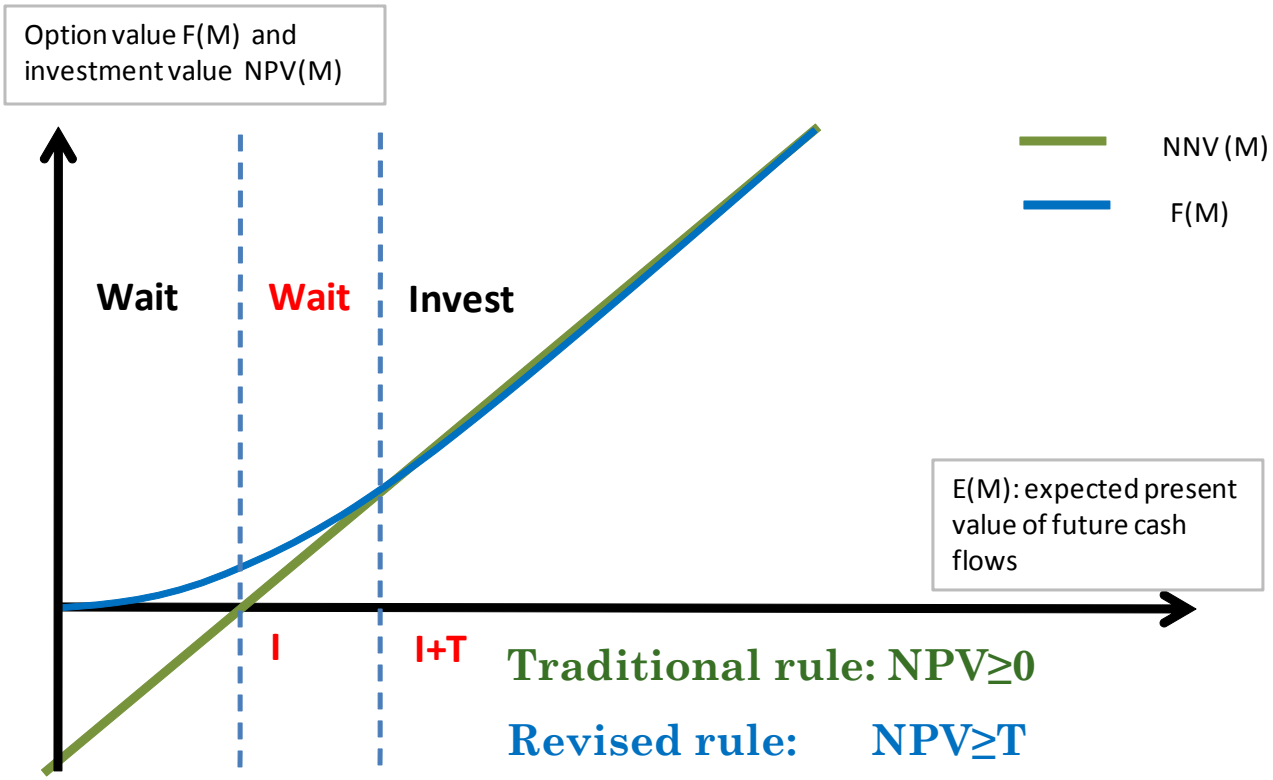
Revised investment rule



Revised investment rule



Revised investment rule



Data for investment options

- Dataset:
  - 229 run off river power plants > 1MW, < 10 MW
  - Year when license is granted
  - Year of construction (if constructed)

- Data given by each investor:
  - Planned Capacity [MW]
  - Expected annual production [MWh]
  - Expected Investment [NOK]

Data for investment options, cont.

- Assumptions:
  - Licence: 6 years (3+3)
  - Lifetime of power plant: 40 years
  - Operation and maintenance costs, sale costs and net tariff
  - Production profil
  - Inflation rate and discount rate
  - Sources of uncertainty:
    - Electricity price (BM and MR)
    - Investment cost (GBM)
    - Expectations regarding subsidies

Real Options Analysis

- Least Square Monte Carlo approach suggested by Longstaff & Schwartz (2001)
- Simulate *n* paths and compare net present value with continuation value (found by least squares)
- If the NPV in one year is higher than the continuation value → Invest in the given year
- If continuation value is higher than the NPV → delay investment

Results

- Matrix of NPV and real options value we can use for testing in regression analysis, values in million Norwegian Kroner, NOK

ROV	2001	2002	2003	2004
2001	26,04	28,34	32,52	35,89
2001	3,18	3,98	4,16	5,48
2002		11,61	13,24	31,85
2002		17,65	20,92	23,55
2002		5,50	6,44	7,58
2002		2,55	3,01	4,74
2002		2,24	2,55	3,14
2002		12,32	14,29	15,83
2003			17,34	19,56
2003			15,75	18,46
2003			14,72	16,73
2003			30,62	33,65
2003			3,06	3,94
2003			12,17	14,30
2003			0,23	0,33
2003			11,11	14,28
2003			3,53	4,21
2003			6,43	7,94

NPV	2001	2002	2003	2004
2001	27,92	30,13	34,47	37,56
2001	-2,45	-1,55	0,69	2,11
2002		12,31	14,11	33,54
2002		19,04	22,12	24,29
2002		5,45	6,71	7,57
2002		-12,13	-8,88	-6,89
2002		1,01	1,91	2,50
2002		13,05	15,10	16,56
2003			18,42	20,30
2003			16,91	18,88
2003			15,43	17,16
2003			32,38	35,13
2003			2,06	2,80
2003			12,71	14,31
2003			-3,96	-3,63
2003			9,43	11,76
2003			3,69	4,17
2003			5,32	6,71

Results, cont.

- Matrix of added value and actual decision

Added value	2001	2002	2003	2004
2001	0	0	0	0
2001	5,63	5,53	3,47	3,36
2002		0	0	0
2002		0	0	0
2002		0,05	0,00	0,01
2002		14,68	11,89	11,63
2002		1,23	0,64	0,64
2002		0	0	0
2003			0	0
2003			0	0
2003			0	0
2003			0	0
2003			1,01	1,14
2003			0	0
2003			4,19	3,97
2003			1,67	2,52
2003			0	0,04
2003			1,11	1,23
2004				0
2004				0
2004				0,06

Decision	2001	2002	2003	2004
2001	0	1	0	0
2001	0	0	1	0
2002		0	1	0
2002		0	0	0
2002		0	0	0
2002		0	0	0
2002		0	1	0
2002		0	1	0
2003			1	0
2003			0	1
2003			1	0
2003			1	0
2003			1	0
2003			0	1
2003			0	0
2003			0	0
2003			0	1
2003			0	0
2004				1
2004				1
2004				0

Results, cont.

- Matrix of added value and actual decision

Added value	2001	2002	2003	2004
2001	0	0	0	0
2001	5,63	5,53	3,47	3,36
2002		0	0	0
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2002		1,23	0,64	0,64
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2003			0	0
2003			0	0
2003			0	0
2003			0	0
2003			1,01	1,14
2003			0	0
2003			4,19	3,97
2003			1,67	2,52
2003			0	0,04
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2004				0
2004				0
2004				0,06

Decision	2001	2002	2003	2004
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2002		0	0	0
2002		0	1	0
2002		0	1	0
2003			1	0
2003			0	1
2003			1	0
2003			1	0
2003			1	0
2003			0	1
2003			0	0
2003			0	0
2003			0	1
2003			0	0
2004				1
2004				1
2004				0

Regression analysis

- Work in progress
  - Binary choice models
  - Panel data techniques

Further work

- Conduct regression analysis
- Conclude

(Questions…)

Thank you

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