A Topography of Knowledge Transfer and low Carbon Innovation

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Abstract: The growth of the knowledge economy and the changing relationship between science and society, have triggered the emergence of a 'new role' for universities as catalysts for innovation within national innovation policy frameworks. The Triple Helix concept of knowledge generation and innovation introduces triadic relationships between government, academia and industry. These often incorporate state driven aims of innovation development and diffusion for greater societal and economic benefit as conditions of the funding programmes. This concept is witnessed in the UK low carbon energy innovation system, where collaborative relationships are formed to develop new technologies for application by industry and society. The dynamics of the Triple Helix model bring many challenges to policy makers and those engaged in knowledge transfer relationships, stemming from the inherent nature of knowledge and the complex human interactions involved with inter-organisational knowledge transfer. Low carbon innovation has an increased need for inter-disciplinary knowledge transfer where specialised pools of knowledge are brought together for the purposes of innovation, in environments typified by uncertainty and unclear user impacts. Obstacles are compounded by the complexity of defining knowledge transfer processes and the debate surrounding the transferability of knowledge. Significant additional challenges exist within low carbon innovation, where influencing technology adoption by the public is seen as a multifaceted problem with no easy solution and requires innovation outputs to be transformed to societal outcomes. This paper aims to explore the nature of these challenges through a review of the literature on knowledge transfer, the continuing transition of academia, government and industry within knowledge generation frameworks and the specific dilemmas faced by the low carbon innovation system. This literature review provides a foundation for future research which aims to explore the concept of knowledge transfer within the UK low carbon innovation system and gather empirical data pertaining to the optimisation of collaborative project performance.

Keywords: knowledge transfer, research systems, innovation policy, low carbon innovation, collaboration

1. Introduction

This exploratory paper reviews the literature pertaining to knowledge transfer (KT) within the context of UK low carbon energy innovation. It examines the knowledge requirements of the innovation system and presents the enablers and inhibitors associated with KT. This paper employs a broad meaning of the term 'knowledge transfer' which includes the multi-directional processes pertaining to the acquisition, assimilation, transformation and exploitation of knowledge. The review was undertaken at the initial stages of a PhD study. A comprehensive and flexible review process was adopted as an appropriate method to navigate broad themes, develop researcher knowledge, define research questions and identify novel perspectives (Boell and Cezec-Kecmanovic, 2011; Ridley, 2012). The review will act as a foundation for empirically exploring the optimisation of KT processes within the UK low carbon innovation system.

The past century has witnessed the diminution of traditional production activities and the emergence of the 'knowledge economy', in which the value of knowledge increases and innovation becomes imperative (Drucker, 1969). In this paradigm, external modes of knowledge acquisition become normalised (Chesbrough, 2003). Concurrently, the co-evolution of science and society exerts novel pressures on research generation, with society demanding greater accountability from the state and academia (Nowotny, Scott and Gibbons, 2001). The emergence of a 'new role' for universities within the Triple Helix model witnesses academia as catalysts for innovation within national policy frameworks (Etzkowitz and Leydesdorff, 2000). This role often incorporates state driven objectives to deliver greater societal and economic benefit (deMan, 2008). Consequently, there is growing incentive for collaborative engagements, applied research and social impact measures for universities.

The growth in UK low carbon innovation is motivated by the UK government's ambitious energy commitments. Subsequent government manifestos prescribe initiatives designed to develop and diffuse innovation, through increased collaborative knowledge generation and by influencing consumer behaviours (Foxon et al., 2005; van der Schoor and Scholtens, 2015). Knowledge transfer within this environment is therefore a critical issue to policy makers, academia and industry. The system encompasses many diverse technologies, each with individual characteristics, policy influences and knowledge requirements, and is epitomised by uncertainty and unclear user impacts. The existing literature suggests numerous facilitators and inhibitors of KT which transpire across individual, organisational, partnership and sectorial layers. Theseh must be identified and controlled to facilitate successful KT.

The paper is structured as follows: firstly it reviews the co-evolution of science and society and explores the 'new roles' for academia and industry. Secondly it reviews the UK low carbon innovation system and establishes the contextual challenges. It then explores the enablers and inhibitors of KT before concluding on the specific KT challenges of the low carbon innovation system.

2. The co-evolution of science and society

The importance of knowledge is asserted by Drucker (1969) who suggests a post-war move from an economic paradigm of predominantly goods production to a 'knowledge economy'. This shift has seen an increase in the value of knowledge and significance of innovation, necessitating that governments become instigating forces in delivering national growth and competiveness (Drucker, 1969; Nonaka and Takeuchi, 1995; deMan, 2008). Concurrently, the relationship between science and society is progressively symbiotic, influencing new research generation models (Burns and Stalker, 1994). This has resulted in society becoming increasingly influential and demanding in scientific agendas (Nowotny, Scott and Gibbons, 2001). Knowledge generation now embodies a series of dynamic models of research generation (e.g. Mode 1, Mode 2 and Triple Helix) (Etzkowitz and Leydesdorff, 2000).

The Triple Helix concept introduces balanced triadic relationships between government, academia and industry (Etzkowitz and Leydesdorff, 2000). Public-private partnerships offer the potential to leverage the resources and expertise of others to generate new knowledge (Szulecki, Pattberg and Biermann, 2011). The dynamics of these collaborations bring many challenges to those engaged in KT activities, particularly where diverse value propositions exist for the realisation of social benefit (deMan, 2008; Pinkse and Kolk, 2012).

This co-evolution witnesses knowledge moving from being deemed a 'public good' to that of a 'private good', prompting greater academic participation in market behaviours and applied research (Slaughter and Rhoades, 2004). This shift has also increased the focus on 'social impact' as a measurement of research quality (Smith, Ward and House, 2011; Hicks, 2012). Knowledge has become highly mobilised, widely distributed and more easily accessible, spurring industry to adopt open innovation paradigms (Chesbrough, 2003) and form alliances with universities (Afonso, Monteiro and Thompson, 2012). This is despite markedly different motivations, rewards and objectives between industry and academia (Cummings and Teng, 2003; Philbin, 2008; Hughes and Kitson, 2012).

3. The UK low carbon innovation system

The UK government has committed to increasing renewable energy in the UK's energy mix and reducing greenhouse gas emissions (Energy and Climate Change Committee, 2014). Subsequently, policy measures focus on: reducing emissions (Foxon et al., 2005); driving innovation and engaging energy consumers (van der Schoor and Scholtens, 2015); and managing the energy 'trilemia' of security, sustainability and affordability (Szulecki and Westphal, 2014). This includes addressing both technology push and market pull dimensions, which requires the ability to traverse many knowledge boundaries to effectively deliver both technological outputs and social outcomes. These challenges drive inter-disciplinary KT where specialised pools of knowledge are brought together for the purpose of innovation, in environments typified by uncertainty and unclear user impacts.

The Department of Business, Innovation and Skills (2013: 7) describes the low carbon energy sector as a "flexible construct or umbrella term for capturing a range of activities spread across many existing sectors like transport, construction, energy etc., but with a common purpose – to reduce environmental impact" The high-level subsectors it identifies are presented in Figure 1.

Environmental
- Air Pollution
- Contaminated Land
- Environmental Consultancy
- Environmental Monitoring
- Marine Pollution Control
- Noise & Vibration Control
- Recovery and Recycling
- Waste Management
- Water Supply and Waste Water Treatment

Renewable Energy
- Biomass
- Geothermal
- Hydro
- Photovoltaic
- Wave & Tidal
- Wind
- Renewable Consulting

Low Carbon
- Additional Energy Sources
- Alternative Fuel/ Vehicle
- Alternative Fuels
- Building Technologies
- Energy Management
- Carbon Capture & Storage
- Carbon Finance
- Nuclear Power

Figure 1: Low carbon environment and goods sector classifications (Department of Business, Innovation and Skills, 2013: 7)

Individual technologies have associated variables including: incremental versus radical innovation aims, end users, risks profiles, infrastructure requirements, fluctuating levels of collaborative knowledge flows (Foxon et al., 2005); costs, public acceptability rates, commercial availability (Fankhauser, 2013); and political, technical and market uncertainties (Kannan, 2009). The collection of technologies necessitates an elaborate funding network, reflecting the diverse expertise and knowledge required and differing policy objectives between technologies dependent on changing government priorities (Foxon et al., 2005).

The following analysis of the low carbon innovation system establishes its distinctive characteristics which cultivate idiosyncratic knowledge challenges. The structure of this analysis is based on Foxon et al's (2005: 2127) innovation system map and offers a trichotomic perspective to system influences including the innovation regime, policy support and demand factors. The holistic functions of KT within this system include: creating and diffusing new knowledge; supplying tangible and intangible resources; building capacity; and creating positive economic movement through effective knowledge sharing in public-private partnerships (Foxon et al., 2005; Szulecki, Pattberg and Biermann, 2011).

3.1 Innovation regime

Figure 2 represents a simplified version of the low carbon innovation system.

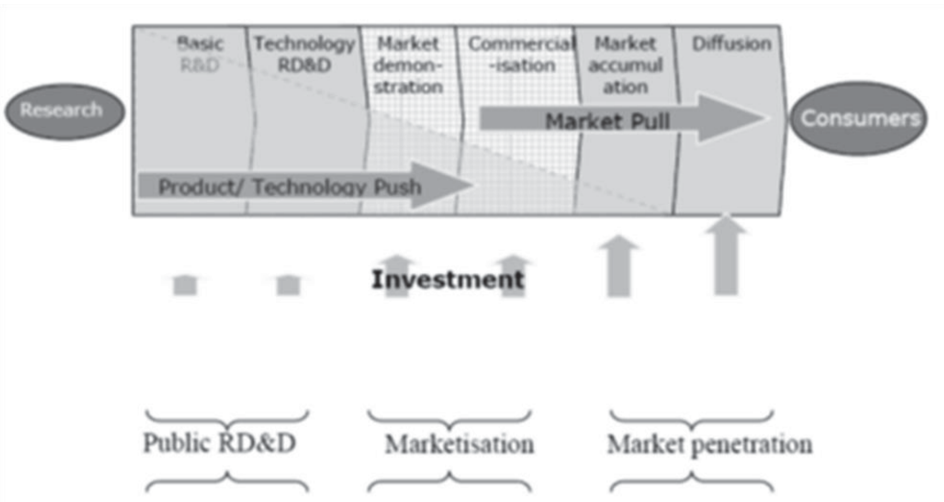

Figure 2: Main stages of the innovation system (Grubb, Haj-Hasan and Newbery, 2008: 335)

In reality the stages of the system are iterative and non-linear, with the potential for a technology to become stagnant within a stage (Foxon et al., 2005) therefore lacking a definitive route from research to consumer.

Each stage has unique variables including distinct funding requirements, risk profiles, market uncertainties, costs and development capacities (Grubb, Haj-Hasan and Newbery, 2008). Within this system, the Triple Helix framework creates organisational, industrial, cultural and process based boundary crossing challenges (Easterby-Smith, Lyles and Tsang, 2008). To facilitate cross-boundary knowledge flows, commonalities must be introduced via common language, common forms of communication and advocated shared meanings (Grant, 1996; Carlile, 2002). This is a notable challenge in the low carbon system due to: the novelty and uncertain nature of the innovations; the multiple parties which hold complex specialised knowledge; interdependent flows of knowledge; and the high risk of 'reusing' both existing knowledge and previously held assumptions (Carlile, 2002).

3.2 Policy support

The need for government intervention occurs when a societal problem exists which cannot be voluntary resolved by other actors in a market economy (Foxon et al., 2005). Innovation policy aims to drive innovation through three stages: R&D and technology demonstration; pre-commercialisation; and market accumulation and penetration (Grubb, Haj-Hasan and Newbery, 2008; Jamasb et al., 2008).

Policy challenges include: defining collaboration incentives, sourcing effective 'knowledge suppliers' (Foxon et al., 2005); creating long-term targets and stability to encourage commitment in knowledge collaborations (Heffron et al., 2013; Kruckenberg, 2015); providing a shared vision for academia and industry (Szulecki, Pattberg and Biermann, 2011); establishing optimal structures to fund, coordinate and facilitate KT activities dependent on desired outcomes (Kruckenberg, 2015); and designating roles that avoid certain partners becoming 'knowledge senders only' which can limit effective KT (Kruckenberg, 2015). Policy focus should arguably be on innovation generation (Fankhauser, 2013). However, there are sizable demand side boundaries to overcome (Heffron, 2013; van der Schoor and Scholtens, 2015) which are reviewed below.

3.3 Demand

Influencing the technology adoption of domestic and industrial end users is a multifaceted problem with no easy solution and requires extensive knowledge to realise large scale, sustainable adoptions (Kruckenberg, 2015; van der Schoor and Scholtens, 2015). The complexity of climate change is challenging for energy users to fully grasp and not easily understood without a contextual knowledge base from which to interpret the circulated information. The distribution of knowledge is complicated by societies being decentralised 'clans' of individuals with varying beliefs, backgrounds and values (World Bank, 2015). This necessitates substantial regional engagement with society on low carbon issues to influence local mental models and drive technology adoption through social contagion (World Bank, 2015). This complexity must be addressed as part of a portfolio of coordinated approaches of relevant information sharing with the public. The knowledge boundary between research outputs and societal outcomes is therefore extremely taxing.

This section has identified the innovation system as non-linear and cross-disciplinary which incorporates policy, innovators and consumers, and has set the context from which to view KT enablers and inhibitors.

4. Inhibitors and enablers of knowledge transfer

This section reviews the inhibitors and enablers of KT within the context of the low carbon innovation system.

4.1 Clarification of knowledge transfer

The nature of epistemology is highly contentious and predominantly based on perception (Newell et al., 2009) leading to an array of heavily debated research about knowledge and KT. The well cited dimensions of explicit and tacit knowledge (e.g. Nonaka and Takeuchi, 1995; Tsoukas, 2003; Busch, 2008), differentiating information and knowledge (e.g. Rowley, 2007) and knowledge as an asset and a practice (e.g. Cook and Brown, 1999; Sveiby, 2007) question the transferability of knowledge.

The transfer of knowledge is arguably not possible due to the inherent nature of tacit knowledge (Polanyi, 1958; Grant, 1996; Tsoukas, 2003; Busch, 2008). However the word 'transfer' by definition suggests that knowledge can be packaged and relocated from one position to another (Liyanage et al., 2009). Information (i.e. codified knowledge) must be processed through unique filters within each individual, dependent on personal experiences and values (Bender and Fish, 2000; Rowley, 2007). Therefore interdisciplinary partnerships should ensure knowledge is de-contextualised by senders and effectively re-contextualised by each stakeholder (Cummings and Teng, 2003).

The multifaceted concept of knowledge fashions a catalogue of terminology, definitions and constructs for KT. Graham et al. (2006) identify twenty-nine similar terms, based on perceptions of incorporated processes and activities. The number of multi-disciplinary stakeholders identified in low carbon innovation which hold differentiated knowledge stores, necessitates that each party has clear expectations on the objectives of the KT process.

4.2 Adequate time allocation

Building knowledge and forming effective KT environments takes significant commitment (Riege, 2005; McNichols, 2010; Hughes and Kitson, 2012) particularly if physical distance is great (Cummings and Teng, 2003) or complex technical knowledge needs to be exchanged and assimilated multi-laterally across a variety of sectors or cultures (Cummings and Teng, 2003; Philbin, 2008; Pinkse and Kolk, 2012). The number of diverse actors and the complex knowledge located within the low carbon innovation system necessitates increased time allocation for projects. Time requirements are amplified due to the extended time frames in energy innovation transitions which incorporate diffusion to a decentralised public.

4.3 Generation of trust

Developing trusting relationships is essential for successful knowledge sharing across networks (Levin and Cross, 2004; McNichols, 2010; Filieri et al., 2014). It is facilitated when both formal and informal opportunities exist to share knowledge over extended time periods (Riege, 2005; Philbin, 2008) and when there is perceived power equality between partners (Easterby-Smith, Lyles and Tsang, 2008; van Burg and Oorschot, 2013). The diverse groups within the low carbon innovation system necessitate frequent interactions to build trust and require that all partners perceive equality in terms of knowledge input opportunities.

4.4 Social capital development

Social capital enables the access to collectively owned assets which deliver returns to individuals and organisations including: access to restricted knowledge, enhanced reputation, exclusive insight into network norms (Inkpen and Tsang, 2005); and improved learning capabilities, resource development and opportunities for new collaborations (Philbin, 2008). Critically, social capital has a direct bearing on the success of industry-university partnerships (Philbin, 2008; Filieri et al., 2014). It is optimised by the development of: strong network ties, a presence of multiple knowledge connections between all partners, goal clarity, tolerance for organisational cultural diversity (Inkpen and Tsang, 2005); a cohesive, engaged network, a long term view to collaboration and frequent interactions (Filieri et al., 2014). However, low carbon innovation is typified by a short term policy focus which may not extend beyond governmental terms. Cohesiveness may also be affected due to the number of collaborative stakeholders who hold diverse objectives and represent different cultures.

4.5 Value creation in rewards and incentives

Common rewards and incentives should be established across multi-sectorial partnerships. Within academia a balance is required between traditional peer review publishing based incentives and industry engagement (Geuna and Muscio, 2009) so participants perceive a presence of sustainable value creation (Gattringer, Hutterer and Strehl, 2014). Espoused values should aim to generate increased commitment; for academia this includes: access to new funding sources, ideas and methods; and exposure to real life problems (Gattringer, Hutterer and Strehl, 2014). Industry values include: cost savings (world class research which leverages government funding), increased production capacities, enhanced business performance and reduced operational costs (Hughes and Kitson, 2012; Gattringer, Hutterer and Strehl, 2014). Low carbon collaborations must therefore deliver value drivers which span the diversity of academic and industry value perceptions.

4.6 Flexibility in intellectual property management

Government funded programmes may stipulate standard terms. Contractual obligations can create clarity in collaborations but concurrently may inhibit trust formation (Malhotra and Lumineau, 2011). Industrial partners are more likely to engage when contract management employs a flexible, customised approach which considers each partner's vulnerabilities (Malhotra and Lumineau, 2011; Bstieler, Hemmert and Barczak, 2015). Policy around government funded collaborations must therefore consider both academic and industry requirements pertaining to low carbon innovation.

4.7 Establish joint norms and objectives

Cultural difference is a well cited barrier to effective KT (Cummings and Teng, 2003; Riege, 2005; Philbin, 2008; Hughes and Kitson, 2012) with the above discussions inferring a need for commonality and the ability to 'speak the same language' to overcome this. This may be achieved through a collaboration agent who is familiar with both cultures and manages the multidisciplinary teams (Cummings and Teng, 2003; Philbin, 2008). The alignment of common goals can bridge cultures (Inkpen and Tsang, 2005; Riege, 2005) but the addition of high level societal goals can inhibit effective network management (deMan, 2008; Pinkse and Kolk, 2012). Therefore methods to manage these high levels goals need to be developed to provide a joint value driver within low carbon collaborations.

4.8 Provision of training

Training programmes may assist actors within low carbon innovation to develop both diverse technical knowledge and the 'soft skills' of business and communication (Donofrio, Sanchez and Spohrer, 2010). This can occur through informal networks and via forums and workshops (Riege, 2005; Easterby-Smith, Lyles and Tsang, 2008; Geuna and Muscio, 2009). These can help to create a common understanding of process expectations, generate awareness and provide opportunities to foster social networks (Geuna and Muscio, 2009).

4.9 Absorptive capacity development

Absorptive capacity is the ability to recognise the value of new external knowledge and assimilate it internally, to enhance learning and innovation through knowledge transformation and exploitation (Cohen and Levinthal, 1989; Zahra and George, 2002; Bishop, D'Este and Neely, 2011). Diversity in knowledge is essential to generate new and distinct knowledge for innovation, but is challenging to assimilate due to existing knowledge stores being contextually based (Cummings and Teng, 2003). Current complementary stocks of knowledge are a necessary foundation for the development of new knowledge (Cohen and Levinthal, 1990; Easterby-Smith, Lyles and Tsang, 2008). Therefore absorptive capacity is increased when there is a commonality in contextual language (Cummings and Teng, 2003). Organisations must possess adequate infrastructure to support the dissemination of knowledge internally (Riege, 2005) and provide opportunities for person-to-person engagement to allow exposure to tacit knowledge (Fabrizio, 2009). Therefore policy makers in the low carbon innovation system must provide structures which attract partners with complementary knowledge stocks, whilst the partnership itself must combine both diversity and commonality in knowledge to facilitate new knowledge development. Policy and partnership strategies must endow end-users with a sufficient knowledge base to assimilate relevant knowledge to aid low carbon technology adoption.

5. Conclusion

This paper aimed to review the KT literature in the context of UK low carbon energy innovation and to present specific knowledge requirements relevant to the system. It demonstrated that the Triple Helix framework triggers academia to become more engaged with external bodies and deliver impact as a measure of research quality. Public-private partnerships within the UK low carbon innovation system must integrate methods which facilitate the attainment of high level societal goals. This challenge will require longer term and more stable policy initiatives, which support the innovation system through a portfolio of inter-disciplinary approaches, addressing both technology development and demand side motivation factors.

The KT enablers suggested in the literature must be considered within the context of the system to optimise cross boundary knowledge flows and navigate the innovation stages. Specifically, the time and commitment required to build trust, develop social and absorptive capacities and align values and objectives is increased due to: the number of stakeholders and technologies, the diversity and complexity of knowledge, differing value perceptions, the integration of distinct end-user requirements and lengthy innovation diffusion timeframes. Training would aid collaborators in comprehending KT objectives and processes and ensure knowledge is effectively contextualised between the partners. Finally, in order to aid technology adoption it is necessary to incorporate a focus on knowledge dissemination to the public, a factor which may go beyond the traditional objectives of some partners.

This paper sets the foundation for future empirical research which aims to explore the concept KT within the context of the UK low carbon innovation system and investigate the optimisation of collaborative project performance.

References

Afonso, O., Monteiro, S. and Thompson, M. (2012) "A Growth Model for the Quadruple Helix", Journal *of Business Economics and Management,* Vol 13, No. 5, pp 849-865.
Bender, S. and Fish, A. (2000) "The Transfer of Knowledge and the Retention of Expertise: The Continuing Need for Global Assignments", *Journal of Knowledge Management,* Vol 4, No. 2, pp 125-137.
Bishop, K., D'Este, P. and Neely, A. (2011) "Gaining from Interactions with Universities: Multiple Methods for Nurturing Absorptive Capacity", *Research Policy,* Vol 40, No. 1, pp 30-40.
Boell, S., K. & Cecez-Kecmanovic, D. (2011) "Are Systematic Reviews Better, Less Biased and of Higher Quality?", [online], *European Conference on Information Systems*, Available at: http://aisel.aisnet.org/ecis2011/223.
Bstieler, L., Hemmert, M. and Barczak, G. (2015) "Trust Formation in University-Industry Collaborations in the US Biotechnology Industry: IP Policies, Shared Governance, and Champions", *Journal of Product Innovation Management,* Vol 32, No. 1, pp 111-121.
Burns, T. and Stalker, G.M. (1994) *The Management of Innovation,* Rev. edn, Oxford University Press, Oxford.
Busch, P. (2008) *Tacit Knowledge in Organizational Learning,* IGI, Hershey, PA.
Carlile, P.R. (2002) "A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development", *Organization Science,* Vol 13, No. 4, pp 442-455.
Chesbrough, H.W. (2003) *Open Innovation: The New Imperative for Creating and Profiting from Technology,* Harvard Business School Press, Boston.
Cohen, W.M. and Levinthal, D.A. (1989) "Innovation and Learning: The Two Faces of R and D", *The Economic Journal*, pp 569-596.
Cohen, W. and Levinthal, D. (1990) "Absorptive Capacity - A New Perspective on Learning and Innovation", *Administrative Science Quarterly,* Vol 35, No. 1, pp 128-152.
Cook, S.D. and Brown, J.S. (1999) "Bridging Epistemologies: The Generative Dance between Organizational Knowledge and Organizational Knowing", *Organization Science,* Vol 10, No. 4, pp 381-400.
Cummings, J.L. and Teng, B. (2003) "Transferring R&D Knowledge: The Key Factors Affecting Knowledge Transfer Success", *Journal of Engineering and Technology Management,* Vol 20, No. 1, pp 39-68.
deMan, A.P. (2008) *Knowledge Management and Innovation in Networks,* Edward Elgar Publishing, Cheltenham.
Department for Business, Innovation and Skills (2013) *Low Carbon Environmental Goods and Services (LCEGS), Report for 2011/2012*, Department for Business, Innovation and Skills, London.
Donofrio, N., Sanchez, C. and Spohrer, J. (2010) "Collaborative Innovation and Service Systems" in *Holistic Engineering Education: Beyond Technology*, eds. D. Grasso and M. Burkins, Springer, New York, pp 243-269.
Drucker, P.F. (1969) *The Age of Discontinuity: Guidelines to our Changing Society,* Heinemann, London.
Easterby-Smith, M., Lyles, M.A. and Tsang, E.W. (2008) "Inter-Organizational Knowledge Transfer: Current Themes and Future Prospects", *Journal of Management Studies,* Vol 45, No. 4, pp 677-690.
Energy and Climate Change Committee (2014) *Innovate to Accumulate: The Government's Approach to Low Carbon Innovation*, The Stationery Office, London.
Etzkowitz, H. and Leydesdorff, L. (2000) "The Dynamics of Innovation: From National Systems and “Mode 2” to a Triple Helix of University–Industry–Government Relations", *Research Policy,* Vol 29, No. 2, pp 109-123.
Fabrizio, K. (2009) "Absorptive Capacity and the Search for Innovation", *Research Policy,* Vol 38, No. 2, pp 255-267.
Fankhauser, S. (2013) "A Practitioner's Guide to a Low-Carbon Economy: Lessons from the UK", *Climate Policy,* Vol 13, No. 3, pp 345-362.
Filieri, R., McNally, R.C., O'Dwyer, M. and O'Malley, L. (2014) "Structural Social Capital Evolution and Knowledge Transfer: Evidence from an Irish Pharmaceutical Network", *Industrial Marketing Management,* Vol 43, No. 3, pp 429-440.
Foxon, T.J., Gross, R., Chase, A., Howes, J., Arnall, A. and Anderson, D. (2005) "UK Innovation Systems for New and Renewable Energy Technologies: Drivers, Barriers and Systems Failures", *Energy Policy,* Vol 33, No. 16, pp 2123-2137.
Gattringer, R., Hutterer, P. and Strehl, F. (2014) "Network-Structured University-Industry-Collaboration: Values for the Stakeholders", *European Journal of Innovation Management,* Vol 17, No. 3, pp 272-291.
Geuna, A. and Muscio, A. (2009) "The Governance of University Knowledge Transfer: A Critical Review of the Literature", *Minerva,* Vol 47, No. 1, pp 93-114.
Graham, I.D., Logan, J., Harrison, M.B., Straus, S.E., Tetroe, J., Caswell, W. and Robinson, N. (2006) "Lost in Knowledge Translation: Time for a Map?", *Journal of Continuing Education in the Health Professions,* Vol 26, No. 1, pp 13-24.
Grant, R.M. (1996) "Toward a Knowledge-Based Theory of the Firm", *Strategic Management Journal,* Vol 17, No. S2, pp 109-122.
Grubb, G., Haj-Hasan, N. and Newbery, D. (2008) "Accelerating Innovation and Strategic Deployment in UK Electricity: Applications to Renewable Energy" in *Delivering a Low-Carbon Electricity System: Technologies, Economics and Policy*, eds. T. Jamasb and M.G. Pollitt, Cambridge University Press, Cambridge, pp 333-360.
Heffron, R.J., Johnston, A., McCauley, D. and Jenkins, K. (2013) "Policy Delivery for Low Carbon Energy Infrastructure in the UK, April 5th 2013: Conference Overview", *Energy Policy,* Vol 61, pp 1367-1369.
Heffron, R. (2013) "The Application of Contrast Explanation to Energy Policy Research: UK Nuclear Energy Policy 2002-2012", *Energy Policy,* Vol 55, pp 602-616.
Hicks, D. (2012) "Performance-Based University Research Funding Systems", *Research Policy,* Vol 41, No. 2, pp 251-261.

Hughes, A. and Kitson, M. (2012) "Pathways to Impact and the Strategic Role of Universities: New Evidence on the Breadth and Depth of University Knowledge Exchange in the UK and the Factors Constraining its Development", *Cambridge Journal of Economics,* Vol 36, No. 3, pp 723-750.

Inkpen, A.C. and Tsang, E.W. (2005) "Social Capital, Networks, and Knowledge Transfer", *Academy of Management Review,* Vol 30, No. 1, pp 146-165.

Jamasb, T., Nuttall, W.J., Pollitt, M.G. and Maratou, A. (2008) "Technologies for a Low-Carbon Electricity System: An Assessment of the UK's Issues and Options" in *Delivering a Low-Carbon Electricity System: Technologies, Economics and Policy*, eds. T. Jamasb and M.G. Pollitt, Cambridge University Press, Cambridge, pp 64-99.

Kannan, R. (2009) "Uncertainties in Key Low Carbon Power Generation Technologies - Implication for UK Decarbonisation Targets", *Applied Energy,* Vol 86, No. 10, pp 1873-1886.

Kruckenberg, L.J. (2015) "Renewable Energy Partnerships in Development Cooperation: Towards a Relational Understanding of Technical Assistance", *Energy Policy,* Vol 77, pp 11-20.

Levin, D.Z. and Cross, R. (2004) "The Strength of Weak Ties You Can Trust: The Mediating Role of Trust in Effective Knowledge Transfer", *Management Science,* Vol 50, No. 11, pp 1477-1490.

Liyanage, C., Elhag, T., Ballal, T. and Li, Q. (2009) "Knowledge Communication and Translation - A Knowledge Transfer Model", *Journal of Knowledge Management,* Vol 13, No. 3, pp 118-131.

Malhotra, D. and Lumineau, F. (2011) "Trust and Collaboration in the Aftermath of Conflict: The Effects of Contract Structure", *Academy of Management Journal,* Vol 54, No. 5, pp 981-998.

McNichols, D. (2010) "Optimal Knowledge Transfer Methods: A Generation X Perspective", *Journal of Knowledge Management,* Vol 14, No. 1, pp 24-37.

Newell, S., Robertson, M., Scarbrough, H. and Swan, J. (2009) *Managing Knowledge Work and Innovation,* Palgrave Macmillan, Basingstoke.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation,* Oxford University Press, Oxford.

Nowotny, H., Scott, P. and Gibbons, M., (2001) *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty,* Polity Press, Cambridge.

Philbin, S. (2008) "Process Model for University-Industry Research Collaboration", *European Journal of Innovation Management,* Vol 11, No. 4, pp 488-521.

Pinkse, J. and Kolk, A. (2012) "Addressing the Climate Change - Sustainable Development Nexus: The Role of Multistakeholder Partnerships", *Business and Society,* Vol 51, No. 1, pp 176-210.

Polanyi, M., (1958) *Personal Knowledge: Towards a Post-Critical Philosophy,* Routledge and Kegan Paul, London.

Ridley, D. (2012) *The literature review: a step-by-step guide for students,* 2nd edn, Sage, London.

Riege, A. (2005) "Three-Dozen Knowledge-Sharing Barriers Managers Must Consider", *Journal of Knowledge Management,* Vol 9, No. 3, pp 18-35.

Rowley, J.E. (2007) "The Wisdom Hierarchy: Representations of the DIKW Hierarchy", *Journal of Information Science,* Vol 33, No. 2, pp 163-180.

Slaughter, S. and Rhoades, G. (2004) *Academic Capitalism and the New Economy: Markets, State, and Higher Education,* Johns Hopkins University Press, London.

Smith, S., Ward, V. and House, A. (2011) "Impact in the Proposals for the UK's Research Excellence Framework: Shifting the Boundaries of Academic Autonomy", *Research Policy,* Vol 40, No. 10, pp 1369-1379.

Sveiby, K.E. (2007) "Disabling the Context for Knowledge Work: The Role of Managers' Behaviours", *Management Decision,* Vol 45, No. 10, pp 1636-1655.

Szulecki, K. and Westphal, K. (2014) "The Cardinal Sins of European Energy Policy: Nongovernance in an Uncertain Global Landscape", *Global Policy,* Vol 5, pp 38-51.

Szulecki, K., Pattberg, P. and Biermann, F. (2011) "Explaining Variation in the Effectiveness of Transnational Energy Partnerships", *Governance,* Vol 24, No. 4, pp 713-736.

Tsoukas, H. (2003) "Do We Really Understand Tacit Knowledge?" in *Managing Knowledge: An Essential Reader*, eds. S.E. Little and T. Ray, 2nd edn, Sage, London.

van Burg, E. and Oorschot, K.E. (2013) "Cooperating to Commercialize Technology: A Dynamic Model of Fairness Perceptions, Experience, and Cooperation", *Production and Operations Management,* Vol 22, No. 6, pp 1336-1355.

van der Schoor, T. and Scholtens, B. (2015) "Power to the People: Local Community Initiatives and the Transition to Sustainable Energy", *Renewable and Sustainable Energy Reviews,* Vol 43, pp 666-675.

World Bank (2015) *World Development Report 2015: Mind, Society, and Behavior.* World Bank, Washington, DC.

Zahra, S.A. and George, G. (2002) "Absorptive Capacity: A Review, Reconceptualization, and Extension", *Academy Of Management Review,* Vol 27, No. 2, pp 185-203.