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'Little ships': the co-evolution of technological capabilities and industrial dynamics in competing innovation networks

Richard Blundel

Abstract

Recent agenda-setting exercises in the national innovation systems and industrial dynamics literatures have highlighted the unresolved methodological challenges faced by those seeking to explore the innovation process in a co-evolutionary perspective. The paper seeks to contribute to this debate by drawing upon the research methods and presentational conventions of business historians. The empirical study concerns the emergence of radical innovations in the design and manufacture of sailing dinghies in mid-20th century Britain. This period saw the displacement of small, highly localised firms engaged in traditional craft practices by a new generation of designers, manufacturers and promoters in pursuit of volume production. The findings are presented in the form of a historical narrative, contrasting the configurations and dynamics of two competing innovation networks in this sector. It shows how actors in each network drew differently on newly-available platform technologies, probes their distinctive approaches to design, manufacturing and marketing, and assesses their longer-term impact on the sector. The concluding section relates the findings to the previously-discussed theoretical constructs and reflects on the potential contribution of historically-informed methodologies.

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INTRODUCTION

Introducing this journal's special issue on 'frontiers of research in industrial dynamics and national systems of innovation', Sornn-Friese (2000) reflected on the agenda of the field, noting the various ways that researchers had sought to tackle the observed heterogeneity in industrial innovation processes and outcomes. The author drew particular attention to the profound methodological implications of this agenda, notably the conceptual and empirical challenges that arise when we attempt to examine these processes at multiple levels of analysis (*ibid*. 6-8, cf. Barnett and Burgelman 1996, Lewin and Volberda 1999). Over the past two decades, contributors to the field have revealed new insights at various levels of analysis, refining our understanding of innovation as an interactive and co-evolutionary process (Clark 1987, Edquist 1997, Edwards 2000, Lundvall 1992, 1999, Nooteboom 2000). Inter-organisational networks have emerged as an important strand in this literature. Empirical and conceptual studies have tackled many facets of the networks and innovation axis, drawing on the seminal insights of Richardson (1972), Lundvall (1985) and Freeman (1991). The intervening years have also seen the proliferation of a diverse inter-organisational networks literature in related fields such as organisation studies (e.g. Grandori and Soda 1995, Ebers 1999). However, there are still important gaps in our understanding. As the authors of a recent wide-ranging review of the innovation literature have noted, network configuration and network dynamics are two areas in need of further clarification through appropriate empirical research:

> 'The evidence suggests that there is considerable ambiguity and contestation in the literature regarding appropriate network configurations for successful innovation. While networking configurations are clearly contingent upon factors such as sector, type of innovation (radical vs: incremental; product vs: process), far more systematic research needs to be conducted in this area. By recognising that networks are inherently dynamic, research could benefit from adopting a longitudinal approach.' (Pittaway *et al*. 2004: 35)

The present paper seeks to contribute to this aspect of the research agenda through a longitudinal examination of co-evolutionary processes in two competing innovation networks. In doing so, the study draws on the research methods and presentational style of the business historian, which may be unfamiliar to some scholars in the field of industrial dynamics. The historical narrative probes the contrasting configurations and dynamics of two competing innovation networks that helped to transform small boat building in post-war Britain. It shows how actors in each network drew differently on the platform technologies, probes their distinctive approaches to design, manufacturing and marketing, and traces their longer-term impact on the sector. The empirical section is prefaced by a short reflection on the potential contribution of historical approaches to the emerging multi-level and co-evolutionary research agenda. The concluding discussion draws together the main themes of the study and reflects on the potential contribution of historical methodologies in addressing this research agenda.

'CO-EVOLUTIONARY' ANALYSIS AND THE BUSINESS HISTORIAN

Recent empirical studies within the national systems of innovation (NSI) and industrial dynamics fields have investigated the ways that context-specific resources and capabilities emerge and persist over time (e.g. Maskell *et al*. 1998, Lorenzen 1998). The increasing emphasis on multi-level and co-evolutionary analyses has been interpreted by leading figure as an important strength of the NSI approach, notably in the defence that they provide against reductionist and determinist modes of explanation. For example, Lundvall (1992) has argued that one of the major results of the NSI analysis has been to reveal patterns of

'interdependence and co-evolution' involving specific sets of inter-firm networks, industrial sectors and institutional contexts:

'This opens up an analysis of the co-evolution of *specialized* competencies and institutions that is more ended than a scheme where it is assumed that the institutional set-up determines the characteristics of the national business system.' (Lundvall 1999: 68 - emphasis added)

The agenda-setting paper by Sornn-Friese (2000: 9) has reinforced this position, identifying 'the co-evolution of technology (including technological capabilities), and industry (especially innovation dynamics and competition)' as one of five issues, 'at the cutting edge' of the NSI field. The term 'co-evolution' was derived from biology, where it refers to a complex but non-purposive process of mutual adaptation between two distinct species. It can be seen as both an extension of earlier evolutionary theorising in industrial economics (Alchian 1950), and as a complement to subsequent applications at the level of the firm (e.g. Nelson and Winter 1982). To date, researchers in the field of human organisation have examined the co-evolutionary interplay between particular levels of analysis, such as firm capabilities, inter-firm relationships and industry structures (Levinthal and Myatt 1994), or individual knowledge, firms and regional clusters (Henry and Pinch 2000). However, as several commentators have noted, the bold ambitions of co-evolutionary theorists have yet to be matched in terms of substantive empirical studies (cf. Barnett and Burgelman 1996, Lewin and Koza 2001). Researchers have faced a number of challenges, including the collection of longitudinal data in a way that allows for interactions to be traced across multiple levels, the analysis of this inherently rich and context-specific evidence, and the presentation of findings in a sufficiently concise and focused format. Critics have argued that social scientific approaches of various kinds, ranging from structural contingency theory to new growth theory, have struggled to capture the interplay between different levels of analysis, and thus to shed light on the relationship between innovation processes and the geographical and institutional contexts in which they take place (Best 2001, Clark 2003, Storper and Salais 1997). Some studies have also paid insufficient attention to the defining characteristic of co-evolutionary processes in the *social* world, whereby adaptation is a product of the subjective perceptions and purposive (i.e. strategic) behaviours of human actors (Penrose 1953, Child 1997, Montgomery 1995). In summary, there are strong grounds for concluding that the co-evolutionary research agenda would benefit from some new methodological combinations (cf. Lewin and Koza 2001: v). More specifically, research methods need to accommodate data that is sufficiently 'rich' to open up the details of particular innovation processes, while remaining open to abstraction and analysis. One solution proposed by innovation scholars is to adopt a 'twin-track' approach, with historically-informed description acting as a necessary pre-condition for more sophisticated abstraction (Mathews 2001). [1] This argument is supported by a wider call for a more historically-informed perspectives to be introduced into organisational research (e.g. Kieser 1994, Rowlinson and Procter 2004). However, in order to bring these two tracks together, it becomes necessary to address the long-standing methodological tensions between history and social science. In the late 19th century, the *Methodenstreit* (i.e. 'battle over methods') rehearsed many of the arguments regarding the contrasting research traditions. It also generated a pioneering synthesis in the form of Weber's *sozialökonomik* (i.e. 'social economy') (Weber [1921] 1978), which had a considerable impact on Schumpeter's later work on innovation and entrepreneurship (Schumpeter 1954, Swedberg 1991: 83-89). Despite these early examplars, social scientists

[1] Similarly, in the case Abernathy's seminal work on the automobile industry in the USA, it is possible to detect a distinct shift from the a-historical linearity of this leading innovation scholar's sector 'life cycle' model towards a tentatively historicized account (Clark and Blundel 2005).

have continued to question the status of historical methods in organisational research, while business historians have debated the extent to which their discipline should incorporate explanatory theory (e.g. Cole 1959, Hannah 1984, Lee 1990). A full account of these debates is beyond the scope of the present paper. However, it is clear that business historians have made substantive contributions to theory in recent years. These scope of these studies ranges from ambitious, over-arching analyses development of industrial capitalism (e.g. Chandler 1990, Fligstein (1990), to more more detailed applications and critiques of particular theoretical formulations (e.g. Sabel and Zeitlin's (1997) collection of studies on historical alternatives to mass production, and Lazonick's (1991) critique of the Williamsonian transactions costs model). In one of the most convincing defences of the empirically-based approach of the business historian, Gourvish (1995) has argued that it has become an essential element in an inter-disciplinary research process. He stresses the explanatory potential of the historical case study, when properly formulated, with an awareness of available theory:

'Of course, we need a blend of theory and empiricism, but this does not negate the value of the single case in stimulating debate, or in helping to develop general theoretical statements about business structures and soico-economic processes.' (Gourvish 1995: 13)

This is the approach adopted in the present paper, which seeks to address specific issues of theoretical interest within the co-evolutionary research agenda, notably the relationship between network configurations, network dynamics and the development of technological capabilities. It does so by relating the relevant theories to empirical evidence, which is presented in the form of a business historical case study. The research methodology for this study is outlined in the following section.

RESEARCH METHODOLOGY

The empirical study draws on the research methods and presentational conventions of business historians in order to address specific issues in the innovation and industrial dynamics research agenda. It does not seek to represent the broad span of business historical research, nor is it proposed as a 'model' for historically-informed innovation research. The aim is more modest, as an exploratory contribution to this on-going methodological debate. [2]

The historical narrative focuses on two rival innovation networks that pioneered contrasting approaches to the design and construction of small boats for a volume market. This industry sector that has attracted little previous attention from innovation researchers, so is interesting in its own right (cf. Parsons and Rose 2003). However, its broader appeal as a research subject derives from the simultaneous emergence of networks based on competing technological capabilities in a particular geographic setting. This provided the researcher with an opportunity to conduct a comparative co-evolutionary study, based around the transformation of this industry sector from craft-based to industrial-scale production methods. The narrative traces the development of the two networks over an extended period between the mid-1940s to the mid 1960s. The multiple case study design adopted in this study has been informed by Jones's (2001) co-evolutionary study of rival innovation networks in the early American film industry. In this instance, the main unit of analysis is the small boat building industry sector in Britain, and the embedded units of analysis are the two networks and their constituent actors (Miles and Huberman 1994, Yin 1994).

[2] Business history has not accumulated an extensive methodological literature. For recent reviews of the field, see: Clark and Rowlinson (2004) and Gourvish (1995). Evans (1997) offers an insightful defence of historical research methods and findings in the face of post-modernist critique.

The narrative was constructed using multiple methods and sources. These included archival data from sailing clubs and dinghy class associations, industry reports and statistics, historical accounts and coverage of relevant issues in specialist publications. Evidence from these sources was clarified and interpreted through a combination of informal interviews with sailing enthusiasts, responses to a call for information in a dinghy sailing magazine and reflections on the researcher's own prior experience as a member of the sailing community. The possibility of bias was controlled through method and data triangulation (Yin 1994), and by making a conscious effort to read the various sources 'against the grain', recognising that historical sources and contemporary respondents are actively involved in the construction of their own rationalisations, meanings and identities (Evans 1997, Silverman 1993).

The narrative is broadly chronological in structure. The innovation networks are depicted in two parallel accounts, providing an opportunity for readers to compare their respective configurations and dynamics. It aims to follow the main conventions of historical writing, which is characterised by a constant attention to verification against source materials, combined with an emphasis on the provisional nature of the resulting interpretations (Evans 1997: 109). As a result, the presentational style includes detailed interpretations of the relevant historical events, with considerable attention being paid to their complexity, uniqueness and contingency (Clark and Rowlinson 2004: 343). The narrative is punctuated by numerous direct quotations from archival material, and is supported by quantitative data and visual images. There is also an extensive use of footnotes throughout the narrative, a technique that historians regard as essential for substantiating, clarifying points and qualifying the narrative. The historical narrative is analysed with reference to the theoretical concepts discussed in the introduction, concentrating on the configuration and dynamics of the two networks, and their relationship with the prevailing institutional structures.

THE HISTORICAL NARRATIVE

'Little ships': creating the modern sailing dinghy

The sailing of small boats or 'dinghies' emerged as a leisure activity in the late 19th century [3]. Early sailing clubs adopted the practice of commissioning local builders to design a boat that would be suitable for local sailing conditions (e.g. rivers, tidal estuaries or more exposed coastal waters). As a result, the number of boats of any individual class was limited, while at a national level there was a corresponding increase in the variety of boats sailed. [4] By the early years of the 20th century there was a demand for less parochial dinghy designs that could be used for national and international sailing competitions. The Yacht Racing Association (YRA) responded by introducing 'open' or 'development' classes, an approach already well-established in yacht racing. The regulations governing development class were flexible, allowing designers to experiment with new layouts in order to improve racing performance. This process was facilitated by an increasing number of dinghy sailing competitions, or 'regattas', where sailors and designers from different parts of the country could meet to share

[3] Sailing dinghies are small recreational boats, which range from about 7ft (2.1m) to 18ft (5.5m) in length. They can be differentiated from sailing yachts in various ways, including their reduced size, lower cost and in being stabilised by a retractable centreboard (or alternatively a daggerboard), rather than a permanent keel. The expression 'little ships' is from a leading English sailor and designer of the period, Uffa Fox (Fox 1959).

[4] The *Water Wag*, sailed by members of an Irish sailing club in Dublin Bay from 1887, was the earliest one-design class in Europe. This 14ft (4.3m), clinker-built and unballasted craft with a centreboard was intended to be both simple in design and affordable. The tradition of local commissioning continued into the mid-20th century, the *Wivenhoe One-Design* (1935) being a late example (Phillips-Birt 1974: 115-117, Trad Boat 2004).

their experiences, and learn from rivals. [5] However, this revolution in design and in sailing competition was not matched by changes in materials or manufacturing methods. Up to the outbreak of the Second World War, the British development classes were of a traditional (i.e. either 'carvel' or 'clinker') construction (Figure 1). Though the country's leading designers produced some highly refined dinghies – Uffa Fox's design for the *International 14* class was described by one informed commentator as, 'the most superb examples of the boatbuilder's art ever to have appeared.' (Phillips-Birt 1974: 250) – dinghy sailing remained a minority recreational activity, serviced by highly localised boat builders and sail makers engaged in craft-based, bespoke production. [6]

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However, over a very short period immediately after the war, radical innovations in dinghy design and manufacturing supplanted these long-established practices. The industry was transformed by new configurations of designers, manufacturers and marketers, applying novel design principles, technologically-advanced materials and production processes, and modern promotion, marketing and distribution techniques. They produced boats in unprecedented quantities, and at much lower costs than their predecessors, and so facilitated the emergence of sailing as a mass-participation sport. Industry data for the period are somewhat sketchy, but Royal Yachting Association membership data provide some indication of the scale of change, both in terms of active participants and in the expansion in sailing clubs around the country (Figure 2). [7] The narrative contrasts the development of two competing approaches to industrialised manufacturing, which helped to fuel the growth of 'affordable' sailing. [8]

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Two routes to 'affordable' sailing: 'hot moulding' and 'build-her-yourself'

In the immediate aftermath of war, there was a strong pent-up demand in the British population for recreational activities such as sailing, but supply was severely constrained. [9] Britain's pre-war fleets of traditional wooden yachts and dinghies had been laid-up for six

[5] Uffa Fox (1898-1972), exemplified the phenomenon of increased mobility and its capacity to expand the horizons of dinghy design and racing practice. For example, in 1928, he sailed his 'revolutionary' planing dinghy, the 14 foot (4.3m) *Avenger*, across the English Channel to compete in a series of races (Fox 1939). This successful design came to dominate the *International 14* class in the inter-war period (Fox 1959: 28-37, Phillips-Birt 1974: 248-250).

[6] Phillips-Birt (1974: 248) recalled that, 'The estuaries, rivers and reservoirs were not dense with dinghies during those [inter-war] years.' See also, Fox (1959: 1-5).

[7] In March 1949, and after considerable debate, the Yacht Racing Association agreed to change its name to the Royal Yachting Association (RYA). The new name was chosen to reflect the organisation's wider responsibilities, which now included activities such as encouraging wider participation in sailing (Fairley 1983: 113).

[8] Though some contemporary commentators expressed doubt or concern over the rapid transition from craft to industry, others highlighted the benefits of more 'affordable' sailing: '[I]deally, each and every boat should be tailor-made to suit the needs of her owner. And indeed this is pretty well what did happen until only a few years ago. In the days when a man went down to the small builder whose yard was a time-worn shed where the lane petered out on a pebble beach he did just that – and had to pay for the privilege. [...] Happily, those days are gone and now, in modern factories with all the appearance of big business, splendid little boats are built by the thousand for the nation's pleasure and profit.' (Rayner 1961: 10)

[9] The desire to escape is reflected in many accounts of the period, with comments such as, 'In the summer of 1945, like so many others, I was looking for a boat.' Leather (2004: 44).

years, and many had fallen into disrepair. The initial challenge of repairing or replacing this fleet was exacerbated by statutory restrictions on the use of timber for non-essential purposes, shortages of other raw materials (e.g. sailcloth, paints and varnishes) and the priority given by boatyards to commercial boat building and repair. The currency was also substantially devalued, in comparison with the immediate pre-war period (Fox 1959: 16). Given the prevailing conditions, dinghy designers, builders and sailing enthusiasts were quick to recognise that there could be no nostalgic return to traditional carvel or clinker construction methods. This realisation stimulated a search for less expensive materials and production technologies capable of meeting the expectations of the country's much-enlarged pool of aspiring dinghy sailors. The yachting establishment had first become aware of the potential of mass production technologies during the Second World War, when they were used in the manufacture of military hardware. At this time, many had remained sceptical of their application in boat building. When the YRA Council discussed the issue in the early 1940s, one member wrote, 'Mass production will no doubt reduce costs of small one-design boats but it is difficult to see where a sufficient number of purchasers will come from to make mass-production possible or practicable.' (Sir William Fife [1943], quoted in Fairley 1983: 94). The celebrated yacht designer, Charles Nicholson echoed this view, while also acknowledging the potential for limited scale economies. [10] However, as peace returned, the scale of the productive opportunity became more apparent. There were two simultaneous responses to the challenge of building 'affordable' dinghies for the emerging mass-market that drew on similar platform technologies but applied them in distinctive ways. One response involved a re-application of sophisticated 'hot moulding' techniques that had previously been used in aircraft manufacturing; this advanced technology enabled boat builders to mould marine plywood with advanced adhesives to form a strong, lightweight and watertight shell. The other response involved a more straightforward combination of these materials with simplified 'chine' construction techniques (Figure 1). [11]

Innovation network (A): Hot moulding at Fairey Marine

Hot moulding was a new manufacturing process, which involved the shaping of plywood sheets into three-dimensional shapes. Like its precursor, cold moulding, the process was pioneered in the aircraft industry in order to form strong, lightweight fuselages. In cold moulding, plywood strips were laid alternately in a concrete mould and saturated in casein glue. Pressure was applied by inflating a rubber bag inside the sealed mould; after 24 hours, the bag was removed to reveal a smooth-sided, bullet like shell. Hot moulding extended these principles by exploiting the qualities of the new synthetic, thermo-setting resins. Advances in the preparation process, notably the precision cutting of multiple veneers and the controlled application of heat and higher atmospheric pressures in an autoclave, contributed to substantial reductions in production times and labour requirements. In addition, because the veneers were thoroughly impregnated with waterproof adhesive, the finished shells were

[10] Nicholson stated that, 'Mass-production is not applicable to the limited demand for a one-design YRA class in this country either for hulls or equipment. As I understand it, assembly on mass production lines is in larger factories passing along assembly lines. It can only be adopted when hundreds of one type are required. *Limited* production (as opposed to MASS-production is certainly possible.' (Charles Nicholson [1943], quoted in Fairley 1983: 94 – emphasis in original).

[11] Marine plywood is a water resistant engineered wood first introduced by manufacturers in the United States in the late 1930s. Synthetic adhesives such as phenolic-formaldehyde (PF) and urea-formalde (UF) were developed in the same period. Their capabilities were demonstrated through wartime application in the plywood structures of aircraft, such as the De Havilland *Mosquito* (Wood 1963, APA 2004, PHS 2004, SAA 2004).

rendered 'virtually rot-proof'. [12] The application of this innovative process to dinghy construction was largely the product of a creative alliance between an established designer and an entirely new type of small boat builder, in pursuit of high production volumes using engineered wood. Richard Fairey's company, Fairey Aviation, was responsible for manufacturing several military aircraft, including fighters, reconnaisance aircraft and torpedo bombers. The company operated three production facilities in Britain, including a site at the mouth of the River Hamble, adjacent to the Solent. During the war, the Hamble site employed approximately 800 people in the manufacture of aircraft and components. During the inter-war years both Richard Fairey and his Managing Director, Colin Chichester-Smith, were keen yachtsman, who had witnessed at first hand the steady progression towards smaller racing yachts and the emergence of national and international dinghy classes. They also faced the pressing challenge of re-deploying surplus manufacturing capabilities and assets. In the late 1940s, the men founded a new subsidiary, Fairey Marine Ltd, located at the company's Hamble site. Their express intention was to exploit the parent company's experience in the volume manufacturing in order to produce a range of affordable sailing dinghies in hot moulded marine plywood. Charles Currey, a friend of Chichester-Smith and a former Olympic sailor, was recruited to assist in managing the new company.

The Yacht Racing Association (YRA) played an important role in the initial promotion of hot moulding. Early in 1946, the YRA Dinghy Committee decided that there was an urgent need for a small, inexpensive dinghy suitable for young people. [13] Several people, including Uffa Fox, were asked to submit a design, with the aim of getting it into production by the Summer. Chichester-Smith, who had close connections with the committee, also contacted Fox to discuss possible designs. [14] Fox wrote back to the committee, offering the design for a 12ft (3.7m) dinghy meeting its requirements. His proposal was based on the *Sea Swallow*, a 1938 one-design class for team racing at Cambridge University, modified for production in hot moulded plywood. In a later recollection, Fox indicated that this connection to the old universities meant that YRA Committee members 'had the advantage of having seen the boats in action for some years' (Fox 1959: 17, Fairley 1983: 98-99). In March 1946, Chichester-Smith was able to report to the committee that his company could have six prototypes ready by the beginning of April. The committee approved the design on 4th April 1946, agreeing a price of £65 (approximately 100 Euros) plus purchase tax. It marked the beginning of a long and productive relationship between the celebrated designer and the aspiring volume manufacturer. Fairey Marine's new dinghy embodied the company's aviation heritage. For example, at the outset, the company made pragmatic use of military surplus birch plywood for the hulls; it also produced around 100 of its early boats with aluminium decks, due to a shortage of 6mm marine grade plywood. The masts were fabricated in rolled aluminium, a relatively new technology that had previously been applied to the wing sections of aircraft. Fairey Marine sourced these masts from Tony Reynolds, an old aviation contact. [15] As if to

[12] During the 1950s, Fairey Marine demonstrated the durability of the hot moulded hull by embedding an unvarnished *Firefly* in mud for several years. Once retrieved, cleaned and re-rigged, it was raced successfully.

[13] The Dinghy Committee also expressed a clear preference for a hot moulded dinghy: 'If moulded ply construction were available the boat should be round bilged but, if not, it would have to be hard-chine and possibly built of ply' (Fairley 1983: 98).

[14] The company's close involvement in the work this Committee is evident from the minutes: 'Major Chichester-Smith mentioned at one debate that, on moulded ply boats, it was a little tricky to produce a bright varnish [i.e. the traditional finish on wooden boats]. It was agreed that there was no objection to the boats being finished in different colours which would also make them distinguishable from the existing 12 and 14ft designs.' (Fairley 1983: 99)

[15] The mast sections, developed in conjunction with the Reynolds Aluminium Company, were cold-formed from a seamless aluminium tube. At this stage, it was not possible to taper the tubes, so a tapered wooden section was

seal the connection, the dinghy class was named the *Firefly*, after one of the parent company's most successful aircraft. [16]

The *Firefly* has a good claim to be the world's first volume production dinghy. By the late 1950s, over 2,000 dinghies were in use around Britain (Fox 1959: 17). The first four of these were purchased by Sir Geoffrey Loules, Commodore of Itchenor Sailing Club (SC), where Chichester-Smith and Currey raced *International 14s*; the dinghies were named, 'Fe, Fi, Fo and Fum'. The *Firefly* became better known in the sailing community when it was selected for the 1948 Olympics. Though subsequently replaced, it became popular with certain groups, including the armed services sailing clubs and 'public' (i.e. fee-paying) schools. The growth of these market segments reflects the type of promotional initiative pursued by members of this innovation network. For example, in 1953, Chichester-Smith and Currey were instrumental in launching the 'Public Schools Firefly Invitation Championships'. The venue for this an annual event, promoting inter-schools sailing competition and encouraging younger sailors was Itchenor SC. In the early years, club members were persuaded to loan their *Firefly* dinghies to participating schools. In addition, Fairey Marine supplied a complete *Firefly* each year for presentation to the winning school. [17]

Uffa Fox produced several acclaimed designs for Fairey Marine, including a new *International 14*, that was modified to take full advantage of hot moulding. However, there was some resistance to this new manufacturing process. At her launch in 1946, the *Firefly* was described by critics as being, 'suitable for those who liked their dinghies to be cooked like waffles rather than built like boats.' (Phillips-Birt 1974: 258). A more serious concern was raised over the price competitiveness of the product; the *Firefly* was reputed to cost almost as much as her traditionally-built predecessors, and even Fairey Marine's own promotional material noted that its *International 14* was 'not inexpensive'. The only serious challenge to hot moulding came from the pioneers of a so-called 'build-her-yourself' approach, which established an entirely different vehicle for volume production.

Innovation network (B): 'Build-her-yourself' – Haylock, Pollock and Holt

Just as the new team at Fairey Marine was beginning its experiments with industrial-scale manufacturing in plywood and synthetic adhesives, another network was forming around a much simpler application of these technologies, which would be particularly amenable to amateur boat building. This seemingly prosaic, yet in some respects more innovative, approach to dinghy construction also has its cast of leading players. Soon after the war, a keen sailor and former Royal Air Force officer, Group Captain Haylock, was invited to take up the editorship of *Yachting World*, a specialist magazine with editorial offices in central London. At about the same time, a pre-war dinghy designer, Jack Holt was re-establishing his business in Putney, west London, and resuming the construction of *National 12* dinghies. In the 1920s, Holt had learned to sail on the tidal waters of the Thames. Apprenticed to a cabinet-maker, he developed the necessary skills to take over his uncle's boat repair business, which had diversified into dinghy manufacturing. Holt and his new business partner, Beecher Moore, were both active dinghy racers. Moore had a rather unusual, trans-Atlantic

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added at the top of the mast. Despite being a 'symptomatic cure', the wooden topmast was promoted as a safety feature, since it would help to ensure that a capsized dinghy could be righted (Bentley, undated).

[16] Fairey Marine proposed the name *Firefly*, and it was subsequently approved by the Council of the YRA on the recommendation of the Dinghy Committee (Fairley 1983)

[17] This annual sailing event for public schools continues to the present, but the original *Firefly* first prize was replaced in 1972 by an engraved plate, the 'Sir Richard Fairey Challenge Trophy' ('History of the Schools Sailing Championships.' Itchenor SC archive).

upbringing, being born in Rochester, New York, raised in England and educated at Harvard. He also had some connections to the yacht racing fraternity, having crewed on Sir Thomas Sopwith's 1934 America's Cup challenger, *Endeavour*. The association between Haylock, Holt and Moore arose out of the efforts of several dinghy sailing enthusiasts to develop an inexpensive alternative to the traditional (i.e. carvel-built) *International 14*. As early as 1946, this syndicate was responsible for commissioning the Holt-designed *Merlin* dinghy, with sponsorship from *Yachting World* magazine. Drawing on this experience, the magazine's editor proposed another new dinghy, the *Cadet*, designed specifically to meet the needs of young people:

'The advent of marine ply which, unlike timber, was easy to bend, gave me the idea – beginning with the *Cadet* – of the Build-Her-Yourself boats. A youngster could buy a set of plans or a set of parts, build his own boat and win a race in her. She could also be built by dad in the spare bedroom (and launched though the window), the drawing room or garage or at school carpentry classes.' (Haylock [1975] quoted in Sandbach 2000: 10)

Home-building was first popularised in the United States in late 1930s, based on simple 'one-design' classes such as the *Snipe* and the *Y-Flyer*. [18] However, with the introduction of the *Cadet* in 1948, Haylock, Holt and other actors played a decisive role in translating this template in the radically-different context of post-war Britain. Having got to know Holt through the *Merlin* syndicate, Haylock notes that he 'naturally' turned to him to design the *Cadet*. Holt's design was assessed and refined with the help of other members of the syndicate. Plans for the new dinghy were again promoted through the pages of *Yachting World*, and a new class association was formed. Within a few years the *Cadet* grew to be the biggest dinghy class in Britain, with more than 3,000 being built in its first decade. For Haylock's next application of 'build-her-yourself', the aim was to design a 'general purpose' dinghy (i.e. suitable for racing, cruising, fishing etc.) in order to meet the needs of young families. When plans submitted by several other yacht designers proved unsuitable, Haylock turned again to Jack Holt, who developed a prototype in 1949. Plans for the '*Yachting World G.P. Fourteen*' (*GP14*) appeared in the December 1950 issue of the magazine, highlighting its home-building potential:

'The *Yachting World G.P. Fourteen* has been specially designed for amateur building by Jack Holt [...] The five sheets of working drawings have been prepared as clear and straightforward as they could be. With the aid of these the details to be given in these three articles it should be quite easy for any enthusiast to complete a successful craft.' (Yachting World 1950: 2)

The original instructions assumed that the home-builder was purchasing marine plywood and other materials independently. However, from the outset, the *GP14* was also supplied as a pre-fabricated 'kit', with precision-cut parts for easy assembly. These kits were manufactured by the Bell Woodworking Company of Leicester, which became another important actor in the network. [19] The company was owned by Dusty Pollock, another keen dinghy sailor and a member of a sailing club in Aberdovey, on the Welsh coast. Bell Woodworking had already established its reputation when it produced the *Cadet* in kit form. The kit-building concept grew out of a long-standing friendship between the woodworker and the *Yachting World* editor. During the war, Pollock's company had developed specialised capabilities in the volume manufacture of a variety of products in the form of plywood kits. The components

[18] These hard chine dinghies made the first use of marine plywood; plans were promoted in sailing magazines to encourage home-building. See for example, Y-Flyer (2004).

[19] The *GP14* dinghy has a 'bell' logo on its sail, reflecting the close ties with to Bell Woodworking. After much debate at its first meeting, the *GP14* class association decided to keep this visual identity, though some preferred to justify it with reference to a local folk-tale (i.e. the 'bells of Aberdovey'). In any case, the company remained an important supplier for many years, its kits being distributed to customers around the world.

were prefabricated for easy assembly and kits could be readily 'flat-packed', reducing transportation and storage costs. [20]

The new chine-built plywood dinghies, like their hot-moulded counterparts, were a radical departure from traditional boat building practice. As a consequence, they attracted some initial resistance and their performance had to be proven. [21] At the end of 1949, Aberdovey SC asked Bell Woodworking to supply a number of fully-assembled *GP14*s for trials on the River Dovey. One of the club members recalled that:

'The locals were aghast with pain at what they saw, a plywood boat – and their comments varied from "it will not float" to "it will capsize as soon as the sails fill – bound to, it has a wooden centre board". However, a boat was launched and came fully up to expectations.' (Howard-Davies [c. 1970] quoted in Sandbach 2000: 8)

Following a successful series of trials, the *GP14* was adopted by the club, and during the 1950/51 season, 'at least ten' other clubs around Britain followed suit. In November 1951, a class association was formed and in 1953, the class became affiliated to Royal Yachting Association (the re-named YRA), further securing its position.

The sailing clubs: a technological testing-ground

During the 1950s and early 1960s, sailing clubs acted as the primary testing-ground for dinghies manufactured under the new technologies. With many new classes being introduced competition on the water mirrored that taking place in the marketplace. As a consequence, clubs and their memberships can be seen as playing a crucial role in the elaboration of each innovation network. Hot moulded and chine-built dinghies continued to have their detractors, with assessments being based on a range of design features, not simply the hull construction:

'At first, the *GP's* raced together and on even terms with the *Firefly's* and rivalry was keen. Patronising references to "picnic boats" were countered by charges of discomfort and downright cruelty to Firefly crews exposed always to the imminent danger of decapitation [by its low boom].' (Royal Windermere Yacht Club 1960)

Sailing club histories provide a valuable insight into the changing fortunes of the rival networks, and the different ways that each engaged with its respective customer base. The process is exemplified in the case of Hardway SC. At the club's foundation in 1945, the fleet comprised a diverse assortment of mostly home-built dinghies. During its initial search for a suitable class for racing, the club adopted the pre-war practice of commissioning local designs:

'After a while, the club started looking for its own Class. Stokes Bay had one design or *Bay* boats, Lee on the Solent the *Seagulls*, Portsmouth the *Stormalongs* and Portchester the *Ducks*.' (Hardway SC archive)

Though the late 1940s and early 1950s, the club introduced two of these one-design dinghies, the Hardway *Winds* and Hardway *Seabirds*. In 1950, it also took on the Holt-designed *Cadet* for junior members, 'but only four were built.' In 1954, Charles Currey of the nearby Fairey

[20] Volume production of pre-fabricated kits appears to have originated as a response to wartime food shortages, and the imperatives of self-sufficiency. Dinghy kits were originally delivered via the rail network. With reference to the *Cadet*, Fox (1959: 14) notes that, 'On arrival, it is wise to examine the two parcels carefully for any breakages, as the railway will not accept damage claims unless they are made within forty-eight hours of delivery.'

[21] Another chine-built dinghy produced in marine plywood at this time, the *British Moth*, gained the derisive description 'Itsy bitsy [i.e. very small] matchboxes' by the owners of traditionally-built dinghies (British Moth Association archive).

Marine sent three of its hot moulded *Albacore* dinghies to local clubs for trials. The *Albacore*, which Fairey had modified from its earlier *Swordfish* design, was 'an immediate success', and proved to be a popular class at Hardway and at other local clubs. However, by 1959, the club records state that racing was 'at a low ebb', and the search was on for another suitable dinghy. This time, the club selected the *Enterprise*, another Holt-designed chine dinghy, which was sponsored by a national newspaper, the *News Chronicle*. From this point on, it is possible to detect signs of a new approach to dinghy sailing, with larger fleets and increased participation in national-level competitions:

'The club already had one *Enterprise* and a syndicate was formed to build six from kits. These were followed by many more, both home and professionally built. Altogether there were 33, and at any one time there were at least 24 in the club, and Hardway were well known on the national scene, with boats travelling all over the country.' (Hardway SC archive).

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The existing sailing clubs could not accommodate the rapidly expanding population of dinghy owners, and many new clubs were formed in this period. Though their memberships were often more geographically dispersed than their predecessors, the new clubs continued to embody a strong communal ethos (Figure 3). Race day catering was provided by 'the ladies', 'working parties' were formed to build and maintain club facilities, and racing was combined with social events, such as 'laying up' dinners. Many clubs actively encouraged self-building, a social practice that coincided with their spirit of egalitarianism and mutual support. [22]

Mirrors and Mermaids: elaborating the 'build-her-yourself' template

By the early 1960s, the combination of 'build-her-yourself' and chine construction techniques had become the dominant template for volume production, and the original innovation network was joined by several imitative collaborations. The subsequent elaboration of these networks is illustrated by the contrasting fortunes of the *Mirror* and *Mermaid* dinghies. During 1963, the special-interest magazine *Do it Yourself* ran a series of articles promoting the *Mermaid*, an 11ft (3.4m) dinghy. In the following year, a high-circulation national newspaper, the *Daily Mirror* sponsored a dinghy of a similar size. The *Mermaid* was designed by a former school teacher, Roger Hancock. [23] *Do it Yourself* magazine described the *Mermaid* as, 'probably the only small general purpose dinghy designed specifically to be built by the amateur without the need or the expense of a factory-produced kit of wooden parts.' (Do it Yourself 1966: 1013). The home-builder was catered for in various ways, including the use of readily-available and standard sized materials, and no requirement for jigs or frames to support the boat during construction (Do it Yourself 1963: 789) (Figure 4). However, though potential purchasers were directed to a number of boat builders, chandlers and timber merchants around the country, the *Mermaid* was not made available in kit-form. One result of magazine promotion was that early owners were widely distributed in Britain and overseas. The class association established regional representatives, with the intention of stimulating competition and further interest in the dinghy. In some cases, this led to the formation of new sailing clubs by *Mermaid* owners, which in turn acted as a catalyst for

[22] For example, Reading SC (founded 1954) aimed to, 'encourage the *building*, sailing and racing of sailing dinghies', while in the early years of Helensburgh SC (founded 1951), 'several members co-operated in the construction of these [kit-form plywood] craft in various sheds throughout the town' (Reading SC and Helensburgh SC club histories – emphasis added).

[23] The design originated from a school project, but Hancock also ran evening classes in boat building, where the first *Mermaid* was built (Earll 2004).

future promotional activity. [24] The *Mirror* and *Mermaid* were regarded as rivals throughout this period, the spirit of competition being particularly evident at sales-oriented events such as the national Dinghy Exhibition. [25]

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The *Mirror* dinghy was based on an original design by Barry Bucknell, a well-known television personality who hosted one of the first 'home improvement' shows. [26] Like the *Mermaid*, it was designed in plywood for amateur construction, but its potential market was broadened in various ways. Firstly, it was easier to build. Bucknell introduced a new construction technique, known as 'stitch and glue', in which the plywood panels were stitched together with copper wire, then sealed with an epoxy resin applied to fibreglass tape. The dinghy was also based on a simple 'pram' design, with a square-shaped bow. Secondly, it was promoted through an initial association with a leading mass-market newspaper and from longer-term relationships with other established industry figures. The *Daily Mirror*'s marketing department created a visual identity for the dinghy, with a distinctive red sail and an insignia that echoed the newspaper's masthead. When the first *Mirror* dinghies were unveiled at the 1963 Boat Show, the unconventional design drew some sceptical comments. However, the *Mirror* gained additional credibility from its explicit connection to Jack Holt, while public awareness was increased through the energetic efforts of Holt's business partner, Beecher Moore. His ambitious promotional programme included the first 'European Championships', held in the South of France as early as 1966. Thirdly, the *Mirror* was widely available in kit form. From the outset, kits were supplied by Bell Woodworking, perpetuating that company's long-established links with Holt and Moore and providing an well-proven vehicle for volume production.

The sales record of the *Mirror* and *Mermaid* dinghies indicate the extent to which boat building and sailing had been transformed. By 1971, when the *Mirror* class association became fully independent of the newspaper, it had already become one of the world's largest dinghy classes. Forty years on from its launch, the *Mirror* remains popular, with more than 70,000 boats having been built to date. The *Mermaid* class grew at a more modest rate. Lacking the continuing support of its original sponsor, *Do-it-Yourself* magazine, the task of establishing a distinct identity fell to the designer, Roger Hancock, and to the early owners of *Mermaid* dinghies. The class association gained RYA recognition in 1965 and membership increased with gradual adoptions by existing sailing clubs, and through new club formations. In 1969 the Mermaid Class association was able to celebrate its 500th sail number, and it is estimated that more than one thousand were built in total. However, these numbers proved

[24] In 1963, the *Mermaid* class association secretary wrote to all those who had purchased plans, 'Good luck with your building; I suggest you choose a secluded corner for your construction; wives tend to get a bit frayed around the edges as building progresses!' He reminded purchasers, 'Don't forget to write to me when you have completed your boat, then I shall be able to arrange meetings in your area.' (Letter to members, 1963 – Mermaid Class Association archive).

[25] For example, in reflecting on the promotional potential of exhibitions, the secretary of the Mermaid class association remarked that, 'Last year was a huge success and a lot of *Mermaid* friendships were made and even one or two "*Mirror*" types were converted. Please come along and help to spread the "*Mermaid*" gospel.' (Letter to members, February 1969 – Mermaid Class Association archive).

[26] Bucknell was not an experienced boat designer, and his prototype was referred to Bernard Hayman of Yachting World, then a Mirror Group publication. Hayman recommended that Jack Holt be consulted regarding its seaworthiness, and a number of modifications were made.

insufficient to maintain the necessary infrastructure for inter- and intra-club competition at a national level. Classes could not survive without a sufficient base of active members, willing to travel to other clubs around the country and participate in championships. Despite two re-designs (including weight reductions and the introduction of 'stitch and glue' techniques) the class experienced a steady decline in its membership during the 1970s. [27]

CONCLUDING DISCUSSION

The remaining paragraphs review some of the main findings from the historical narrative in relation to the main theoretical issues identified in the introductory paragraphs. Though, as we have noted, historical writing makes a point of conveying the 'provisional and uncertain' nature of interpretation (Evans 2000: 109), it is possible to identify some tentative conclusions regarding network configurations, network dynamics, and the co-evolution of technological capabilities, firms and networks in their respective institutional settings. The closing section reflects on the historical narrative approach adopted in this study, and comments on its potential application in the field of innovation and industrial dynamics.

Contrasting network configurations and network dynamics

The narrative showed how British boat building took two distinct routes towards the volume production of dinghies. The 'build-her-yourself' network reproduced essential elements of an imported template, based around one-design, chine construction and with a strong orientation towards home-building. By contrast, the 'hot moulding' network can be seen as a classical hybrid, combining novel technological capabilities in volume production (i.e. processes derived from aircraft manufacturing), with the perpetuation of earlier institutional practices associated with Britain's elite yachting heritage. The subsequent dynamics of intra-industry competition in the period 1945-1965 were based on an interaction between these pre-existing capabilities and the actors' contrasting perceptions of market opportunity. In reflecting on this process, it may be helpful to begin by considering outcomes: was either of the original innovation networks 'successful' in its stated goal of producing affordable dinghies in sufficient volume for the post-war market? The result is not quite as straightforward as it might appear. In terms of sheer numbers of dinghies manufactured in the period 1945-1965, we can conclude that hot moulding in plywood proved itself unequal to 'build-her-yourself'. Most of the new British dinghy classes in this period were of chine construction and by the early 1960s new entrants such as the *Mirror* were imitating and elaborating upon 'build-her-yourself' rather than the rival technology. However, hot moulding did continue in operation throughout the period, producing many successful designs. Fairey Marine, the pioneer of hot moulding, has a strong claim to be the world's first volume manufacturer of fully-assembled dinghies. Furthermore, in the next episode of technological innovation (i.e. from the mid-1960s), the focus of volume manufacturing would shift decisively away from the kit manufacturers and home-builders, and towards volume manufacturing in FRP. Forty years on, factory-based production of moulded FRP dinghies has become the norm, so in this sense, the hot-moulders anticipated the future of volume production.

In turning to an explanation for the extended co-existence of these networks, and for their distinctive trajectories, we begin to confront the complex interplay between different levels of

[27] The Mermaid Class Association's September-October 1977 newsletter highlights the requirements for success in the new competitive landscape: 'Will the Mermaid be racing next year? This remains to be seen. Remember, the Kingsmead club would no longer suffer us due to our poor attendance ... and despite their hospitality, the Pagham Yacht Club may soon close their doors to us. ... So come on you lethargic bunch of non-travellers, wake up and revive YOUR class!' (Mermaid Class Association archive).

analysis. For example, the narrative has highlighted focal individuals, such as Fairey, Chichester-Smith and Currey (hot moulding) and Haylock, Holt, Moore and Pollock (build-her-yourself). It is clear that each network was intensely personal, being populated by individuals whose shared enthusiasm for sailing provided the basis for a number of strong ties with other actors (cf. Parsons and Rose 2003, Blundel and Thatcher 2005). The energy and entrepreneurial initiative of these individuals in 'created' new paths into the future by enacting and refining their pre-existing networks of informal contacts (Conway 1997, Johannisson 2000). However, the ways in which individuals in each network drew upon available resources to generate new technological capabilities was shaped by their immediate context (e.g. Fairey's aviation heritage) and by proximate institutions (e.g. Chichester-Smith's close connections with the YRA and his colleagues' strong ties to other parts of the yachting 'establishment').

These networks were each created in response to the same 'structure-loosening event' (Madhavan *et al*. 1998). The former template, based around localised networks of small, artisanal boat builders, was fatally disrupted by the consequences of war. The new networks pursued their distinctive strategies in order to negotiate and gain legitimacy in the immediate post-war environment (cf. Jones 2001: 921). The hot moulders made use of established institutions (i.e. the YRA, elite sailing clubs and the Olympic Committee) to bolster an innovative proprietary technology, while the build-her-yourself network drew on a newer, more egalitarian set of values, in which access to a much simpler and more easily replicated technology was actively disseminated through popular magazines and newspapers. One common element is that both networks sought to legitimise the new construction technologies through the reputations of established designers. These legitimacy strategies were reflected in the contrasting initial configurations of the two networks. The hot moulding network revolved around a close alliance between the managerial team at a new manufacturing subsidiary within the sector (Fairey, Chichester-Smith, Currey), and an established designer of racing yachts and dinghies (Fox); the principal actors were all co-located in the Solent area, the traditional home of British yacht racing. By contrast, the build-her-yourself network was broader-based and more geographically dispersed. It was orchestrated by a London-based sailor-turned-journalist, (Haylock), and included a boat designer in west London (Holt), an Anglo-American businessman (Moore) and a manufacturer of pre-fabricated kits based in a provincial city (Pollock). These differences in network configuration and in legitimacy strategy had the effect of inserting an institutional isolating mechanism between the networks, which reduced the scope for imitative behaviour (Oliver 1997). [28] As a consequence, though each innovation network drew upon similar platform technologies, they were applied in entirely different ways, giving rise to contrasting sets of extended capabilities. In accounting for the differences in configuration and dynamics of each network, it is also important to acknowledge some blurring at the margins. For example, many chine dinghies, including the *GP14*, were also manufactured by professional boat builders and joinery companies, albeit on a modest scale and primarily to serve regional markets (Sandbach 2000: 50-52). Similarly, in addition to its fully-assembled dinghies, Fairey Marine did produce a number of hull shells, some of which were sent for finishing to professional builders, with others being supplied to home-builders (*International 505* Class Association archive). However, these overlaps only serve to emphasise the divergence in performance and outcomes observed during this period. The hot moulders did not manage to establish themselves as manufacturers of less expensive,

[28] Several British firms developed hot-moulding capabilities during the Second World War, but it appears that Fairey Marine was the only firm to apply the technique to volume production of sailing dinghies. For a comparative perspective on the role of isolating mechanisms, see Jones's (2001) insightful historical analysis of co-evolution in the American film industry, 1895-1920.

high volume dinghies, despite isolated efforts in this direction (e.g. the Fairey Marine *Gannet*, a simpler 14ft (4.3m) dinghy). The build-her-yourself network and its later imitators were thus able to occupy the 'mainstream' market for almost two decades, prior to the arrival of a new generation of FRP moulding firms that entered the industry from the mid-1960s.

Methodological reflection

This paper comprised an empirical examination of co-evolutionary processes, presented in the form of an historical narrative. The study addressed the interplay between technological capabilities and industrial dynamics, with a particular focus on the contrasting configurations and dynamics of two rival innovation networks. In constructing the narrative we have drawn on the methodologies and presentational conventions of the business historian. Though the results remain somewhat tentative, they provide an opportunity for reflection on the potential role of historically-informed studies in promoting the co-evolutionary research agenda.

The justification for adopting business historical methods, and the associated narrative format, was based on their capacity to reveal intricate and highly context-specific causal relationships between levels of analysis. Furthermore, it was argued that evidence of this kind would not be forthcoming from commonly-used social scientific approaches. The inclusion of quotations from contemporary sources and other detailed evidence was supported on the grounds that by seeking to reconstruct the subjective perceptions and strategic actions of actors, the historian can counter-balance the deterministic flavour of some evolutionary theorising (Penrose 1959, Montgomery 1995). However, in emphasising the 'story-telling', contribution of the historical approach, the study also exemplified its inherent tension with the social scientific pursuit of abstraction and theoretical analysis. Following Gourvish (1995), we have examined the proposition that historical case studies have considerable explanatory value, subject to being formulated in the light of relevant theoretical constructs. Notwithstanding the success, or otherwise, of the present study in satisfying this purpose, it has served to highlight two broader methodological questions for those seeking to promote the co-evolutionary research agenda. Firstly, can inter-disciplinary research in this field find a way of reconciling the different imperatives of historians and social scientists, or at least of promoting a more productive dialogue across disciplinary boundaries (Hannah 1984, Clark and Rowlinson 2004). Secondly, is it necessary to incorporate over-arching social theoretical frameworks, such as critical realism (e.g. Whittington 1989, Jones 2001), structuration (e.g. Karnøe and Nygaard 1999, Windeler and Sydow 2001), or social mechanisms (e.g. Coleman 1990, Hedström and Swedberg 1998), in order to meet the empirical challenges of articulating between different levels of analysis? (Blundel 2006). In the light of these questions, we conclude that co-evolutionary research would benefit from an expansion in the body of published empirical work, coupled with a more vigorous critical debate that probes its conceptual foundations and elaborates its methodologies.

References

Alchian, A. 1950: Uncertainty, evolution, and economic theory. *Journal of Political Economy*, 58: 211-221.

APA 2004: *Milestones in the history of plywood*. Tacoma WA: American Plywood Association.

Bentley, P. (undated) 'Fairey boatbuilders: the Hamble site.' Southampton: The Fairey Owners Club.

Best, M. 2001: *The new competitive advantage.* Oxford: Oxford University Press.

Blundel, R.K. 2006: Critical realism: a suitable vehicle for entrepreneurship research? in: Neergard, H and Ulhøi, J.P. (eds.) *Handbook of Qualitative Research in Entrepreneurship*. Cheltenham: Edward Elgar.

Blundel, R.K. and Thatcher, M. 2005: Contrasting local responses to globalization: the case of volume yacht manufacturing in Europe. *Entrepreneurship & Regional Development*, 17, 6: 1-25.

Clark, P.A. 1987: *Anglo-American innovation*. New York: De Gruyter.

Clark, P.A. 2003: *Organizational innovations*. London: Sage.

Clark, P.A. and Blundel, R.K. 2005: Penrose, critical realism and the evolution of business knowledge: a methodological reappraisal. *British Academy of Management 2005 Conference*, Saïd Business School, University of Oxford, 13th-15th September.

Clark, P.A. and Rowlinson, M. 2004: The treatment of history in organisation studies: towards an 'historic turn'? *Business History*, 46, 3: 331-352.

Cole, A.H. 1959: *Business enterprise in its social setting.* Cambridge: Cambridge University Press.

Coleman, J.S. 1990: *Foundations of social theory.* Cambridge MA: Harvard University Press.

Conway, S. 1997: 'Strategic personal links in successful innovation.' *Creativity and Innovation Management,* 6, 4: 226-233.

Do it Yourself 1963: Introducing the DIY Mermaid sailing dinghy. *Do it Yourself*: 789-793 (July).

Do it Yourself 1966: The DIY Mermaid sailing dinghy. *Do it Yourself*: 1013 (September).

Earll, G. 2004: Personal correspondence (12th September).

Ebers, M. (Ed.) 1999: *The formation of inter-organizational networks*. Oxford: Oxford University Press.

Edquist, C. 1997: *Systems of innovation: technologies, institutions and organizations*. London: Pinter.

Edwards, T. 2000: Innovation and organisational change: developments towards an interactive process perspective. *Technology Analysis & Strategic Management*, 12, 4: 445-464.

Evans, R.J. 2000: *In defence of history*. London: Granta.

Fligstein, N. 1993: *The transformation of corporate control*. Cambridge MA: Harvard University Press.

Montgomery, C.A. (ed.) 1995: *Resource-based and evolutionary theories of the firm: towards a synthesis*. Norwell MA: Kluwer.

Fox, U. 1939: *The crest of the wave*. extracted in: Stephenson, R. (ed.) 1978: *op cit*. 96-100.

Fox, U. 1959: *Sailing boats*. London: Newnes.

Freeman, C. 1991: Networks of innovators: a synthesis of research issues. *Research Policy,* 20: 499-514.

Gourvish, T. 1995: Business history: in defence of the empirical approach? Acco*unting Business and Financial History*, 5, 1: 3-16.

Grandori, A. and Soda, G. 1995: Inter-firm networks: antecedents, mechanisms and forms. *Organization Studies*, 16, 2: 183-214.
Hannah, L. 1984: Entrepreneurs and the social sciences. *Economica*, 51: 219-234.
Hedström, P. and Swedberg, R. (eds.) *Social mechanisms: an analytical approach to social theory.* Cambridge: Cambridge University Press.
Henry, N. and Pinch, S. 2000: Spatialising knowledge: placing the knowledge community of Motorsport Valley. *Geoforum*, 31, 2: 191-208.
Howard-Davies, E. [c1970]: 'How it started' reproduced in: Sandbach (ed.) *op cit*. 7-8.
Huygens, M., Baden-Fuller, C., Van Den Bosch, F.A.J. and Volberda, H.W. 2001: Co-evolution of firm capabilities and industry competition: investigating the music industry 1877-1997. *Organization Studies*, 22, 6: 971-1012.
Johannisson, B. 2000: Networking and entrepreneurial growth. in: Sexton, D.L. and Landström, H. (eds.) *The Blackwell handbook of entrepreneurship,* Oxford: Blackwell.
Jones, C. 2001: Co-evolution of entrepreneurial careers, institutional rules and competitive dynamics in American film, 1895-1920. *Organization Studies*, 22, 6: 911-944.
Karnøe, P., Kristensen, P.H. and Andersen, P.H. (Eds.) 1999: *Mobilizing resources and generating competencies: the remarkable success of small and medium-sized enterprises in the Danish business system*. Copenhagen: Copenhagen Business School Press.
Lawson, C. And Lorenz, E. 1999: Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies*, 33, 4: 305-317.
Lazonick, W. 1991: *Business organization and the myth of the market economy*. Cambridge University Press, Cambridge.
Leather, J. 2004: The affordable cruiser. *Classic Boat*, 195: 44-48.
Lee, C.H. 1990: Corporate behaviour in theory and history: I. the evolution of theory. *Business History*, 32, 1: 17-31.
Levinthal, D. and Myatt, J. 1994: Co-evolution of capabilities and industry: the evolution of mutual fund processing. *Strategic Management Journal*, 15: 45-62.
Lewin, A.Y. and Koza, M.P. 2001: Empirical research in co-evolutionary processes of strategic adaptation and change: the promise and the challenge. *Organization Studies*, 22, 6: v-xii.
Lorenzen, M. (ed.) 1998: *Specialisation and localised learning: six studies on the European furniture industry*. Copenhagen: Copenhagen Business School Press.
Lundvall, B-A 1985: Product innovation and user-producer interaction. Aalborg: Aalborg University Press.
Lundvall, B.-A (ed.)1992: *National systems of innovation: towards a theory of innovation and interactive learning.* London: Pinter.
Lundvall, B.-A. 1999: National business systems and national systems of innovation. *International Studies of Management and Organisation*, 29, 2: 60-77 (Summer).
Madhavan, R., Koka, B.R., and Prescott, J.E. 1998: Networks in transition: how industry events (re)shape interfirm relationships. *Strategic Management Journal*, 19**:** 439-459.
Maskell, P., Eskelinene, H., Hannibalsson, I. and Malmberg, A. 1998: *Competitiveness, localised learning and regional development: specialised learning in small open economies*. London: Routledge.
Matthews, J. 2001: 'Competitive interfirm dynamics within an industrial market system.' *Industry and Innovation*, 8: 79-107.
Nelson, R.R. 1995: Co-evolution of industry structure, technology and supporting institutions, and the making of comparative advantage. *International Journal of the Economics of Business,* **2**, 2, 171-84.
Nooteboom, B. 2000: Institutions and forms of co-ordination in innovation systems. Organization Studies, 21, 5: 915-939.

Oliver, C. 1997: Sustainable competitive advantage: combining institutional and resource-based views. *Strategic Management Journal*, 18, 9: 697-713.
PHS 2004: *The history of plastics*. London: Institute of Materials/Plastics Historical Society.
Parsons, M. and Rose, M.B. 2004: *Invisible on Everest: innovation and the gear makers*. Philadelphia PA: Northern Liberties Press.
Penrose, E.T. [1959] 1995: *The theory of the growth of the firm* (3rd edn.) Oxford University Press, Oxford.
Phillips-Birt, D. 1974: *The history of yachting.* New York: Stein and Day.
Pittaway, L., Robertson, M. Kamal, M. and Denyer, D. 2004: *Networking and innovation: a systematic review of the evidence.* Lancaster: Lancaster University Management School Working Paper 2004/016.
Rayner, D.A. 1962: *Small boat sailing*. London: Collins.
Richardson, G.B. 1972: The organisation of industry. *Economic Journal*, 82: 883-96.
Rowlinson, M. and Procter, S. 1999: Organizational culture and business history. *Organization Studies*, 20, 3: 369-396.
Sabel, C.F. and Zeitlin, J. 1997: *World of possibilities: flexibility and mass production in western industrialization*. Cambridge: Cambridge University Press.
Sandbach, P. (ed.) 2000: *Fifty years on the water*. Crewe: GP Fourteen Class International Association.
Schumpeter, J.A. 1954: *Capitalism, socialism and democracy* (4th edn.). London: George Allen and Unwin.
Shaw, V. undated: *A brief history of the Mirror dinghy*. Mirror Class Association Archive.
Silverman, D. 1993: *Interpreting qualitative data: methods for analysing talk, text and interaction.* London: Sage.
Sornn-Friese, H. 2000: Frontiers of research in industrial dynamics and national systems of innovation. *Industry and Innovation*, 7, 1: 1-13.
Spurr, D. 2000: *Heart of glass: fiberglass boats and the men who made them*. Camden MA: International Marine/McGraw-Hill.
Stephenson, R. (ed.) 1978: *Small boats and big seas: a hundred years of yachting*. London: Paul Elek.
Storper, M. and Salais, R. 1997: *Worlds of production*. Cambridge MA: Harvard University Press.
Trad Boat (2004) Class associations for dinghies, keelboats and classic one-designs. Surrey: Charles Smith.
Weber, M. [1921] 1978: *Economy and society*. Berkeley CA: University of California Press.
Whipp, R. and Clark, P.A. 1986: *Innovation and the auto industry: product, process and work organisation*. London: Francis Pinter.
Whittington, R. 1989: *Corporate strategies in recession and recovery*. London: Unwin.
Wood, A.D. 1963: *Plywoods of the world: their development, manufacture and application*. Edinburgh and London: Johnston & Bacon.
Yachting World 1950: 'Yachting World G.P. Fourteen: how to build from Yachting World plans.' *Yachting World*: 2 (December).
Y-Flyer 2004: *The design of the Y-Flyer*. Indianapolis IN: American Y-Flyer Yacht Racing Association.

Figure 1 Dinghy construction methods: comparative cross-sections

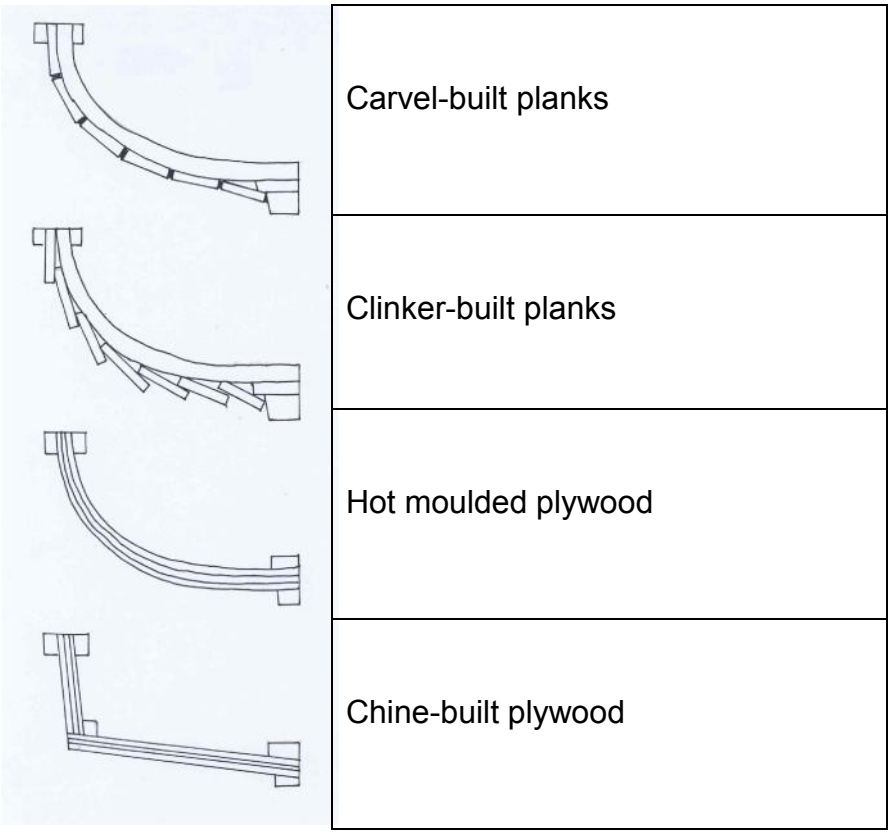
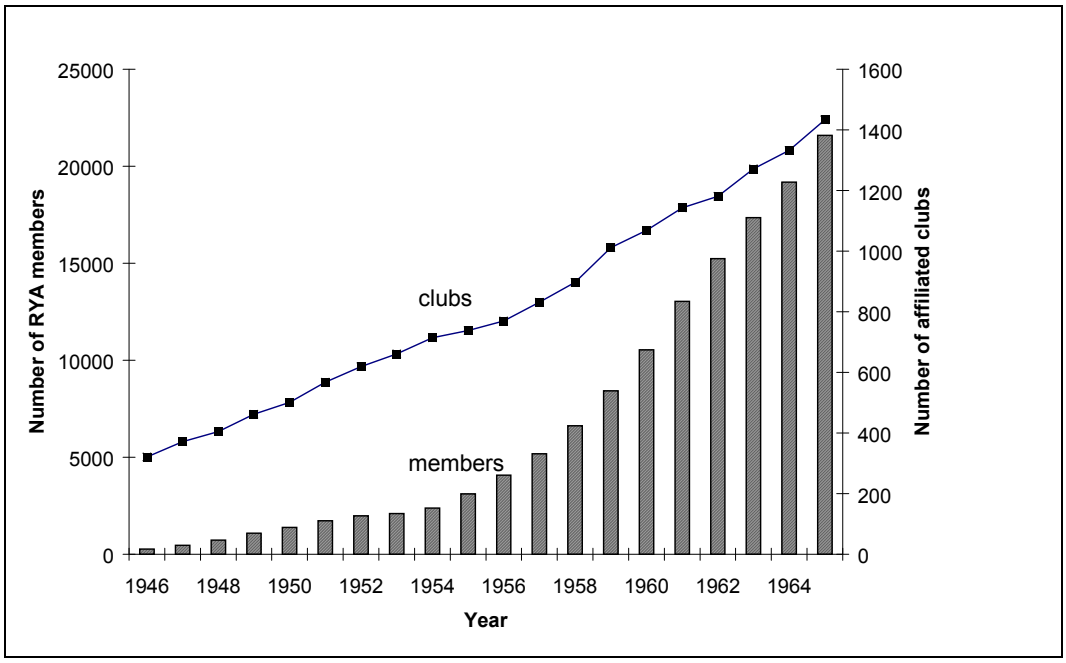
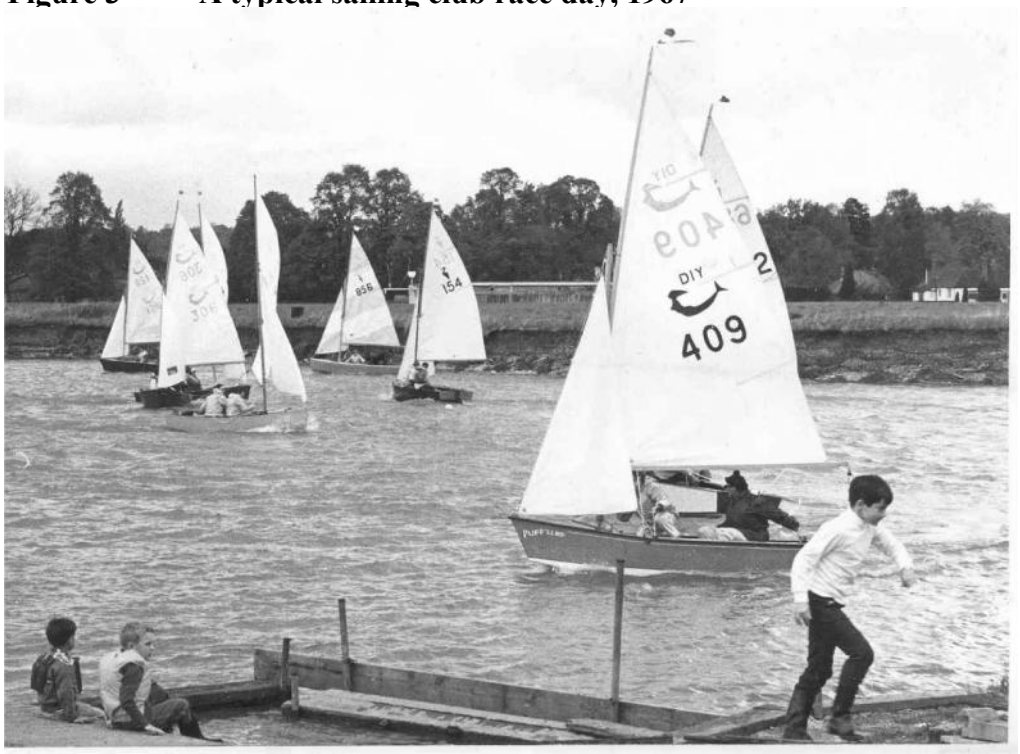


Figure 2 RYA membership and club affiliations (1946-1965)



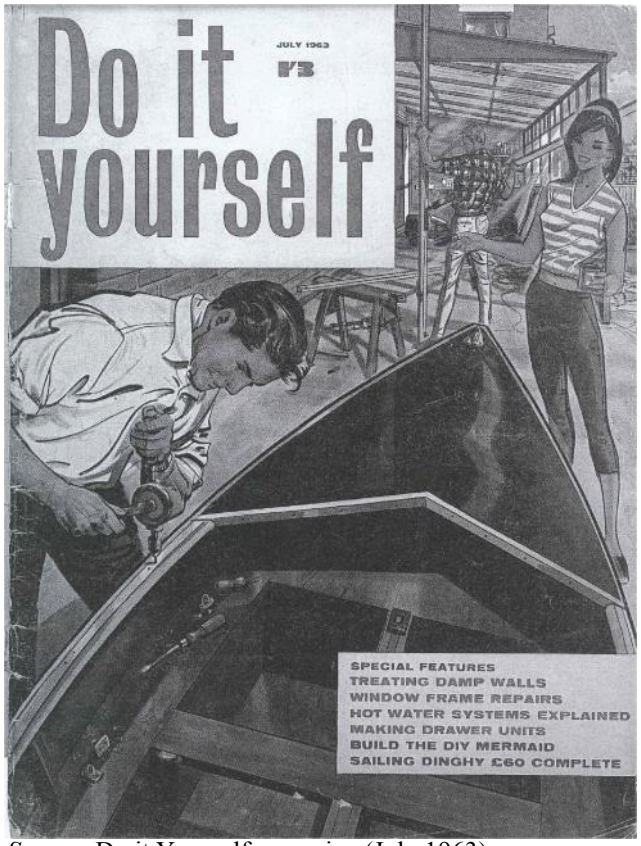
Source: RYA (2004) membership statistics – extract.

Figure 3 A typical sailing club race day, 1967



Source: Maidenhead SC archive

Figure 4 Promotional feature: *Do it Yourself* magazine, July 1963



Source: Do it Yourself magazine (July 1963)