GRETCHEN
policy mix for renewables

Modeling technological change in the renewable electricity generation sector

Some theoretical considerations

- work in progress -

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Kirsten S. Wiebe, INFORUM World Conference, Florence, September 2012

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About GRETCHEN

- Impact of climate, renewable energy and innovation policies on technological and structural change in renewable power generation technologies
- Combination of environmental and innovation economics
- 3 empirical levels
  - Micro: influence of the policy mix on company-internal invention, innovation and diffusion
  - Meso: impacts on innovation networks and market structures
  - Macro: impact on technological change, welfare, trade and structural change

Macro-level analysis

1. Identifying the effect of the policy mix on innovation and hence on technological change.
2. **Quantifying the effect of technological change on the model parameters and variables.**
3. Analyzing the resulting effect on the economy.

⇨ How can technological change in the renewable electricity generation sector be endogenized in INFORUM-type models?

The renewable power generation sector

- RE 19.3% of global power generation (IEA, 2011)
- Global RE sector growth of 17.8% 2005 – 2009
- Renewable energy (RE) power generation
  Solar PV & CSP, **Wind**, Biomass, Hydro, Geothermal

Innovation and technological change (TC)

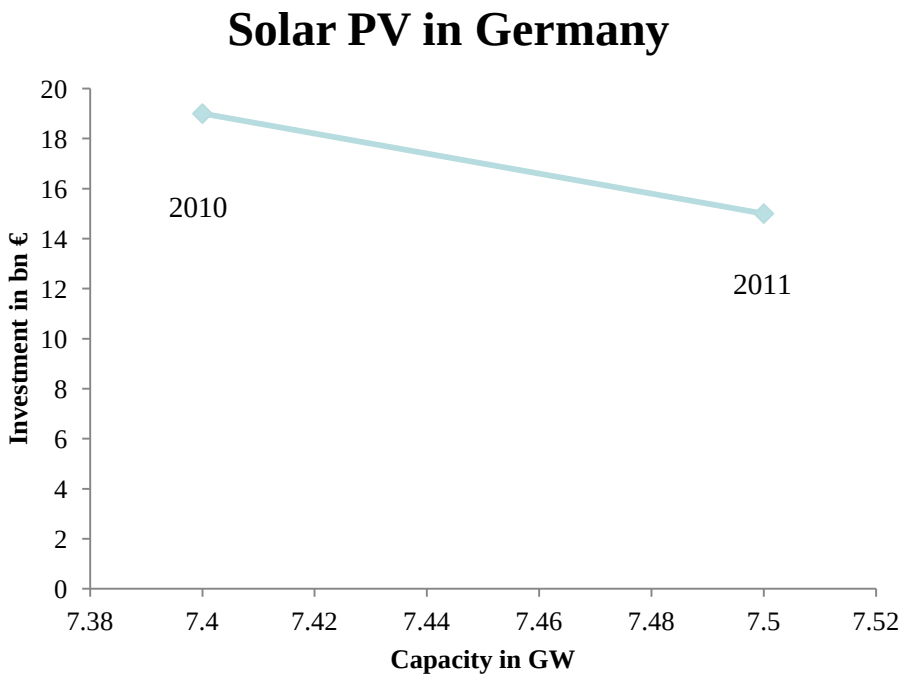
- Innovation
  - Technology-push ⇔ demand-pull
  - Product ⇔ process

- Modeling of innovation in macro-economic models?

⇨ Technological change
  - Exogenous: $Y = A * Y(K, L)$
  - Endogenous: $Y = A_t * Y(K, L)$, $A_t = A_0 B_t^{-b}$

Technological change in the renewable power generation sector

- TC affects costs and deployment
- Learning curves
  - Simple or logistic
- Necessary data
  - Capacity installed
  - Investments
  - Costs
  - Prices
  - Critical mass
  - Material efficiency



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Modeling of TC in RE sector

1. Where are renewable energy technologies in the model?
2. Can the technology be modeled explicitly or implicitly? If explicitly, how?
3. What changes were to occur in the model if there was technological change?

1. Where are renewable energy technologies in the model?

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A: Sectors in IO table

- Usually one aggregated mechanical engineering sector in the IO table
- Needs to be split according to technologies

B: Energy module

- Transformation sector in energy balance (EB)
- Aggregated RE sector solar/wind/other in IEA EB

2. Can the technology be modeled explicitly or implicitly?

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A: Sectors in IO table

- Explicitly according to sector classification

	PV
Agriculture, Hunting, Forestry and Fishing	0%
Mining and Quarrying	0%
Chemicals and Chemical Products	6%
Other Non-Metallic Mineral	2%
Basic Metals and Fabricated Metal	7%
Electrical and Optical Equipment	21%
Manufacturing, Nec; Recycling	1%
Electricity, Gas and Water Supply	0%
Construction	7%
Service sectors	6%
Imported intermediates	15%
Labor costs	26%
Value added	34%

Source: Renewably employed!

B: Energy module

- Implicitly: capacity installed of each energy carrier

	Coal, Oil, NG	Nuclear	Hydro	Geothermal	Solar/wind/other	Comb renewables	Electricity	Heat	Total
Production	75283	42493	1684	148	2695	12978	0	0	135282
Imports	250144	0	0	0	0	0	4890	0	255034
Exports	-35578	0	0	0	0	0	-5283	-4	-40865
International marine bunkers	-2466	0	0	0	0	0	0	0	-2466
Stock changes	-1710	0	0	0	0	0	0	0	-1710
Total primary energy supply	**285672**	**42493**	**1684**	**148**	**2695**	**12978**	**-393**	**-4**	**345274**
Transfers	590	0	0	0	0	0	0	0	590
Statistical differences	-2012	0	0	0	0	0	0	0	-2012
Main activity producer electricity plants	-61562	-42493	-1653	0	-2452	0	43595	0	-64565
Autoproducer electricity plants	-5742	0	-31	0	0	-5	1789	0	-3989
Main activity producer CHP plants	-14389	0	0	0	0	-4005	5334	8613	-4447
Autoproducer CHP plants	-7548	0	0	0	0	-927	2037	6875	437
Main activity producer heat plants	-636	0	0	-21	0	-241	0	3090	2192
Autoproducer heat plants	0	0	0	0	0	0	0	878	878
Petroleum refineries	-1980	0	0	0	0	0	0	0	-1980
Coal transformation	-5512	0	0	0	0	0	0	0	-5512
Liquefaction plants	0	0	0	0	0	0	0	0	0
Non-specified (transformation)	-152	0	0	0	0	0	0	0	-152
Own use	-7794	0	0	0	0	-84	-5035	0	-12913
Distribution losses	-497	0	0	0	0	0	-2526	-1517	-4540
Total final consumption	**178435**	**0**	**0**	**127**	**243**	**7717**	**44802**	**17935**	**249259**

3. What changes were to occur in the model if there was TC?

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A: Sectors in IO table

- TC in RET engineering sector: Input coefficients change depending on learning curves
  - Simple one factor LC

$$a_{ijt}^{N} = a_{ij0}\left[\sum_{t} K(t)\right]^{-b}$$

  - Logistic curve

$$a_{ijt}^{N} = a_{ij0}\left[\alpha_l + \frac{\alpha_u}{\left(1+\theta e^{-\beta\left(t(1+G)-\frac{\pi}{1+G}\right)}\right)^{1/\theta}}\right]$$

B: energy module

- Changes in costs structures of technologies depending on learning curves
- Changes in demand for solar panels/wind mills
- Changes in installed capacity
- Installed capacity (KW) * annual hours of electricity generation (h) = electricity supply in KWh in energy balance

Conclusion?

- How should the renewable energy technology sector be modeled to endogenize technological change?
  - No preference for either one of approaches A or B yet
  - Any comments/suggestions ideas?
  - Any experience with either one of the approaches?
  - Are there other ways to do this?

Thank you!

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