Path-dependent Foundation of Global Design-driven Outdoor Trade in the Northwest of England

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This article explores path dependency in the design-based outdoor clothing and equipment sector in the northwest of the United Kingdom in the 1960s. The industry developed a strong export market and remains strong internationally. The article offers several key insights that promise to transform our understanding of the improvements that have taken place in design practice in some industries. In particular, the article focuses on the social, economic and technological factors that shaped the potential for successful design and manufacturing in the outdoor clothing and equipment sector in a region suffering from social and economic collapse. It also examines the role of users as designers and business founders.

The region this article examines was a vital centre of the Industrial Revolution. The article shows that skills and knowledge originating in the Industrial Revolution have been vitally important to the development of today's design-driven industries. The cases presented here involve internationally competitive mountaineering equipment firms. Mountaineering clothing and equipment design was originally based on function and lead-user innovation. Innovative functional products emerged when firms with knowledge and technology originating in the Industrial Revolution combined their skills with lead-user sporting expertise to generate a user-driven design process. One core finding of this study is that fundamental changes have occurred in the relationship between manufacturers and customers that are vital to design success today. This marks a departure from past practice.

Keywords **-** Design Evolution, Design Processes, Path Dependency, Lead-user Innovation, Mountaineering, Physical Geography.

Relevance to Design Practice - The research offers four beneficial insights for improving design practice: studying historical factors can reveal design opportunities; traditional industrial communities can create new product pathways; commercial designs can come from non-commercial leisure activities; and professional design input is not always essential for creating commercially successful design-based products and industries.

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Introduction

During the 1960s, the northwest region of the United Kingdom (illustrated in Figure 1) became the home of several innovative design-based companies producing clothing and equipment for mountaineering and outdoor sports. This region borders on the Pennines. It includes north Cheshire, Manchester, Lancashire, Derbyshire, Sheffield and parts of what is now Yorkshire. From the early 18th century, these adjoining regions played a central role in the newly emerging Industrial Revolution. Design activity in Manchester and Sheffield led to hundreds of new technologies and products, many of them world-changing. At the time, Manchester was a world leader in design activity that resulted in radical technical, social, commercial, organisational, educational and political changes.

In contrast, the cutting-edge design activity taking place in Sheffield was focused more tightly on steel production. From as early as the 14th century, the Sheffield area specialised in cutlery production. In early 18th-century Sheffield, the design of the crucible process, a new way of making better steel, facilitated new engineering and product design in the emerging Industrial Revolution. From that time to the middle of the 20th century, Manchester and Sheffield were the home of design and manufacture in cotton, textile machinery and specialist steel, together with related industries such as printing, linoleum-making and machine production.

The 20th century industrial decline of Manchester and Sheffield, and the accompanying decay and unemployment, came with rising foreign competition. However, despite this decline, there remained a legacy of experience and skill, and a deeply embedded culture of design and innovation, which, combined with new knowledge and applied to new activities, contributed, amongst other things, to the design of new outdoor clothing and equipment and to sporting innovation.

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New outdoor clothing and equipment businesses included Karrimor, Troll and Mountain Equipment. During the 1970s, these and other outdoor clothing and equipment firms emerged as international brands. This article focuses on the factors that shaped design processes and design choices in this innovative design-based sector. Drawing on a review of the history of the region, the experiences of the authors and case studies of Karrimor and Troll, the article undertakes a longitudinal study of how design-driven commercial success was shaped by path-dependent factors related to the industrial, social and sporting history and the physical geography of this Pennine region.

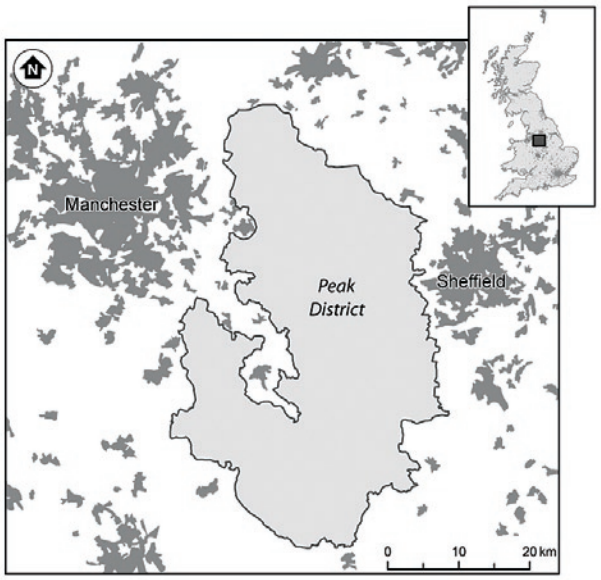

Figure 1. Map showing the proximity of the Lancashire cotton cluster around Manchester and the Sheffield steel cluster in Yorkshire. Working-class climbers from both towns found it easy to get to the crags in the Peak District and Yorkshire. Sheffield was increasingly where climbers, whether from Lancashire or Yorkshire met, planned and discussed their climbing plans. It became a climbing hub linked to centres of equipment innovation that extended across the Pennine boundaries.

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Mike Parsons has spent over 40 years in the outdoor equipment trade. Formerly Managing Director of Karrimor International—a company with 320 employees—he now runs OMM Ltd., a specialist in lightweight outdoor gear, and is an Entrepreneurial Fellow at the Institute for Entrepreneurship and Enterprise Development at Lancaster University Management School. His iconic product designs include the Karrimat, Whillans and Haston Alpiniste, KS-B's, Jaguar SA, Hot Ice and Hot Earth. He holds 42 patents and a dozen or so brand registrations worldwide.

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The article is divided into six substantive sections. In the first section, the characteristics of the innovative 19th-century industrial clusters of Lancashire and Sheffield are reviewed along with the legacy of the social and industrial history of this cross-Pennine region. The second section explores the ways design-related factors identified in the first section created a pathway to the formation of the new outdoor clothing and equipment industry in the region. This section also includes a discussion of the roles of the textile engineering legacy, social issues and the growth of outdoor pursuits in the region. The second section is followed by a case study of Karrimor, with a particular focus on the design relationship with the region's textile legacy. Prior to the second case study, is a short section on design by lead users. The case study of Troll Products focuses on the role of lead users in the company's design activities. The penultimate section draws attention to the significant fillip to business success provided by the media in proclaiming the design-led benefits of the new products as essential to high-profile British mountaineering successes. The article concludes with a summary and a review of the contributions to design theory. Conclusions are drawn that demonstrate the strong relationship between design processes and outcomes, the development of the outdoor sector, social, industrial and sporting history, and physical geography.

Terminology and Concepts

This article uses the term *design* to refer to all activities associated with the creation of a design as a specification for a solution, product, service, system or organisation. This view of design aligns with Herbert Simon's (1981, p. 164) definition of design and extends to the design of innovation systems, business processes and technology platforms. Design activity involves a broad range of processes, each of which contributes to the ability to produce a specification for a preferred outcome, and these are cumulatively referred to in this article as *design process*.

Design activity occurs in many different fields that, as a whole, form three distinct groups. Fields such as engineering design and software design form one group. The second comprises the art and design fields. The third group contains the increasing number of design fields such as business design and organisational process design that do not fit under either of the first two groupings. Many of the design-related concepts used in this paper, such as the role of "lead-user innovators in design," are drawn from the design literatures of the first and third groups. This is because the focus of the article is a review, via case studies, of the social and technical path-dependent factors shaping success of design-based businesses that depend on design activity for competitive advantage.

Path Dependence, Design, Industrial Clusters and the Industrial Revolution

Industrial districts are hubs of design and manufacturing activity distinguished by a closely interrelated evolution of skills, knowledge, technologies and products based upon path-dependent characteristics. David, in Magnusson and Ottosson (1997), explained path dependency as follows:

> …The influence of past events and of the states they bring about must be communicated–like the deepening of wheel ruts by each successive vehicle–through some definite chain of intervening causal events, effects and resultant states–down to the present state, whence they can be passed on to future events. (p. 23)

Tacit knowledge based on learning by doing, a central component of creating design knowledge, is embedded in communities and is at the heart of theories of path dependency (Gertler, 2004, p. 142). Learning by doing within industrial regions is reinforced by communities of practice in which shared experience reinforces learning and shapes product design and technology development (Wenger, 1998, p. 45). This is different from saying that there is something fixedly predetermined about the development of innovation or design. Instead, it emphasises the ways that history matters in the evolution of design and innovation, and the effects historical factors have on design choices.

Regions, their technologies, organisations, designs and products have distinctive histories shaped by the knowledge and experience of those working within them. This means that responses to change and its initiation are based on social processes, which are also shaped by the past. In the northwest of the United Kingdom, design and innovation have been intimately related to the industrial legacies of two overlapping 19th-century industrial clusters. One was centred on Manchester and Lancashire, with this area's focus on textile production and machine making. The other was centred on Sheffield in Yorkshire, with its expertise in specialist steel production, cutlery and machining.

By the late 19th century, Lancashire had evolved into the most sophisticated and specialised industrial district in the world. It had significant vertical, and particularly spatial, specialisation. The region aligned almost perfectly with economist Alfred Marshall's (1890) description of the classic industrial district:

> …When an industry has thus chosen a locality for itself, it is likely to stay there long; so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organisation of the business have their merits promptly discussed; if one man starts a new idea, it is taken by others and combined with suggestions of their own; and thus it becomes the source of further good ideas. And presently subsidiary trades grow up in the neighbourhood…. Conducing to the economy of its material. (p. 225)

In 19th-century Lancashire, the primary focus was textile production, and individual communities concentrated on producing distinctive yarns and fabrics using machines that were designed and evolved synergistically (Rose, 2000, pp. 21-98). By the First World War, interrelated business, design and manufacturing sectors were involved in the manufacture of over 300 different fabric types, the production of synthetic dyestuffs, a strong printing and newsprint industry, textile finishing, coal mining, and a massive rubberised rainwear industry (Levitt, 1986; Wilson & Singleton, 2003).

In design terms, Manchester was far more than an industrial town. As a city, it was the commercial heart of spatially-specialised manufacturing and design industries. Manchester's commercial sector provided the crucial link with the outside world. Its numerous commercial knowledge-based institutions facilitated information flow and acted as a conduit for intermediate goods and services, with numerous shipping houses linking manufacturers with diverse national and international markets (Hudson, 1989; Rose, 2000, p. 79; Staber, 1998; Wilson & Popp, 2003). Networks of information and commercial intelligence were brought together through the Manchester Royal Exchange, described as the "nerve centre" of industry (Farnie, 1979, pp. 97-98).

A wide range of merchant textile converters and fabric finishing companies in the environs of Manchester were at the very heart of the Lancashire system. This meant that very few textile manufacturers had direct contact with their customers (Chapman, 1996), thus reducing opportunities for user-driven design in cotton manufacturing itself. This contrasted strongly with the close design connections at that time between machine makers and their client users, the textile manufacturers. These latter relationships were early examples of a tradition of lead-user contribution to design (von Hippel, 2005) that is found even more strongly in the later outdoor clothing and equipment industry that is the subject of this article.

In terms of design and innovation theory, this is a significant point. The path-dependent approach of this article describes how commercially successful design-based innovation can result from integration of design activities based on lead-user innovation with longer term innovation processes resulting from industrial knowledge networks involving communities of practice.

In the 19th century, the development of communities of practice in the northwest of the United Kingdom was especially linked to accumulated and distinctive capabilities tied to specific products, geared to particular markets. For example, the expansion of South Lancashire's spinning industry was closely linked to improvements in the design of steam power technology and innovations in textile engineering. Such interaction and skill building within individual Lancashire towns was reinforced by relationships between machine makers, and by their input into the curricula of local technical colleges (Rose, 2000, p. 172).

Lancashire's lead in textile capability depended on innovative design and development of machine tools, engineering and related skills around Manchester. Technology develops in an evolutionary path-dependent manner, being shaped by past skills and the transfer of knowledge within industrial communities. The role of technology-based path dependence in business development is especially well illustrated by Lancashire's engineering legacy. In the 18th century, after centuries of craft-based evolution, the

first machine shops were closely linked to the need for precision parts for improved designs of the steam engine. Likewise, machine tool design for textile machinery was inextricably linked to design factors associated with technical flexibility, versatility and sophistication, by which textile manufacturers and finishers gained competitive advantage (Boschi & Drew-Smythe, 2006; Halton, 2007; Moss & Burns, 2006a).

Design and innovation in technology is crucially related to personal networks and the exchange of knowledge. Within Lancashire, this was especially true for engineering designer and innovator Joseph Whitworth. According to Rolt (1965), Whitworth was:

> ...not an inventive genius but …sought out the best features of contemporary design, improved upon them and combined them in one masterly synthesis. (pp. 92-117)

Whitworth gained knowledge as a mechanic in the Manchester cotton industry in the 1810s. He combined this with knowledge gained from employment with Henry Maudslay, the London-based originator of screw cutting lathes (Rolt, 1965, pp. 83-118).

A hallmark of Whitworth's designs was that they were made to the highest levels of precision of that time. For example, his machines of the 1850s could detect differences of one-millionth of an inch (0.0000254 mm) (The Whitworth Society, 2005). This is more accurate than many current production machine tools. Whitworth's machine designs provided the ability to make precision parts and enabled the design of more sophisticated textile machinery. The design of improved machine tools and mechanically more complex mechanisms was also supported by the use of Whitworth's standard for screw threads, another major contribution to Lancashire's machine-building capability. The Whitworth thread form proved robust, easy to manufacture and, in spite of its relative coarseness, was the primary screw thread standard until 1948. As described later in this article, nuts using Whitworth's screw threads were to later play a role in the development of climbing hardware in the 1950s.

A Manchester design and manufacturing company, Mather and Platt was another early industrial player that shaped the Lancashire industrial region and had path-dependent impact on design evolution in the later outdoor clothing and equipment sector. In its early days, the company's importance was increased through active participation by Sir William Mather in the region's economic and social development (Moss & Burns, 2006b). The business was originally established at Salford Ironworks, and by 1795 was of considerable capacity and noted for its steam engines (Boschi & Drew-Smythe, 2006). Colin and William Mather were designers and entrepreneurs who had established a business as engineers, machine makers and millwrights. They joined with the Platt family, who had leased Salford Ironworks, and designed and manufactured dozens of new types of textile finishing machines. In the early days, because of its foundry, Mather and Platt preferentially focused on designing and manufacturing larger-scale machines for the textile finishing trades rather than the smaller machine elements for spinning and weaving.

The Mather and Platt business had a strong international focus, with Colin and William making many trips overseas. These activities resulted in Mather and Platt having central roles in the international development of the textile industries of many countries, notably Russia, India and America. This was to the point that *Matherplatt* became a generic term in textile printing (*Matherplattieren* in German and *Plattning* in Swedish). The design and business decisions of Mather and Platt, and the closely related evolution of frame, shaft and roller-based machine technologies that they developed, had a significant effect on design in this region. As described later in this article, this machine design path gave particular advantages to the new design-focused outdoor clothing and equipment industry that developed after the collapse of Lancashire's cotton industries in the mid-20th century.

Part of this evolution of technology was a shift in the materials of machine-making from wood to iron, and thence to steel. This was another path-dependent factor that shaped the development of industries in the northwest of the United Kingdom. This shift in materials, aided by the move away from the wooden gearing of mills, combined with and supported the design of new types of machinery. It brought changes in power transmission crucial to the design of large, complex multi-machine arrangements that distributed power from a single source throughout large textile mill buildings. In addition, the design of high-speed linked shafting made possible the later development of effective systems using process control to manage multiple sub-processes in, for example, cotton spinning, fabric treatment, linoleum manufacturing and the printing of fabric and paper.

The Industrial Revolution was, of course, not confined to Lancashire. Close relationships evolved with neighbouring industrial districts such as Sheffield, the home of specialist steel-making. Sheffield's skill and craft expertise had evolved over centuries, from Roman times, and resulted in Sheffield becoming the UK's largest 19th-century centre of specialist steels. In its heyday in the 19th century, Sheffield was also the world's largest cutlery centre and a leading producer of specialist tools. Sheffield's strong connection with the Lancashire textile and machine-making industries lay in its expertise in creating tool steels that enabled other materials to be shaped. These advanced materials were of course designed for and used by the machine tool makers so crucial to Lancashire's engineering industry (Tweedale, 1993, pp. 14-15).

Joseph Schumpeter, the father of entrepreneurship studies, saw innovation as evolutionary and path dependent (Schumpeter, 1947). He believed the trajectory of any innovation was intimately related to its historical context, and argued that creativity involves not necessarily developing something new, but having the imagination to see old things in new ways and to move "outside the ruts of established practice." Schumpeter's views on innovation have been interpreted as a radical contribution to economics. However, work that draws on Schumpeter emphasises how the majority of designs and innovations represent "new combinations of old and new" —old product and new process, old product and new material, old skills and new products (Abernathy & Clark, 1985). New combinations of new and old skills, new and old materials and new and evolving outdoor sporting pursuits lay

at the heart of the emergence of the design-driven internationally competitive outdoor sports companies that appeared on the Pennine fringes in the 1960s. Innovative products were designed in which industrial and technical knowledge from Lancashire and Sheffield was combined with sporting skills and needs at a time when the market for climbing and outdoor products was growing strongly.

In the 20th century, external changes, along with market and technological shifts, undermined the industrial buoyancy of the Manchester and Sheffield industrial clusters. By the 1970s, the NW textile industry was virtually dead, many mills demolished, and Lancashire's industrial past increasingly scrapped or consigned to the heritage industry (Aspin, 1996). The start of the decline of the Lancashire cotton industry predated the First World War. It gathered momentum during the interwar period. Absolute decline, when output, capacity and employment in spinning and weaving declined, began after 1939. Several forces lowered investment and made it hard for firms at the lower end of the market to change in ways that might have stemmed the region's decline (Rose, 2000, p. 262). These adverse forces and factors included wartime utility schemes, inexperience in Continental European markets, collapse of the Indian textile market, supply side weaknesses, structural changes and government policy.

However, not all sectors of cotton textiles declined, nor were all skills and accumulated knowledge lost. The textile finishing trades expanded during the 1950s and 1960s as demand for specialist, protective and high-performance fabrics rose. Sheffield's decline, in particular, was more protracted. In 1964, the city was still the most famous name in steel and the city bore "all the hallmarks of its nineteenth century heyday." However, a decade later, changes in patterns of world demand and manufacturing generally, and reduction in demand for alloy steels in particular, undermined Sheffield's international standing (Tweedale, 1993, pp. 331-349).

Nevertheless, the legacy of decline was more than decay, demolition and industrial museums. Some skills, such as cotton spinning and weaving, became redundant as the cotton industry shifted to Asia, but other skills combined in new ways with new materials and uses in ways that would later contribute to design processes in a newly emerging sector—clothing and equipment for outdoor sports. For example, at the time that spindleage and loomage were being scrapped, the output of the coating trades essential to the design of high-performance outdoor garments and tents grew from £50 million in 1950 to £93.6 million in 1970 (Government Statistical Service, 1976).

Pathway to the New Outdoor Clothing and Equipment Industry Sector

Path-dependent aspects of social and industrial histories, and evolving communities of design and manufacturing practices, played crucial roles in the development of both Lancashire and Sheffield in the 19th century and in their later decline. To a fair degree the decline of both industrial districts stemmed from "lock in" in a rapidly changing world. The recent development of a strong design-focused outdoor clothing and equipment industry provides, however, evidence of creative entrepreneurial responses that combined the industrial and social legacy of the area with lead users involved in new outdoor sports pursuits, to develop innovative designs.

The textile and steel-making industries of Lancashire and Sheffield created technological, social and institutional foundations that influenced future design and innovation and business development. These prior industrial conditions acted as evolutionary selection criteria that defined the mix of skills, resources and technologies available after the collapse of the textile and steel industries. This particular mix aligned well with the design, manufacture and marketing of innovative outdoor clothing and equipment. The mix of human and technological resources available after the collapse of the textile industry was not well-suited to other alternative uses. The main physical technology resources (mills with large roller and frame machinery) were hard to relocate, and could not follow easy technological transfer paths to other commercial activities. This lack of an alternative use reduced the relative costs of these resources to new entrepreneurs in the outdoor clothing and equipment industries and thus increased their national and international competitiveness.

Specific aspects of the technology and skill legacies of Lancashire and Sheffield that shaped design capabilities in newly emerging outdoor clothing and equipment companies were the knowledge and skills that combined finishing processes, engineering and specialist metals. Residues from the decline of the Lancashire textile industry that impacted positively on the design of outdoor products were less the direct impact of the collapse of spinning and weaving than the skills embedded in the ancillary trades—both textile finishing and engineering. These skill bases especially benefited companies like Karrimor and Troll.

The factors that provided benefits to the new outdoor industry did not do so simply or linearly. Nor were they related to cotton spinning or weaving per se. The path dependency of Lancashire's cotton past has been a complicated one. In part this is due to the high level of 19th- century specialisation. An example is the consequences for the shift to nylon in outdoor products in the 1960s and 1970s. Waterproofing nylon was not a straightforward development. Nylon, invented by Du Pont scientists in 1934, is not naturally a wet-weather fabric. Unlike cotton, when rained on nylon fabrics/fibres do not swell after absorbing water and hence do not have any natural ability to repel water as does cotton. Unlike cotton, it does not matter how tightly nylon is woven. In addition, the nature of nylon fibres tends to prevent nylon fabric from retaining proofing. The consumer today assumes nylon is easier to proof than cotton. The opposite is true, and in the 1970s, high-performance textile designers faced similar problems as did Macintosh before 1850 (Levitt, 1986). Indeed, as a first step, coating manufacturers used a synthetic version of Macintosh's original rubber to bond the waterproof polyurethane (PU) coating to the nylon fabric. However, the result was extremely heavy and unsuitable. As chemical technologies evolved, it was found possible to design new ways to chemically bond PU to the very shiny nylon fibres (Hounshell & Smith, 1988, pp. 249-257). The skills from Lancashire's earlier rubberised rainwear industry, especially those associated with coatings, undoubtedly played an important role in building the competitive advantage of companies

like Peter Storm and Karrimor in the 1960s and 1970s, and Regatta in the 1990s. All these outdoor companies relied heavily upon the accumulated expertise of Lancashire suppliers of coatings—some old and some new—for the competitive performance of their clothing, rucksacks and tents.

Design and the Textile Engineering Legacy

For the new developments in outdoor clothing and equipment design, engineering and metal-working skills and other processes associated with Lancashire's textile legacy were also important. Machinery composed of frames with large shafts and rollers was found across a wide range of industries in this northwest region of the United Kingdom. The techniques and design skills underpinning the development of these machines and their associated applications, mostly developed for textile manufacture by firms such as Mather and Platt, were applied in many other industries, such as lino production, steam engines, industrial sewing machines, large volume generation of sterilising fluids using electrolysis, electric motors and machinery and food processing (Boschi & Drew-Smythe, 2006).

In design terms, the opportunities offered by the existence and extent of this large roller machinery technology acted as evolutionary selection criteria shaping the future outdoor industry business via path dependencies. Rather than closing, some companies in the textile arena redesigned their businesses to use the available machines and existing skill sets in new ways, recognizing the opportunities that existed in producing the high-performance coated and treated fabrics described above that were so vital for companies like Karrimor. The complexity of elements involved in this business transformation in turn also acted as evolutionary criteria selecting *against* firms that did not utilise these opportunities. It also reduced competition against firms in the region that offered added value in the supply chain through designing products using high-performance coated fabrics.

Social Factors and the Growth of Outdoor Pursuits

The dynamics of the growth of new outdoor sporting pursuits such as climbing, hill-walking, canoeing, caving and mountaineering contributed greatly to the emergence of new dynamic design-driven outdoor equipment companies. Mass participation in outdoor activities such as hill-walking and cycling began in the 19th century and grew significantly during the interwar years. Nevertheless, this did not immediately result in a mass market because incomes were still low. Before the Second World War, the competitive advantage of outdoor clothing and equipment companies in the United Kingdom lay in tents and in windproof clothing. Anything more sophisticated was imported, and this continued to be the case in the immediate postwar period. However, increasing leisure time, greater mobility, increased media profiling of adventure activities, and changing laws that provided the average industrial worker with greater access to countryside that had previously been only the province of the rich, made outdoor activities more popular. In addition, the first ascent of Mount Everest in 1953 made mountaineering more visible and, through its leader John Hunt, provided a vital boost to the idea of outdoor education in the UK. Outdoor education centres were created to provide "character improvement," particularly for young people. These became a crucial bulk market for UK outdoor clothing and equipment companies in the 1960s and 1970s. Demand continued to rise in the 1970s and 1980s, bolstered by the development of activities such as backpacking, Scottish ice climbing and skiing.

Central to much of this growth in outdoor pursuits was the Pennine region between Manchester and Sheffield. This was the heart of the growing levels of urban climbing and outdoor activity and increasingly important to lead-user design of new innovations. As Figure 1 shows, The Derbyshire Peak District and the Pennines to the east of Manchester, with their proximity to both Manchester and Sheffield, became increasingly popular with urban working-class and lower middle-class residents during the interwar period. On a typical weekend in 1931, 10,000 walkers visited Derbyshire, mainly from the neighbouring conurbations, with many becoming involved in the access movement and the Mass Trespass of 1932 (Parsons & Rose, 2003, p. 119). This was a new breed of outdoor enthusiasts who pursued different "rules of the game" and had different knowledge and skills from the moneyed, public school educated professional elites that had previously formed the core of British mountaineering in the 19th century.

The slump that devastated industries like cotton and steel, in the interwar period, led to a sharp rise in unemployment in both Manchester and Sheffield. Many of the unemployed flocked to the Gritstone edges of the Peak District and Saddleworth, and to the limestone hills and caves of the Yorkshire Dales. These new venues (see Figure 2 for an example of a Gritstone edge) were located between Manchester and Sheffield, and amongst their enthusiastic sporting visitors a different outdoor culture emerged (Byne & Sutton, 1966).

> …Peakland mountaineering did not share the upper class origins of the sport elsewhere in Britain and the district surrounded by the great industrial masses of Sheffield, Nottingham, Derby, the Potteries and Manchester and its neighbours has been primarily a working-man's playground, while Wasdale and Ogwen remained for a long time in the leisured atmosphere of the traditional climbing families and their friends, there grew up in the Peak District an independent tradition of hard walking and hard climbing that owed little to external influence. (p. 29)

After the Second World War, this working-class group emerged at the leading edge of British climbing and formed the crucial lead-user design bridge between regionally-based industrial skills and the design of innovative outdoor products.

Prior to the 1960s, most technical outdoor equipment, from rucksacks to climbing hardware, was imported (Parsons & Rose, 2003, pp. 226-228). The emergence of the new group of climbers, cavers, walkers and other outdoor enthusiasts altered the profile of British climbing and influenced equipment development fundamentally. This new breed of urban working-class climbers shared an outlook and background similar to that of Continental climbers. In the late 19th and early 20th centuries, climbers and

Figure 2. Gritstone outcrops amongst the peat moors of the Derbyshire Peak District make superb climbing areas. Formerly the steep river valleys surrounding them drove waterwheels to power the cotton mills of the industrial revolution. Located within easy travelling from the district of the major conurbations of Manchester and Sheffield, gritstone rock climbing areas like these became a magnet for working-class climbers like Joe Brown and Don Whillans in the 1950s and 1960s.

outdoor equipment designers and manufacturers had developed technical rock climbing in both the Western and Eastern Alps (Byne & Sutton, 1966, p. 30). In the Alps, the combination of local industrial, practical and climbing knowledge influenced innovative design of mountaineering hardware and other equipment used by Alpine climbers.

This trend was replicated in the Peak District and other areas bordering the Pennines (Parsons & Rose, 2003, pp. 134-162). It led to the development of communities that were involved in outdoor sports and design practice, and in which lead users designed new products and innovated to meet their own personal needs, sometimes becoming lifestyle entrepreneurs (Shah, 2000; von Hippel, 2005, p. 19). What is significant, in the emergence of the outdoor clothing and equipment trade in this northwest region, is the extent to which this activity mapped onto the region's industrial past. It manifested itself in a number of ways, including in the emergence of people who combined knowledge of materials, manufacturing and craft processes with a knowledge of the demands of outdoor sports.

Designers and innovators are involved in the interplay of two questions: "What is needed?" and "What is possible?" The above combination—of the knowledge of the capabilities of materials, industrial processes and sporting needs—was a creative mixture. It played a fundamental role in the innovation and design process of mountaineering and climbing equipment and in the raising of climbing standards in the United Kingdom from the 1950s onwards. Being entirely separate, socially and geographically, from the earlier traditions of British mountaineering, the working-class climbers "did not know what they were not supposed to do." However, they recognised that their Gritstone rocks called for technical climbing equipment. In other words, the distinctive physical geography of the Pennine region resulted in a different sort of climbing compared with that found in the Lake District and in North Wales, where the mountaineering elite typically climbed. This need for new, more technical forms of equipment had a significant impact on design and development in the outdoor clothing and equipment industry after the Second World War.

By the 1960s, UK textile-related equipment for climbing and mountaineering was well developed and often many years in advance of what was being made in Continental Europe. Climbing hardware, on the other hand, was 50 years behind (Parsons & Rose, 2003, pp. 134-176). Part of the reason for this lay in the ethos of the traditional British climbing establishment, which abhorred artificial aids. Another factor was the physical difference between most of the climbing areas favoured by the British climbing establishment. These were very different to the Eastern Alps, with its big walls, where many of the major climbing hardware innovations originated. However, the design of a new device—the nut—that did not damage the rock face had a lasting impact on the development of climbing hardware design in the United Kingdom. The device was called a "nut" simply because the initial inspiration was an engineer's nut with the thread removed.

The sporting origins of the removable nut, made to replace the piton (which was left embedded in the rock face), came from the practice among British climbers to thread their rope behind a small rock that was naturally jammed in a crack. Many of the peak climbers worked in engineering workshops and collected Whitworth nuts, filing the threads from the inside, threading a nylon cord through them and using them instead of stones. The

first manufactured nut, the Acorn, was made by climber John Brailsford, a one-time Sheffield steel apprentice and blacksmith, who was by 1961 working as a craft teacher in Derbyshire (see Figures 3 and 4). By using aluminum die-casting techniques, Brailsford went on to design the much improved MOAC nut, one of the crucial innovations on which the UK mountain hardware industry was based. John Brailsford was not the only innovator in mountain hardware in the United Kingdom, but he became supporting master craftsman for many who followed (M. Parsons, personal communication, 2001). This, combined with his shift into outdoor education and later into working as a mountain guide, meant Brailford's knowledge had an inordinate impact on developments in the 1960s and 1970s.

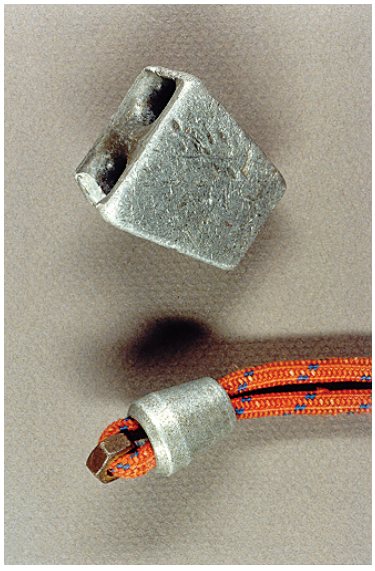

Figure 3. The first Brailsford nuts were based on engineering nuts.

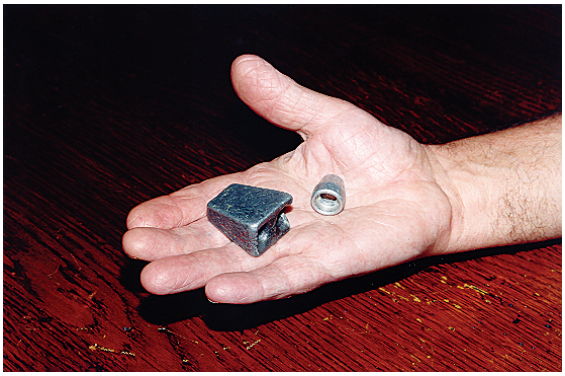

Figure 4. The MOAC and an Acorn.
The Acorn was first manufactured by John Brailsford, using his lathe.

Case Study 1: Karrimor's Links with Lancashire's Textile and Engineering Legacy

Karrimor was founded in 1946 by Mary and Charlie Parsons to supply their Rawtenstall cycle shop with cycle bags. It began as a small workshop above the shop, and when Mike Parsons joined the company in 1960, he was the seventh employee and turnover was two-thirds that of the retail store. In building the business, Parsons gained a deep understanding of the manufacturing process and, being based within old textile Lancashire, of the capabilities of textiles and their associated processes. As an active sportsman, he had a working knowledge of mountain sports and regular dialogue with mountaineers and others involved in outdoor pursuits. This bridge between technical knowledge and sporting needs played a crucial role in Karrimor's use of design and advanced manufacturing to establish a growing dominance of the rucksack market. By 1975, the company employed 163 workers and controlled 80 percent of the UK rucksack market, exporting 40 percent of its turnover (excerpt from fragmentary memoir of Charlie Parsons in the possession of Mike Parsons; e-mail from Mike Parsons to Mary Rose, 8 May 2000; Karrimor Company Accounts, 1952-1975; (Parsons & Rose, 2003, pp. 223-224)).

Karrimor could not have been more firmly embedded in Lancashire. Its early development involved combining old and new technologies, materials and skills with a far higher level of customer interaction than had been common in the cotton industry.

Mike Parsons and his product manager, Eddie Creig, developed a close relationship with the Lancashire textile industry and especially with coating companies over a 20-year period. As Eddie Creig explained (Creig, 1982) (also included in a series published by the Equipment Unit, convened by Tony Lack):

> …The basic point on any development [is] co-operation and experience. A sharing of knowledge. Although this is concerned with the development of fabrics the same careful co-operation exists between myself and our suppliers of zips, mouldings, met fasteners, foams etc. (pp. 49-50)

During the late 1960s Parsons began to shift rucksack production into nylon and encountered difficulties with the PU coating, which regularly peeled off. This resulted in discussions with their supplier, Gordon and Fairclough of Darwen. Founded in 1971, this small company had worked closely with Courtaulds, an international textiles corporation based in Manchester, before moving into PU coatings. Discussions were robust and ultimately creative, as Karrimor product manager Eddie Creig recalled in *Development of Rucsack Fabrics* (Creig, 1982):

> How can you expect to have the correct material if you don't speak to the people who know what coated fabric is?…. The resultant meetings always seemed to me the main reason why we have led the field in our section of the leisure industry… In subsequent years I got to know the dyer that our coaters were using at that time. It was most important that the fabric was properly dyed and only by close contact between dyer and manufacturer could he have a real understanding of what was required and why. (pp. 49-50)

The result of this co-operation was the introduction, in 1979, of the KS-100e fabric. This was described as "a completely new rucksack fabric with a new elastomer coating." According to Karrimor advertising material for KS100e, it was the first fabric purposely designed for rucksacks (Creig, 1980).

Parsons is clear, however, that this co-operation involved a major break from past practice, by tapping into the knowledge of coating and related chemical processes that was a legacy of Lancashire's industrial past. Direct contact within the supply

chain was not a feature of 19th century Lancashire, as industries at that time relied heavily on specialist merchants at every stage. In addition, while the coating processes were a direct legacy of the 19th century, the chemistry involved in achieving a chemical bond between the PU coating compounds and nylon fibres was new. This presented its own new problems. It was found that the new coatings locked the nylon fibres together so strongly that the tear strength of the resulting coated fabric decreased significantly. It was ten to fifteen years before new types of waterproof elastomeric coatings were developed that allowed the fabric to regain its flexibility and tear strength. KS-100e was the first such fabric to do so (see Figure 5). (For a full discussion of KS100e, see Parsons & Rose, 2005.)

Figure 5. Advertisement for KS-100e.

Lead-user Innovation

The interplay between practical manufacturing knowledge, craftsmanship and sports is not the only source of path dependence for design in UK outdoor products. The Peak District and other areas of the Pennines were the playground of outstanding working-class climbers who emerged as lead-user innovators (see Figure 6). Of these, the best-known were Don Whillans and Joe Brown, whose climbing expertise captured the nation's imagination during the 1950s and 1960s. Intensely practical and trained as a plumber, Don Whillans had an "analytical attitude to gear," according to Pete Hutchinson, owner of Mountain Equipment. He was a typical lead-user designer—looking for the solutions to his own particular climbing needs (von Hippel, 2005, pp. 22-35). Whillans' classic designs included the Whillans Box, a high-altitude tent developed for him by Karrimor, and the Whillans sit-harness, developed with Troll. Both of these were of key importance to his move into high-altitude climbing in the Himalayas in the 1960s (Parsons & Rose, 2003, pp. 237-238). Some lead users, like Whillans, were not even remotely interested in becoming "life style" entrepreneurs and were not interested in the business side of innovation. There were others, however, such as Tony Howard, a founder of Troll Products, who was a lead user, designer and subsequently a manufacturer (M. Parsons, personal communication, 2001). The Troll company derived its name from the Troll Wall in Norway, climbed by Tony Howard and his climbing partners in 1965 (M. Parsons, personal communication, 2001).

This marked another facet of the growth of what would become an internationally competitive industry sector. Lead users such as Tony Howard and other members of the northwest's climbing clubs explored new climbing areas overseas. Lessons learned in designing, making and using outdoor equipment in the United Kingdom were transferred to technical climbing and caving situations in other countries. This led to increased international visibility for the designs of outdoor products from the northwest of the United Kingdom. As a parallel development, the lead users of the United Kingdom learned from their experiences in using UK outdoor products overseas, and thus were able to contribute to improving and developing the designs for a wider market.

Figure 6. Advertisement for Karrimor climbing sacs.

Case Study 2: Troll Products and Lead-User Design

Troll Products' original premises were a wooden shed in Greenfield, West Yorkshire. Greenfield is a small ex-textile town on the Lancashire side of the Pennines. Historically, its industrial significance lay in its location at the intersection of roads from Manchester to Huddersfield and Holmfirth, and the nearby Huddersfield Narrows canal, with its technologically impressive 5-kilometer Standedge tunnel that provided the key transport link across England from the Mersey to the Humber estuaries.

Tony Howard explained in an interview with Mike Parsons that climbing waist belts, Troll's first products, were a direct response to the technical climbing developments taking place on the Peak District Gritstone edges from the 1950s onwards (M. Parsons, personal communication with Tony Howard, 2001). The shift toward aid climbing meant that climbers were carrying more gear. The waist belts allowed them to carry this gear more easily.

The design of the early waist belts was also linked to the decline of the textile industry, as these early waist belts were made of old leather belting from local textile mills. This was later replaced by nylon webbing. One of the authors of this study, Terry Love, began working for Troll Products around 1968. At that time, its workshop was made up of three small, interconnected sections, each about 8 feet (2.5 meters) square: office, machine shop, and store/polishing room. The business's products at that time comprised: "chocks" (another name for "nuts"), etriers (short ladders for climbers made of nylon tape and stiffened with polystyrene cement), and cagoules (knee-length waterproof smocks made from polyurethane-coated nylon with stitched and glued seams).

In its early days, all of the people who worked for Troll Products were active climbers and product innovators. All of them designed and developed new climbing equipment and techniques. The pace of design and development was high, and there was much synchronicity in the design of new products. For example, around 1968, Terry Love, along with climbing partner Paul Pierce of Greenfield (whose older brother Steven Pierce previously also worked for Troll Products), began using trapeze harnesses from racing dinghies as a seat for resting whilst exploring new artificial climbing techniques. This strong multilayer sailcloth seat also showed potential in acting as a safety harness.

A year later, in 1969, Troll Products was approached by Don Whillans about the development of what became the definitive sit-harness (Figure 7) for high-altitude resting during climbs (M. Parsons, personal communication with Tony Howard, 2001).

> …There were no sit-harnesses on the market and Don came up with the idea of a fabric seat linked into the waist belt. We played around with Don's idea and took the fabric out and replaced it with web. Eventually we came up with the basic Whillans harness still using mill belting. Although it was initially slagged off by the journalists it took off and nothing replaced it until 1978.

Importantly, sit-harnesses provided an excellent means for resting using the climbing safety rope. Previously, waist belts had provided a means to connect to the safety rope in the case of a fall and as a means for carrying climbing gear. However, waist belts ride up under the chest painfully and restrict breathing (potentially fatally) when pulled from above, as in the case of a fall or when resting. Whillan's design of Troll's sit-harness addressed these problems. Lead-user design by Don Whillans of Troll Products' sit-harness resulted in five significant benefits: it integrated well with the established method of connecting a rope to a climber via a waist belt (thus was easy to adopt); it directed most of the load in a fall to the leg loops rather than the waist belt; the leg loops did not get in the way when climbing or walking (a significant problem with the stiff fabric of the trapeze harness seat!); it provided a safe and effective arrangement for abseiling down a rock face; and the harness was light, soft to handle, robust and packed small. Its main failing was it could be uncomfortable in a fall if the leg loops were not well-adjusted. Over time, with lead-user testing and co-design, Troll Products redesigned and improved the Whillans sit-harness, and the design became dominant internationally as well as in the UK.

Figure 7. The Whillans Sit Harness, made by Troll. A significant feature was its ability to be worn over a wide range of thicknesses of clothing (in part due to the way the rope was attached).

Role of the Media

Karrimor and Troll were among the pioneer UK outdoor companies in the 1960s that shared another characteristic. They were among the suppliers of Chris Bonington's 1970 expedition to Annapurna, an expedition that was a turning point for both British mountaineering and British outdoor clothing and equipment companies. In climbing terms, the techniques of big wall and technical climbing developed in Continental Europe and America had been further improved by Britain's new breed of climbers. The high-profile media coverage of the Annapurna expedition turned its suppliers into international brands overnight. In a retrospective interview, Tony Howard confirmed that he saw the Annapurna South Face expedition as the key turning point for his company's development due to the high profiling of Troll Product's Whillans sit-harness in photographs, on TV and in lectures (Lack, 1992). This was not just publicity hype, as the sit-harness was a technological breakthrough that realised a whole new level of safety and performance in climbing. Bonington (1971) described it as:

> …an outstanding success, for it enabled one to rest back in the seat while jumaring up snow slopes. (p. 246)

The 1970 Annapurna expedition had a similar impact on Karrimor rucksacks, the Whillans box—the special aluminum-framed high-altitude tent designed to Whillans' specifications and made by Karrimor using pack-frame technology—and the Karrimat, also a Karrimor product. So great was the level of publicity that the company had to struggle to keep up with demand (Parsons & Rose, 2003, pp. 235-236).

Neither company could have survived long, however, had their only market been leading-edge climbing, however high profile that market might be. Such a market is tiny and some of the design innovations—such as the Whillans Box—did not diffuse into the general market. The media reports of such expeditions, however, did enhance the companies' reputations for designs with high levels of functionality and usability. This media promotion and the resulting enhanced reputation were crucial in selling to the emerging bulk markets linked to outdoor education and backpacking during the 1970s and beyond.

Conclusion

In the latter part of the 20th century, design opportunities were created from the interplay between the historic conditions of Lancashire and of Sheffield and the dynamic development of climbing in the UK after the Second World War. The mixture of knowledge, expertise and technology from these three sources was crucially important to the design and innovation processes of new outdoor clothing and equipment companies in this region. This interplay provided a platform for new combinations of expertise, the blending of tacit knowledge and the mixing of manufacturing and sporting innovation. The proximity of Lancashire and Sheffield to one of the most creative areas for British technical climbing and outdoor activity was important.

This article has shown how path dependency can impact positively on decisions to innovate and develop new design-based industry sectors. It has described how design in the outdoor clothing and equipment industry sector in the northwest of the United Kingdom has been strongly shaped in a path-dependent manner by combinations of social and industrial technology and expertise, lead users, outdoor sporting developments, market opportunity, overlapping social networks and the physical geography of the surrounding Pennines. In the Pennine region, a number of companies emerged whose design, manufacturing and marketing advantages were inextricably linked to the industrial skills and technologies of the past. Innovative designs resulted from new ways of utilising these skills in designing new products and from combining them with the development of outdoor sports via the action of lead users. This new understanding that path dependency can result in new successful design-based industries contrasts with conventional wisdom that emphasises the decline of industrial sectors such as the Lancashire cotton industry or the Sheffield steel industries via "lock in" of past technological and industrial design and business choices. The case studies in this article have highlighted ways in which these path-dependent factors combined with lead-user design and innovation to influence design processes and decisions after 1960.

A new model of design and innovation emerges from the analyses in this article. This new model combines two previously incompatible theoretical approaches: design innovation based on communities of practice and design by lead users. The analyses of this article show how these two conceptually different contributions to innovative product design can be seen to have worked in tandem in the evolution of the outdoor clothing and equipment industry in the northwest of the United Kingdom.

The article results in four contributions to the knowledge base of design. First, it shows the importance of exploring historical technological factors as a way to identify new design opportunities. The analyses demonstrate how the decline of existing technologically-based industries can offer design opportunities based on recycling existing spatially-fixed technology for new commercially successful purposes at a low cost. Second, it reveals the potential for significant design advantages in drawing on existing socially-situated communities of practice and knowledge and design skills where these can be redirected toward new product and service pathways. Third, the case studies show how new commercial design innovations can be derived from exploring opportunities offered by non-commercial leisure activities. Finally, the article suggests it is important to identify and understand how successful designs and design-based commercial enterprises can often be created by those who are not professional designers. In the case studies, design activity and innovations primarily occurred via a combination of lead-user innovation and relatively tacit design skills available within a technologically competent social community of practice. In this case, it involved a regional community that historically had cut its innovative teeth in the process of acting as a central player in establishing and promoting the Industrial Revolution.

In conclusion, this article has provided a practical historical review of factors shaping successful design-based innovation in the outdoor clothing and equipment industry of the northwest of the United Kingdom. It has demonstrated via a longitudinal study how successful design activity and successful design-driven businesses are shaped by many factors that are currently not well-addressed in the design literature. In particular, the article draws attention to the roles of path dependence; historical social and technological factors; lead users; geography; leisure pursuits; tacit knowledge of communities of practice; recycling of spatially-fixed technologies for new purposes; and the skills and contexts necessary to integrate these into design-driven commercial opportunities.

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