Strategic responses to low-cost competition: Technological lock-in in the Dundee jute industry

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Abstract

This paper examines path dependency and technological lock-in in the evolution of the Dundee jute industry, from its beginnings in the 1860s to its demise in the 1970s. The evolution of the industry is explored using the resource-based view of the firm (RBV). The results suggest that the nature and construct of jute fibre was the root cause of a lack of sustainable strategic responses in the sector. Path dependent decisions and technological lock-in meant that many firms were not able to make successful strategic switches, although the capabilities of their engineering skills allowed some firms to endure for longer. Thus, the paper extends the RBV to a deeper firm capability level and complements cognate literature on the UK textile sector with a finer specification of the phases in jute's evolution.

Keywords: Dundee jute industry, strategic response, resource-based view, lock-in, path dependency, innovation, technological change, strategic change.

Introduction

Cotton apart, jute was the top fibre in global production volumes from 1845 to 1945 (Atkinson 1964).[1] Throughout this time, it met most of the world's packaging needs, until containerisation was introduced after WWII. But, for over two millennia previously, it was spun and woven on a small scale by traditional handlooms in India with output localized. The spring to globalization was affected through the development and application of advanced production techniques in the city of Dundee (Scotland) in the 1860s. These lowered production costs, built scale *and* specialization, and quickly, a worldwide reputation for the city. As a commoditised industrial textile, price elasticity was always high. Together with intense international competition from India later in the 19th century, such features started to erode Dundee's global domination. Its jute industry declined for most of the twentieth century (Howe 1982).[2] This rapid ascendance and gradual fall from grace within a century has attracted a growing interest amongst scholars concerned with history and strategy (Masrani and McKiernan 2011; Morelli, Tomlinson, and Wright, 2012; Masrani, Parks, and McKiernan 2014; Morelli 2014).[3]

Strategically, the Dundee firm's responses to the intense Indian competition were twofold. First, primary emphasis was placed upon increasing productivity, though in a sluggish manner. The jute industry was dominated by three machine manufacturers: James Mackie, Fairbairn and Lawson, and Urquhart Lindsay. But, innovations in their machinery technology were few and far between, providing limited opportunity for improving productivity. For example, while automatic looms had been introduced in the Lancashire cotton industry by the 1890s, only a few jute firms were using them by the 1920s (Woodhouse and Brand 1934).[4] Importantly, productivity benefits from the use these automatic looms were limited by the maximum number of looms that a single weaver could attend. Due to the need for constant human oversight, there was a point beyond which the use of automated looms entered diseconomies, with detrimental effects in the quality of the cloth. Moreover, the next significant production innovation in jute did not occur until after 1945, when the labour-saving 'Ecco-loader'[5] was developed by the Dundee-based engineering firm TC Kay. Strategies in decline usually involve whole domestic sectors in political lobbying. The Dundee jute industry was no exception. To bolster competitiveness and to preserve its viability, the sector received a wide range of state support that covered initiatives around import protection (Masrani and McKiernan 2011; Morelli, Tomlinson, and Wright, 2012; Masrani, Parks, and McKiernan 2014; Morelli 2014).[6] Consequently, after 1945, more firms made capital investments in productivity enhancing machines in weaving, for example in

circular and automatic looms. (Howe 1982: 139; BJTRA 1949)[7 8] Furthermore, in order to ensure higher productivity, the machines required fibres made from higher quality raw jute. But, during 1950s and 60s, this quality of raw jute was in short supply, making it difficult to gain the full benefits of modernisation (Jute and Canvas Review 1963).[9] Therefore, while productivity enhancing strategies gave short-term benefits, they did not prove to be an effective, sustainable strategic response to international competition over the long-term. Consequently, with the removal of import protection during the 1960s, the industry experienced significant contraction and eventually a complete demise in the 1980s (McDowell and Draper 1978: 4-7).[10]

As a second reaction to international competition, the Dundee jute firms pursued product-market specialisation strategies. While the Indian firms concentrated on the traditional sacks and bags segment, the Dundee firms attempted positioning strategies in higher market segments. This enabled them to attract higher prices, which were sustained for a while by the technical barriers to entry provided by in-house engineering skills. For example, a significant development during the post-1945 period was the use of jute as a tufted carpet backing cloth (Tomlinson, Morelli, and Wright 2011: 97-98).[11] While this was a useful strategy for the firms, little is known about the challenges in implementing it. The main objective of this research is to explore the reasons behind the relatively limited strategic response of the Dundee jute firms, when faced with such adverse international trading conditions.

An important element in developing the strategic response of positioning new products in new markets segments in textiles is the nature and flexibility of the fibre itself. In this paper, we examine the technological challenges related to jute, as a fibre at the courser end of the fibre spectrum. We do this in three ways. First, we analyse the limiting role of jute fibre in the industry's attempt to specialise. This data was collected through interviews, published material and archival records.[12] Second, we analyse the nature of, and barriers to, collective initiatives to innovate and diversify. This data was collected from interviews and archival records.[13] Third, we analyse the role of technological capability in enabling some firms to diversify and innovate more readily than others. This data derives from case studies of three weaving firms: a large, integrated spinning and weaving firm, Jute Industries (JI); Craiks, a medium-sized firm; and Scott & Fyfe, a medium-sized firm.[14] Data on JI and Craiks was collected from archival records that include board minutes, personal letter books and financial records, while that on Scott & Fyfe is based on an interview with a former Chairman of the Board.[15]

To achieve these objectives, we respond to demands that business history adopt more cross-disciplinary approaches (Hendry 1992; Jeremy 2001; Harvey and Wilson 2007). [16] Here, we utilise the resource-based view of the firm (RBV) and contribute to its growing application in business history (Lockett and Wild 2013; Wild and Lockett 2016).[17] Broadly, these studies have demonstrated the value of using the notion of resource heterogeneity, a core RBV concept, to analyse differences between firm strategies and performance. Firm heterogeneity, as David Higgins has argued persuasively, can be long-lasting and result in significant differences in firm performance, despite a shared environment (Higgins 2003: 55, 66).[18] Similarly, comparative research on strategy, structure and governance suggests that relative performance is influenced strongly by the differing capacities of firms to create, capture, and assimilate intangible resources, particularly knowledge (Toms, and Wright 2002: 93; Jones and Miskell 2007: 10, 17, 19).[19] However, this research uses macro-level data and points to the need for RBV-informed studies of the nature and dynamics of firm heterogeneity. Lock-in effects, another important tenet of RBV, has been underutilised. We build on this by combining the concepts of firm heterogeneity and lock-in effects.

After this introduction, the paper is divided into five sections: we begin by considering the RBV and how it might help explain the Dundee jute firms capabilities; then, we discuss the increasing competitiveness in the industry, placing emphasis on both trading tariff differentials and low-cost competition; next, we examine the challenges of innovation in jute, the resultant lock-in effect at the technology level and how this limited the overall scope of specialisation within the industry; finally, we turn to the issue of firm specialisation by examining three cases to illustrate how resource heterogeneity allowed some firms to specialise more successfully than others. In the final section we discuss the implications of our findings with regards to jute, RBV and the British textiles industry.

RBV, Lock-in and Path-dependency

The RBV has its contemporary origins in Selznick's thesis on leadership-induced competences within firms and especially, Edith Penrose's growth theory, which consider firms as unique 'bundles of resources' (Selznick 1957; Penrose 1959).[20] The RBV assumes that firms have a unique set of tangible and intangible resources,[21] which are path dependent on the firm's history as they are configured by prior managerial decisions (Wernerfelt 1984; Barney 1991). Even where original resources might be equivalent, each firm's bundle is configured differently.

Understanding the development of these unique resources is crucial, since embedded capabilities tend to be 'sticky', difficult to alter and chronically recursive (Teece, Pisano, and Shuen 1997: 514).[22] The ambition of the RBV project is to synthesise strategic management, institutionalism and evolutionary economics (Helfat and Peteraf 2003: 998).[23] Further, the objective is not simply to understand relative firm performance but, to provide heuristic devices to improve managerial decision-making (Langlois and Stienmueller 2000: 1168).[24] Hence, it is unsurprising that the concepts and logic of the RBV have been criticised for being terminologically ill-defined, ambiguous, theoretically tautological, circular, non-scientific, non-measurable and non-testable (Aharoni 1993; McKelvey 1997; Eisenhardt and Martin 1999; Barney 2001b; Priem and Butler 2001; Arend 2004, 2006; Nothnagel 2008).[25]

Since resources are firm specific, the use of the RBV may help to identify specific resource 'bundles' that lead to some firms pursuing specialisation more successfully than others, and to explain long-run, inter-firm differences in performance and profitability (Penrose 1959).[26] The RBV stresses the importance of deeply embedded forms of tacit knowledge inscribed in technical and administrative systems (Leonard-Barton 1992; Lockett and Wild 2013).[27] In the RBV, the organisational sources of competitive advantage need not be sustainable (Eisenhardt and Martin 1999: 110).[28] Firm-level RBV historical research has focused on industries with distinct, identifiable product generations marked by radical discontinuities in functionality and competitive dynamics. In semiconductors, for instance, competition is based on product innovation and costs - unlike jute, where an inherently simple commodity offered little scope for technological innovation or differentiation. Contemporary, longitudinal RBV studies provide highly stylised commentaries characterised by limited accounts of firms' competitive strategies and internal capabilities inferred from outcomes (Eisenhardt and Schoonhoven 1990: 505, 508).[29] There is none of the deep archival research characteristic of business history, nor any reflection upon historical methodologies (Holbrook, et al 2000: 1018).[30] However, the combination of deep archival research, coded and read through Penrosian categories used by Tom McGovern and Tom McLean's longitudinal study of Clarke Chapman, provides a signpost of how a single RBV case study might be produced best (McGovern and McLean 2013).[31]

Central to the RBV is Penrose's argument that firm performance depends upon intangible assets which, through non-imitability, create a barrier to competition. Firms can acquire cultures that are rare, valuable and non-inimitable and which produce economic rents (Penrose 1959; Barney 1991).[32] Further, Penrose observed that while the difficult to replicate resources

help a firm to grow, they also shape the scope of what can be developed (Penrose 1959: 78).[33] This constraining effect is better understood through the notion of path-dependency and lock-in. Path dependence is understood as when past choices profoundly affect subsequent processes through stochastic iterations (Mahoney 2000: 513).[34] Lock-in, on the other hand, occurs when there is 'a state of equilibrium with a very low potential for endogenous change - put simply, lock-in is a hard to escape situation' (Vergne and Durand 2010: 743).[35] Technology is a key resource that helps shape firm capabilities (Langlois and Stienmueller 2000; Kenney and von Burg 1999).[36] But understanding of technological lock-in, especially conditions surrounding it, remains limited with few empirical studies (Vergne and Durand 2010).[37] Moving away from the overly deterministic permutations, organisations, individually and collectively, may engage in 'deliberate path breaking' activities to create new strategic alternatives (Vergne and Durand 2010: 702-704; Ding, Kininmonth and McKinstry 2017).[38] The breaking of an existing or creation of a new path is an 'intentional deviation from existing structures'[39] which represents 'windows of opportunities' that could potentially dissolve the lock-in effect (Garud and Karnoe 2001: 6; Bassanini and Dosi 2001: 62).[40] An important element in understanding the dynamics of lock-in and path dependency is to understand different phases that are involved in the process (Dobusch and Schüßler 2013: 638).[41]

Usefully, Sydow, Schreyögg and Koch provide a three-phase model to examine path dependency and lock-in (Sydow et al 2009).[42] Put simply, Phase I is termed as an 'open situation', where extensive choice exists. Phase II is a 'critical juncture' that reduces options and leads to the gradual emergence of a path. In this phase, there is a gradual emergence of a path which is consolidated by self-reinforcing mechanisms. There are four major types of self-reinforcing mechanisms: First, coordination effects: reduced costs because a firm engages in rule-guided behavior with similar effects to scale economies; second, complementary effects: reduced cost through synergies of resources, or economies of scope; third, learning effects: efficiency from continually performing an operation; fourth, adaptive expectation effects: conformity in preference resulting from the social need for belonging and associated rewards. In Phase III, a dominant pattern emerges and, owing to high switching costs, leads to a 'lock-in' effect.

By examining the limiting role of jute technology, firm-level and collective initiatives to generate innovation, we contribute to the understanding of lock-in and the barriers to creating alternative patterns of development. We look at the whole history of the industry from 1850s

to 1970. We believe this allows us to locate the beginning of the technological lock-in and fully examine the conditions that caused lock-in using the Sydow, Schreyögg and Koch framework. The next section provides a brief overview of the Dundee jute industry, to provide a detailed context against which the case firms can be assessed.

Competitive Position of Dundee's Jute Industry, 1854-1970

The Dundee textile industry began with the prosperous flax spinning and weaving industry in the late eighteenth century. However, the external shock of the Crimean war in 1854 abruptly halted flax imports, triggering a sudden price rise. The industry was forced to substitute flax with jute. With little international competition, Dundee emerged as the leading global supplier of jute goods. From 1870 to 1890, the industry more than doubled in size, with the number of spindles increased from 94,520 to 268,165, looms from 3,774 to 14,107, and people employed from 14,911 to 43,366 (BOT 1948). [43]

The Dundee jute industry's remarkable growth did not last long. Traditionally, scholars have cited the strong cost advantages of the Indian industry as the primary cause of decline but, archival research for this study has identified tariffs as a further cause that aggravated the sector's competitive standing. For instance, there was little restriction on the import of yarns and cloths into Britain. But there were high import tariffs, first in Europe and then in India, that curbed Dundee's exports. These tariffs affected Dundee from the 1870s and continued into the mid-1930s.[44] Damage was of particular significance between 1925 and 1934, when Dundee suffered a 62% reduction in export of yarn and a 46% in cloth.[45] Coupled with this affliction was the deep market penetration enabled by India's significant cost advantages in raw material, wages, working hours[46] and exchange rates.[47] These advantages resulted in the rapid expansion of the Indian industry between 1882 and 1892 - with the number of mills increasing by 29%, looms by 43% and spindles by 78%. Indian exports damaged the Dundee industry's performance in major international markets e.g., North and South America, and Australia. Countervailing attempts from Dundee to restrict working hours in India, under the guise of concerns about the state of working conditions, all failed. Indian overproduction continued and, when global demand fell in the 1920s, the Indian industry was unable to reduce output because not all firms joined in a common agreement to curtail working hours. There were many new entrants with new machinery, and it was in their interests to grow to recoup their investment.[48] Dundee's output, including yarn, cloth, sacks and

bags, suffered as imports into the UK rose sharply. During the 1920s, production increased in India by 49% and in continental Europe by 21%, while it decreased in Dundee by 35%.[49]

Of strategic importance for Dundee's jute industry, the Indian industry's expansion was mainly in narrower width cloth (96% of its machines in 1933). The narrower widths were used mainly for the sack and bag trade, which the Dundee firms were trying to moving away from. Between 1945 and 1970, through the imposition of both Jute Control, which controlled imports of raw jute and jute goods into the UK, and the Gentlemen's Agreements, which fixed the prices of jute goods, the Dundee industry managed to restrict imports, with yarn down 73% and cloth down 59% between 1951 and 1970. Import restrictions allowed the Dundee industry to increase production until the 1960s, when protection was removed. [50] With the removal of the Gentlemen's Agreements, the industry lost any protection from intense international competition in the domestic market (Masrani and McKiernan 2011; Morelli et al 2012).[51] This forced firms to innovate and look beyond jute- a task that was riddled with challenges.

In the next section we deploy the Sydow, Schreyögg and Koch sector phase model to analyze the circumstances surrounding the lock-in in jute and the collective initiatives to path-creation. In doing so, we discuss the limiting role of jute and its implication for product specialisation.

Challenges of Innovations in Jute Technology

The Dundee textile industry had experimented with various substitute fibres before jute was adopted in the 1850s. Jute was one of the fibres that some in the industry had tried around 1833. These trials did not lead to jute, or any other fibres, being adopted because of the technical complexities in adapting the new fibre to the existing flax machinery; and, to customer skepticism (Woodhouse and Brand 1934).[52] Moreover, the flax was in ample supply, so there was no urgent need for it to be replaced. This can be categorized as Phase 1 of the Sydow, Schreyögg and Koch model. Phase 2 begins with a major external shock, the Crimean War in 1854, that halted the supply of flax from Russia. As a result, manufacturers were forced to look for alternatives and jute emerged as a successful substitute. Between the 1860s and 1880s, jute became widely accepted. Its rapid adoption was due to two factors, both of which were central in creating a self-reinforcing mechanism and became a benchmark condition to satisfy for any possible alternatives. The first was the physical characteristics of jute fibre. The flax industry specialised

in coarse fabrics and heavy yarns. Coarse hard-wearing jute fibre was an acceptable alternative to flax, particularly in the manufacture of bags and sacks - the industry's staple products (Warden 1967: 632; Gauldie 1969; Lenman et al 1969).[53] Jute continued to grow through the second half of the nineteenth century, stimulated by demand for sand bags during the American Civil War (Carrie 1953).[54] The second was jute's cost advantage over flax led to its rapid and widespread adoption (Warden 1967: 596; Woodhouse and Brand 1934; Stewart 1998: 50-54).[55] Lower prices eased customer resistance and created adaptive expectation effects.

Between 1890s and 1960s, the industry experienced an extreme case of lock-in, because of the lack of alternative fibres to replace jute. In order to counter competition from India during this time, various ad hoc attempts at path-creation, mainly through searches for substitute fibres, were made by the Dundee industry. These enjoyed a limited success. For example, during the 1890s, two fibres were tested, 'Rhea' and 'Ramie', but neither was adaptable to the existing jute machinery and, importantly, both proved more expensive than existing jute products.[56] A major and systematic effort to replace jute fibre was carried out after the Second World War, with the establishment of the British Jute Trade Research Association (BJTRA), an institution owing its existence to the recommendations of the Jute Working Party Report in 1946. The state and industry funded the BJTRA jointly. Member firms contributed through a per capita subscription. Accordingly, two Dundee firms - Jute Industries and Low & Bonar - paid almost half of the industry's subscription and so dominated the Association. In 1946, G.E. Scott, of James Scott & Sons, spinner and manufacturer, was its Chairman and Colonel L.E. Hill, Vice Chairman. Its members consisted of a cross-section of firms, including producers - weaving and spinning -, merchants and machine manufacturers.[57] The association was set-up in a 21000-square foot facility and was the first cooperative industrial research laboratory established in Scotland. The Association's core staff had extensive experience in industrial research. The Association's Director of Research had worked with Tootal Broadhurst Lee (a major textile firm) in Manchester since 1930, that had developed non-crease fabrics.[58] Others were recruited from ICI (a major UK chemical firm) and had been members of the research team that had developed Nylon.[59] Additionally, there was no expense spared in acquiring the latest equipment for the centre.[60]

The association's research focused on two key areas: developing alternatives for jute and finding new applications of jute.[61] The Association represented a collective attempt to break path dependency and create an alternative technological path. The Association used the global

network of British Embassies to help source locally grown fibres with specific consideration given to a) their physical characteristics and b) the cost of processing the fibre. The efforts began with trials of natural fibres consisting of linseed-straw, South African stokroos, sunn, hemp, and willow bark.[62] The linseed-straw appeared suitable for spinning as it met the necessary standards of cleanliness required for processing yarns. While it could be processed on the existing jute machinery, the fibre proved unsuitable for use in carpets – which were a major jute outlet.[63] Various other fibres were tested, but all proved unsuitable 'as far as physical properties' were concerned.[64] After trying a variety of natural fibres from around the world, the Association accepted that it would be difficult to find a substitute for jute. Hence, the focus turned to finding new applications for jute. Initial efforts developed 'blends' of various man-made fibres with jute, such as viscose/rayon, nylon, Terylene and polyester.[65] These hybrids were found to be stronger than the equivalent all-jute yarn.[66] But, in terms of physical properties, they were akin to fine fibres that were suitable primarily for the furnishing and apparel trade, where appearance and *feel* were critical. However, in jute's traditional markets, cost and performance and not *feel*, were paramount. Further promising experiments found that jute could be used as a substitute for fibreglass and plastic in the body panels of buses and rowing boats. Once again, cost halted this development, as the jute absorbed far more resin than fibreglass; and, resin was an expensive material.[67]

Hence, the scope for innovation using jute fibre was limited due to its technical attributes and cheapness. Ironically, these were the attributes that had allowed jute to replace flax, and to remain the dominant fibre. Recalling the problems faced in innovating with jute, the BJTRA's Director of Research noted:

> "…you had the jute research institute working from about 1950 till 1974 or whenever it folded up …and *nothing came* out of it. You've got the Indian research institute, which has been working longer. *Nothing* of significance has come out. You've got the Bangladesh institute working from 1960s into the present being. *Nothing* has come out of it. Yes, all right, minor things here and minor things there, little bits and pieces. But there has been no wholesale redevelopment of the process. The process today is exactly the same as it was in the 1890s. Fundamentally, it's the same … And equally there has been no market of any size developed, despite about 150 research years. It's rather sad but I think it just means that jute is ideal for sacks and bags. Finish. Full stop."[68]

Also, BJTRA was beset by low member engagement, a reflection of the importance of intangible knowledge – of customers and of productive technologies – to competitive advantage. While the industry supported BJTRA publicly, members proved reluctant to share proprietary knowledge with rival firms in private. The Association's Research Director could not persuade member firms to trust him with their problems.[69] To reveal a weakness in producing products with specific features or difficulties in meeting delivery schedules was to provide information that might alert a rival to a commercial opportunity. By the time the BJTRA had secured members' trust, many had established their own testing facilities, which reduced their dependence on the Association. Importantly, the two largest firms in the industry, Jute Industries and Low and Bonar, had their own research facilities and so their involvement in cooperative research was never more than lukewarm. Further, while BJTRA researchers were technically skilled, they did not have the knowledge of end applications. In 1961, the Association's second research director, implored members to share their market knowledge and encourage their salesmen to be in contact the Association directly.[70] This plea confirmed the importance of intangible market knowledge to jute manufacturers.

No economically viable replacement for jute's traditional markets was evident until the introduction of Polypropylene in the mid-1960s. Comparing this new artificial fibre with the many natural fibres that had been tested, the Director of Research at the Scottish Textiles Research Association (formerly the BJTRA) asked:

> "What is the future? Polypropylene tape is the first synthetic material to challenge jute both on technical merit and price. It is likely to be the first of many challenges. So, research work must keep well ahead of commercial development."[71]

Polypropylene's main technical advantage over jute was its ability to resist rot and so withstand harsh weather conditions. Moreover, it provided a cost saving in the process of making tufted carpets.[72] Goods manufactured from polypropylene were also cheaper than jute, as the latter was subject to the erratic fluctuation in its raw price (See Figure1). This advantage played a major role in this new fibre being adopted widely by the industry.[73]

Figure 1 about here

In the next section we identify the taken-for-granted shop-floor skills that played an important role in the heterogeneric responses of jute firms to the crisis.

Machine Capabilities

From the late nineteenth century, technological change in production was driven by efficiency maximisation, rather than quality or product innovation (Atkinson 1964: 139-143; Woodhouse and Brand 1934: 133).[74] However, the realisation of efficiency gains in spinning and weaving proved difficult due to the high capital costs of new machinery, and the financial attraction of adapting existing machinery (Atkinson 1964: 85, 104, 127; Woodhouse and Brand 1934: 54, 57, 61).[75] For Dundee jute manufacturers, the growing domestic and international demand for linoleum in the late nineteenth century, and for carpet backing after the Second World War, offered some respite from Indian competition. Jute was the backing cloth for linoleum and carpet: cheap, durable, and consistent in weight, texture and dimensions. However, both these products required lighter, longer and wider cloth than the standard widths for jute bags (Whatley, 1992: 199-201).[76] Wide-width looms were available, but largely rejected because the risk of investment in specialist plant was compounded by the physical limitations of weaving sheds that were too small to accommodate larger looms and ancillary machines (Watson 1992: 21).[77] The alternative was to adapt existing conventional narrow-width machines, which was a difficult operation technically. A complex crankshaft coupled the narrow looms, while the joining beams required a differential capable of maintaining a uniform tension and equal diameter across the yarn and beams Woodhouse and Brand 1934: 123).[78] The capacity to adapt existing machinery to changing demand, and to minimise downtime was vital for a firm responding to shorter lead times for relatively small orders of cloth sizes.[79] Equally, the capital cost of in-house adaptation was less than ten per cent of the installation cost of a new, integrated single loom system.[80] Even so, production flexibility had to be complemented by fine commercial judgements about the cost and risk of holding buffer stocks, and the granting of extended credit in the short-term to cement relationships with new and price sensitive buyers: ‘our linoleum friends are adopting a hand-to-mouth policy’.[81]

The adaptive capacity of firms was dependent upon the skills of shop floor workers, specifically tenters and engineers. Tenters were responsible for maintaining and adapting looms and beams. [82] Formally, tenters were semi-skilled, but their tasks required significant tacit knowledge of decades-old, heavily used machines. This invaluable tacit knowledge underpinned

their status as labour aristocrats, who enjoyed enhanced earnings and job security (Cox 2013: 2-26).[83] The tenters' tacit knowledge was more *firm*-specific than it was *machine*-specific. Tenters were 'key men' precisely because their skills were essential to maintaining production continuity and flexibility in a specific plant.[84] The tenters' strategic importance was acknowledged in 1960 when the jute industry collectively considered the introduction of a five-year apprenticeship, followed by a two-year apprenticeship, to replenish the disappearing skills of tenters being lost to retirement.[85] The strategic importance of internal engineering know-how, was implicit in the firms' determination to ensure that this tacit knowledge remained uncodified and so an intangible asset within the firm:

> "The technical know-how is …not only the technical know-how of how to make fabrics, which comes from experience and being prepared to buy a machine and have a go at it and see what you can do with it and learn about it, learn as much as the machinery manufacturer without telling him anything. Because he then goes and tells everybody else in terms of buying the machine. Most of our machines are to some degree modified internally, we have a design department that does that, we have two or three draftsmen, we have CAD systems for design, most things that are special to us are either standard machines bought from Karl Mayer… Now, Karl Mayer are the company you never tell anything about what you are doing [to their machines]. We modify the Mayer machine to do a job for a customer and learn about the machine as we go along. We don't go to Mayer and say, "build us machine". We go to Mayer and buy a standard machine and then do A, B and C to it. We design it here and get the parts and then add it and don't let the Mayer technician near it for as long as possible."

Jute manufacturers recognised the source and the value of their adaptive capabilities and the risks of codifying this knowledge, or even of sharing this indirectly through machine makers such as Karl Mayer.[86] Three other firms dominated machine manufacture (James Mackie, Fairbairn Lawson and Urquhart Lindsay) and effectively restricted innovation.[87] BJTRA's new Auto Leveller, that made the sliver[88] coming out of the drawing machine more consistent, was blocked by Mackie's insistence that the BJTRA had no mandate to compete with machine manufacturers.[89] Furthermore, the Dundee firms' deep allegiance to the combative approach to competitiveness, undercut the possibility of inter-firm co-operation through collective initiatives such as the BJTRA, as a route to the joint creation of rents, however temporary.[90]

Therefore, unless the jute-manufacturing firms had an in-house technological capability to modify the machines, they were dependent on the machine manufacturers, who were acutely aware of the value of this dependence.[91]

In the next section we analyze how some firms used these skills to innovate within the overall technological constraints imposed by the jute fibre.

The Nature of Specialisation: Firm Case Studies

The strategic responses of three firms in the Dundee jute industry act to examine the theoretical issues explored above and to elaborate on the practical limitations of the fibre; Scott & Fyfe (S&F); Jute Industries and Craiks. Between 1920 and 1970, due to resource heterogeneity, strategic differences existed amongst the three case firms e.g., between 1920 and 1945, Scott & Fyfe (S&F) continued to rely on the traditional sack and bag market by making narrow width cloth, leaving it fully exposed to Indian competition. Conversely, JI and Craiks innovated to develop specialised products, especially in wider widths and longer rolls, where international competition was restricted or non-existent. JI adopted an aggressive approach to locating and developing new market segments and, by the mid-1920s some 70% of its output was no longer in direct competition with the Indian products.[92] JI was formed by an amalgamation of seven firms, and so it had inherited a broad range of cloths including medium-width cloth, fine hessians, webbings, velvet pile fabric, twill for miniature golf courses and end products, such as jute carpets. Before 1939, JI concentrated on strengthening its position in wide-width cloth and using its' in-house engineering expertise to modify its' looms to meet demand for medium and wide widths. This sheltered it from international competition, but it still faced price wars domestically. Instead of matching prices, JI used its technical capabilities to innovate further in width variety and length of roll, where its ability to manufacture longer lengths than competitors lowered customer costs in linoleum manufacture and its own costs in scale of operation. JI was one of the few firms in Dundee to trial automatic looms, purchased from Urquhart Lindsay & Co., in the 1920s. However, after the initial trials, the looms were converted back to plain looms because the consistency in cloth quality required by the linoleum market could not be produced on the automatic looms.[93]

Like JI, Craiks planned to move away from traditional jute markets after the First World War.[94] Though it focussed on producing medium and wide-width cloth, its share of the coarser, narrow width cloth still constituted just over fifty per cent of total sales. [95] However, unlike JI, Craiks had

no in-house engineering skills, but relied on external contractors to convert its looms to wide-widths. Their aggressive proactivity for higher market segments exhibited the extent of their sustained search for competitive advantage over competitors whose organisational and technical capabilities and market positions were well known.[96] Though, after 1945, the possession of in-house engineering skills would become crucial in a firm's ability to pursue further specialisation.

After 1945, the UK Government pushed the Dundee jute industry to modernise through investments to improve productivity, moving them out of commodity products into higher market niches.[97] S&F, an inter-war laggard, used the chance to catch up and, using its own engineers, replaced all its looms with the state of the art machinery.[98] Further, this engineering capability was used to manufacture a highly specialised backing cloth for rubber carpets, patented by Uni-Royal.[99] In 1956, a factory fire halted these wide-width product experiments, but, on re-building, S&F used its engineers to develop a capacity for long length rolls that only a few firms could supply (e.g., JI). This ability was a major factor in retaining and defending the growing business of rubber underlay with Uni-Royal, as the woven cloth was a 'very, very light scrim'- a particularly difficult process whose technical demands acted as a barrier to entry to other firms.[100] Meanwhile, JI fortified its leading position by levering its own engineering know-how to enter major new markets, such as tufted carpets, first in the US and later in the UK.[101] Between 1954 and the mid-1960s, this wide-width backing cloth became the backbone of JI, such that narrow end products (sacks and bags), was only 6% of the group's turnover in 1967. [102] In contrast to JI and S&F, Craik's lack of engineering capability continued to limit its ability to develop. Craiks entered cotton weaving after 1945, investing heavily in new Northrop automatic looms. This gave them the ability to weave various widths and offset the fluctuating demand in jute.[103] However, a continuing lack of adaptive engineering capability meant that it had to rely on Northrop to resolve its technical problems.[104] Nonetheless, demand remained buoyant and Craiks increased its weaving capacity. [105] New investment in jute only began in the mid-1950s, when it installed the latest automatic looms that replaced traditional shuttle looms,[106] strengthening its position in wide-widths and so enabling it to enter the growing linoleum backing market.

By the early1960s, there was a lingering threat that the Gentlemen's Agreements, which had sheltered the industry against international competition since the end of the Second World War, would be dismantled.[107] Furthermore, the American tufted carpet industry, dissatisfied with the quality of the jute backing, was beginning to look for substitutes - especially from the longer lasting, artificial fibres like polypropylene. As it had experimented with the fibre previously[108], JI moved

quickly by buying polypropylene tapes from Courtaulds. Moreover, close friendship between the Chairmen of JI and Low and Bonar, led to a joint venture (Polytape Ltd) in 1966 between the two companies, and avoided direct competition in the new area. The threat of international competition and the loss of major markets forced both firms to set aside secrecy over some existing core capabilities and to co-develop the synthetic fibre for the future.[109] Polytape allowed them to make the tape internally and avoid dependence on suppliers such as ICI and Courtaulds (a major UK textile and chemical firm). Synthetic Fabrics (Scotland) Ltd was set up in 1968, to manufacture the fabric. The manufacturing of Polypropylene tape and cloth was considerably different to that of natural fibres. Working closely with both polymer suppliers and customers, JI directed its first synthetic products at replacing jute in existing products (e.g., tufted carpets). S&F was an early adopter of polypropylene, overcoming a series of technical entry barriers internally. First, it was difficult to wind the tape on the cops and adjust the beam of the loom.[110] Its engineers worked co-jointly with the US-based loom manufacturer, Lesona, to develop a beam appropriate for polypropylene weaving. This was one of the first 'beamer jobs' to be done for polypropylene in the Dundee jute industry. Second, the new fabric shrank after it was woven. Here, S&F sought help from WR Grace (major US chemical firm), developing jointly a low-shrink tape to feed onto the looms. Then, S&F ordered 24 modern shuttle-less looms to begin commercial production. Considering that the weaving of polypropylene on a large scale was relatively new, this can be seen as a bold decision. But, internal engineering know-how meant that S&F could customise its machines and break into new areas e.g., stitch bonding and knitting. A number of successes followed, including a high-tension cable wrap and new product improvements for the backing of Uni-Royal's rubber carpet. By the end of the 1960s, S&F was successful in replacing jute with polypropylene in most of its existing products. Again, Craiks struggled, with its substantial operations in cotton and jute now exposed to increasing international competition.[111] Its response was to improve productivity and move into specialised goods; and then, search for a replacement fibre, having seen polypropylene developments in other firms in the Dundee jute industry.[112] With no in-house expertise, it had to rely on general technological progress within the industry before it could proceed with commercial production e.g., for synthetic fibres.[113] Yet, polypropylene production remained out of reach until 1972, when the Scottish Heritage Trust provided funding assistance to enable Craiks to enter the market by purchasing 135" Northrop Sensamatic and Dornier looms.[114] Polypropylene proved to be a major boost for some Dundee jute firms, altering its competitive dynamics and helping to defend them against international competition. Success demanded a new set of technical skills as the industry re-branded itself from 'jute' to 'industrial textiles and packaging'.

The non-imitability of resources is a central tenet in the RBV. In the Dundee jute industry, flexible-engineering skills produced firm-specific technological advantages. These were so 'taken-for-granted' by managers that they were all but invisible to them, far less to their rivals.[115] Additionally, the firms most likely to take advantage of radical innovation would be those that possessed the relevant capabilities.[116] Radical innovation like Polypropylene required firms to possess considerable flexible engineering skills in order to conduct trials. JI and Scott & Fyfe, having experience in this area, were able to use it to make experiments early, whereas Craiks found itself highly dependent on technical developments to take place first, before it could make a foray into Polypropylene. Further, these three cases throw light on the nature of engineering capabilities in implementing a specialisation strategy. The contrasting experience of these three Dundee jute firms suggests that their strategies were not deliberate and codified. Rather, effective adaptation involved conscious but uncodified, iterative decision-making. This emergent process of strategic adaptation involved the orchestration of taken-for-granted shop-floor skills, combined with a deep knowledge of customer requirements. Emergent strategy is realised, or becomes evident, through resource allocation - which generally implements somewhere between one-third and a half of formal strategic priorities. For business historians, the implication is that formal strategic planning involves a portfolio of alternative and competing priorities for resources.[117] Resource allocation choices are shaped more by pre-existing organisational structures and embedded routines than by formal strategy, a reversal of the classic Chandlerian strategy-structure couplet. Innovation unfolded incrementally in response to the opportunities that presented themselves and was constrained and shaped by conditions that were generally outside the individual firm's control (Langlois and Robertson 1995: 1171-1172).[118]

Discussion and Conclusion

There are two key technologies that underpin competitive positions in textiles: manufacturing (machines) and base fibre. The latter's role in shaping British textile industry's strategic response to international competition has received very little attention. Results from this study suggest that the fibre played an important role in shaping jute industry's product-market specialisation. While current research informs us about the type of specialisation firms in the industry pursued, this study examined the constraints faced in implementing this important strategy.

This study drew on the RBV of the firm to interrogate long-run interaction of firm-level strategies, technological lock-in, path-dependence and path creation. The two factors that played a crucial role in creating self-reinforcing mechanisms were cost and the technical properties of jute. The Dundee jute firms would have preferred to have used substitute fibres as part of their strategic response to fierce international competition, as more product-market segments could have been created, occupied and, hopefully, protected. However, owing to a lack of suitability in their physical characteristics and cost, potential substitute fibres were not able to replace jute. Therefore, factors that had played an important role in the wide-spread adoption of jute originally, also acted as a barrier that had to be overcome during path creation. Such inability to diversify effectively led to lock-in and path-dependency around the jute fibre.

The Sydow, Schreyögg and Koch phase framework proved useful in understanding technological lock-in by helping to conceptualise phenomena in phases. One limitation of the model is that it does not articulate path creation. Evidence from this study showed that path creation activities occurred during the period of lock-in. The most important attempt to path creation from the Phase 3 lock-in was collective, the formation of the BJTRA. Collective action to generate alternative technological paths through product development proved unsuccessful. Technical problems were resolved but failed to meet established market expectations in terms of price and physical properties. A substitute fibre - polypropylene, was able to replace jute only when it was able to meet the two conditions that had created the lock-in: polypropylene was both technically superior to jute as a fibre and economical in value. Therefore, in order to fully understand the causes of lock-in and path dependence, it may be useful to study path creation activities that are being pursued during the lock-in period. Additionally, an examination of unsuccessful path creation activities would likely prove fruitful in comparison.

The jute firms relied on incremental innovations within the jute fibre during the period of lock-in. Firms which had relevant technical capabilities were able to pursue this strategy more vigorously than others. Here, support is found for Penrose's argument that the firm's resources necessarily bind managers (Penrose 1959: 78).[119] While jute firms were restricted by product and production technologies, there was evidence of strategic heterogeneity. In turn, strategy was enabled and constrained according to the relative flexibility and adaptability of the technical knowledge of shop floor workers. We have stressed the importance of shop floor skills to the relative adaptive capability of jute firms. This adds to the range of intangible assets that can be considered by, and incorporated into, the RBV of the firm as it helps to identify the critical

capability that underpins a firm's long-run competitive dynamic. The study supported aspects of the RBV, especially the interaction of tangible (machine-based) and intangible (engineering know-how) assets that helped some firms specialise and stay ahead of the competition and others to lag, as they relied on machine manufacturers for innovation. The importance of these capabilities is underlined by the fact that member companies of the BJTRA did not come forward to share their knowledge of their carefully cultivated production know-how, or of the dynamics of customer preferences. Here, we offer an important corrective to the RBV's tendency, however qualified, to concentrate on consciously organised executive choice. As a result, both forms of knowledge remained non-imitable and crucial to firm heterogeneity.

The RBV requires fine-grained data to isolate a firm's tangible and intangible assets. This is not often available, even though deep archival work, where firm and public records are necessarily incomplete. In this study, while it was possible to identify technical capabilities, it was not possible to gain insights into micro-level activities and routines that helped some firms build their capabilities. The Dundee experience suggests that to limit deep archival research to executive decision-making is unlikely to identify the embedded shop floor routines that are either taken-for-granted or beyond the executive 'gaze'.

Our findings suggest that firm heterogeneity was not confined to strategy, but that patterns of operational flexibility and rigidity were vital. Rigidities in work organisation are widely portrayed as part of Britain's chronic productivity failings. Using the RBV suggests that the flexibility of skilled labour could produce competitive advantage in terms of responsiveness, adaptability and innovation. Here, we complement macro-level analyses of British business history influenced by the RBV by providing a fine-grained analysis of firms locked into the same production technologies and which confronted intensely competitive global markets for a simple commodity. In jute, fine differences in strategic choices and operational routines proved significant in terms of diversification, innovation and competitive advantage.

Jute offers an opportunity for comparative analysis with cotton, another important component of the British textile industry during the same era. There are important parallels between the two: both were heavily reliant upon exports, and both proved vulnerable to tariffs in key markets (Marrison 1996: 239).[120] For each, their major markets transformed into rival production centres. In cotton, Europe and Latin and North America turned into major competitors in the second half of the nineteenth century; and India and Japan during the inter-war period (Sandberg

1974: 172; Bowden and Higgins 2015: 225).[121] In cotton, British investment after 1945 was primarily defensive, to protect existing production and profit levels (Singleton 1991: 45, 166-7).[122] By the early 1970s, as in jute, Britain's cotton manufacturers again faced foreign penetration into their domestic market.

The technological choices of British cotton firms have been central to analyses that have tried to understand the long-run dynamics of competitive advantage and disadvantage. Researchers have focused mainly on manufacturing technology and its implication for productivity and competitive advantage. Unlike their international rivals, British spinners remained wedded to mule technology, despite the productivity advantage of ring-spinning, although ring spinning required additional processing of fibres (Robson 1957: 355; Leunig 2001, 2003).[123] Importantly, Lancashire mules were a fully depreciated technology, with no risk of incurring additional capital costs during downturns (Toms 1998; Higgins and Toms 2003).[124] Fully depreciated capital stock, plus low and volatile profits, deterred risky technological investment in cotton. After 1945, those Lancashire firms that adopted ring spinning did so because of labour shortages of mule spinners and taxation incentives (Higgins 1993: 349, 355-356).[125] Japanese firms produced standard cloths to maximise their productivity advantage. Lancashire firms responded by manufacturing specialist products and fine cotton, a response that confirmed their reliance upon mule technology (Sandberg 1974; Leunig 2001: 460).[126] Therefore, between 1860 and 1960, a combination of product market choices and financial structures locked-in British manufacturers to mule technology. But commenting on the investment strategy of the cotton industry, especially between 1950 and 1965, Singleton concluded that the productivity enhancing investments in the form of automatic looms and ring spinning were 'misguided' (Singleton 1991: 219).[127] As discussed in the Introduction, productivity related strategies did not offer sustainable advantage when competing with predominantly cost-based international competition in the jute sector, either.

Fibre constitutes an important element of technology in textile manufacturing. The jute industry became aware of the importance of substitute fibres by the late 19th century. However, it was not until the 1960s, that a meaningful substitute (polypropylene) was found. In cotton, cellulose fibres, especially Rayon, were tried in the cotton industry by the early 1930s and, by 1936, Rayon constituted 1% of total yarn production (Lazonick 1983: 221).[128] These figures remained stagnant until the 1950s and, it was only after 1964 that production of Rayon and other man-made fibres advanced (pp. 221).[129] Hence cotton, as well as jute, appears to have recognised the

need for substitute fibres as part of a strategic response. Its significance appears to gain roots in the 1960s, as Singleton noted a recommendation made by one of the Directors of Courtaulds that: 'Lancashire would have to reduce its reliance on cotton and increase its involvement in man-made fibres if it intended to survive' (Singleton 1991: 219).[130] Drawing from the insights from this study, it might be worth examining the circumstances surrounding attempts to introduce substitute fibres in cotton during the same period, and assessing whether cotton firms suffered from a technological lock-in to that fibre.

Even though an industry may be experiencing conditions of technological lock-in and path-dependency, it does not mean that there is lack of entrepreneurship or path creation initiatives at the firm level. In jute, product-market innovations and attempts to find substitute fibres point to the industry's efforts at path-creation. Cotton also displayed a similar pattern. Broadberry and Marrison found that Lancashire firms responded to the Japanese competition by producing specialised products such as jaconets, madapollums, mulls and cambrics (Broadberry and Marrison 2002: 71).[131] However, we know very little about the role of technical capabilities at the firm level in creating heterogeneity among the Lancashire firms. Parsons and Rose examined firms involved in one of the less researched areas of the cotton industry, the finishing section - especially those firms that operated in the outdoors market (Parsons and Rose 2004, 2005).[132] After the decline of cotton in the 60s, they examined how the technical experience gained in the industry helped firms to carve out a niche when man-made fibre, especially Nylon, was introduced (Parsons and Rose 2005: 693).[133] The lack of any in-house research and development capabilities had left these firms disadvantaged and exposed during this transition period (p. 702).[134] Firms overcame this by tapping into external knowledge-bases that resided within surrounding industrial clusters of specialist chemical and finishing industries, often leading to the development of new products and the establishment of new companies (p. 703).[135] While a direct comparison might not be possible between the experience of the finishing and weaving (the focus of this study) sections, in jute, we find that firms relied heavily on their internal technical capabilities until the 1960s, when jute was the predominant fibre. Coming to the period of transition from jute to polypropylene, we find that there was some collaboration to tap external knowledge-bases, initially to overcome a lack of relevant technical skills. Yet, firms preferred to internalise the learning and reduce their dependence on external networks for key capabilities.

Like jute, cotton also displayed a preference for a collective research and development strategy. This was in the shape of the Shirley Institute. But unlike the BJTRA in jute - which was established after post-1945, the British Cotton Industry Research Association was established in 1920. Like the BJTRA, the Shirley Institute provided vital support to the industry in form of testing facilities to establish standards (Higgins and Velkar 2017).[136] This study shows that the BJTRA took significant R&D initiatives to overcome the challenges that jute faced in terms of fibre technology. A similar investigation into Shirley may lead to a clearer evaluation of its role in product market innovations, and the technical and non-technical challenges faced in the process.

Our primary objective was to examine the strategic responses of Dundee jute firms to intense international competition. Try as they did to escape the clutches of market demise through the identification of new market niches and by a clever use of engineering skills and routines, their attempts were bounded by the technical nature of the fibre, causing considerable lock-in. Some firms made the grade but, others went the way of the Dundee sector itself. In the end, the very attributes that caused jute to triumph over flax in that city, were the ones heralded its downfall. Many theoretical strategic responses were simply not possible to enact.

Notes

[1] Atkinson *Jute*: 9
[2] Howe *The Dundee Textile Industry*
[3] Masrani and McKiernan "Accounting"; Morelli et al, "Managing of Competition"; Morelli "Dutch Disease"; Masrani et al, "Rhetoric"
[4] Woodhouse and Brand *A Century's Progress: 133*
[5] Ecco-loader was an automatic loader for shuttles, which meant that the looms did not have to be stopped to remove empty insert full shuttles. As a result, the device enabled weavers to attend more looms per weaver.

Traditionally, a weaver attended one or two looms. However, the Ecco-loader allowed a weaver to attend upto six looms.

[6] Masrani and McKiernan "Accounting"; Morelli et al, "Managing of Competition"; Morelli "Dutch Disease"; Masrani et al, "Rhetoric"

[7] Howe *The Dundee Textile Industry: 139*

[8] DUA MS 114 BJTRA, Third Annual Report, 1949

[9] Jute and Canvas Review, May 1963 (768)

[10] McDowell and Draper *Trade Adjustments: 4-5*

[11] Tomlinson, Morelli and Wright *The Decline of Jute: 97-98*

[12] WYL365 Fairbairn Lawson, West Yorkshire Archive Service (WYA); MS114/1 BJTRA Annual Reports, MS 84/39/12/17 Minutes of Meetings of various ad hoc committees, MS 84/9/1 Wage Structure-Tenters Scheme, Dundee University Archives (DUA); list of interviewees, their primary position / role and interview date: David Fullerton: Owner of a merchant firm Fullerton & Wilson Limited (13th October 2006); Frank Barker; Factory manager (28th December 2006); Douglas Brewer: Owner of a spinning firm (20th December 2016); Ian Hutcheon: Production manager at Jute Industries and Low & Bonar (15th December 2006); Sandy McKay: In-charge of Research and Development at Jute Industries, Low & Bonar and Scott & Fyfe (10th January 2007); Joanne Taylor: In-charge of Research and Development at Low & Bonar (5th January 2007); Mr Jim Balfour Jute machine engineer (18th January 2007).

[13] MS114/1 BJTRA Annual Reports, DUA; Interview, R.R Atkinson: In-charge of research at British Jute Trade Research Association and Jute Industries during 1950s and 60s (8th January 2007).

[14] Firms were selected based on three criteria: first, availability of relevant archival sources; second, size of operations; and third, those that showcase contrasting approach to specialisation strategy.

[15] Jute Industries: MS 66, DUA; Scottish Records Office SEP4/2952, Sandy McKay: In-charge of Research and Development at Jute Industries, Low & Bonar and Scott & Fyfe (10th January 2007); Craiks: DUA MS 74, Low and Bonar Private Collection; Scott & Fyfe: Interview with Hamish Tough, Chairman and Shareholder in Scott-Fyfe (16th January 2007);
Additional information on the industry's specialisation strategy was collected through interviews with: Christopher Bonar: Son of the founder and Executive director at Low & Bonar (3rd January 2007).

[16] Hendry "Business Strategy"; Jeremy "Business History"; Harvey and Wilson "Redefining Business History"

[17] Lockett and Wild "Bringing history"; Wild and Lockett "Turnaround"

[18] Higgins, 'British manufacturing', pp. 55, 66.

[19] Toms and Wright, 'Corporate Governance', p. 93; and 'Divergence and Convergence', pp. 268-270; for a firm-level examination of knowledge acquisition in Unilever's strategy and structure, see Jones and Miskell, 'Acquisitions', pp. 10, 17, 19.

[20] Selznick *Leadership in Administration* ; Penrose *The Theory of the Growth*

[21] Wernerfelt, "A Resource-Based View"; Barney "Firm Resources"

[22] Teece et al, "Dynamic Capabilities" 514

[23] Helfat and Peteraf "The Dynamic" 998

[24] Langlois and Steinmueller "Strategy and Circumstance" 1168

[25] Eisenhardt and Martin "Dynamic Capabilities"; Priem and Butler "Tautology"; McKelvey "Quasi-natural Organization"; Aharoni "In Search for the Unique"; Arend "SME–supplier Alliance Activity"; Barney "Is the Resource-Based "View""; Nothnagel "Empirical Research"

[26] Penrose *The Theory of Growth*

[27] Leonard-Barton "Core Capabilities"; Lockett and Wild "Bringing History".

[28] Eisenhardt and Martin "Dynamic Capabilities" :110

[29] Eisenhardt and Schoonhoven, 'Organizational growth": 505, 508

[30] Holbrook, Cohen, Hounshell, and Klepper, 'The nature": 1018

[31] McGovern and McLean, "Growth and Development", pp. 451-453.

[32]Penrose *Theory of Growth;* Barney "Firm Resources"

[33] Penrose *Theory of Growth*: 78

[34] Mahoney, "Path Dependence", p. 513.

[35] Vergne and Durand "Missing Link", p743.

[36] Langlois and Steinmueller "Strategy and Circumstance" ; Kenny and von Burg "Technology"

[37] Vergne and Durand "Missing Link"

[38] Ibid: 702-704; Ding et al, "Cocooned"

[39] Garud and Karnoe "Path creation": 6
[40] Bassanini and Dosi "When": 62
[41] Dobusch and Schüßler "Theorizing": 638
[42] Sydow et al, "Organizational Path"
[43] Jute Working Party Report
[44] DCC Minute Book 31st March 1869, 28th March 1878, November 1875, 23rd January 1879, and 31st March 1886; MS/84/1-64: Dundee Jute Spinners and Manufacturers Association (DJSMA) Annual Reports, 1930, DUA; MS/84/1-64: DJSMA Annual Reports, 1934, DUA
[45] DJSMA Annual Reports, 1934, DUA MS/84/1-64.
[46] Average working time in Dundee was 56 hours per week. The Indian industry averaged 72 hours per week.
[47] Monetary instability in the world markets, resulting from the demonetisation of silver, led to significant devaluation of the Indian currency
[48] Gupta "Why did Collusion".
[49] DJSMA, Annual Report, 1934, MS/84/1-64, DUA.
[50] Yarn output rose from 75000 in 1945 to 144100 in 1960, then declined to 87500 tons in 1970. Similarly, output of cloth rose from 49200 in 1945 to 83500 in 1960, but declined to 40900 tons in 1970 (Howe *The Dundee*).
[51] Masrani and McKiernan "Accounting"; Morelli et al, "Managing of Competition";
[52] Woodhouse and Brand *Century's Progress*
[53] Gauldie *The Dundee Textile Industry;* Lenman, Lythe, and Gauldie *Dundee and Its Textile Industry;* Warden *Linen Trade:* 632
[54] Carrie *Dundee*
[55] Warden *Linen Trade:* 596; Woodhouse and Brand Century's Progress; Stewart *Jute and Empire*: 50-54
[56] DCC Minute Book 9th January 1874; 5th January 1882, GD/CC/4/5; *Dundee Advertiser*, 8th April 1896; DCC Minute Book 27th December 1895, GD/CC/4/7.
[57] Initial members included: Craiks (weaver), Don Brothers Buist (spinning and weaving), Fullarton & Wilson (merchant), A&S Henry (merchant manufacturer), Jute Industries (spinning, weaving and merchanting), Low & Bonar (merchant manufacturer), Baxter Brothers (flax weaver- part of Low & Bonar), Thomas Bonar (merchant- part of Low & Bonar), Fairbairn Lawson (machine manufacturer), Douglas Frasier (machine manufacturer), James Mackie (machine manufacturer) and Scott & Fyfe (weaver).
[58] *Jute and Canvas Review*, July 1948
[59] *Jute and Canvas Review* March 1948; *Jute and Canvas Review*, July 1948
[60] *Jute and Canvas Review*, December 1949
[61] *Jute and Canvas Review*, November 1950
[62] MS 114/1/1, BJTRA Annual Report 1948, DUA
[63] MS 114/1/2, BJTRA, Annual Report 1950, DUA
[64] MS 114/1/2, BJTRA Annual Report 1951, DUA; Interview Mr Atkinson
[65] MS 114/1/6, BJTRA Annual Report 1957, DUA
[66] MS 118/7 BJTRA, 'Blends of Jute Continuous Filament Man-made Yarns Part 1', by R.R. Atkinson and I.G. Cumming, Bulletin No 61; 'Blends of Jute and Continuous Filament Man-made Yarns Part 2', by R.R. Atkinson and I.G. Cumming, Bulletin No 62, DUA
[67] Interview R R. Atkinson 8th January 2007
[68] Ibid
[69] *Jute and Canvas Review*, September 1965; Interview with McKay, 2007
[70] *Jute and Canvas Review*, June 1961
[71] *Glasgow Herald*, 25th August 1969
[72] *Jute and Canvas Review*, December 1966; McKay "Primary"; interview with I. Hutchison and S. McKay,
[73] *Jute and Canvas Review*, December 1966; Dundee Jute Spinners and Manufacturers Association Annual Report, February 1970, MS 84, DUA.
[74] Atkinson, *Jute*, 139-143; Woodhouse and Brand, *Century's Progress*, 133

[75]Atkinson, *Jute*, 85, 104, 127; Woodhouse and Brand, *Century's Progress*, 54, 57, 61; Richardson, JI, to Mackie, 27 January 1937, MS 66/X/11/34, DUA.
[76] Whatley *Onwards*: 199-201
[77] Watson *Jute*: 21
[78] Woodhouse and Brand *Century's Progress*: 123
[79] Correspondence between New York Agent and F.M. Richardson, Commercial Director at Jute Industries, 1929-30, 27th November 1929, MS 66/X/11/27, File No. 7, DUA; Correspondence between F.M. Richardson and Edward Paynter and L.J. Hiltz of Jute Industries Ltd NY 1931-35, 8th February 1932, MS: 66/X/11/29, File No. 7, DUA.
[80] JI, Board of Directors' Minutes, 7, 14 May, 21 June, 27 August 1929, MS66/X/11/1/2, DUA.
[81] Richardson, Commercial Director to JI, 26 November 1932, DUA MS66/X/11/39; Richardson to Greenall, 9 May 1932, MS66/X/11/27, DUA.
[82] Tenters' White Book, Section C 'Work Specification', 1954, DUA, MS 84/39/12/17.
[83] Cox *Empire* 2-26; Jute Wage Structure, 1952, MS 84/33/2, DUA.
[84] 12 November 1941, Internal Correspondence, JI, MS66/X/11/30, DUA.
[85] 11th May 1953, Association of Jute Spinners and Manufacturers, Personal Impressions of H. G. Scott on Meeting with Technical College Authorities on Tenters' Training Scheme, MS 84/9/1, DUA.
[86] Kogut and Zander, "Knowledge of the firm", p. 384.
[87] Woodhouse and Brand *Century's Progress*;
[88] sliver is a continuous strand of loose fibre, which can then be spun
[89] Interview, R. R. Atkinson 8th January 2007
[90] Masrani and McKiernan "Accounting"; Arend "The Definition of Strategic Liabilities": 1020
[91] F. Lawson Private Letter book (Anderson Letter book) 22nd December, 1908, West Yorkshire Archive Service, WYL365.
[92] *Dundee Advertiser*, 2nd March 1922.
[93] Correspondence between F.M. Richardson and Edward Paynter and L.J. Hiltz of Jute Industries Ltd NY 7th November 1932; 13th January 1933, MS: 66/10/11/29, File No. 7, DUA; Correspondence between F.M. Richardson and Edward Paynter and L.J. Hiltz of Jute Industries Ltd NY, 8th February 1932, MS: 66/10/11/29: File No. 7, DUA.
[94] 15th February 1917, Minute Book, MS 74/1/1, DUA
[95] Coarse fibre was used mainly for sacks and bags.
[96] Barney "Resource-Based"
[97] Jute Working Party Report 1946, DUA MS/86/25/7.
[98] Interview, Hamish Tough, 16th January 2007
[99] This company was earlier known as the United States Rubber Company and established in 1892. It became Uniroyal, Inc., in 1961. In 1990, Uniroyal was acquired by Michelin.
[100] Scrim can be either very light and translucent or heavy and coarse. S&F's version was the former type, which is ideal for curtains and in theatre use.
[101] *The Scotsman*, 17th Sept 1969
[102] *Glasgow Herald*, 15th November 1967.
[103] 25th June 1952, Minute Book, MS 74/1/2, DUA
[104] 8th August 1957, Minute Book, MS 74/1/2, DUA
[105] 3rd November 1952, Minute Book, MS 74/1/2, DUA
[106] 16th April 1956, Minute Book, MS 74/1/2, DUA
[107] Masrani and McKiernan "Accounting"
[108] Interview, Sandy McKay, 10th January 2007
[109] 16th April 1956, Minute Book, MS 74/1/2, DUA
[110] Interview, Sandy McKay, 10th January 2007
[111] 6th March 1961, Minute Book, MS 74/1/2, DUA
[112] 30th May 1963, Minute Book, MS 74/1/2, DUA
[113] 14th September 1966: Minutes of Directors Meeting, Low & Bonar's Private Collection
[114] 6th May 1969: Minutes of Directors Meeting, Low & Bonar's Private Collection
[115] Armstrong and Shimizu "A Review of Approaches"
[116] Langlois and Robertson *Firms*

[117] For an overview of the concept of emergent strategy, see Mirabeau and Maguire, "From Autonomous ", especially pp. 1203-1207.
[118] Langlois and Steinmueller "Strategy and Circumstance" 1171-1172
[119] Penrose *Theory*:78
[120] Marrison "Indian Summer": 239
[121] Sandberg *Lancashire* : 172; Bowden & Higgins "Investment": 225
[122] Singleton *Lancashire*: 45, 166-7.
[123] Robson *Cotton*: 355; Leunig "New answers"; "British"
[124] Toms "Growth"; Higgins & Toms "Financial"
[125] Higgins "Rings": 349, 355-6
[126] Sandberg *Lancashire*; Leunig "New answers": 460).
[127] Singleton *Lancashire:* 166-167
[128] Lazonick "Industrial": 221
[129] Ibid: 221.
[130] Singleton *Lancashire*: 219.
[131] Broadberry and Marrison "External": 71.
[132] Parson and Rose "Communities"; "Neglected"
[133] Parson and Rose "Neglected": 693.
[134] Ibid 702.
[135] Ibid 703.
[136] Higgins and Velkar "Spinning"

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