

Environmental adaptation, technology development and competition

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Introduction

The Swedish forest industry is of great importance to the Swedish economy and accounts for 11 percent of the total export value out of which the pulp and paper industry accounts for the main part, approximately 70 percent. Sweden is moreover today the third largest producer of pulp and paper in Europe, and the seventh largest producer in the world (Bergquist & Söderholm, 2011). About four decades ago, however, the situation for the Swedish manufacturing industries, including the pulp and paper industry, were critical and called for an urgent industrial renewal based on new technology and know-how to regain competitiveness. These problems came to surface due to increased competition on the international market after the 1960s, but the problems were also structural in its nature (Gårdlund, 1985). At the same time, a new regulation; the Environmental Protection Act was launched in 1969 which put additional pressure on industry to transform.

In this paper we examine how a single individual mill, the sulphite pulp producer, Domsjö sulphite mill with its company MoDo, on a long term basis adapted to the transformation pressure from increasing international competition and national environmental regulation during the 1960s to the 1990s. In the seminal works of Michael E Porter, it is suggested that there might be a “win-win” situation due to the dynamic effects caused by pressure induced by environmental regulations. This is known as the “Porter hypothesis”. In our paper we, through the perspective of the individual company, examine whether the environmental regulation facilitated the transformation process of the Swedish pulp and paper industry during the 1970s and onwards or whether environmental regulation instead obstructed or worsened the ability for industry to transform. We specifically direct focus on the in-house and collaborative R&D activities in achieving technological progress and

industrial renewing. We examine to what extent the R&D activities were coordinated between problems that was environmental in nature with other R&D activities aiming at production efficiency goals or new products. By doing this, our study contributes to an understanding for what extent the environmental adaptation process interplayed with the overall transformation processes in the Swedish pulp and paper industry from the late 1960s to the 1990s.

Background and previous research

Modern environmental regulation has put new restrictions for the business development. During the last four decades, market pressure has moreover interplayed with regulation as a driver towards greener production processes and products. This development essentially took off in the late 1960s, with the rise of the environmental movement and implementation of environmental regulation frameworks. Scholars have approached this development within several disciplines, such as within economics, business administration and political science. Research on the field has, to say the least, become extensive. One explanation ought to be the high policy relevance from research dealing with the interplay between economic development, environmental degradation and policy measures. Today, the climate change issue attracts the biggest attention, which due to its close connection to the energy system and economic growth has been of interests to economic historians (e.g. Lindmark, 2004; Kander & Lindmark, 2004; Gales et.al. 2007). Still, the interest among business historians is rather modest, which was pointed out by Rosen and Sellers already in 1999 in a special issue in *Business History Review* (Rosen & Sellers, 1999, see also Rosen 2005). Research overviews in more recent studies (Lindmark & Bergquist, 2008; Sluyterman, 2010; Söderholm & Bergquist, 2011) points to the same: not much has happened during the last decade. We find this unfortunate since business historians can contribute to a deeper understanding of the dynamics between business development, environmental pressure and institutional change, not the least by revealing motives behind (and changes of) business strategies in dealing with the environment and the causality between market pressure, environmental regulation and the performance of firms.

Looking at the Swedish case, estimates by Lindmark (1999) shows that Sweden experienced a period of substantial emission reductions after the 1960s, this after a century-long period of increasing emission levels. Bergquist (2007) furthermore reports that hazardous emissions from the 1000 biggest and most polluting industrial facilities were overall reduced by more than 70 percent during the 1970s and the 80s. We find that it is important with an in-depth analysis of this shift since it indicates a process in which production became more resource efficient and at the same time less environmentally damaging. As mentioned by Ekins (1997), less environmentally damaging production

can in the long run be traced to technological change and progress. It has also proved to be a central determinant of emission reductions in Sweden during the 20th century (Kander & Lindmark, 2004).

The Swedish manufacturing industries experienced an overall transformation pressure in the late 1960s and entered into a crisis in the 1970s, mainly triggered by the two oil crises but also ultimately driven by structural factors (Dahmén, 1980, 1988; Schön, 2002; Storm, 2007). Moreover, this was also the period of a radical environmental debate (Sörlin, 1992), which in combination with new environmental regulations and the energy crises saw the rise of a new institutional environment for the polluting and energy-intensive industries. Schön (2007) suggests that the uprising environmental issue illustrates an important component of the structural transition in the 1970s, not the least with the increased need of new know-how on how to accomplish economic growth with less energy and material use.

One central and long-term driver for pollution reduction in the Swedish industry was the implementation of the Environmental Protection Act (EPA) in 1969 (e.g., Lundqvist, 1980). Besides stipulating emission limits, previous studies suggest that the EPA imposed additional costs, not the least for the pulp and paper industry (Facht, 1976), but also that it induced significant innovation activities in order to comply with the targets (Lindmark & Bergquist, 2008; Bergquist & Söderholm, 2012). As the costs for complying with the environmental regulation were borne by the polluter (in line with the Polluter Pays Principle), the damages caused by pollution became largely internalised in the overall costs of Swedish industrial production. According to the environmental economics literature (e.g., Palmer et. al., 1995) a strict environmental policy imposes costs for companies, something which affects their competitiveness and hence, in the end, will imply negative economic impacts such as lower employment rates. This traditional view has, however, been challenged by the seminal works of Michael E Porter, who suggests that there might be a “win-win” situation due to the dynamic effects caused by pressure induced by environmental regulations. This is known as the “Porter hypothesis” (Porter, 1991; Porter & van der Linde, 1995).

The idea of the “Porter hypothesis” is related to the long-running discussion on the pressure on companies to develop and transform. The hypothesis can be traced back to Schumpeter (1939) and, among others, the works of the Swedish economist Erik Dahmén (1950, 1988). At the core, Porter argues that that environmental regulation (if it has the right kind of design) affects the information held by firms and thus makes firms realise new opportunities for improved productivity and efficiency. The pressure from a strict and properly designed environmental regulation might, according to this line of reasoning, foster innovative solutions that fully or partly mitigate environmental investment costs.

It has been suggested that the long-term co-operative strategy to the structural problems of the Swedish manufacturing industry during the 1970s, facilitated environmental adaptation in the Swedish economy (Jänicke, 1992). The new environmental regulation implemented in 1969 required far-reaching and long term measures to mitigate emissions at the level of polluting firms. Our previous studies (see e.g. Söderholm & Bergquist, 2012) have indicated a strong importance of inter-firm collaboration for accomplishing green technology development within the business sector, especially in the 1960s and 70s. An important and comprehensive question related to these activities, but which requires a micro perspective in the analysis, is whether the environmental issue overall formed an important priority for the industrial renewing; to get an idea of this you preferably focus on strategy plans and R&D activities of the individual firm. The following questions will be used as guidance to understand this issue through the activities of MoDo concerning Domsjö sulphite mill in the late 1960s to 1990:

- To what extent was environmentally related R&D and investments coordinated with technical change aimed at improved energy and material efficiency as well as with economic goals such as productivity, cost reductions and product development?
- How were these goals formulated in long-term business strategy plans and within R&D projects? Were strategies co-ordinated between firms in the line of business?

The Swedish pulp and paper industry and MoDo: a short background

Pulp and paper production started on a larger scale in Sweden in the end of the 19th century and formed an important component of the Swedish industrialization. In its initial phase, the industry sector was typically dominated by small paper mills, often with integrated production of pulp and paper. As the demand for paper grew stronger, a large number of saw mill companies established in the northern part of Sweden started to produce pulp. The production in the north was designed for export on the international market, such as the United States, Great Britain and Germany (Melander, 1997). The major player in the north region was MoDo, a company owned by the Kempe family who as far back as in 1779 started a small saw mill business, and later, in the years of 1902-03, established a sulphite pulp plant in Domsjö, close to the northern town Örnsköldsvik.

At the initial phase, the Domsjö pulp plant had the capacity to produce 6000 tons of pulp, but in time for the Second World War the production capacity had expanded to 80 000 tons per year. Up until the 1960s, the production was diversified, with production of viscose, chloralkali, alcohol, and wallboard (Gårdlund, 1986 pp. 1-30). At the same time MoDo had grown into a multinational

company engaged in forestry, sawmill industry, chemical industry and, at the heart of the business, pulp and paper production.

During the post-war era and the forthcoming decades, sales of pulp were totally dominating for the business of MoDo. This also implied a vulnerability to competition and price changes on the world market. In the 1960s, the domestic price of wood was increasing in relation to the competing countries, which put a pressure on the Swedish pulp producers, including MoDo, to cut their production costs. At the same time, the US market, which earlier counted for one third of MoDo:s exports, had more or less disappeared due to competition from the North American producers. Moreover, US- and Canadian producers expanded on the European market which put even more pressure on the Swedish producers to cut their costs.

Concerning the Swedish economy in general, signs of economic recession emerged in the mid-1960s due to increasing international competition. Sweden did not participate in the Second World War and had therefore competitive advantages towards other European countries in the 1940s and 50s. However, during the 1960s, other countries were catching up and at the same time the Swedish costs for labor were increasing faster relatively Europe in general. As a response to this upcoming crisis, MoDo as well as other bigger Swedish forest companies were forced to employ new strategies to increase scale and diversify the production to reach new (and more stable) markets (Gårdlund, 1986 p. 148). This strategic diversion of production called for big investments in R&D, marketing and new machinery. However, the crisis was indeed structural, and to increase scale, the whole industry sector was concentrated which involved shut-downs of inefficient plants. Between 1960 and 1980 the number of Swedish pulp plants decreased from 110 to 35 while production increased by 74 percent (Söderholm & Bergquist, 2012).

One of the more costly upcoming changes was the demand on environmental investments followed by the EAct implemented in 1969. The EAct was based on case-by-case judgments of every individual production unit engaged in polluting activities. The individual permits were administrated by the Franchise Board of Environmental Protection (FBEP), a quasi-judicial court which also was established in 1969. The Swedish Environmental Protection Agency (SEPA) had been founded a few years earlier, in 1967, and became a unified body for almost the entire area covered by the EAct (for a detailed survey of the environmental policy development and new bodies, see e.g. Söderholm & Bergquist, 2012; Lundgren, 2005; Lundqvist, 1980). The basic principal for regulating the industrial pollution (according to the EAct) was that emission standards were negotiated with each industry, sometimes over extended periods of time, taking into account such parameters as local environmental impact, possibilities for technological development and not least the long-term

competitiveness. The strategy practiced among the Swedish environmental authorities was that the individual permits should be based on performance rather than technology standards. Any identified problems meant that the activity could be closed down or expansion plans cancelled (Söderholm & Bergquist, 2012).

It is recognized that the stricter environmental regulation in the late 1960s contributed to a phase out of sulphite pulp mills in Sweden (Söderholm & Bergquist, 2012). Calcium-based sulphite mills had many environmental disadvantages in terms of their discharges of Biochemical Oxygen Demand, lignin, gases and dust, which required radical external purification works. Pulp producers therefore strategically aimed for production expansion based on the adoption of the sulphate process, which had the potential to recover chemicals and at the same time generate electricity. Structural rationalization did, however, only mitigate some of the environmental problems and the Swedish pulp and paper producers invested heavily to curtail the remaining problems. The costs for environmental investments, based on the Swedish forest industry's questionnaire data, accounted for 9-14 percent of total industry investments in the 1970s and 1980s. Over 60 percent of these investment costs involved internal process changes aiming for decreased wastewater and improved chemical and fibre recycling, while about 14% of the costs concerned external wastewater purification measures. The cost share for air-purification measures only amounted to 15 per cent (Söderholm & Bergquist, 2012).

Even though MoDo had made important investments in the 1950s and 60s that had cut some emissions substantially, this case will show how the new regulation enforced more wide-ranging process changes and investments at higher costs. Furthermore, the new regulation implied costs for the technical and administrative personals at the plant level dealing with planning, negotiations (with the authorities) and implementation of the regulation at the plant level (Gårdlund, 1986 p. 150). In the remaining part of this study we will focus on the implications of the enforcements of the EAct on Domsjö sulphite mill in the 1970s to the early 1990s and the strategies carried through by the company (MoDo) for compliance. We will especially investigate how environmental R&D and investments was coordinated with the overall need for productive investments to improve the competitiveness of the firm. The empirical investigation is moreover focused on emissions to water. This is motivated since water emissions was the most critical, research intensive and costly problem to solve. Our survey does thereby not represent a complete investigation of all aspects related to Domsjö sulphite mill and the environment over the investigated period, but indeed some core problems. The source material underpinning our study is mainly based on company board minutes and archive materials from the lengthy licensing process under the EAct that the company was involved in over the investigated period.

Domsjö sulphite mill

In hindsight, the management of Domsjö sulphite mill has typified the 1970s as a decade “strongly characterized by environmental improvement measures.”¹ In this context, they mention two sedimentation basins completed in 1972 and a new bleach plant that went operational in May 1976, at which discharges from the bleach plant were cut in half by changing the order of bleaching stages. Also mentioned is a new control system for sulphite cooking, which both improved pulp quality and reduced the quantity of bleaching chemicals.² Given the fact that the company was subject to a licensing process under the EAct essentially throughout the 1970s and was not granted a permit until 1980, it is remarkable that these environmental investments were even made.

Let us begin in April 1971 when the MoDo board made a policy decision to expand the Domsjö sulphite mill to an annual capacity of 300,000 tons.³ The decision was consistent with the company’s ambitions to invest its way out of the crisis that had been exacerbated by squeezed pulp prices since the transformation of the US, starting in the 1950s, from a leading export market to a leading competitor.⁴ When the company in the fall of 1971 began compiling the application forms for the licensing process under the EAct due to the wish to expand the capacity at Domsjö sulphite mill, the technical director at MoDo, Axel Scholander, compiled a text which gives us a picture of how the environmental issue recently had grown in importance and how prominent figures in the Swedish pulp and paper industry thought about it. The document, titled “Mo and Domsjö AB in the 1970s” was presented to the MoDo board when it met in January 1972.⁵ In the introduction, Scholander points out that the paper was largely his personal take on what conditions and developments were ahead for the pulp and paper industry in the 1970s. Environmental protection aspects are given considerable attention in the document and Scholander expresses himself as follows:

“The environmental protection discussion, referring to the natural environment – water, air, noise, ecological disruptions – has primarily become a discussion among youth and politicians. Fears about mankind’s future living environment and the genetic legacy are so strong that counter arguments of

¹ Domsjö sulfitfabrik 90 år. En bildkavalkad 1903-1993, 14.

² Ibid.

³ MoDo styrelseprotokoll 2/4 1971 § 588 (Brux, Örnsköldsvik).

⁴ Gårdlund, 1986, 64f.

⁵ “Mo och Domsjö under 70-talet” av Axel Scholander den 25/10 1971, bilaga till MoDo styrelseprotokoll 14-15/1 1972 (Brux, Örnsköldsvik).

an economic nature will never be accepted – although it may be possible to adapt the rate of environmental protection work to economic realities. We are going to experience a global movement in this area because it is essentially politically non-partisan and must be accepted by all politicians worldwide. It will become as politically absurd to oppose environmental protection as it would be to oppose health care, elderly care, retirement pensions, or measures to reduce unemployment.”

Concerning MoDo, Scholander wrote:

“The environmental protection element of MoDo’s investments is something we are expecting to increase and preferably – if we can manage it – with at least five years’ advance planning ahead of more rigorous government standards. This is going to impact our “productive” build-up rate.

Environmental protection aspects may also lead to restructuring on both the production and consumptions sides; to the decline of the sulphite industry (serious water and air pollution that can only be prevented through high capital and operating costs that squeeze out sulphite in favor of kraft); high retooling costs in the kraft pulp industry to avoid odor problems and water pollution (sulfur-free cooking, oxygen bleaching). This may bring positive effects on the consumption side because cellulose materials are easily biodegradable and thus environmentally friendly.”⁶

Although Scholander assumed that the environmental protection aspects might lead to the downturn of the sulphite industry, the MoDo board decided to invest in sedimentation basins at Domsjö sulphite mill. Those were emphasized as a key action to reduce discharges in the application the company filed with FBEP in December 1971 for current (225,000 tons) and expanded (to 300,000 tons) operations at Domsjö sulphite mill. The board probably thought they might as well invest in sedimentation basins because they would soon be required to do so by the environmental protection authorities anyway. Another likely explanation behind the investment is the fact that the company was able, during the board meeting in December 1971, to confirm that the Swedish government had presented a bill for the parliament calling for a 75 percent subsidy of investments in environmental protection,⁷ for which the company also resolved to apply for “to the greatest extent possible.”⁸

Continued low pulp prices combined with the difficult raw materials situation led the board to decide in June 1972 to appoint a committee to study the conditions for the proposed production expansion at Domsjö. The committee was to work according to three main alternatives: expansion, integration,

⁶ Ibid.

⁷ ”På grund av rådande sysselsättningskonjunktur” bilaga 10b, MoDo styrelseprotokoll 29/2 1972 (Brux, Örnsköldsvik).

⁸ MoDo styrelseprotokoll 16/12 1971 § 32 (Brux, Örnsköldsvik). The sedimentation basins were finished as early as in 1972, and had the capacity to return 1,000 tons of fiber to production (Domsjö sulfitefabrik 90 år. En bildkavalkad 1903-1993, 15).

or shutdown.⁹ A final report was presented in 1975, concluding that it should be possible to rebuild or expand the Domsjö sulphite mill while maintaining the current quality orientation and satisfactory earnings trends.¹⁰

In the fall of 1973, the Swedish government decided to also subject Domsjö sulphite mill to a site approval process under §136(a) of the Planning and Building Act. The MoDo board expected this to delay the licensing process by at least six months. They further believed the site approval process to entail restrictions to the planned capacity expansion.¹¹ The delay turned out to last for several years, but in no way meant that the licensing trial process was at a standstill or that the company just twiddled its thumbs while waiting for the final standards to be set. One proof of this is that after SEPA had made it clear that the agency could not approve the expansion without more comprehensive measures than had thus far been taken - among else, SEPA recommended that the wash effect after the cooking plant needed to be immediately raised to 96% - the company immediately performed cost/benefit analysis and applied for a SEPA grant for investments in filter washing. SEPA approved a grant of more than 40 percent of the cost and parts of the project were in test operation 18 months later.¹²

At a meeting in February 1974 the MoDo board stated that the case was progressing, albeit slowly and in constant interaction with SEPA, which was successively increasing its demands. At the same time, the board noted that government environmental protection grants had made it possible for the company to partially meet the demands. The board also noted that the government's decision, which it found "surprising," to simultaneously subject the mill to a site approval process had made the basis for planning unwieldy, especially in reference to the bleach plant, which the company intended to eventually replace. At that point, operating and maintenance costs were relatively high for the bleach plant and if the expansion of the Domsjö sulphite mill were to be postponed, the board determined that these costs would remain for many years.¹³ Moreover, the company was forced in the fall of 1974 to suspend the chemical recycling project it had undertaken through the application to develop at the mill. The reason was that a new method – black liquor neutralization – was under

⁹ MoDo styrelseprotokoll 12-13/1 1973 § 820 (Brux, Örnköldsvik).

¹⁰ MoDo styrelseprotokoll 23-24/1 1976 § 144 (Brux, Örnköldsvik).

¹¹ MoDo styrelseprotokoll 22/10 1973 § 141 (Brux, Örnköldsvik).

¹² PM angående ökade utbetalningar för projektet 'filtertvätt' vid Domsjö sulfittfabrik 29/5 1975, bilaga till styrelseprotokoll 16/6 1975 (Brux, Örnköldsvik).

¹³ PM beträffande Domsjö sulfittfabriks blekeri, 22/2 1974, bilaga till styrelseprotokoll 18-19 /1 1974 (Brux, Örnköldsvik).

development that would further increase recycling. The method was already being tested at Domsjö and other pulp mills in Sweden and the board concluded that it would be recommended by SEPA.¹⁴ This is a suitable place to discuss the extensive internal R&D capacity that the company had available for many years and which may help explain why the company had already begun testing the new method at the Domsjö sulphite mill.

R&D at MoDo – an overview

R&D at MoDo's three pulp mills was decentralized until the 1940s and supported by small operational labs, although development work often took place on a plant scale. Production at Domsjö was oriented early on towards specialty pulp qualities, with great interest devoted to the production of viscose pulp. The viscose pulp puts greater demands on the manufacturing process than other pulps and R&D was needed for control and development. Hence, R&D was early on extensive at the Domsjö unit. In the late 1930s, development was directed by the production manager jointly with a couple of engineers and operational lab staff. Attempts to use birch wood as a raw material in the kraft process began in the 1940s at Husum, one of the company's other pulp mills. Since bleaching with chlorine dioxide was one of the prerequisites for attaining this goal, development efforts were initiated at the R&D lab in the early 1940s to produce the new bleaching agent chlorine dioxide.¹⁵ The development work was fruitful and the Husum bleach plant was equipped for chlorine dioxide bleaching in the late 1940s, followed by the Domsjö sulphite mill just a few years later.¹⁶ This was a method that would three or four decades later come to play a key role in environmental efforts, especially because chlorine dioxide bleaching reduced the AOX and dioxin load in wastewater relative to chlorine bleaching.

By the early 1950s, the company's R&D had been largely centralized to the Domsjö area, with about 70 employees in shared premises with laboratory space and for tests on a semi-technical scale. At this point, development was focused heavily on problems related to the use of calcium as a base for sulphite pulp production, such as encrustation and raw materials restrictions, since pine wood could

¹⁴ PM angående kemikalieåtervinning och tunnllutsneutralisering vid Domsjö sulfitfabrik 25/9 1974, bilaga till styrelseprotokoll 17/10 1974 (Brux, Örnsköldsvik).

¹⁵ Gårdlund, 1986, 116.

¹⁶ Gårdlund, 1986, 38.

not be used with a calcium base.¹⁷ This work was soon oriented, partly in cooperation with other companies, towards the use of other bases and it proved that use of a sodium base both made it possible to switch woods and improved the quality of the pulp. Accordingly, the base was switched at the Domsjö sulphite mill in the summer of 1959. The use of sodium base furthermore reduced discharges, since black liquor recovery was improved and part of the sulfur was returned to the process.¹⁸ In the 1960s, when staff at the company's research labs had increased to about 100 people, R&D was oriented towards further improving sulfur recovery, now through flue gas washing with scrubbers. In addition to recycling sulfur, recovering heat from the flue gases was an important driver of this work.¹⁹ After having tested the devices on a lab scale, the first scrubber was installed at Domsjö in 1963.²⁰ When the acidification problem was brought to light at the national and international level a few years later, scrubber technology became an accepted environmental improvement measure in the context.

During the late 1960s, R&D at the company was oriented towards another chemical recovery measure that would also play a central role in future environmental effort – the oxygen bleaching technique – which saved half the chlorine and sharply reduced discharges of organic substances from the bleaching process. This was not an entirely new technique, but MoDo, working together with the chemical manufacturer, Canadian Industries Ltd, and machinery manufacturer, Sunds Ab, played a significant role in developing the technique to make it useable on plant scale. For various reasons, the first full-scale oxygen bleaching system was not built at any of the company's mills, but rather at ASPA in 1973. MoDo's R&D staff however made strong contributions to putting the ASPA system into operation. Oxygen bleaching was introduced at Husum in 1977 and eventually at Domsjö as well (see below).²¹

The 1970s - continued

SEPA maintained a tough approach in the license trial process over the second half of the 1970s and based it on two main aspects linked to the fact that the company's discharge area was in the

¹⁷ The viscose pulp required a lot of wood and the company needed the ability to utilize pinewood (Interview with Ronald Gustavsson, environmental manager at Domsjö sulphite mill in the 1970s and 1980s, Östanå, Sweden, June 14, 2012).

¹⁸ Gårdlund, 1986, 117-118.

¹⁹ Gårdlund, 1986, 118.

²⁰ Domsjö sulfitfabrik 90 år. En bildkavalkad 1903-1993.

²¹ Gårdlund, 1986, 116-119.

Örnsköldsvik Bay, which is connected to the Baltic Sea: 1) The 1974 Convention on the Protection of the Marine Environment of the Baltic Sea Area, which SEPA had committed to comply with, and 2) Örnsköldsvik Bay itself, which bore a heavy recipient load. SEPA referred to this as the short-term aspect of the problem and pointed out that there was also a long-term aspect, wherein the toxic substances found in wastewater discharges from the chlorine phase of the bleach plant were currently being studied in a joint project among the Nordic countries. SEPA stated that it was not yet clear what effects these waste discharges had, but it was possible that they had impact on vital processes and might accumulate in organisms.²² – What we see here is the opening salvo of the debate on the toxic effects of bleach plant wastewater that would culminate in the dioxin scare 10 years later. In turn, company representatives argued that there was no reason to take "baseless" risks into account:

"They [SEPA] have a general sense that there are risks. But they cannot claim that they have well-founded reason to assume that there are risks associated with the discharges. Until we have made further progress, there is hardly reason to take these risks into account."²³

In response, SEPA replied that it would probably take time to study the issue of how wastewater from the chlorine phase could be treated to remove the toxic part of the whole: "This is probably not a measure that will be carried out before 1980."²⁴ SEPA would not yet specify any conditions, but nevertheless argued that the company should be ordered to continue efforts to develop methods for treating its wastewater. In this context, SEPA argued heavily in favor of external treatment of bleach plant wastewater and for a biological waste treatment plant.²⁵ Nils Jirvall, a SEPA representative, made a statement related to the fact that the agency was in favor of an external measure, rather than an internal one:

²² Protokoll 11/12 1975, s 11ff, Koncessionsnämnden för miljöskydd, Dnr Ö 9/75, aktbilaga 34, och Dnr Ä 107/71, aktbilaga 42. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:39, Doss. 84-101 (Länsarkivet, Härnösand).

²³ Protokoll 11/12 1975, s 13, Koncessionsnämnden för miljöskydd, Dnr Ö 9/75, aktbilaga 34, och Dnr Ä 107/71, aktbilaga 42. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:39, Doss. 84-101 (Länsarkivet, Härnösand).

²⁴ Protokoll 11/12 1975, s 17, Koncessionsnämnden för miljöskydd, Dnr Ö 9/75, aktbilaga 34, och Dnr Ä 107/71, aktbilaga 42. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:39, Doss. 84-101 (Länsarkivet, Härnösand).

²⁵ Protokoll 11/12 1975, s 16ff, Koncessionsnämnden för miljöskydd, Dnr Ö 9/75, aktbilaga 34, och Dnr Ä 107/71, aktbilaga 42. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:39, Doss. 84-101 (Länsarkivet, Härnösand).

"We [the Environmental Protection Agency] believe we have taken the right initiative in Sweden by concentrating on internal measures. I do not want to deny the merits and the benefit of the company's in many respects pioneering activities. This is a completely appropriate initiative, but I am also convinced that it will not lead to a total solution to the problem. The external methods we believe must come to pass will be much cheaper than they would have been if no internal measures were taken. Things are progressing very quickly, but we cannot sit and wait for tomorrow's technology to be ready, because then we will get nothing. In addition to the internal measures, we believe the right thing to do would be to focus on external treatment of the bleach plant and to include this and enclose the whole in a biological treatment plant. If this is successful, we will reduce pollutant volumes for BS7 and toxic substances and then you could say that the environmental protection problems in the forest industry would essentially be solved."²⁶

FBEP decided in April 1976, in accordance with SEPA's motions, to order the company to study: 1) biological treatment of all polluted wastewater from the mill or of certain heavily polluted substreams, and 2) treatment of chlorine-containing bleach plant wastewater that would enable destruction or return of pollutants to the liquor system.²⁷ The company was given a couple of years to perform the studies and submit their reports. The fact is that the company already several years earlier had begun to study biological treatment of wastewater, among else in cooperation with Vattenbyggnadsbyrån, a consultancy firm. It is likely that the company had already received an informal request by SEPA to do so. The company had thus commenced attempts in 1974 to treat wastewater from the sulphite mill together with municipal wastewater in the nearby municipal treatment plant. Full-scale tests were initiated after the FBEP decision. During the test period, however, problems arose with sludge that was difficult to dewater. The management of the municipal treatment plant believed these problems were caused by the wash water from the mill and the municipality subsequently refused to permit further tests. In parallel with these tests, the company was also testing biological treatment on a lab scale in cooperation with an engineering firm, Orrje & Co. These tests showed that the studied wastewater was biodegradable, but that treatment was impossible in an aerobic pool because there were no available land areas and due to the high BS content of the water. Instead, the company stated in a 1978 report to FBEP that it might be possible to perform the biological treatment using the Deep Shaft method, where the biodegradation takes place under high hydrostatic pressure in a shaft in the ground at about 100 meters depth. The company had studied the method in cooperation with the British chemical group 'Imperial Chemical

²⁶ Protokoll 11/12 1975, s 18-19, Koncessionsnämnden för miljöskydd, Dnr Ö 9/75, aktbilaga 34, och Dnr Ä 107/71, aktbilaga 42. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:39, Doss. 84-101 (Länsarkivet, Härnösand).

²⁷ Naturvårdsverket – Koncessionsnämnden 29/5 1978, Remissvar. Dnr Ä 107/71, Aktbilaga 86. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

Industries', but adequate testing had not yet been performed and the technical conditions were thus still uncertain.²⁸

With regard to the bleach plant wastewater and despite the continued uncertainty about the possibility of expanding the Domsjö sulphite mill as planned, the company decided to invest in an entirely new bleach plant which went operational in May 1976.²⁹ One explanation for why MoDo carried out the investment is probably that in addition to lower operating and maintenance costs it allowed for significantly reduced emissions of chlorine-containing wastewater from the bleach plant.³⁰ At FBEP's request in a formal decision of April 1976, the company however continued to investigate the opportunity to further reduce discharges of chlorine-containing bleach plant wastewater. Thus, the company studied in lab scale how a higher admixture of chlorine dioxide in the chlorine stage affected the quantity of released environmentally destructive substances. This study showed that discharges of BOD₇ and COD were not affected by the chlorine/chlorine dioxide mix. The company also studied how changes in bleaching frequency combined with partial closure of the stages affected bleachability, chemical consumption, and the environment. This study showed that closure of the bleaching plant was possible, but would result in much higher costs for chemicals.³¹ In addition to the studies mentioned, the company also carried out tests of various internal measures aimed at reducing polluted discharges to water, such as counterflow multistage washing and various methods to thereafter dispose of the water from the counterflow wash, including through combustion. Among else, MoDo studied a combustion plant at another company for this purpose, but determined that the method was not yet a satisfactory technical solution.³² The company carried out the tests of internal measures aimed at reducing discharges in order to show that external

²⁸ Biologisk behandling av förorenat processavloppsvatten i separat eller med sulfitfabriken gemensam anläggning, Bilaga till Naturvårdsverket – Koncessionsnämnden 29/5 1978, Remissvar. Dnr Ä 107/71, Aktilaga 86. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

²⁹ Domsjö sulfitfabrik 90 år. En bildkavalkad 1903-1993, 14.

³⁰ Bleach plant discharges could be halved by changing the order of bleaching stages, in which the alkali stage was put first instead of the chlorine stage, which made it possible to pipe all fluid from the first bleaching stage via washing to evaporation and incineration in the soda boiler. After the alkali stage followed the chlorine-containing bleaches chlorine, hypochlorite and chlorine dioxide (Domsjö sulfitfabrik 90 år. En bildkavalkad 1903-1993, 14).

³¹ Miljöaspekter vid blekning av sulfitpappersmassor, Bilaga till Naturvårdsverket – Koncessionsnämnden 29/5 1978, Remissvar. Dnr Ä 107/71, Aktilaga 86. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

³² Ytterligare interna åtgärder för minskning av föroreningsutsläppen till vatten, Bilaga till Naturvårdsverket – Koncessionsnämnden 29/5 1978, Remissvar. Dnr Ä 107/71, Aktilaga 86. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

biological treatment might not be necessary. A plant of this kind would, of course, involve a major investment for the company.

SEPA, however, continued to argue for biological treatment in order to achieve satisfactory recipient conditions: discharges must be reduced significantly below current levels and "biological treatment is the technique that can be used immediately for the purpose."³³ SEPA therefore argued that the company should be ordered to implement biological treatment of all polluted wastewater before January 1, 1982. With regard to the bleach plant wastewater, SEPA argued that the company should be given an opportunity to "monitor the technical progress that can be expected in the next few years" before any decisions were made about further measures in the bleach plant. In parallel with this fence-sitting about the issue of bleach plant wastewater, SEPA nevertheless argued that the company should be ordered to introduce, in consultation with SEPA, a higher percentage of chlorine dioxide in the chlorine stage and to complete the study of system closure and destruction of bleach plant wastewater.³⁴

At the same time as the company carried out studies of biological treatment and the bleach plant wastewater during the fall of 1977, the company's president noted that the market situation had forced the Scandinavian pulp industry into further price reductions, but the competition was in any case now aware that the Swedish pulp industry was determined not to lose further market shares in Europe.³⁵ In the spring of 1978, the company board further established that long term investing activities in the 1980s, beyond the requirement for profitable processing of the wood raw material, must also take special consideration of the company's responsibility for its employees, public environmental protection standards, and the adopted energy policy. In this context, the board decided to once again investigate Domsjö mill's future production orientation.³⁶

The 1980s

When the company had truly entered the 1980s a couple of years later, the board of directors determined that the investment plan for the 1980s should also have taken into account a number of preconditions of a risk nature, such as: A) rapid economic downturns; B) much steeper energy prices;

³³ Naturvårdsverket – Koncessionsnämnden 29/5 1978, Remissvar. Dnr Å 107/71, Aktbilaga 86. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

³⁴ Ibid.

³⁵ MoDo styrelseprotokoll 21/10 1977 § 288 (Brux, Örnsköldsvik).

³⁶ MoDo styrelseprotokoll 9-10/2 1978 § 317 (Brux, Örnsköldsvik).

C) inconsistent wood supply; and D) stronger demands for environmental protection investments.³⁷ The Domsjö sulphite mill had not generated acceptable earnings for much of the 1970s and actually made a loss in the final years of the decade.³⁸ However, the board was still not ready to throw in the towel and instead planned for new investments. The biggest investments involved a deresination plant that was the result of many years of internal R&D aimed at achieving resin control: this was motivated especially by the orientation towards viscose pulp.³⁹ The deresination plant – which reduced chip stacks by a full 90 percent and thus helped avoid wood losses in stack storage – was a global innovation in the pulp industry.⁴⁰ The biological treatment plant was another major and imminent investment that the company, however, was still not sure whether it would have to make.

In 1979, the company had made a serious and in-depth attempt to argue against the demand to invest in a biological treatment plant, including by referring to the annual cost for a similar plant, which the company claimed was SEK 12 million or equal to the cost (wages and social security contributions) for 120 full-time workers for one year. "If biological treatment is ordered, it would thus put the continued operation of the Domsjö sulphite mill in jeopardy."⁴¹ In this context, MoDo noted that environmental protection investments at Domsjö during the period of 1971-1978 had already mounted up to SEK 100 million,⁴² including about SEK 20 million in government grants, calculated from 1979 monetary values.⁴³ The company further noted that environmental protection

³⁷ MoDo styrelseprotokoll 25/1 1980 § 449 (Brux, Örnköldsvik).

³⁸ MoDo styrelseprotokoll 1979-01-22--23, s 6, Koncessionsnämnden för miljöskydd, Dnr Å 107/71, aktbilaga 89, och Dnr Å 108/71, aktbilaga 70. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

³⁹ Gårdlund, 1986, 118-119.

⁴⁰ Domsjö sulfitfabrik 90 år, 10.

⁴¹ "PM beträffande miljövårdsfrågornas ekonomiska konsekvenser för Domsjö sulfitfabrik" 31/10 1979, Bilaga b till MoDo – Koncessionsnämnden 12/11 1979 med bilagor, Dnr Å 107/71, aktbilaga 102. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

⁴² Här räknade bolaget också med investeringar i tvätt-, silnings- och blekutröstning med motiveringen att denna utrustning byttes ut för att kunna göra en slutning av processen möjlig och inte därför att den var i sådant skick att den inte gick att använda för lång tid framåt i produktionen ("Pm beträffande bedömning av Domsjö sulfitfabriks miljövårdsinvesteringar 31/10 1979, Bilaga c till MoDo – Koncessionsnämnden 12/11 1979 med bilagor, Dnr Å 107/71, aktbilaga 102. Planeringsavdelningen utom Försvarsenheten, 1971-1989, Vol. E6d:74, Länsarkivet, Härnösand).

⁴³ "PM beträffande miljövårdsfrågornas ekonomiska konsekvenser för Domsjö sulfitfabrik" 31/10 1979, Bilaga b till MoDo – Koncessionsnämnden 12/11 1979 med bilagor, Dnr Å 107/71, aktbilaga 102. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

costs were higher for the Swedish paper and pulp industry than for the Finnish and Canadian industries, although lower than for the American: "However, the higher costs of environmental protection in the US, at SEK 30-50 per ton of pulp, are more than offset by the lower cost of wood in the US."⁴⁴ The company finally also referred to an IVL⁴⁵ study that showed that treatment of wastewater from Domsjö in an aerobic pool would, above all, significantly reduce discharges of easily biodegradable organic compounds, but would not entail any appreciable reduction of discharges of not easily biodegradable organic compounds.⁴⁶ The company instead offered to investigate the possibility of reducing wastewater emissions through internal measures.⁴⁷

In March 1980, the company finally obtained a license from FBEP to run its current operations at the Domsjö sulphite mill with a maximum annual production volume of 225,000 tons of pulp. In accordance with §21 of the Environmental Protection Act, however, the FBEP indefinitely postponed a decision on the conditions that would apply to the mill's discharges of polluted wastewater (methods and outcomes were to be further studied by the company in cooperation with others including SEPA). However, the company was ordered to have taken such measures by July 1, 1983 that discharges of BOD₇ from the mill – excluding the final bleaching – did not exceed an annual average of 6 t/day.⁴⁸ This was, to put it mildly, tough conditions considered that the company just before had stated that the proposed systems would enable a reduction of the BOD₇ discharge to 27 t/day.⁴⁹ However, SEPA had made it clear in the early years of the licensing process that a reduction

⁴⁴ Ibid. When the MoDo management had discussed rising environmental protection costs five years before, they did not believe there would be any appreciable differences between the countries (Bilaga 14/1 1974 "Basutredningen – sammanfattning av delrapporter, rapport nr 1; Styrelseprotokoll 18-19/1 1974).

⁴⁵ The half state/half industry founded Swedish Environmental research institute.

⁴⁶ "Resultat från utredning av syresituationens beroende av MoDo:s utsläpp av organiskt material till Domsjöfjärden, med syftet att belysa effekten av olika reningsalternativ", IVL 4/1 1979, Bilaga till MoDo – Koncessionsnämnden 12/11 1979 med bilagor, Dnr Ä 107/71, aktbilaga 102. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:74 (Länsarkivet, Härnösand).

⁴⁷ Provided that it was not ordered to invest in biological treatment, the company instead offered to study the prerequisites for reducing discharges from the bleach plant (SEPA had previously pointed out that almost half of the mill's total discharges of BOD₇ were released through the bleach plant) and to introduce a higher quantity of chlorine dioxide in the chlorination stage (MoDo – Koncessionsnämnden 12/11 1979 med bilagor, Dnr Ä 107/71, aktbilaga 102. Planeringsavdelningen utom Försvarsenheten, 1971-1989, Vol. E6d:74, Länsarkivet, Härnösand).

⁴⁸ KN beslut 19/5 1982, Dnr Ä 107/71, aktbilaga 157. Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand).

⁴⁹ NV, skrivelse 13/12 1982, Dnr 393-3515-82, Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand).

to 27 t/day was not good enough in light of the poor condition of the Örnköldsvik Bay.⁵⁰ At least the tough conditions came in the middle of a period when the pulp market was characterized by the company's president as "extraordinarily strong," in part due to higher prices for American pulp. Of the company's operations, cellulose production had shown the strongest earnings improvements since the net loss in 1978. The president further noted:

"In the current situation, as we listen to the internal North American discussions about the gathering storms, it all feels familiar from our own discussions during the recent years of crisis: the American debate on poor competitive advantage, inflationary cost trends with high wage demands, rising environmental costs, lack of understanding on the part of the government – it's all there."⁵¹

Only a few months after the FBEP decision, the company applied for a one-year extension in order to study certain technically and financially interesting alternatives to conventional biological treatment – the "pekilo" and "Anamet" methods – which both enabled the extraction of valuable byproducts. The board of directors stated that it was of pressing importance to find more "profitable" methods than a conventional biological treatment plant, which in addition to a costly initial investment would entail "very substantial" operating costs.⁵² The company was granted a one-year extension.⁵³ The Finnish pekilo method, which allowed a high-value protein for animal fodder to be produced from the wastewater, was the first method to be tested. The tests, carried out on a pilot scale, were successful, but the method was abandoned due to the uncertain revenue opportunities for the protein. The Anamet method, whose main application had been wastewater treatment in the food industry, permitted the extraction of methane gas from wastewater. In the summer of 1981, the company approached AB Sorigona, which sold the Anamet method, and successful trials were thereafter performed on the wastewater in question.⁵⁴

In 1982, the company applied for an additional two-year extension until July 1, 1984 to take such measures originally required by July 1, 1983 that discharges of BOD₇ from the mill – excluding the

⁵⁰ NV-KN 1/12 1975, Dnr 314-1898-75 Ti, Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:40, Industridossier 84-101 (Länsarkivet, Härnösand).

⁵¹ "Koncernchefen Matts Carlgrens anförande vid MoDos bolagsstämma 1980-05-05", s 4, bilaga till styrelseprotokoll 14/3 1980 (Brux, Örnköldsvik).

⁵² MoDo styrelseprotokoll 4/2 1982 § 591 (Brux, Örnköldsvik).

⁵³ NV- Jordbruksdepartementet 21/1 1983 "Besvär av MoDo över koncessionsnämndens för miljöskydd beslut", Dnr 314-6353-B2 Ti, Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand).

⁵⁴ MoDo – NV 18/8 1982, Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand).

final bleaching – did not exceed an annual average of 6 t/day. The argument for the extension this time was the current uncertainty regarding the timber situation, which made it indefensible, according to the company, to invest about SEK 60 million in a biological treatment plant before the structural issues had been studied. SEPA denied the request on the grounds that the timber supply situation was of such a nature that it should have been foreseeable by the company at the time of the earlier decision, and that the Örnsköldsvik Bay had been subjected to serious pollution for so long that treatment measures should not be postponed any longer.⁵⁵ However, FBEP chose to grant the company the requested extension.⁵⁶

The company did not believe it was possible to determine whether sulphite pulp production at Domsjö could be maintained and made profitable enough for the foreseeable future unless the conditions for the future supply of raw materials to the company's pulp mills could first be pinned down. The company had, with scanty results, tried to get its hands on the timber freed up when other Swedish mills were shut down. The uncertain market outlook for the "waning" product of sulphite pulp was another problem.⁵⁷ During the second half of the 1980s, MoDo management determined that there were a number of negative factors for sulphite pulp that were beyond the control of any individual producer. The number of sulphite mills in the world had been more than halved in the last 20 years and the sulphite pulp share of world trade pulp had been reduced from 35 to 15 percent. This in turn had created serious "psychological barriers," such as an ambition among paper manufacturers to get away from sulphite dependency, even though the properties of sulphite pulp were satisfactory and its price was consistently lower than that for kraft pulp.⁵⁸ Among the world's sulphite mills, Domsjö was by far the largest manufacturer of bleached sulphite pulp intended for trade.⁵⁹

⁵⁵ NV-KN 17/9 1982, Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand).

⁵⁶ Regeringsbeslut 25/8 1983, Planeringsavdelningen utom Försvarsenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand). Only a few months later, the company requested another postponement to July 1, 1986. This time, FBEP granted an extension of the implementation date by only nine months, instead of 24. The company tried to appeal this decision to the government, which denied the appeal in August 1983 (Regeringsbeslut 25/8 1983, Planeringsavdelningen utom Försvarsenheten, 1971-1989, Vol. E6d:139, Länsarkivet, Härnösand). The deadline was thus April 1, 1985.

⁵⁷ MoDo styrelseprotokoll 20/1 1983 § 655 (Brux, Örnsköldsvik).

⁵⁸ Styrelseprotokoll 10/2 1987 § 927 (Brux, Örnsköldsvik).

⁵⁹ Styrelseprotokoll 27/1 1986 § 867 (Brux, Örnsköldsvik).

Domsjö sulphite mill was one of the corporation's oldest companies and had a large workforce. Concern for the workforce was an explicit factor in the management's decision to try to maintain production at Domsjö.⁶⁰ The prevailing uncertainty about the future of sulphite pulp contributed to the board's decision in 1984 to limit investments in sulphite pulp and instead work towards a gradual transition to production of high-yield chemithermomechanical pulp (CTMP).⁶¹ The decision to focus on CTMP is explained by the fact that the company had for many years devoted extensive R&D to producing various types of refiner mechanical pulps (RMP), including CTMP. These efforts had included a pilot plant built in 1973 in the research lab's testing hall where tests were carried out on RMP in cooperation with another company, AB Defibrator.⁶² The CTMP plant at Domsjö was opened with a great ceremony in December 1985, the same year as the biological treatment plant (see below), and had a production capacity of 65,000 tons/year.⁶³ The courageous dive into CTMP would, however, soon prove to be a giant belly flop, partly for environmental reasons (more on this below).

Because discharges of BOD₇ were limited to a maximum of 6 tons a day effective April 1, 1985, the board allocated funds for a biological treatment plant using the recently developed Anamet method in October 1983. The total investment cost was ultimately estimated at a hefty SEK 73 million. The oil savings consequent upon the methane gas production were estimated to a full 6,000 m³ per year, equivalent to a reduction in the mill's oil requirement by about 40 percent.⁶⁴ The biological treatment plant, the biggest in the country, started at full capacity in early 1985 and discharges of BOD₇ could eventually (after some years) be reduced from the high level of 45 tons to 6 tons per day.⁶⁵ According to prevailing environmental manager at Domsjö the plant paid off at once.⁶⁶

The matter of final conditions for discharges of bleach plant wastewater had been postponed in the 1980 decision, but the company was ordered to continue studying opportunities to replace elementary chlorine with chlorine dioxide or otherwise change the bleaching process to reduce discharges. The deadline was postponed several times at the company's request and with the

⁶⁰ MoDo styrelseprotokoll 27/1 1986 § 862 och 10/2 1987 § 927 (Brux, Örnsköldsvik).

⁶¹ MoDo styrelseprotokoll 1/2 1984 § 724 (Brux, Örnsköldsvik).

⁶² Gårdlund, 1986, 121.

⁶³ Domsjö sulfitfabrik 90 år. En bildkavalkad 1903-1993, 10.

⁶⁴ Gårdlund, 1986, 132-133.

⁶⁵ Domsjö sulfitfabrik 90 år, 10.

⁶⁶ Interview with Ronald Gustavsson, environmental manager at Domsjö sulphite mill in the 1970s and 1980s, Östanå, Sweden, June 14, 2012.

consent of the authorities to investigate opportunities to replace chlorine bleaching with another brightening process in order to reduce discharges.⁶⁷ In the latter half of the 1980s, the authorities also demanded the company to work with SEPA to study the dispersion of chlorinated organic materials – including dioxins, etc., - in bottom silt, sludge and wastewater. This was an effect of the dioxin scare in the mid-1980s. SEPA stated in 1987 that extensive studies had been performed by both the agency and the pulp and paper industry with regard to discharges from bleach plants.⁶⁸ These studies had shown that there was serious impact on fish even after relatively extensive measures and dilution, which indicated that bleaching with elementary chlorine must eventually “virtually” cease. SEPA also stated that the discharges of chlorinated organic substances ought to be considerably lower than they were at Domsjö. “The reason for this must be investigated and the situation rectified as soon as possible.” SEPA noted that this also required development of the company’s analysis techniques.⁶⁹

Thus, discharges from the bleach plant had grown during the latter half of the 1980s into a troublesome fact for the company, both with regard to the levels of chlorinated organic substances that were still being discharged and which were difficult to overcome, and the impact/dispersion studies that the company had to mobilize in addition to developing measures to reduce discharges. In parallel, the financial situation had deteriorated for the company compared to the first half of the 1980s. The very good earnings that the Domsjö sulphite mill had shown in the first half of the decade had reversed and earnings were poorer in 1985 and 1986. In early 1986, negative cash flow for Domsjö was estimated at losses of SEK 32 million for 1985 and 88 million for 1986.⁷⁰ Moreover, capital investments at the mill had been very extensive in the mid-1980s, with the biological treatment plant and the CTMP plant being two prime examples. As early as in January 1986, the

⁶⁷ KN beslut 11/9 1984, Dnr Å 107/71, Aktilaga 233, Planeringsavdelningen utom Försvarenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand); Koncessionsnämndsbeslut 10/7 1987, Nr 134/87, Dnr Å 107/71, Aktilaga 274, Planeringsavdelningen utom Försvarenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand).

⁶⁸ Miljö/cellulosa samt SSVL-85.

⁶⁹ Koncessionsnämndsbeslut 10/7 1987, Nr 134/87, Dnr Å 107/71, Aktilaga 274, Planeringsavdelningen utom Försvarenheten (1971-1989) Vol. E6d:139 (Länsarkivet, Härnösand). Considering that cooking at the Domsjö sulphite mill had reduced the kappa figure to considerably lower levels than kraft pulp cooking and the process thus should have a much lower need for bleaching chemicals, discharges of chlorinated organic substances, according to SEPA, ought to be considerably lower than they were at Domsjö.

⁷⁰ MoDo styrelseprotokoll 27/1 1986 § 862 (Brux, Örnköldsvik).

board of directors began to express concern that the investment in CTMP did not seem to be profitable.⁷¹

In 1989, FBEP established the discharge conditions for total organic chlorine, with the limit set at 1.5 kg per ton of pulp in 1991 and 1.0 kg per ton of pulp in 1992. As of 1993, 1.0 kg per ton of pulp could not be exceeded. More rigorous standards were set for BOD discharges at the same time. The limit for 1989 was set at 12.5 tons of BOD₇/day for sulphite and CTMP production combined. The limit would be lowered to 10 tons of BOD₇ per day effective 1991.⁷² The board of MoDo could then establish that conditions had been “seriously underestimated by the company.” In order to meet the higher BOD standard for 1989, the company was forced to both curtail operations at the sulphite mill and temporarily shut down the CTMP production, which strongly contributed to the discharges. In addition, the company investigated whether an investment in an active sludge plant would be necessary in addition to the investments already made.⁷³ The serious situation demanded decisive, powerful action.

So, in the fall of 1990, the company had found a solution to the environmental standards. An entirely new concept had finally been developed after many years of studying whether chlorine bleaching could be replaced with another bleaching process in order to reduce discharges. The concept was based on increasing the percentage of peroxide- and oxygen-bleached pulp and proportionately decreasing the percentage of chlorine dioxide-bleached pulp in parallel with closing the bleach plant with counterflow wash. The concept created a platform that in the aftermath of the dioxin scare yielded the desired bright, chlorine-free and chlorine dioxide-free pulp with a better price picture than standard-grade kraft pulp.⁷⁴ The bleach plant was rebuilt according to the new concept soon after, in the fall of 1990, whereupon the chlorine valve could be shut off for good. When the bleach plant was closed, discharges to water from this department stopped completely. The new product, MoDoCrown 90P, was bleached in 1991 to the same brightness as the former chlorine-bleached paper. The Domsjö sulphite mill was the first in the world to produce a chemical pulp brightened to the highest level of brightness without chlorine or chlorine dioxide. While sulphite pulp production at Domsjö thus remained, CTMP production was discontinued in part due to a declining market, but

⁷¹ MoDo styrelseprotokoll 27/1 1986 § 862 (Brux, Örnköldsvik).

⁷² MoDo styrelseprotokoll 3/4 1990 § 49 (Brux, Örnköldsvik).

⁷³ MoDo Cellkraft AB Styrelseprotokoll 10/1 1990 § 39 (Brux, Örnköldsvik); MoDo Cellkraft AB styrelseprotokoll 3/4 1990 § 49 (Brux, Örnköldsvik).

⁷⁴ MoDo Cellkraft AB Styrelseprotokoll 3/10 1990 § 73 (Brux, Örnköldsvik).

also because the product was associated with serious discharge problems. The company's chlorine and chlorate production was also shut down in the early 1990s as an effect of the more environmentally friendly bleaching process.⁷⁵

⁷⁵ Domsjö sulfitfabrik 90år. En bildkavalkad 1903-1993, 6-7.

Discussion

Our study essentially shows that environmental issues have been an important aspect of the business development at MoDo, essentially since the late 1960s. But above all, we find that our study proves the great complexities and uncertainties related to technological change. Solving environmental problems is a complex issue and its performance determines how the firm will be able to sustain competition on the international market. In the long run, this includes the company's ability to transform while integrating far reaching environmental improvements. In this process, the company's access to competent human capital and R&D is critical, which in the case of MoDo (the owner of Domsjö sulphite mill) had been built up even before the environmental issue had its real breakthrough in the late 1960s.

MoDo relied heavily on its in-house R&D in the difficult work to handle the environmental issues over the 1970s and 80s. This is explained both by the company's ability to do so – the company had built up a solid in-house R&D activity since the 1930s and fostered a workforce sufficiently skilled to resolve the issues internally – and by the lack of directly transferable technological solutions to solve the specific process related problems at Domsjö. Our previous studies have indicated a strong importance of inter-firm collaboration for accomplishing green technology development within the business sector. The MoDo case shows a different development path which likely is explained by MoDo's specific sulphite process developed by MoDo's own engineers. However, even though we cannot identify any R&D collaboration of importance with other pulp producers, the cooperation with equipment suppliers and producers of chemicals was still of some importance.

During the late 1960s and 70s, the sulphite producers generally experienced difficulties to compete successfully. This was due to a combination of weak demand on sulphite pulp, costs of adapting to new environmental standards and the fact that many sulphite pulp producers were small compared to craft pulp producers. Thus, Swedish pulp producers at this time generally aimed for production expansion based on the adoption of the craft pulp process, which with technologies available had a better potential to recover chemicals and at the same time generate electricity. In 1972, the director of technology at MoDo furthermore explained to the Board that the ongoing environmentally driven structural change of the Swedish pulp and paper industry could cause a serious downturn of the sulphite industry in Sweden, which actually was happening. MoDo was by then a major player on the market for sulphite pulp and, despite all, took the decision to invest offensive in the sulphite process. An important explanation to this decision is probably the fact that MoDo some years earlier had exchanged the base of the sulphite process, for sodium, which offered environmental advantages

over the more common calcium base. The decision to invest was, however, not taken without hesitation and was followed by many investigations and torments among the board of directors.

By the company's application to the FBEP in 1971 for production expansion, a long-term renewing process of the sulphite mill was initiated. To comply with new environmental standards, which become incrementally stricter during the studied period, the company was enforced to develop and invest in new technologies. Of course, these requirements could not have been foreseen by the company before the licensing process started. During the 1970s and 80s, the survival of the mill was uncertain, not only because of the environmental requirements but also due to fluctuating market prices which endangered the company's financial situation.

The role of environmental regulation and the authorities

The company's strained finances in combination with a need to develop greener technologies complicated the ability for the company to comply with stipulated environmental requirements. But the authorities practiced a flexible approach that gave the company generous prohibition periods to find measures at economic feasible means. This enabled the company to develop and rebuild the processes and test and adapt new technologies. Of major importance from an environmental point of view was the bio purification plant according to the Anamet-method, which enabled both energy saving and environmental improvements. Worth noticing is that this method not only reduced discharges of hazardous emissions but also reduced the consumption of oil with 40 percent. The choice of the Anamet-method was motivated by both environmental and economic reasons, a solution which in the end proved to be economically feasible. Without the prohibition period given by the environmental authorities, it is not certain that the company would have found an economically feasible solution in this matter. Given the uncertain economic situation for the company, this was a very important point for continuing the business.

Moreover, the flexible approach practiced by environmental authorities with respect to prohibition periods was balanced by a strict reclaim regarding the environmental standards. When the Swedish environmental authorities first raised the issue of the toxicity of chlorine in the mid-1970s, the company was told to investigate the possibility to cut the emissions from the bleaching process. This initiated a long term R&D activity on the bleaching process at Domsjö which came at hand when the company in the late 80s got strict reclaims regarding emissions of both BOD and total organic chlorine. The chlorine free MoDo Crown product was solely based on in-house R&D development. With this process change and new product, the company not only achieved great emission cuts but also great market advantages as this was the first chlorine free pulp with highest brightness on the market. The dioxin issue had been raised in the mid-80s, and there was indeed a growing market for

this product. This competitive advantage was however not known in advance, i.e. when the toxicity of chlorine first started to get investigated from an environmental point of view in the 1970s. This is a clear example of how environmental requirements can result in market benefits which initially could not have been foreseen, and is principally related to the argument that underpins the Porter hypothesis.

Finally, this study has been an attempt to shed some light on the environmental aspects of business in business history. By focusing on environmental aspects in manufacturing, we find two major points of importance. First of all, few other issues have perhaps involved such extensive governmental involvement in the technology development, at least in the Swedish business, as the environmental issue. Secondly, it is not possible to understand the transformation of the polluting manufacturing industry after the 1960s without including analysis of societal demand for environmental improvements, essentially environmental regulation and preferences for greener products. Of policy importance of such analysis is not the least how the frame of environmental regulation and institutional contexts foster different firm strategies in order to comply.

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