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 heteorogeneous 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

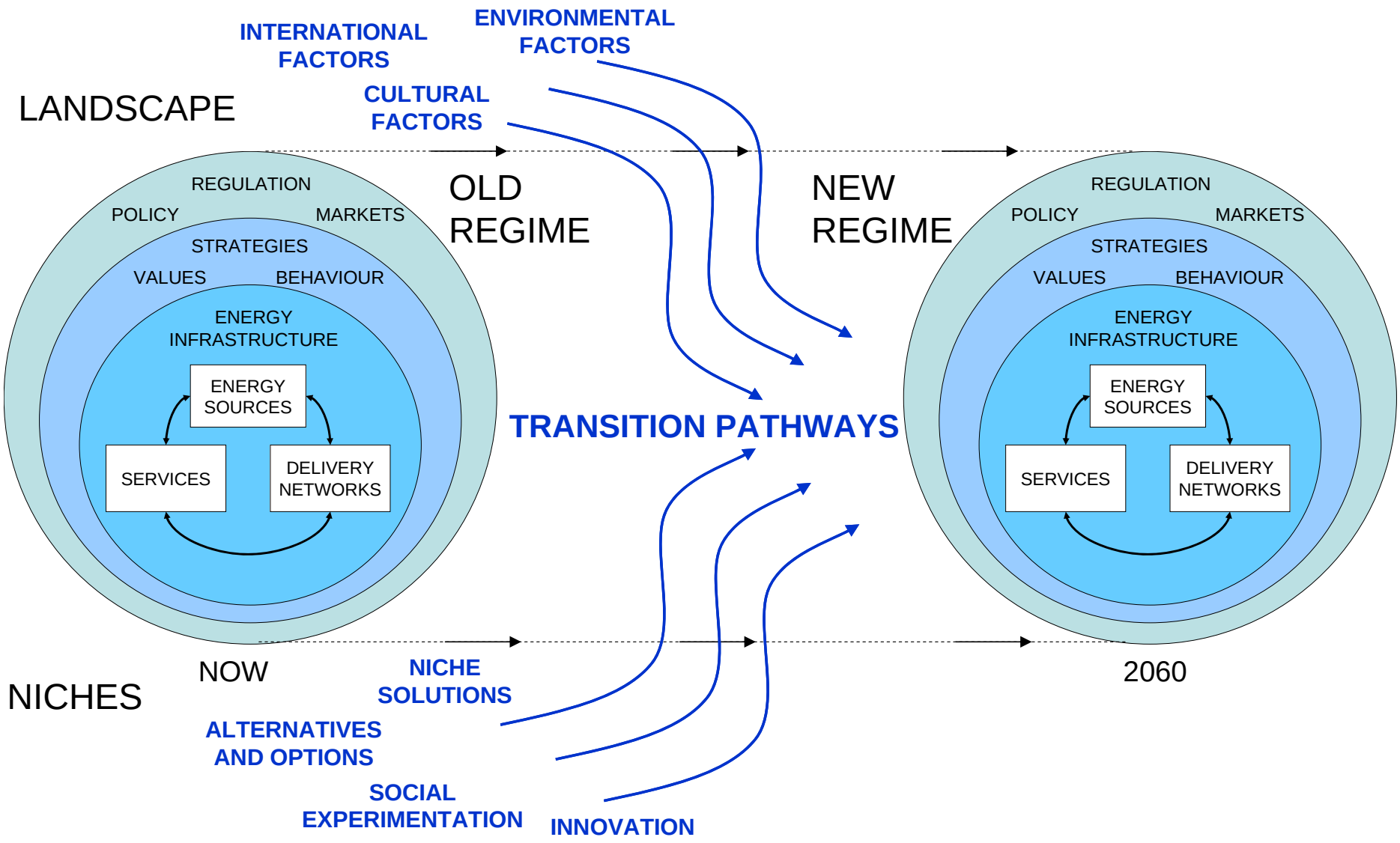
(1) Analysing historical dynamics of transitions using multi-level perspective:

- 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



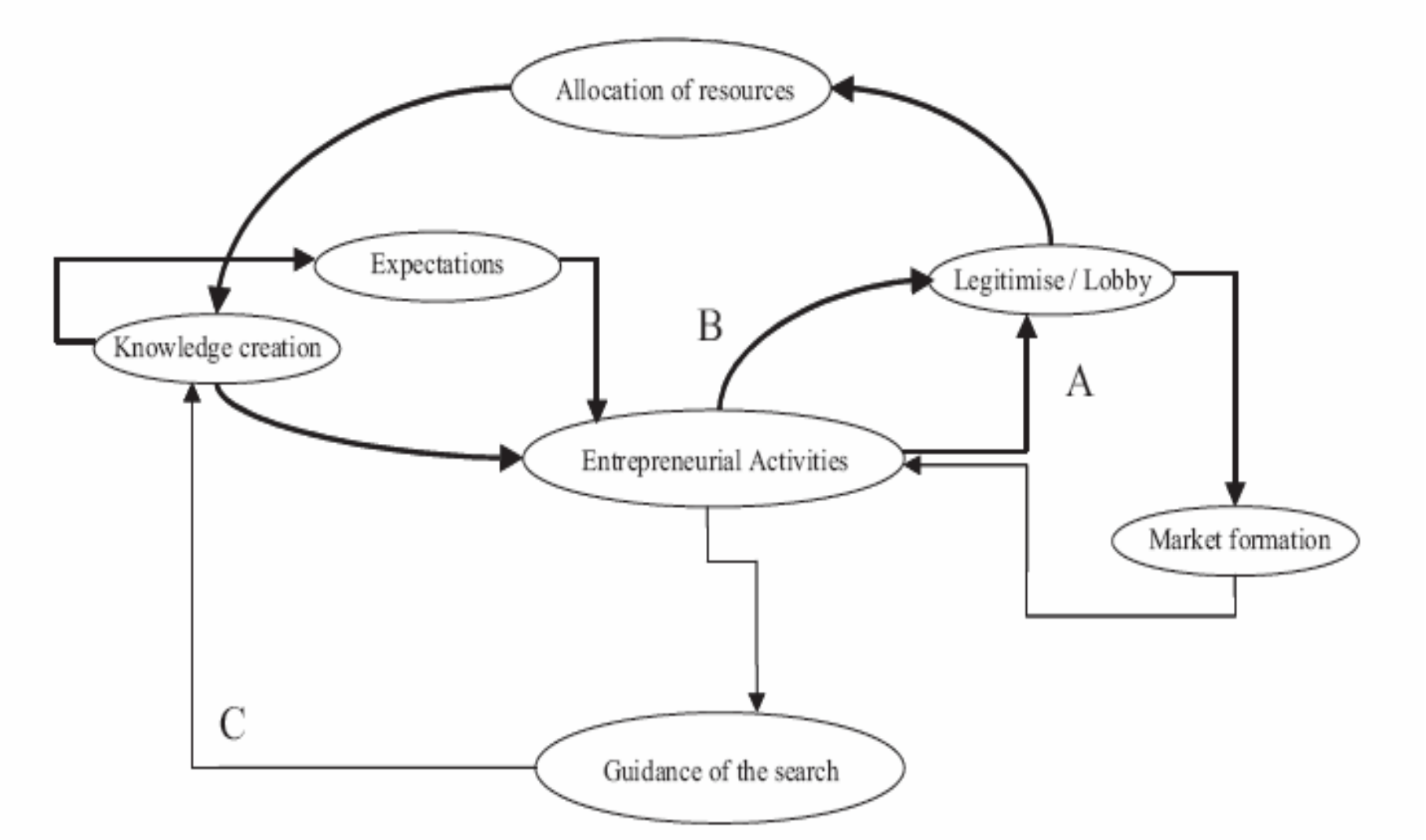
Technological innovation systems (micro-meso level)

- 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 CO_2 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