In the beginning was the network

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Abstract

This paper looks at two case studies to show that networks are not a new idea. Businesses have always joined already existing networks of companies and relationships and operated within them. Rather than companies creating or building networks in line with their individual strategy, it is much more valid to say that "in the beginning was the network". In this way, any company action can usefully be interpreted as an interactive process through which those around the company and the company itself adjust to changing network structure

The paper draws conclusions about management decision making and reaction in this context.

Keywords: networks, innovation, network evolution, leather, ice-industry, technology.

Introduction

The fascination of the business community, and the academic world, with the potential of new techniques has held the arena of much of business marketing for the last five decades. Managers and researchers have been overwhelmed with techniques and concepts on which to focus in their attempts to understand and operate business better. Obvious examples include the idea of product life cycles, management by objectives, statistical production control, quality circles, business process re-engineering, total quality management, just-in-time, and Porter's Diamond. Most recently, ideas of networks, networking or network management have been promoted, not simply as more accurate descriptors of current business, but as techniques for managers to adopt in current circumstances.

In this paper we use two longitudinal case studies to look at business over an extended time frame, and use this to see what insights we can obtain about the nature of innovation and the development of the firm. These and other cases make it apparent that networks are by no means a new phenomenon to add to the list of business tools, but rather they have an axiomatic existence, in that they are effectively present *before* the businesses that apparently occupy them have been created. The cases chosen highlight how businesses use their interactions to fit into different parts of a wide variety of networks, not all of which are immediately obvious.

The choice of case studies

Various attempts have been made to describe and analyse networks and company position *at a particular point in time* and to help companies to manage or change their position (Håkansson and Snehota 1995, Ford et al 2003). Although some studies have examined network evolution over time, such as Lundgren (1995) and Andersson (1996), there have been few attempts to examine a network's evolution over an extended period.

In order to get a true feel for the evolution of both innovation and the various network positions in which a company may find itself, a long study is required. To look at a business situation over decades, or better through an entire century, requires that we delve into history. It is necessary to find material which is complete, relevant and accessible. A small number of studies of this sort have been carried out.

Schwerin (2004) in his work on the Clyde shipyards in the 19th century, analyses the dynamics of innovation and institutional change in Clyde shipbuilding. During the nineteenth century shipbuilding transformed into a modern high-tech industry, driven by emerging innovation systems in regions such as the Clyde. His paper, based on newly evaluated archive materials, identifies several overlapping channels of information exchange within the shipbuilders' network. From a dynamic perspective, it discloses changes in the pattern of individual and organizational behaviour. Moreover, it establishes the importance of 'correctly' mixing formal and informal institutions in an analysis and describes the link between these institutions and the geographical size and evolution of the innovation system.

Alessandro Nuvolari (2003, 2004) looks at the invention of the Cornish pumping engine during the Industrial Revolution in Britain, but primarily through an examination of the patents applied for during the forty year period involved. He has also looked into the development and the diffusion of steam engine technology as well as adding to the patent research with an historical examination of the major UK inventors between 1770 and 1830.

He notes that while economic historians have discussed the nature and the determinants of technical change in the early phases of industrialisation (Habakkuk, 1962; Landes, 1969; Mathias, 1983), much less attention has been devoted to the diffusion of new technologies in this historical period. He covers the aspect of general purpose technologies which Bresnahan and Trajtenberg (1995), defined as "technologies endowed with three salient characteristics: a) they perform some general function, so they can be employed in a wide range of possible application sectors, b) they have a high technological dynamism, so that the

efficiency with which they perform their function is susceptible of being continuously improved, c) they generate “innovation complementarities”, that is to say that their adoption stimulates further rapid technical progress in the application sectors”. Steam power, electricity and information and communication technologies are frequently put forward as examples of GPTs.

Nuvolari’s work also shows that when inventions become heavily controlled by patents, as with Watt’s steam patents, the diffusion and the incremental improvement of a technology can be greatly slowed. Nuvolari does not consider network implications. Similarly, although Schwerin does cover some network aspects in his Clyde studies this is done in a peripheral way.

The Ice Industry in New England offers rich material for examination as the documents related to the business reside in the library at the Harvard Business School and have been the subject of both academic research (Utterback, 1994) and research for general literature. Unlike the Cornish and Clyde study the available information offers insights into the interaction with many other industries and on an international scale.

It is recognised that the study of economic geography owes much of its academic origins to the work of Hoover (1937, 1948) on the New England leather and footwear industry. The development of this industry in the period of rapid US population growth, industrialisation and internationalisation is well recorded. The Booth Group of Liverpool and New York were a major element in the development of this industry and as well as good archival material being available the authors have been given access to privately held company and family material which permits analysis of how the managers viewed their relationships with other actors in the networks.

Consequently both the Ice Industry and the Leather Industry offer sufficient material of a quality to analyse the evolution of the business in relationship to a wide variety of actors in many networks, in areas and during times that new technologies both incremental and disruptive were making their impact on events.

The New England Ice Industry of the 19th Century.

In 1805 the brothers William and Frederic Tudor from Boston in New England invested in a scheme to harvest and export ice from the frozen winter lakes in the region to the West Indies. As described in detail by Weightman (2002) and Utterback (1994) it seemed incredible that ice could be removed in the winter from a frozen lake and delivered the next summer to hot tropical climates such as the Caribbean. And all this was to be done without any artificial refrigeration.

Over the next decades they were part of a process which took the ice to the southern states of the U.S. and to India as well as the Caribbean. They perfected techniques of harvesting the ice efficiently from the lakes, storing it safely for months until shipping, packing it to travel with limited shrinkage across half the world, and storing it again in extremely hot destinations. The ice house in Chennai (Madras) stands proudly to this day.[1]

[1] **ICE HOUSE**

Vivekanandar Illam on the Marina, Chennai, built 160 years back, has a long and interesting history. It was meant to store ice, whence it got its popular name, the Ice House. Eventually this house became a silent spectator of a series of diverse historical events, some of which have lifted this building to a status of an outstanding historical and cultural monument.
Mr. Frederic Tudor, the 'Ice King', built three houses in Calcutta, Bombay and Chennai to keep ice under proper insulation so that it could be stored for months together. Amongst the three buildings the one at Chennai alone stands today. It was built in the year 1842. Tudor maintained his business in Chennai from 1842 up to around 1880. After the invention of making ice by 'steam process' in India, his business collapsed.

In 1856 Frederic Tudor shipped "146,000 tons …. in 363 separate cargos to such U.S. ports as Philadelphia, Charleston, Savannah, New Orleans, and San Francisco, and to the Caribbean islands, Havana, Rio de Janeiro, Madras, Bombay and Hong Kong."(Utterback, p 146). Locally, according to Utterback an equal quantity was also being used in New England for "meat processors, dairy farmers, restaurants and hospitals". What fifty years ago had been thought of as "totally worthless" had been turned into an indispensable commodity.

As children the Tudors were accustomed to using the ice from their farm to prepare ice cream and cool drinks, and it was this benefit that they wished to transfer to hot climes where ice was not naturally available.

To achieve this they had to find ships willing to accept this curious cargo, and the failure to do so forced them to the most unusual action of actually buying their own vessel, a brig called the *Favorite*. Normally a shipper would simply buy space on a vessel to ship his goods, but the ships' captains who carried mixed cargoes were not prepared to have melting ice in the hold damaging the rest of their shipment. Eventually the Tudor Ice Company ended up owning quite a number of ships with names such as Iceland, Iceberg and Iceking.

The feeling amongst the Boston business community about the venture was expressed in the Boston newspapers:

"No joke. A vessel with a cargo of 80 tons of Ice has cleared out from this port for Martinique. We hope this will not prove to be a slippery speculation."[2]

The initial trips to Martinique and St. Pierre were not very successful as neither local storage nor the market place had been prepared. The Tudors realised they had to teach the market place about ice cream and how to use ice. Profits started to be identified by 1807 when shipments began to Havana, where the café owners were shown how to use it for chilled drinks and ice cream.

The business with the West Indian Islands was made difficult since the British authorities who owned them would not give Tudor permission to do business, since London just did not believe such a business could exist. Permission to do business in Barbados, Antigua and Jamaica was only granted when Frederic Tudor adjusted his argument to promote the medical benefits of ice, which from his position at that time was a rather tenuous argument, but worth using as a last attempt to gain access to the markets.

Continued work on insulating the ice was also successful and after a few voyages other ship-owners realised that the ice did not melt in the hold, and the ships appeared to be undamaged. The outcome was that ice became considered as a suitable material for ballast. This was an interesting concept since most ships left Boston empty to go abroad to collect cargoes, and needed ballast for stability on the outward journey. Thus for them the shipping of ice for Tudor at very low cost was a much better deal than the very expensive exercise of dredging stones out of the bay for ballast.

Weightman (p 30) notes that if ballast had not been a problem for Boston ship-owners the ice trade would have struggled to get established. At the same time the destinations to which Tudor wished to send his ice, such as India, caused Boston to re-open new trade routes by giving them income on long outward journeys.

New technologies tend to breed new ideas, such as the concept of the use of ice in hospitals which steadily developed. Another area in which work was done with some success was the transport of fresh fruit, and some Baldwin apples were shipped with a cargo of ice to Cuba arriving in good condition. This inevitably lead to the next idea, of bringing fresh tropical fruit

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http://www.rkmchennai.org/Svhouse.htm accessed March 05

[2] Boston Gazette, February 10th, 1806 Quoted in Weightman (2002)

back from the Caribbean to New England, although for various logistic reasons the first voyages were not profitable.

By 1815 the business had developed considerable expertise. It had large numbers of agents, suppliers, carpenters (for building ice houses and carrying structures in ships), and ice-house keepers working for it and with it. Tudor had developed leading edge expertise in preserving ice in hot climates and during transportation. Profits had been slow coming only because each season seemed to bring one disaster or another, be it pirates, storms, difficulty in obtaining licenses to trade, or illness; and with this came cash flow problems and serious debt and temporary incarceration.

In 1825 one of the Tudor ice suppliers Nathaniel Wyeth invented a contraption based on a conventional plough to improve the ice harvesting technique. An impressed Tudor hired Wyeth (Weightman p 76) to manage the cutting, storage and loading of his ice supplies. In 1829 the invention received patent protection but since it was easy to copy the patent was not really enforceable. Indeed being so efficient and easy to copy it actually reduced the barriers to entry for competitors.

Consequently others began entering the business using the same techniques as Wyeth and Tudor and the business began to expand to other States such as Maine, which Tudor had only previously used when the winter was mild in Boston.

The India concept was introduced in April 1833 at the suggestion of a Boston merchant named Samuel Austin. He thought that taking ice to India might "stimulate shipping to the East India in general" and a joint venture was agreed with Tudor. Weightman's description (p 104) of the British attempt to keep cool in India make interesting reading:

- saltpetre and water were used to make a cooling mixture in which beer and wine were placed
- "hooghly slush", an ice produced by taking advantage of cool winds and low night temperatures to produce thin layers of ice over straw in pits
- building houses with underground sitting rooms
- using raised terraces to capture any breezes
- hanging wet towels over windows
- using servant to operate overhead pulley driven fans called "punkahs"

When news reached Calcutta that ice was reaching Havana and they had ice-cream in Cuba the market for ice in Calcutta was at once established and rather than creating difficulties the local communities supported the ice house building and did all they could to help. Had communications been better and Tudor more aware of his success he would have made much more of this trade.

The return trips from India brought back jute which was the raw material for the New England mills to make sacks and ropes.

It was also in India that the medical aspects were pursued. Ice was put on swellings, swallowed to cool the insides, and applied to the heads of patients with fever. Also in Florida, where the connection between mosquitoes and malaria was yet to be made, using ice to cool the air in hospitals was thought a way to treat malaria and yellow fever. Blocks of ice were hung in the air to cool the wards.

Other bi-product effects arose such as the use of charcoal and sawdust for insulation. In 1847 4,600 cords of sawdust at $2.50 a cord were used to spread between the blocks of ice as an insulator. Before that the sawdust from the forestry industry had no value and was dumped in the rivers where it caused pollution, blockages and even floods.

It was around this time that Tudor decided to test the sophisticated London market, at a time when London was prosperous and upbeat for a couple of decades after the defeat of Napoleon.

“Crystal Clear” Rockland Lake Ice had started to take lead market share in New York and it was Wenham Lake Ice that was to do the same in London. Tudor shipped US bar-tenders over with the ice to train London bar staff about mixing cocktails with ice. This was supported by adverts in the Times. In London at that time ice had mostly been used for keeping fish fresh, so although its benefits were realised they had not been exploited.

A clever marketing tool was to place a large block of ice in the window of the Wenham Ice Co offices in the Strand, shocking the public into the realisation that such a large block of ice appeared not to be melting. The clarity of the ice was further proven when a block was used with a fish frozen inside it.

This gave the UK the impression that New England ice lasted longer before melting, and was purer than other ices, and so no dinner party in London was complete for a few years without the correct American ice. It was used “by appointment” in Buckingham Palace. The ice was clear enough for table use - to put with butter and jelly and to add to water and to milk, as well as the full range of alcoholic drinks

Success in the UK only lasted about 5 years as Norway realised what an interesting market the UK was and that they could ship ice in cheaper. Yet they could not overcome the strong Wenham marketing until they renamed Lake Oppegaard near Oslo “Wenham Lake” and created brand confusion in the London market.

The use of ice in drinks did not fully take off in London as in the US, as we see to this day, and the big markets for ice in London became the ice cream makers and for the preservation of fish, fruit and meat.

The impact of unexpected events continued when during the civil war access from Boston to the southern US ports was prevented. Maine managed to maintain access and increase their market share. At that time New Orleans became interested in mechanically produced ice and managed to smuggle in two French devices for use in hospitals.

It was, therefore, in the 1860s that Boston lost its US production leadership to Maine and the Midwest. Maine, Massachusetts, Pennsylvania, and Wisconsin were fighting for the market.

The railways had started to open shipping ice inland and the ships just worked the coastal routes. Americans liked German beers which had to be brewed and served chilled. This was previously only possible in the winter, but ice allowed it to become a 12 month exercise, and kept it cool in bars for drinking.

The railways had also led the meat packing industry to move to Chicago, where Swift and Armour moved the meat around using ice chilled rail wagons. It was not long before this area also wanted to test steam driven artificial refrigeration units.

Yet it was India where the steam driven machines killed the ice industry first. Unreliable supplies had led them to import machines in 1878, and by 1882 the sea shipment of ice to India was dead.

The New England Leather Business and the Booth Group

The Liverpool Booth family – Alfred and Charles – set up a leather business in New York in the early 1860s to import part processed sheepskin to feed demand in the US which was growing rapidly with the fast population growth on the continent (John 1959).

They had no background in leather but a lot of training in International shipping and worked with young newly established UK tanners who were willing to experiment with them in new markets.

To get started they used family organised training in trading houses in New York to understand one aspect of the business, and a partner in New York, a Mr. Walden who knew

the US leather market. After two years Walden retired early through ill health, but the brothers were able to carry on without him.

Initially they intended to sell only into the clothing and light weight footwear market, but they found a good market for gloves in Gloversville in upstate New York. This led them to have to deal with a potential loss when one of their customers got caught up in a fraud situation. They supported the stranded partner by buying the factory and found themselves not only tannery owners but also financing some radical technical innovations which were to change the industry globally.

The partner they supported invented one new leather and then after a chance meeting in a New York eating house they gave access to another technical expert, albeit not a tanner, to work on some ideas. By 1884 this expert had patented the technique of chrome tanning. It was not at once suited for the Gloversville leathers but did after a few years prove to be excellent for goat and kid shoe leathers which were made in Philadelphia. After a few years Booths became sole agent for the best production of this chrome kid in Philadelphia and just after the turn of the century purchase outright the tannery in Philadelphia which was by then the largest kid tannery in the world.

Booths were able to help in these situations since the invention in Gloversville while only moderately good for gloving, did meet a need for a light weight shoe leather which they had identified in the Boston footwear market. It also required other types of skins such as kangaroo which they could source via their well connected international trading friends.

The chrome leather from Philadelphia also played well for them as it needed extra goat skins. As it happened the Booths, via a friendship and intermarriage with the famous Liverpool shipping family Holt, had set up a small steam ship line working from Liverpool to the Amazon. Northern Brazil had a large supply of goatskin so Booths began a triangular trade which involved taking skins from Brazil to Philadelphia to be tanned for export to Europe, which was a business they were well placed to carry on.

By the early 20th century they were the strongest dealers in the US and had connections from Australia for kangaroo through India and Africa for goatskins as well as the strong links to Brazil where the built and managed the port of Manaus. They opened an office in London to gain access to the European sheepskins (where many Europeans came to sell their skins in the London auctions) and had a clutch of tanners and fellmongers in the UK which were largely dependent upon them.

A Complexity of Cool Networks.

Utterback's study of the ice industry was based on his interest in technical innovation, and in particular its "impact on competitive success". He remains fascinated by the "disturbing regularity with which industrial leaders follow their core technologies into obsolescence and obscurity" (Utterback p 166).

If we follow the trail of events in this somewhat "commonplace" technology of cooling we see that US production of ice had grown to millions of tons per annum. By 1880 the Kennebec River in Maine had 36 ice companies with 53 ice houses with a holding capacity of over 1 million tons on just one very short stretch of river near Bath.

Yet at this time new technologies were being tested, although mostly in distant areas where access to ice was difficult or the cost was high. Typically, according to Utterback, the incumbents did not take the new technologies seriously but rushed on with many incremental improvements to their own products and processes.

From the records we have some feel for the prices. In 1868 the New Orleans mechanical ice cost $35 a ton to make, when it was felt that for mechanical ice success would not come unless the price could be reduced to $2-3 a ton. Yet when there was a mild winter the New Englanders would push their wholesale prices up from $5.50 to $15.50 and above and in

times of yellow fever some of the inland southern locations found that this translated into prices of nearly $125 a ton. Security of supply as well as price drove interest in innovation.

The technologies which were to develop were first the machine made ice, using steam which was replaced by electricity in 1890, and then electronic refrigeration. Yet despite the developments of these new technologies the quantities of ice harvested in the US grew annually until the first decade of the 20th century when it was measured in many millions of tons. It was from 1900 to 1920 that large numbers of ice producing plants were built. Issues like the level of pollution in the Hudson River speeded the process. When, after the First World War refrigeration replaced ice, the natural ice industry was effectively dead.

Utterback (p 155) makes the point that the ice industry had "created an entire system" with production, storage, distribution that was "remarkably efficient". Yet because of their great investments they were in some way "impeded" from making industry altering innovations.

In a crowded world we know that being inventive is important, and that in the 19th centuries inventors were busy throughout the world filing patents for new machines and chemicals. Less obvious was how to be inventive with an apparently ubiquitous aspect of every day life in the north like ice.

Frederic Tudor liked mixing ice with milk to make ice-cream on the family farm and did not like the oppressive heat he found while on a trip to Cuba. Putting two and two together he founded a business as illogical and yet as profitable as the modern craze for bottled water (which is frequently no more than mildly adjusted bottled tap water. (Gross 2003))

To get this business started in a sceptical and difficult business world. The Tudor brothers first had to get into the business of sea transportation. Buying a ship and staffing it they also had to work on what they would be bringing back to make the journey economic. Both these areas of ship-owning and international logistics were well established networks into which they had to enter just to get started.

The provision of ballast for ships leaving Boston was another associated network linked in to shipping. They did not have to get too involved, but they did need to build adequate relationships to understand the economics and the pricing mechanisms which would give them an idea of what they should pay others for using ice instead of ballast.

To harvest, store and transport the ice required another set of competences. As argued by Ford and Saren (1996) new technologies are frequently brought in via building relationships more into separate networks and thus linking to new business areas in a novel way. Through his career Tudor was to do this time and again.

Technical help on harvesting he got from Wyeth, and on storage he got help with ice houses from his brother in law. He hired and trained carpenters to build the ice houses and to fit out the ships to take the unusual cargo.

The initial plan had been to sell ice for domestic use. To get access to certain markets the perceived benefits of ice for medicinal purposes was promoted and in India, the Caribbean, Florida and other southern states the business of ice began to build strong relationships into the medical business. In hiring a doctor to argue his claims to the Foreign and Commonwealth Office in London he recognised the significant opportunities in this market if he could establish the correct links. Yet this was a typical adaptation (Ford, 2003) forced on him to deal with an unexpected set of circumstances.

Indeed the actions of the Tudor Ice Company undeniably had impacts on the relationships in the network. They had to persuade ship-owners to change from refusing to carry ice to searching it out as a cargo in place of expensive ballast. They suggested new destinations such as India. The impact of actions on Tudor within and via the network were even greater.

In London he targeted high society, cleverly and with some success for a few years, but eventually he had to adapt to the reality that it was the business to business market of ice

cream makers and more industrial users where long term success was to be had in Europe, rather than in the retail entertainment network.

Also of interest was how major events impacted the business via interaction in the network. The US Government stopped shipping to the Caribbean during the Napoleonic war period and he had to divert his shipping and his marketing to the southern US states, and yet again in 1860s (although Frederic Tudor (1783-1864) had lost some interest by then as was busy on more philanthropic works in his new island community north of Boston) when the Civil war stopped shipping to the south Tudor Ice renewed its focus on India and other foreign parts. The Ice company owned some ships, but mostly worked through hiring space or joint ventures so the issues of how and where to trade with those ships would have had a profound impact on the Ice Company's thinking.

By the late nineteenth century people the world over had come to rely on ice not just for refreshment, but for medicinal and industrial purposes(Gross). Ice became so important that inventors devised steam- and electricity-driven refrigeration systems, and the traditional ice trade, based on the whims of nature, declined.

This brings us to the point of Utterback's study: why did the Tudor Ice Company die out? The simple fact that refrigeration technology replaced ice cutting does not explain why neither Tudor nor any of the other ice producers exploited the new ice making technology. As Utterback argues they had the global customer base, the international transport and logistics networks that were still needed for selling the ice - which was initially made in large industrial refrigeration plants and shipped.

The normal analyst view is that they misunderstood what business they were in, but in reality Tudor had not built a network, but rather had the relationships which allowed his business to operate. To continue in business after the introduction of mechanically produced ice would have involved changing those relationships drastically. A company is strongly controlled by the relationships it has and it would be easier for a new entrant to the network to build the number and type of relationships to exploit the new technology.

Seeing the many exciting and innovative things which happened in the century of natural ice it is attractive to argue that Tudor "built a network" when what he in fact did was establish a unique series of relationships both within and between already existing networks. By establishing new relationships he gained access to technologies and markets which would otherwise have been inaccessible, and highlighted the aspect shown by Lundgren (1995) and Håkansson and Waluszewski (2002) that new technologies often evolve and are exploited at the overlap between businesses.

Lou Agosta (Amazon 1999) reviewed Utterback's analysis of the ice industry and considered that it should have a "sobering effect on the complacent technology manager". In this situation radical innovation is represented by refrigeration while for some reason the established ice industry was unable to envision refrigeration. Industry outsiders were the ones who did so. According to Utterback, industry insiders have a heavy investment, both technological and emotional, in the existing system of infrastructure, distribution, and production. "...from a practical point of view, their managerial attention is encumbered by the system they have - just maintaining and marginally improving their existing systems is a full-time occupation." In contrast, we could say that that the relationships of incumbents and their view of their network position is such that they are easily prevented from recognising that new relationships were needed to understand and participate in some of the changes that are occurring. Furthermore that even when they did recognise change, their position and investment in existing relationships limits their ability to adjust those existing relationships or to build new and different ones (Hakansson and Ford 2003)
Extending some of Agosta's metaphor the "chute is the path by which managers dedicated to the customers of the about-to-be obsolete technology follow it into oblivion and obscurity. This is a grim prospect, and, according to Utterback's cases, one that occurs about 70% of the time. In the case of David and Goliath, history is on the side of the sling shot".

The Ice Industry was an exciting and fascinating phenomenon which served many in New England and especially the "Ice King" Frederic Tudor very well. His success was to build the relationships and to, albeit with great difficulty and many stumbles, make the adjustments needed to fit efficiently into a wide number of networks. His was a story of endless interactions and adaptations, and of many crossovers as interaction with different actors forced changes in direction. From selling "cooling" in terms of ice cream and iced drinks to families in Cuba, the Tudor ice company became studied in medical uses of ice, the transportation of chilled fruit both from and to the tropics, the café society of the colonies, and industrial uses for ice. In addition they developed outstanding skills in the storing and transportation of this amazing commodity. Today an ice house in Chennai and a wharf in Charlestown harbour, Boston, are the only remains of this great business.

A skin-full of interaction

In a similar way an apparently narrow and simple network related to the leather industry is seen after even superficial consideration to be placed within a very large number of networks of diverse natures.

The nature of the many networks in which the leather industry works was discussed at length by Ford and Redwood (2004) and much of that paper also covered the Booth Group Case study. Leather as part of a network for clothing and coverings goes back to Genesis and as part of a library and record keeping network is found in evidence for using skins for writing from the 4th dynasty in Egypt. Throughout history the most important network into which the leather industry fitted was that of military supply as no war could be undertaken without a secure supply of leather. In the early days armour, shields, helmets were all made of leather and before that even the weaponry depended heavily on rawhide ropes and ties. Later the important elements of war that relied on leather became horse furniture – saddlery and harness materials, and footwear; although gloves, breeches, chamois for wear under chain-mail, all were vital at different times. Even in the 21st century the US government has moved to avert the closure of one of its last domestic tanneries in order to maintain a home based supplier of army boot leathers.

Looking at the Booths starting their new business again one could say that they somehow "created a network". But instead one recognises the way in which they developed relationships in trading, banking, and in the UK and US leather industry that allowed them to interlink a number of existing networks with different technical and geographic competences. Through these they were able to create their unique configuration that was to be effective and useful at the time.

The US leather industry had been cattle-hide dominated and the introduction of sheepskins and goatskins to the country brought completely new geographic areas into the equation about which the US industry had little knowledge. Within the USA it made sense for the Booths working out of New York to work with customers in Boston, Gloversville, Newark and Philadelphia. While there were reasons for Philadelphian tanners to visit Boston and Newark to work with New York the traditional structure of the industry gave no reason for the other communities to build connections. Thus the Booth network position was exceptional and perfect for the exploitation of new technologies, which they were both able to foresee and exploit. With their network position and insights they were better able to asses the risks and rewards of these new innovations. So at the end of the 19th century while the US tanning industry was fighting over ownership and access to forests to get bark for traditional tanning methods Booths had helped create two new tannages that had no such dependencies. One of these was to be a major global tannage method for 40 years, and indeed was only eclipsed when the other – tanning with chromium compounds –became the dominant tannage which it still is to this day.

The traditional leather industry struggled with changes in final customer demand and new technologies in much the same way as the traditional ice business did in the early 20th century (Church 1971, Dewing 1911, Donham 1930). But the Booths were able to move goat and kangaroo skins around the world to meet increasing demand for strong water resistant

lightweight footwear upper leather. It was not so much that they had some prefect foresight but rather that they had a network position and the associated strong relationships to make them not just able to manage but to help lead the changes.

Conclusions

Tudor Ice was an entrepreneurial business based on using frozen lake ice, which was not a new technology. The company was successful because of its ability to exploit the existing technology in new ways via relationships with others. The company used the relationships that they were able to establish and acted themselves only when the correct relationship was not forthcoming. They bought ships initially only because they did not have the correct relationships. These relationships also provided access to other necessary technologies, such as new ways of cutting and storing ice, the use of ice as ballast, and for medical purposes. Even in the case of a very simple technology such as ice, the process of innovation involved its use in different applications in varied geographical areas, each of which required new relationships and the application of intellectual resources. These resources were transformed into capabilities through interaction.

The simple case of the ice industry also illustrates the relationships between the development and refinement of technology and its application in different areas. Both the ice and leather cases illustrate the characteristics of general purpose technologies (GPT) such as “innovation complementarities” as described by Bresnahan and Trajtenberg (1995).

Networks are not new phenomena and there are no new networks. In both of the cases we have described, the companies redefined the network they enter and see it differently from the incumbent actors. The cases illustrate that much of the process of technical innovation is a process of redefinition of relationships. Since the network changes in unknown and unpredictable ways through the interactions of each actor, no actor has control over the network, nor of how the technology within it will be used in different applications or the outcomes from that use.

Both companies in the cases were faced with many macro-environmental changes in terms of war, economic depression, currency and gold standard changes and technology. But these “external” perturbations were both manifested and mediated by the relationships in which the companies were enmeshed. Both companies were industry start-ups and both can be characterised as having built connections into not one simple network but many complex networks. The Booths were well prepared for these changes with connections and relationships which gave them access to the required technologies and customers. Tudor Ice found it harder to both choose and establish the necessary relationships and had difficulty with its interactions with large parts of the network. They had to make many adaptations to achieve eventual success in terms of a profitable and sustainable business.

As a consequence of the multitude of interactions involved in establishing these businesses the final structure of each business and its network position were quite at variance with the initial concepts of the founders. Tudor certainly dug ice out of lakes and sold it round the world and Booths traded in leather but the locations, the methods, the many partners, the products and processes could not have been imagined when either party set out on their great adventures.

In the beginning was the network and these and all the other companies were fashioned by the network as it existed at their birth and as it evolved through their own interactions and those of others.

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