The Impacts of Technological Change on the Industry - The Case of the Scandinavian cement industry in the 20th century

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Abstract

Purpose of the paper and literature addressed
The aim of the study is to find out the deep reasons for the structural changes in the Scandinavian (including Finland but excluding Iceland) cement industry in 1950-2000. The cement technology has evolved from the wet methods to dry methods. The cement burning technologies in the late 1970s, changed the structure of the U.S. cement industry (Anderson and Tushman, 1990). However, according to some industry specialists the reasons for structural changes at least in the Finnish cement industry have been the large scale plants and the vision of reduced construction activities in Finland (Lehto, 1996). Conceptually our goal is to define how well the modified version of the model suits to our task to identify the impacts of technological change on the Scandinavian cement industry. We also apply the network perspective to industry evolution (Lundgren, 1993, Håkansson and Snehota, 1995).

Research method
To study the actual problem, a technological change in the market, a longitudinal, historical and contextual case was applied. “Pettigrew (1985)” argues that to understand a change one has to study it as a continuing process in the context in which it appears, and he encourages one to adopt contextual and historical perspectives on processes of change.

Findings
The manufacturing of Portland cement in Scandinavia started at the end of the 19th century. The rotary kiln introduced at the end of 19th century changed the manufacturing process dramatically. Later on high energy consuming wet burning processes (raw materials are first mixed in slurry which is first dried and then burnt to clinker) were replaced by dry burning processes (dry raw materials are mixed thus drying is not needed). Several cement manufacturing companies were founded in Scandinavia in the early 20th century. The Scandinavian companies followed the industry development well, partly because of the co-operation with FLS Industries, a Danish cement manufacturing equipment designer and manufacturer. By 1980 all Swedish, Finnish and Norwegian producers used dry manufacturing processes. The average capacity per day of 16 kilns installed in 1960-1980 was 1070 tons a day. In Europe the maximum capacity per a kiln in the early 1980s was 3500 tons per day. Within 26 years (1968-1994) all Swedish, Norwegian and Finnish cement manufacturers were merged under a one company, Cementa. By 1999 four multinational companies owned the Scandinavian manufacturers.

Analysis and Conclusion
The European manufacturers obtained new technology quickly in the 1950s. However, the Scandinavian manufacturers switched not until the 1970s to new, dry technology. The Nordic manufacturers diversified heavily to other industries, which made cement industry less interesting. Moreover, continental manufacturers had got competitive advantage with the new technology. The impacts of the opening of the markets and globalization plus the decrease in demand have to be taken into account in the analysis. The Scandinavian cement industry would be interested to study form the stakeholder point of view. It would be interested to look compare the two industries the Scandinavian cement and flat glass industries.

Keywords: Technological change, industry change, internationalization of an industry

Introduction

Purpose

Since the pioneering work of Schumpeter (1942), research has concentrated on the effects of technological change on industries. The effects are studied in several disciplines, for example in industrial economics, organizational research and population ecology. In this study the research tradition of technological change and its impact on industrial structure is viewed from the point of the emergence of a dominant design (Anderson and Tushman, 1990) and its diffusion within the industry.

The aim of the study is to find out the deep reasons for the structural changes in the Scandinavian (including Finland but excluding Iceland) cement industry in 1950-2000. One reason may have been the manufacturing technology as it was for the Scandinavian flat glass industry. One major change, float glass, in manufacturing technology of flat glass had immense impacts on the Scandinavian flat glass industry in 1960-1990 (Uusitalo, 1997). The cement technology has evolved from the wet methods to dry methods. The cement burning technologies, for instance precalcining in the late 1970s, changed the structure of the U.S. cement industry (Anderson and Tushman, 1990). However, according to some industry specialists the reasons for structural changes at least in the Finnish cement industry have been the large scale plants and the vision of reduced construction activities in Finland (Lehto, 1996).

The remaining part of the paper is organized in the following way: in the next section we briefly describe the theory / literature underlying our study. Here we build on the modified version (Uusitalo, 1995) of the Anderson and Tushman's (1990)'s cyclical model of technological change. Conceptually our goal is to define how well the modified version of the model suits to our task to identify the impacts of technological change on the Scandinavian cement industry. We also apply the network perspective to industry evolution (Lundgren, 1993, Håkansson and Snehota, 1995).

Then we report our case, i.e. the cement manufacturing technology and the evolution of the Scandinavian cement industry. This is based on a longitudinal, historical and contextual case description applying multiple sources of data. After this we analyze the case, where we in particular try to enlighten not only what happened, but also why to, i.e. we try to explain the various recurrences. Finally, we draw conclusions, and discuss implications.

Literature

We apply in our analysis a cyclical model of technological change (see Figure 1, Anderson and Tushman, 1990). First, technology progresses in an irregular pattern, characterized sometimes by incremental and sometimes by major breakthroughs, which advance a technology past its previous limits. Second, these epochal innovations are followed by a period of de-maturity, experimentation and flexibility in R&D. Third, a dominant design or technological paradigm, or technical guidepost emerges, thus establishing the direction of future change along few natural trajectories, until some event triggers another change.

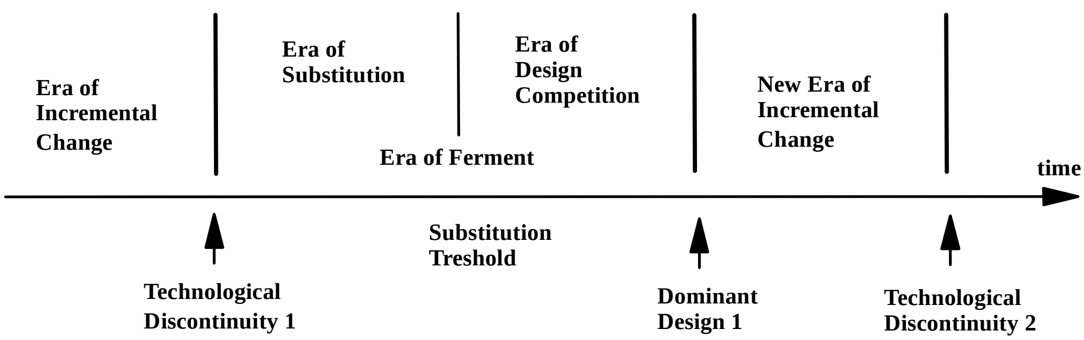

Figure 1. Cyclical model of technological change (Anderson and Tushman, 1990)

Tushman and Anderson characterized technological discontinuities as competence-enhancing (i.e. significantly advancing the state of the art yet build on, or permitting the transfer of, existing know-how and knowledge) or competence-destroying (i.e. significantly advancing the technological frontier, but with a knowledge, skill and competence base that is inconsistent with prior know-how). Uusitalo (1995) redefined three crucial concepts, performance parameter, technological change and dominant design of the original model.

The network perspective to industry evolution is close to the relational dimension of the industry field metaphor. Network theory postulates that industries can be described through sets of interrelated actors performing interconnected activities by employing interdependent and usually heterogeneous resources (Lundgren, 1993, Håkansson and Snehota, 1995).

Actors can be either individuals, groups, organizations, or collectives as a net of firms. As we are specially interested in industrial evolution from a technological perspective Lundgren's (1993) view on industrial networks as "unions" of technological systems and networks of exchange relationships is important. This dualistic view can be further combined with the control aspect of resources through which networks can also be regarded as a form of governance (Håkansson and Johansson, 1993).

A simple but strong way to describe industries is to identify the key actors, assess the resources they possess and the activities they predominantly perform, and the relationships established between actors. This descriptive information indicates the macro characteristics of the network. The following questions and issues provide an idea of the richness of a network description (Uusitalo and Möller, 1997).

- How hierarchically organized is the industry; how many layers of actors can be found in a value-added chain? The hierarchy may also indicate power, as to how the control of resources is dispersed within the industry.
- The relationships between actors and their interdependence describe the density of the network. Highly interdependent and dense networks usually resist the external change. Reorganization or innovation in one part of network demands adjusting actions from interrelated actors.
- Many industries are characterized by competing clusters of actors providing similar end products through different subnets or actors and activities. Clustering of a network reflects the spreading and structure of relationships.

In sum, through a set of relatively sparse constructs network theory strives to provide a constructive description of the contents of industries. This is only a structural aspect of industrial network, however. Another, and more complex, aspect of understanding how industries work is the dynamic processes shaping industrial landscapes. Two macro issues dominate the discussion: technological change including innovation research and change in the governance structures within an industry. Technological change alters the relative value of resources and capabilities of specific actors in the industry influencing also the power structure of actors. Control of resources, which are becoming either more obsolete or more critical, shifts the balance and position of actors.

Governmental actions either through direct regulations or changing the existing balance of power in favour of some actors or revaluing specific resources provides another driving force of change.

Håkansson with his colleagues suggest that network change can be illustrated and analyzed through six fundamental network "patterns" which are based on a firms' behavior (Håkansson and Lundgren, 1995, Håkansson and Henders, 1995). "Specialization" and "generalization" are based on how the activities performed by actors are distributed among firms. Specialization tendency refers to the specialization of firms into certain activities. This process increases the efficiency of firms and the network, but tends to decrease flexibility. Firms wanting to use their resources and capabilities in several application areas provide the counterforce to specialization. This is a generalization tendency within a network.

"Hierarchization" and "extrication" refer to two primary tendencies to control resources. Competition for control of critical resources leads to concentration / hierarchization over time. The companies having less control counteract this. They try to develop alternative technical or organizational solutions to reduce the criticality of hierarchized resources. Extrication is getting rid of resources which are becoming less valuable – to free resources for other applications. "Structuring" and "heterogenization" processes are related to the combining of activities and resources by the firms.

Structuring is the striving to rationalize the use of resources in key activities. It can be recognized in the tendency to standardize both resources and activities. Heterogenizing is a counteracting process depicting firms' innovative behaviour of seeking new solutions that combine activities and resources for carrying out transformation or exchange activities. Generally heterogenizing works within an existing network but large scale innovations may also lead to emergence of a new competing network.

Håkansson and Lundgren (1995) argue that these six network patterns jointly form the "coalecence" and "dissemination" tendencies describing the macro evolution of networks. Coalescence represents strengthening of network structures and works through specialization, structuring and hierarchization; dissemination refers to the breaking up of network structure and is related to radical change. Network theory is supported with constructs from technological studies, especially the dominant design research (Anderson and Tushman, 1990).

Research method

To study the actual problem, a technological change in the market, a longitudinal, historical and contextual case was applied. “Pettigrew (1985)” argues that to understand a change one has to study it as a continuing process in the context in which it appears, and he encourages one to adopt contextual and historical perspectives on processes of change. A holistic case study is practically possible, since there has been or is limited number of companies (around ten), in the industry. In a case study the most important is the depth of the analysis, both in terms of the number of factors studied and sources of information used “(Yin, 1984)”. To accumulate knowledge our research process had both inductive and deductive phases as suggested by “Eisenhardt (1989)”. Triangulation was also used “(Jick, 1979)” to construct case studies from a variety of information sources. Main data sources are company and industry histories, industry trade journals, key persons’ interviews (persons from the 1970s, 1980s and 1990s can still be reached), archival records and industry statistics.

The Cement Industry in Scandinavia in 1950-2000

The manufacturing of Portland cement in Scandinavia (including Finland) started at the end of the 19th century. The rotary kiln introduced at the end of 19th century changed the manufacturing process dramatically. It was a big step ahead. Later on high energy consuming wet burning processes (raw materials are first mixed in slurry which is first dried and then burnt to clinker) were replaced by dry burning processes (dry raw materials are mixed thus drying is not needed).

Suspension preheater technology, a new dry cement manufacturing process, was developed in Europe in the 1930s. This fuel saving but a bit higher labor costs requiring technology was introduced in the European cement industry in 1951 and Japanese manufacturers invested in the suspension preheater technology and new plants in 1950s and 1960s. (Duda, 1985). By 1966 totally 285 kilns (excluding the US) operated with the preheating technology delivered by six European manufactures. The European manufacturers adopted quickly this new energy saving technology. The Scandinavian cement industry also switched from original dry processes to suspension preheaters (4 stage cyclones) and pre-calciners. The raw material moisture content, the desired alkali content of the final clinker and the suitability of raw material for preheating and pre-calcining had affected or affect the choice between wet and dry burning processes. (Duda, 1985).

Several cement manufacturing companies were founded in Scandinavia in early 20th century. The rotary kiln was introduced in Denmark in 1899, in Sweden in 1908, in Finland 1914 and 1918 in Norway. The Scandinavian companies followed the industry development well. One reason for this has been the co-operation with FLS Industries, a Danish cement manufacturing equipment designer and manufacturer.

In Denmark the largest manufacturer, Aalborg, invested in 1972 in a wet process. That time it had five kilns operating in wet processes. In 1981 in Norway both wet and dry processes were used. In 1950-1980 totally 32 new rotary kilns were installed in four countries in question. In the early 1950s the maximum capacity per a kiln was 500 ton per day and in the mid 1960s 1800 tons a day and in the early 1970s 2500 ton a day. The average capacity per day of 16 kilns installed in 1960-1980 was 1070 tons a day. In Europe the maximum capacity per a kiln in the early 1980s was 3500 tons per day. The latest technology was also available for the Scandinavian companies. In 1973 Scancem, the only producer in Sweden, had in seven plants 24 kilns of which around 40 percent were operating on dry process. In 1981 the company had only six kilns in three plants and all the production was made with the dry process. Two Finnish cement manufactures, Lohja and Paraisten Kalkkivuori (later Partek), introduced dry processes in 1972 and 1975, respectively. In 1977 Partek had ceased production in all its five wet process kilns.

After the II WW the local national cement manufacturers served domestic customers (see Table 1). The demand for cement increased steadily from the mid 1940s to the mid 1970s. The oil crisis hit the industry in 1973 and in 1982. During the research period several fre trade agreements have been signed. In 1960 EFTA (European Free Trade Area) was signed between for instance by the UK, Sweden, Norway and Finland (as an outside member). In 1973 Denmark and the UK joined the European Commission (EC). The UK kept also the free trade agreement with EFTA countries. In 1992 the EU and EFTA countries made a free trade agreement of 18 countries. In 1995, the fourth enlargement of the EU took place with the accession of Austria, Finland and Sweden. The Europe of the Fifteen was born.

Table 1. The Scandinavian cement manufacturers in 1965

Country	Company	Founded	Plant locations	Kilns
Sweden	Cementa	1870	Limhamn	3
			Hellekis	4
			Slite	4
			Köping	2
			Stora Vika	2
	Gullhogen	1914	Skovde	5
			Degerhamn	2
Denmark	Aalborg Portland	1890	Rordal	9
			Danmark	1
			Dania	3
			Kalsrup	1
	Dansk Andels Cement	1915	Lindholm	4
Norway	Christiania Portland	1892	Slemmestad	3
	Dalen Protland	1916	Dalen	3
	Nordland Portland	1918	Kjopsvik	1
Finland	Paraisten Kalkki	1914	Parainen	2
			Lappeenranta	1
			Kolari	1
	Lohja	1919	Lohja	4

Since the 1950s a lot of merges and restructuring have taken place. In the 1960s there were two cement manufacturers, Aalborg Portland (plants in Rordal, Danmark, Dania and Karlsrup) and Dansk Andels Cement (plant in Lindholm). In the mid 1975 Aalborg Portland closed Danmark, Dania and Karlsrup plants and in 1978 Dansk Andels Cement withdrew from the industry. In 1968 Norcem was formed by the merger of Norway's three existing cement works in Slemmerstad, Dalen and Kjopsvik. In the early 1980s Norcem's capacity was 2.3 million tons and it was one of the largest exporters of cement in the Western Europe. In 1973 the Swedish cement manufaturers, Gullhögen and Cementa, were merged under Scancem. In 1986 Scancem and Norcem merged under the name of Scancem. In 1988 Scancem and the Norwegian Aker acquired the second largest cement manufacturer in the UK, Castle Cement, which and 25 % market share and capacity of 4 million tons. The Swedish market was that time 1.9 million tons. In 1990 the companies bought the largest Spanish cement manufacturer, Valenciana (capacity of 6.6 million tons). The early 1990s was hard time for Scancem and its international subsidiaries. Valenciana was sold in 1993.

Lohja and Partek had one had one third and two thirds of the Finnish market, respectively. In the 1950s the Finnish cement manufacturers had decided to enter other construction material industries such as concrete, concrete pipes, concrete building elements and insulations. In the 1970s the Finnish cement manufacturers diversified in the metal, machinery and electronic industries to lessen their dependence on the domestic construction business. The Finnish companies also looked the export market, but not for cement. In 1980 Partek and Norcem founded an export company to find out the export of cement to Africa was not profitable. In Finland the merge of the two manufacturers took long time. After 20 years of negotiation in 1993 Partek Cement, the cement division of Partek, and Lohja were merged into Finnsementti. Manufacturing continued in two areas, Lappeenranta and Parainen. Lohja plant was closed. Finsementti was again merged into the Swedish Scancem. Scancem was owned by a large Swedish construction company, Skanska and a Norwegian Aker. (Smeds, 1998)

In 1999 two large multinational companies acquired the businesses and plants of the traditional Scandinavian companies. Scancem once owning all Norwegian, Finnish and Swedish cement plants was split in two parts. Finnsementti operating in Finland was sold to the Irish CRH concern and the Norwegian and Swedish operations went to the German Heidelberger Zement Group. Aalborg Portland A/S in Denmark is jointly owned by FLS Industries, a Danish, well known cement manufacturing equipment designer and manufacturer, which holds one 50% share, and by Blue Circle Industries PLC, UK, which also holds another 50% share.

Analysis and Conclusions

Since our results are at the moment very preliminary we are not able to assess the impact of technological changes on the structure. The impacts are not as dramatic as was expected based on the evolution of the Scandinavian flat glass industry. Unlike float glass in the flat glass industry there was not any particular technology (that is the suspension preheater) that was immediately clearly the best one. The suspension preheater technology was adopted earlier and more quickly in the Continental Europe than in Scandinavia. It became a dominant design (more than 50 percent of the sales of new kilns in three consecutive years had the suspension technology) there soon. The technology increased the capacities and efficiency of the European kilns, which made the export from Scandinavia more difficult.

Håkansson and Lungdren (1995, p. 304) suggest that coalescence represents the strengthening of specific network structures and is most often associated with a conservative technological change. Dissemination implies the breaking up of certain network structures and is most often associated with more radical changes.

The dry cement manufacturing (suspension preheater) process was for the Scandinavian cement industry as a conservative technological change and not a radical one. The Scandinavian manufacturers used for a long time wet processes. The companies invested in 1950-1980 several new kilns. The companies also could increase the capacities of the kilns and thus exploit the economies of scale. Along with the macro environmental changes such as the opening of the market, internationalization of industries and oil crisis strengthened the further coalescence started by the European manufacturers. Moreover, the diversification of the Scandinavian cement manufacturers to other building materials and machinery lowered the specialization of them on cement. The impact of a technological change seems to have been weak.

As was mentioned the case of float glass innovation in the Scandinavian sheet glass industry was different. Float glass was radical or even revolutionary. The sheet glass network, which was at the beginning as heterogenized as the cement net, went through dissemination as a result of the radical float glass innovation, as proposed by Håkansson and Lundgren. The float made the traditional way of producing sheet obsolete, the innovation was competence destroying.

The Scandinavian cement industry would be interested to study form the stakeholder point of view. It would be interested to compare the two industries the Scandinavian cement and flat glass industries more in detail.

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