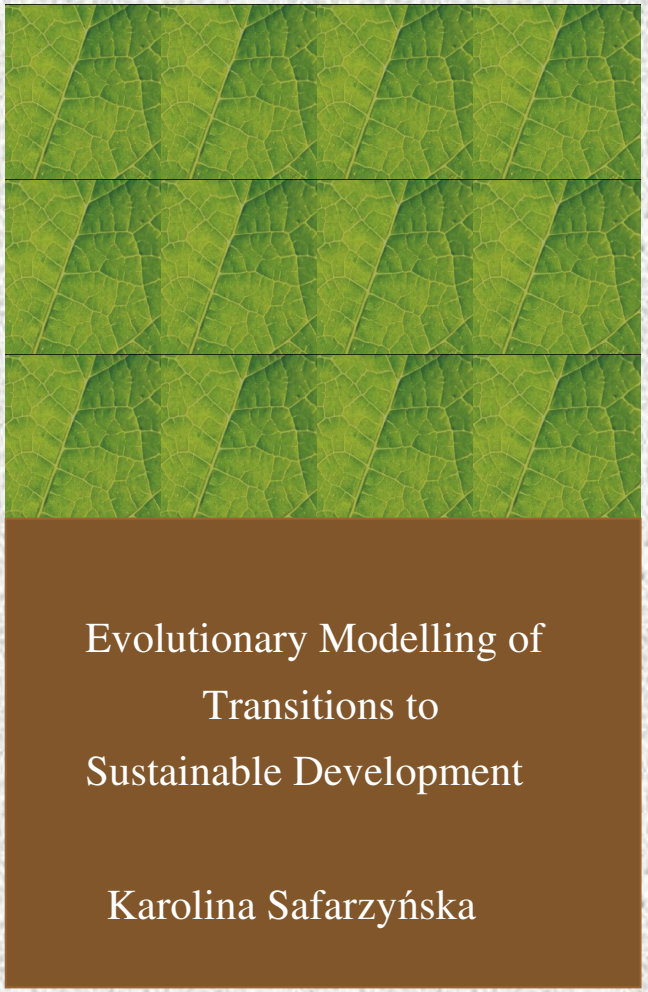
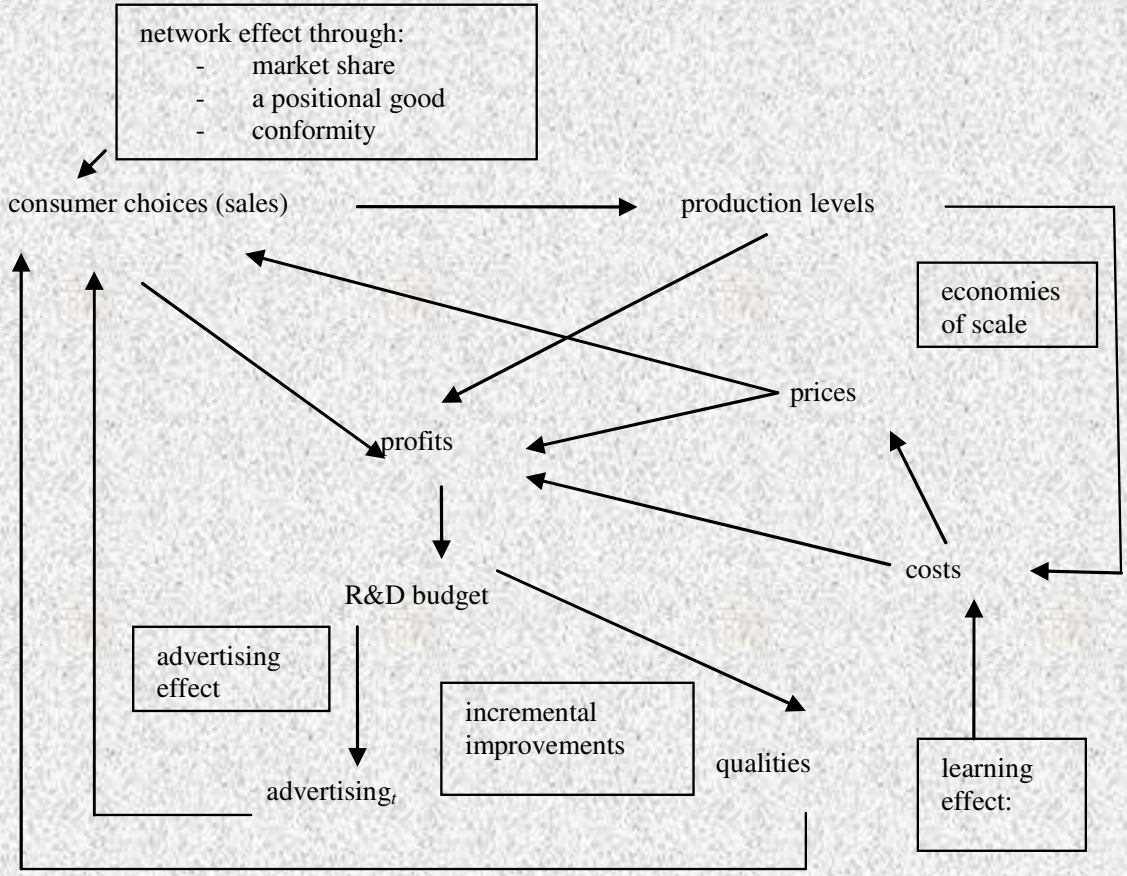


Producer-consumer coevolution and innovation dynamics

Outline of the presentation

- a coevolutionary model of demand and supply
- energy transitions with interactive selection-innovation dynamics
- a history friendly model of the evolution of electricity industry

An agent-based model of demand-supply coevolution



Appeared as: Safarzyńska, K., van den Bergh, J.CJ.M., 2010. Demand-supply coevolution with multiple increasing returns: policy analysis for unlocking and system transitions. *Technological Forecasting and Social Change* 77: 297-317.

Supply side

- firms set the desired production level for the next period
- firms invest in capital expansion
- firms invest (remaining) profits in advertising and R&D activities towards quality improvements
- if its sales are insufficient a firm can carry out marketing research; it considers innovating radically

Demand side

Each consumer attempts to purchase a product that renders the highest utility:

$$u_{it} = \chi \frac{x_{jt}^{\alpha_i} n_{jt}^{\zeta} f_{jt}^{\varpi} b_{jt}^{\varpi}}{p_{jt}^{0.5-\alpha_i} l_{jt}^{\kappa}}$$

Types of network effect

Network effect:

- through market share:

$$n_{jt} = m_{jt-1}$$

- through a positional good:

$$n_{jt} = x_{jt} - \bar{x}_{t-1}$$

- through conformity:

$$n_{jt} = \tilde{x} - abs(x_{jt} - \bar{x}_{t-1})$$

Increasing returns

Demand:

- Network Effect
- Snob Effect
- Advertising Effect (Informational Increasing Returns)

Supply:

- Learning-by-Doing
- Economies of Scale
- Incremental Improvements

Model simulations

- Simulations involve the interactions of 100 consumers in 2 classes (peer groups), 0-15 firms (stochastic)
- Monte-carlo based on 500 simulations. Logit regression analysis (1=lock-in occurred, 0 not).
- For 3 alternative network effects: market share, positional good and conformity

Insights

- Increasing returns on the demand side are more likely to prevent the diffusion of innovations than increasing returns on the supply side.

- The effectiveness of unlocking policies is sensitive to the demand-side specification.

An Evolutionary Model of Energy Transitions with Interactive Innovation-Selection Dynamics

How much capital to take away from fossil fuel towards renewable energy technologies so as to provide the latter with good learning opportunities, while ensuring security of energy supply?

Trade-off between:

- diversity and efficiency
- long- and short- term benefits

An Evolutionary Model of Energy Transitions with Interactive Innovation-Selection Dynamics

$$\dot{x}_{et} = \sum_j x_i f_{it} q_{ji} - x_{et}\phi_t + r\sum_{kj} \gamma^e_{kj} x_{it} x_{jt}$$

where:

x_{it}	shares of investments
f_{it}	technology fitness
ϕ_t	the average fitness
γ^e_{kj}	= 1 if technologies may recombined
α^e_{ij}	weights at which technologies are recombined
r	recombination
q_{ik}	mutation

Selection environments

- Constant costs

$$c_{it} = c_{i0}$$

- Costs decreasing steadily over time

$$c_{it} = \frac{c_{i0}}{gt + b}$$

- Costs decreasing along learning curves

$$c_{it} = c_{i0}\left(\int_0^t x_{it}\,dt\right)^{-\beta_i}$$

Model dynamics

- Market dynamics last $T=500$ time steps, referred to as the investment period
- 3 technologies: 2 exist and 1 emerges:

  $x_{1,0}=x_{2,0}=0.5$ and $x_{3,0}=0$

  x- technology shares
- Other parameter values are:

  $c_{1,0}$=0.1 $c_{2,0}$=0.2 $c_{3,0}$=0.4,

  c- unit costs

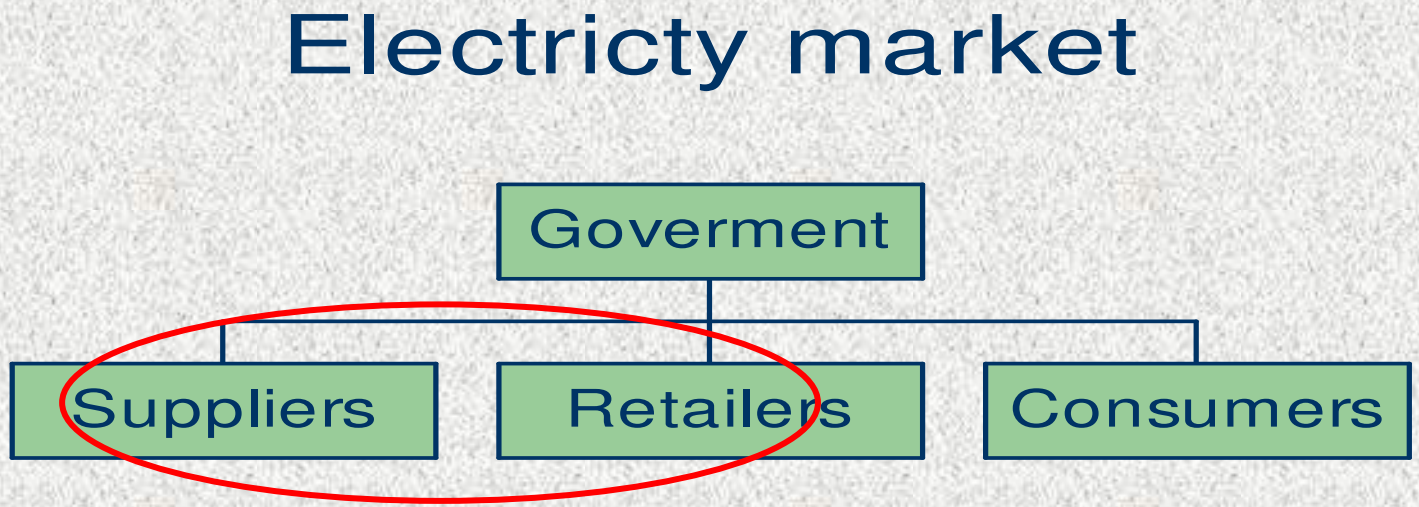
  β_1=0.05, β_2=0.05, β_3=0.35.

  β- learning rates

Insights

- Diversification of a research portfolio can be an important source of innovation due to potentially novel combinations of incumbent technologies.
- In the long run, it may also ensure the lowest average cost of maintaining a specific technology mix.

Industry Evolution, Rationality and Transition to Sustainable Electricity Production



Two versions of the model:

- with rational investors
- with boundedly rational investors

Structure of the model

- Plants set their production and forward position in a two step maximization procedure:

  - 2nd stage: setting production given plant's forward position

  - 1st stage: forward position
- Each plant employs inputs for production according to their marginal productivity.
- A new plant enters a market

  - Rational model version: technology choice based on the discounted value of investments

  - Evolutionary model version: random

Insights

- The version of the model with rational agents replicated well the core characteristics of a transition from coal to gas in the UK.
- In the version with boundedly rational investors, the dominance of nuclear energy in electricity production was observed in the majority of simulation runs.
- In both versions of the model, in the presence of a forward market, fuel and labour use were much higher than without it.

Conclusions

- Modelling exercises attempted to unravel some general tendencies of system dynamics and to identify possible mechanisms of change.
- Proposed models can be modified to incorporate features of specific sectors or industries undergoing transitions.

Thank you for your attention