Co-evolutionary of technologies, institutions and business strategies for a low carbon future

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Outline

- Introduction: complexity economics
- Need for a co-evolutionary, multi-level framework
- Key research and policy challenges
- Transition pathways to a low carbon economy
- Conclusions and further research
Complexity economics: sources

• **Evolutionary and institutional economics**
  – Path dependency and lock-in (‘history matters’)

• **Ecological economics**
  – Situate human economic systems within environmental systems providing resources and waste assimilation

• **Behavioural economics**
  – Bounded rationality of decision-making

• **Complex systems thinking**
  – Network interactions and emergent properties

• **Social shaping of technological change**
  – Influence of institutions and ways of thinking
Economies as complex adaptive systems

• **Dynamics:**
  – economies are open, dynamic systems, far from equilibrium;

• **Agents:**
  – made up of heterogeneous agents, lacking perfect foresight, but able to learn and adapt over time;

• **Networks:**
  – agents interact through various networks;

• **Emergence:**
  – macro patterns emerge from micro behaviours and interactions;

• **Evolution:**
  – evolutionary processes create novelty and growing order and complexity over time.
Co-evolutionary, multi-level framework

• Understanding and analysing transition pathways to a low carbon economy
• Co-evolutionary approach
  – Co-evolution of technologies, institutions, business strategies and user practices
• Multi-level framework
  – Interactions between macro, meso and micro levels
• Draws on insights from three research areas:
  – Socio-technical transitions (Kemp, Rotmans, Geels)
  – Technological innovation systems (Jacobsson, Bergek, Hekkert)
  – Co-evolution of technologies and institutions
Socio-technical transitions approach

(1) Analysing historical dynamics of transitions using multi-level perspective:

- Landscape: broader cultural values and institutions
- Socio-technical regime: prevailing set of practices, technologies, skills, institutions, infrastructures
- Niches: Spaces partially isolated from regime where technological and social learning can occur

(2) Transition management as process of governance

- Modulate dynamics of transitions through interactive, iterative processes between networks of stakeholders
- Shared visions and goals; transition experiments
- ‘Transition arena’: innovation-oriented stakeholders
Developing and analysing transition pathways

LANDSCAPE

INTERNATIONAL FACTORS
CULTURAL FACTORS
ENVIRONMENTAL FACTORS

REGULATION
POLICY
MARKETS

STRATEGIES
VALUES
BEHAVIOUR

ENERGY INFRASTRUCTURE
ENERGY SOURCES
SERVICES
DELIVERY NETWORKS

OLD REGIME
TRANSITION PATHWAYS
NEW REGIME

NICHE SOLUTIONS
ALTERNATIVES AND OPTIONS
SOCIAL EXPERIMENTATION
INNOVATION

NOW
2060
Technological innovation systems (micro-meso level)

- Technological innovation systems
  - Range of actors and interactions (both market and non-market) leading to production, diffusion and use of new, and economically useful, knowledge
  - Actors exhibit bounded rationality, uncertainty about future
  - Processes of learning and expectations about future markets and technological improvements
  - Institutional factors (social rule systems) create drivers or barriers to innovation
  - ‘Virtuous’ or ‘vicious’ cycles arise through positive or negative feedbacks
Functions of innovation systems

• Analysis of how innovations at micro level, within niches, challenge dominant regime at meso level

• Functions of innovation systems:
  – Entrepreneurial activities
  – Knowledge development
  – Knowledge diffusion through networks
  – Guidance of search activities
  – Market formation
  – Mobilization of resources
  – Creation of legitimacy /overcoming resistance to change

• Virtuous and vicious cycles
Virtuous cycles between key process in technological innovation systems

Source: Hekkert et al., 2007
Co-evolutionary approaches (meso-macro)

• Co-evolution of technologies and institutions
  – ‘Carbon lock-in’ arises through co-evolution, driven by path-dependent increasing returns to adoption (Unruh)

• Co-evolution of technologies, institutions and firms’ strategies
  – Historical study of synthetic dye industry (Murmann)
  – Take-up of renewable energy (Stenzel et al.)
  – Sustainability-driven entrepreneurs (Parrish and Foxon)

• Co-evolution of physical technologies, social technologies and business plans
  – Institutions as ‘social technologies’ (Nelson)
  – Driving creation of wealth through innovation of physical and social technologies (Beinhocker)
Co-evolutionary framework

• Two evolving populations co-evolve if and only if they both have a significant causal impact on each other’s ability to persist
  – By altering selection criteria, or
  – Changing replicative capacity of individual entities

• Incorporates basic evolutionary economic concepts
  – Bounded rationality, diversity, innovation, selection, path dependency and lock-in, co-evolution

• Co-evolution of technologies, institutions, business strategies and user practices
  – Roles for both agency and structure in causal influences
  – Linking macro, meso and micro levels
Key research and policy challenges

• Inform mix of policy measures to promote successful innovation and diffusion of low carbon technologies (micro-meso level)
  – Address system failures in innovation systems
  – Maintain diversity, whilst ensuring that promising options benefit from increasing returns and learning effects

• Assess implications for economic growth of a transition to a low carbon economy (macro-meso)
  – 60% reduction in global CO₂ emissions by 2050 would reduce global GDP by 1-2% (Stern review)
  – Difficulties in overcoming techno-institutional lock-in?
  – Shift in energy investment portfolios
Innovation of renewable energy technologies

• **Role of incumbent firms in take-up of renewable technologies in Germany, Spain and UK** (Stenzel et al.)
  - Germany: dual-track strategy of investing in renewables, but also lobbying against support mechanisms
  - Spain: virtuous cycle as price support provided selective pressure for investment in wind farms, development of technological capabilities and lobbying for further support
  - UK: incumbents squeezed out small firms, but wind power remains niche activity

• **Sustainability entrepreneurs in US** (Parrish and Foxon)
  - Innovative business strategy helped to enable adoption of small-scale renewables by local communities
  - Help create institutional niche, favouring selection of similar business strategies
Transition pathways to a low carbon economy

• New project developing and analysing transition pathways to a low carbon energy system in UK:
  (1) Characterise existing energy regime, its internal tensions and landscape pressures on it:
  (2) Identify dynamic processes at the niche level:
  (3) Specify interactions giving rise to transition pathways

• Dominant drivers of change:
  – Institutional innovation for legally-binding carbon reduction targets on path to 80% reduction by 2050
  – Leads to selection pressures in favour of low carbon technologies, and changes to business strategies
  – Lobbying by dominant energy firms to replicate existing regime by new nuclear and coal power stations
Potential transition pathways

1) Later-action/centralized generation systems:
   • Energy companies focus on large-scale technologies: nuclear power, offshore wind and capture-ready coal
   • Overseas investment counts towards UK targets

2) Later-action/decentralized generation systems:
   • Technical, social and economic concerns lead to renewed interest in decentralized options

3) Early-action/centralized generation systems:
   • Strong institutional support for domestic investment in centralized generation technologies

4) Early-action/decentralized generation systems:
   • Local leadership in decentralized options
Development of formal, multi-level evolutionary economic models

• **Limited development so far of evolutionary economic models:**
  – Evolutionary models of economic change (Nelson/Winter)
  – ‘History-friendly’ models of industry evolution (Malerba)
  – Selection-innovation dynamics models (Safarzynska and van den Bergh)

• **Apply co-evolutionary framework**
  – General approach, within which additional layers of complexity can be applied
Conclusions

• **Framework for examining**
  – co-evolution of technologies, institutions, business strategies and user practices
  – for a transition to a low carbon economy

• **Analysing causal mechanisms by which**
  – activities within one system influence the selection criteria and replicative capacity within other systems

• **Multi-level approach, combining**
  – Micro-meso level analyses of innovation and diffusion of low carbon technologies
  – Macro-meso level assessments of implications for economic growth of a transition to a low carbon economy