Sailing Ship/ Last Gasp Effects, Low Carbon Technologies and High Carbon Incumbents

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Sailing ship and last gasp effects

- The ‘sailing ship’ effect (SSE) or the ‘last gasp effect of obsolescent technologies’ (LGE) – occurs where competition from new technologies stimulates improvements in incumbent technologies/firms
- Recent analyses of industries threatened by technological discontinuities offer insights into
  - Why incumbent technologies might show a sudden performance leap (Furr & Snow 2013)
  - How current analyses may overestimate new entrants’ ability to disrupt incumbent firms
  - & underestimate incumbents’ capacities to see the potential of new technologies & to integrate them with existing capabilities (Bergek et al. 2013)

Context & Propositions

Context: many governments, e.g. EU (via Directives) & UK (Climate Act 2008), seek transitions to lower carbon energy systems via the penetration of low carbon technologies (LCTs).

- The role & performance of incumbents are important influences on the success of LCTs
- But LCTs face the challenge that high carbon incumbents firms & technologies may respond & so protect their competitiveness, without embracing LCTs
- Even if LCTs have similar attributes to existing technologies, apart from low carbon, if the existing technologies are already under pressure to improve, then LCTs may face a moving target (Pearson & Foxon, 2012).

Sailing ship and last gasp effects

- As well as responding with performance enhancements, high carbon actors also lobby to resist institutional & policy changes that favour low carbon technologies
  - Example: efforts of large German utilities in the 1990s to lobby for repeal of renewable energy FiTs
- So sailing ship & last gasp effects can act to delay or weaken low carbon transitions
- *Note:* the threat to incumbents here is from LCTs promoted by government rather than simply by market actors; and
  - As yet not all such technologies have attributes that are superior &/or cost-competitive with incumbents
  - Placing incumbents in a strong position to respond

Background and Literature

- Research on competition between sailing & steamships by Gilfillan (1935), Graham (1956) Harley (1971) & Geels (2002)led to suggestion of SSE
- Rothwell & Zegfeld (1985) claimed the existence of the SSE in the C19 alkali industry
- Utterback (1996) cited two C19 US cases: gas vs. electric lighting ('The gas companies came back against the Edison lamp … with the Welsbach mantle') & mechanical versus harvested ice
- Cooper & Schendel (1976) studied 22 firms in 7 industries: '[i]n every industry studied, the old technology continued to be improved & reached its highest stage of technical development after the new technology was introduced.'
- Tripsas (2001) identified the effect as the 'last gasp' of a technology

Background and Literature

- Although there is some debate about whether all instances of the SSE bear closer scrutiny (Howells, 2002; but see Arapostathis et al. 2013)
  - This paper suggests that the proposition that some firms respond when the ascendancy of their technologies is threatened by new competition, carries weight.
- Growing management & innovation literatures have investigated the performance & responses of incumbents in the face of radical technological innovation;
- We consider three recent studies by: (i) Arapostathis et al. (2013) (ii) Furr & Snow (2013); (iii) by Bergek et al. (2013)

An early SSE: the Incandescent Gas Mantle*

- Gas light consumption in the UK grew steadily in the latter half of the nineteenth century (gas from coal)
- Gas lighting had developed through incremental innovations such as changes to the shape of the burner
- But in 1892, the chemist Carl Auer (later von Welsbach) patented a key innovation, the incandescent mantle,
- Mantle lighting was brighter, cleaner & cheaper, requiring "about a quarter of the gas consumption for a given degree of illumination"
  - But early mantles were fragile & expensive (monopoly)
  - Some gas engineers feared increased efficiency would lead to lower gas consumption

*** Source:** Arapostathis et al. (2013)

An early SSE: the Incandescent Gas Mantle*

- By early 1900s the situation changed: the cost of incandescent electric light (Edison/Swan) had decreased, increasing competition with gas
- In 1901 the industry got together to mount a successful legal fight against the holder of the British Welsbach mantle patent
- Incandescent gas mantles were then widely adopted
- Strengthening the competitive position of gas light, enabling it to stay in the lighting market
  - Electric light only became competitive with gas light by around 1920
- So this was an early SSE

*** Source:** Arapostathis et al. (2013)

Furr & Snow (2012), 'Last gasp or crossing the chasm? The case of the carburettor technological discontinuity'

- Furr & Snow: insufficient empirical research on the LGE
- So they examine carburettor manufacturers' behaviour, when threatened by electronic fuel injection (EFI) from 1980 on
- Using data on the performance & attributes of 700 car models per year for the period 1978-1992
- Rather than previous assumptions that the LGE comes from incumbents simply 'trying harder'
  - They tell a more nuanced story: some incumbents explored hybrid technologies that contributed to the LGE & helped them cross to EFI
- The paper offers some empirical verification of the LGE

Furr & Snow: Hypotheses

- The paper explores 4 hypotheses: when threatened by a new technology generation

  1 The technology trajectory of an existing technology may exhibit a last gasp (a sudden increase in product performance in excess of existing technology trajectory)

And incumbents may innovate, reconfigure or recombine, via:

  2 Efforts *to extract greater performance* from existing technology

  3 Reconfiguring to market segments where they have comparative advantage relative to the threatening technology

  4 Recombining components from the threatening technology with extant technology

Furr & Snow: Findings (i)

- Paper offers initial empirical verification of the LGE, in the carburettor industry, when threatened by a potential technical discontinuity - the emergence of EFI.
- It suggests two other potential sources of the LGE — reconfiguration & recombination—as well as the common 'trying harder' explanation in the literature.
- All three sources contribute to a LGE, but in some unexpected ways:
  - Some incumbents retreat & reconfigure, creating an apparent LGE: the performance 'improvement' comes from the product retreating from less to more efficient applications
  - Recombination, or creation of hybrids between old & new technology generations, contributes significantly to the LGE

Furr & Snow: Findings (ii)

- Once they accounted for incumbent technology choices
  - » Incumbents focusing their efforts on the original carburettor contributed to a last gasp in standard carburetors;
  - » Those focusing on hybrid carburettors contributed to a last gasp in hybrid carburettors.
- The LGE deferred the technology discontinuity for a time
- While no incumbents leapt immediately to EFI, only those incumbents first investing in hybrid carburettors survived the transition to EFI technology

- The development of hybrids occurs elsewhere in the literature, including in Bergek et al. (2013)

Bergek et al. (2013)* on 'Technological Discontinuities & the Challenge for Incumbent Firms'

- They contest two explanations of the 'creative destruction' (Schumpeter) of existing industries from discontinuous technological change
- These *competence-based* (Tushman & Anderson 1986) & *market-based* (Christensen 1997/2003) explanations suggest that incumbent firms are challenged only by 'competence-destroying' or 'disruptive' innovations
  - which make the firms' knowledge base or business models obsolete, leaving them vulnerable to attacks from new entrants
- From different standpoints, both assume incumbents are burdened with 'core rigidities' & legacy of old technology
- Hence these approaches suggest that technological discontinuities open up possibilities for new entrants

Bergek et al: Existing Approaches

- Both approaches explain the 'attacker's advantage' thus:
  - incumbents are unable or unwilling to respond due to organizational, technological & strategic inertia
  - So allocate insufficient resources to respond to the threat
  - & lose position because old competences are destroyed
  - or their performance trajectory & value network are disrupted as new performance attributes replace existing ones as the main basis for competition
- General prediction is that
  - While sustaining & competence-enhancing discontinuities reinforce the competitive positions of incumbents
  - incumbents will be threatened by disruptive or competence-destroying technological discontinuities
  - Hence innovations will be pioneered by new entrants, who take market shares from incumbents

Bergek et al: Critique of Existing Approaches

- The cases analysed by Bergek et al. in the automotive & gas turbine industries suggest these approaches tend to
  - Overestimate new entrants' ability to disrupt established firms
  - Underestimate incumbents' capacities to see the potential of new technologies & integrate them with existing capabilities via processes of 'creative accumulation'
- Bergek et al: creative accumulation' (Pavitt1986) requires firms to
  - Rapidly fine-tune & evolve existing technologies
  - Acquire & develop new technologies & resources
  - Integrate novel & existing knowledge into superior products & solutions

Bergek et al: Empirical Analyses of 2 Industry Cases

- Bergek et al. studied 2 competence destroying & potentially disruptive innovations (microturbines & electric vehicles (EVs)
- And 1 sustaining & 1 competence-enhancing innovation (combined-cycle gas turbines (CCGT) and hybrid-electric vehicles respectively).
- In the gas turbine industry, incumbents were predicted to be challenged by new entrants developing microturbines
- In automobiles, Christensen argued that ‘electric vehicles have the smell of a disruptive technology’

Bergek et al. Gas Turbines & Microturbines

- Findings: these are industries where predictions of existing frameworks on competence destroying & disruptive innovation haven't materialized,
- While actual innovation processes have been harder for incumbents than existing theories assume
- Microturbines: 'a distributed technology that failed to disrupt'; it is 'unlikely that microturbine technology ever will become "good enough" in a comparison with large CCGTs'
- But competition in large gas turbines was 'a life and death race', where 2 incumbents (Westinghouse & ABB) were forced to quit the market after failing to innovate on the basis of established technologies

Bergek et al: Battery Electric Vehicles & Hybrids

- As yet BEVs have failed to disrupt the car industry, despite major investments
- The Toyota Prius 1 (1977) was a critical discontinuity; now all major manufacturers have hybrids
- ‘Hybrid-electric power-trains remain the dominant alternative power-train… in spite of the hype surrounding EVs’, while ‘pure electrics may require extensive policy support until the late 2020s’
- Despite greater complexity, hybrids are relatively successful because of key performance advantages
- Toyota’s strategy shows that when the knowledge base changed, as well as technical R & D, they had to access knowledge on manufacturing & cost, by joint ventures or in-house component production

Bergek et al: Findings (i)

- The attackers & and their potentially disruptive innovations failed in both industries because of :
  - Failure to meet performance demands in main markets
  - Lack of “overshooting” in main markets
  - Industries’ embeddedness in hard to change large socio-technical systems
- The cases studied did not bear out the prediction of the competence based & market based approaches, that incumbents are challenged only by ‘competence-destroying’ or ‘disruptive’ innovations
- The incumbent firms’ abilities to compete in new technologies depended on their management of the challenges of ‘creative accumulation’.

Bergek et al: Findings (ii)

- Their analyses suggested that the competence based & market based approaches tend to
  - Overestimate new entrants' ability to disrupt established firms
  - Underestimate incumbents' capacities to see the potential of new technologies & integrate them with existing capabilities via processes of 'creative accumulation'
- Their findings help explain why some new energy technologies may find it harder to penetrate than might be anticipated
- But also suggest that some incumbents have or may develop the ability to embrace new technologies, particularly when hybridisation makes it possible to extend the life of existing technologies

Potential Significance of SSE/LGE for Lower Carbon Transitions

- In cases where incumbents significantly increase their competitiveness in response to new LCTs, this can:
  - Slow LCT uptake & penetration
  - Hence delaying travel along LCT experience curves
  - As LCTs chase incumbents' shifting experience curves
  - And raising policy costs via higher subsidies needed for competitive penetration
  - While forecasts that don't allow for SSEs/LGEs could overestimate penetration
- So, appreciating SSEs/LGEs matters for a low carbon transition,
- And suggests giving proper attention to dynamic interactions between new & incumbent technologies & industries

Conclusion

- The proposition that some incumbents threatened by competition from new technologies tend to respond, carries weight:
  - the SSE/LGE & related concepts merit deeper analysis & empirical study
- For some low carbon technologies & contexts, incumbents' responses could delay (or in some cases enhance) their successful penetration & development
- Policy makers should be mindful not only of support for new low carbon technologies but also incumbents' strategies & behaviours, as they resist or embrace the prospects of these technologies

Sources & Notes (i)

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- Adner, R. & Snow, D (2010), 'Old technology responses to new technology threats: demand heterogeneity and technology retreats', *Indust. and Corporate Change* 19(5), 1655–1675
- Anderson , P. & Tushman, M.L. (1990), 'Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change', *Administrative Science Quarterly* 35(4) 604-633.
- Arapostathis, S, Carlsson-Hyslop, A, Pearson, P J G, Thornton, J, Gradillas, M, Laczay, S & Wallis, S, (2013), 'Governing transitions: Cases and insights from two periods in the history of the UK gas industry.' *Energy Policy,* 52, 25–44. http://dx.doi.org/10.1016/j.enpol.2012.08.016
- Bergek, A., et al., (2013), 'Technological discontinuities and the challenge for incumbent firms: Destruction, disruption or creative accumulation? ' *Research Policy.* http://dx.doi.org/10.1016/j.respol.2013.02.009
- Christensen, C.M., (1997/2003), *The Innovator's Dilemma. The Revolutionary Book That Will Change the Way You Do Business.* HarperCollins Publishers, New York.
- Christensen, C.M., Rosenbloom, R.S., (1995), 'Explaining the attacker's advantage: technological paradigms, organizational dynamics, and the value network', *Research Policy* 24, 233–257.
- Cooper, A.C., Schendel, D., (1976), 'Strategic responses to technological threats,' *Business*
- *Horizon*s 19, 61–69.
- Foxon, T.J, Pearson, P.J.G., Arapostathis, S., Carlsson-Hyslop, A. & J. Thornton (2013). 'Branching points for transition pathways: assessing responses of actors to challenges on pathways to a low carbon future', *Energy Policy* 52, 146–158. http://dx.doi.org/10.1016/j.enpol.2012.04.030
- Furr, N.R. & Snow, D.C. (2012), 'Last gasp or crossing the chasm? The case of the carburetor technological discontinuity', under review at *Strategic Management Journal.* http://siepr.stanford.edu/system/files/shared/Furr%20and%20Snow_Last%20Gasp_SMJ%20Submission%20Full%20Document.docx

Sources & Notes (ii)

- Geels, F (2002), 'Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study', *Research Policy* 31, 1257-1274.
- Gilfillan, S. C. (1935), *Inventing the ship*, Chicago, Follett Publishing Company.
- Howells, J (2002), 'The Response of Old Technology Incumbents to Technological Competition - Does the Sailing Ship Effect Exist?' *J. Management Studies* 39(7), 887-906
- Jacobsson, S., Lauber, V., 2006. The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology, *Energy Policy* 34, 256–276.
- McVeigh, J., Burtraw, D., Darmstadter, J. & Palmer, K. (2000), 'Winner, loser, or innocent victim? Has renewable energy performed as expected?' *Solar Energy* 68**,** 237-255.
- Pavitt, K., 1986. 'Chips' and 'trajectories': how does the semiconductor influence the sources and directions of technical change? In: MacLeod, R. (Ed.), *Technology and the Human Prospect*. Frances Pinter, London, pp. 31–54.
- Pearson, P.J.G. & Foxon, T.J. (2012), 'A low carbon industrial revolution? Insights and challenges from past technological and economic transformations.' *Energy Policy* 50, 117-127. http://dx.doi.org/10.1016/j.enpol.2012.07.061
- Pierson, P (2000), 'Increasing returns, path dependence, and the study of politics', *American Political Science Review*, 94(2), 251- 267.
- Rosenberg, N. (1976), *Perspectives on technology*, Cambridge, Cambridge University Press.
- Schumpeter, J. (1943), *Capitalism, socialism and democracy*, London, Allen & Unwin.
- Stenzel, T & Frenzel, A (2007), 'Regulating technological change—The strategic reactions of utility companies towards subsidy policies in the German, Spanish and UK electricity markets', *Energy Policy* 36(7), 2645-2657
- Tushman, M., Anderson, P., (1986), 'Technological discontinuities and organizational
- Environments'. *Administrative Science Quarterly* 31, 439–465.
- Usher, A. P. (1928), 'The Growth of English Shipping 1572-1922'. *QJE* 42, 465-478.
- Utterback, J. (1994), *Mastering the dynamics of innovation*, Boston, Mass. Harvard Business School Press.