The Making of a Green Innovation System

The Swedish Institute for Water and Air Protection and the Swedish Pulp and Paper Industry in the mid-1960s to the 1980s

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Abstract

In this paper, we address the issue of organizational networks and the diffusion of green knowledge within the Swedish pulp and paper industry (P&P) from the mid 1960s to the 1980s. During this period, the Swedish P&P underwent a period of rapid environmental improvements. Our case demonstrates that the environmental adaptation of this line of business cannot be understood from merely a corporate focus, i.e., as something accomplished by single firms or industries simply as a response to environmental regulation. By employing an innovation system approach, we find that the knowledge and technology development underpinning environmental adaptation within the Swedish P&P have involved a network of diverse actors. In this context, the semi-governmental Institute for Water and Air Protection (IVL), and its service company held important roles as intermeddlers of knowledge within the network, not the least because of IVL’s position “in between” government and industry. We suggest that one of many important challenges for future research should be to compare how different national institutional settings have shaped the formation of “green” innovation systems. This would beneficially include national features of corporate stakeholder relations, as these influence firms’ interplay with other firms as well as with other actors of the innovation system.
Introduction

In this paper, we address the issues of organizational networks and the diffusion of green knowledge among firms of the Swedish basic polluting industry by the influence and support of the Swedish government from the mid-1960s to the 1980s. It has been argued that mainstream business literature within the Chandlerian tradition has not paid enough attention to the role of the state in shaping the technological capabilities of firms (see e.g. Lipartito and Sicilia, 2004). Furthermore, the environmental dimensions of business are still not commonly applied by mainstream business historians (Sluyterman, 2010). As stated by Rosen, historians have not given much attention neither to the business impact on the environment nor to the impact of environmental issues on business activities (Rosen, 2003, 2005). While the environmental dimensions of business are still underrepresented in the business history literature, it constitutes an expanding research field in related disciplines, such as in economics and business administration.

Governments have influenced firms’ technological capabilities by several types of regulations over time, but more recently, environmental, safety and health regulations have clearly altered innovation investment incentives, and have forced the development and diffusion of new technologies (Lipartito & Sicilia, 2004). As also suggested by Rosen, in understanding the history of industrial environmental management, grasping how legal and political development1 has induced the development of pollution control technologies will be important (Rosen, 2003). Environmental regulation has imposed critical challenges for polluting and energy intensive firms all over the western world during the second part of the 20th century. It has had far reaching impacts on the extraction and processing of industrial materials as well as on the R&D activities of the concerned industries. Important emissions from Swedish ‘dirty’ industries, such as the producers of pulp and paper and basic metals, have been cut by over 90 percent under the influence of modern environmental regulation since the 1960s, while production has increased steadily over the same time period (Bergquist, 2007, Bergquist & Söderholm, 2010a). This transformation towards less polluting and cleaner production processes has involved important technical progress. Technical change can be seen as an ultimate factor for environmental improvements experienced by polluting intensive industries since the 1960s, with regards to more efficient resource utilisations and decreasing emission levels. Firms’ compliance with environmental regulations has also incurred costs,

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1 Rosen and Sellers (1999) furthermore put forward that besides the influences of the government, also technology, the market as well as ideas, values and perceptions of critical players are important.
which in turn have influenced investment and production decisions but also altered the incentives for R&D development.

During the 1960s to the 1980s, the Swedish pulp and paper industry experienced a period of radical environmental improvements in combination with structural rationalizations and industrial renewing. This process was at the core based on new knowledge concerning both the industry’s impact on the environment and clean technology development within the line of business. One important aspect of this was that the pulp and paper producers pooled resources to jointly facilitate environmental R&D programs, including environmental technologies (Bergquist & Söderholm, 2010a). The development of this “green knowledge” was also supported by the Swedish government who already in 1966 established the jointly financed Institute for Water and Air Protection (IVL) together with the Swedish pulp and paper producers and other interested parties from the country’s manufacturing industries. Closely tied to the Institute was further a service company, the Water- and Air Protection of the Industry AB (IVL AB), also established in 1966. While IVL played a role in the environmental adaptation of the entire Swedish industry, our focus is on the pulp and paper industry.

The Swedish environmental protection system taking shape in the beginning of the 1960s was based on a cooperative policy style that fostered tolerably trustful relations (and knowledge flows) between the environmental agencies and the regulated parties (Lindmark & Bergquist 2008; Lundqvist, 1980, 1997). It has been suggested that IVL represented an important cornerstone within this policy setting (Linderström, 2001; Bergquist & Söderholm, 2010b), not the least as it represented an impartial inter-sectoral arena for environmental and policy discussions among the relevant parties. For an understanding of the knowledge base and the technological development underpinning the environmental adaptation of industry, the collaborative tradition implies an approach that goes beyond that of in-depth studies of single firms.

Scholars have increasingly recognised the importance of R&D collaboration for the individual organisation to obtain information. This line of thinking is due to the growing complexity, risks, and economic costs of innovation (Hagedoorn, 2002). Historical studies also report that the incentives behind R&D collaborations have involved cost-sharing and risk-saving opportunities related to production and research expenditures (Cortat, 2009). With the increasing complexity of technology, it becomes irrational for a firm to internalize all
resources for in-house R&D why firms seek to access knowledge created by other firms, universities and other knowledge producing bodies (Powel et al., 1996). Moreover, since environmental problems typically have features (e.g., requiring solutions inhibiting clear scale economies) which make them particularly difficult to solve for a single firm (Hildén et al., 2002), firm collaboration and the creation of networks for achieving innovation and technical change should be expected.

For our purposes it is useful to draw on the literature on innovation systems, especially with respect to the functions of the system, and the role played by the state, but also to consults or other intermediaries of innovation systems. By focusing on the network-facilitating functions of IVL and the service company, we will examine how these organizations facilitated the national innovation system for industrial environmental adaptation, and the role played by the state. Lipartito and Sicilia (2004) emphasise that the state is an important participant in the national innovation system, and that the state inevitably becomes important for business historians if they choose to employ an innovation system approach. According to Lipartito and Sicilia (2004), public policies have profoundly shaped the relationships among all the actors in the system, including those that link firms to one another. This can not the least be seen in the field of environmental protection. As was find in a comprehensive study of the Finnish pulp- and paper and chemical industries, networks for innovation were developed as a consequence of – and in response to – environmental regulatory instruments (Hildén et al., 2002). We will supplement the theoretical discussion with elements from the literature on Network Governance. We thereby attempt to employ a theoretical approach not commonly used in the literature of business history.

In sum, we recognise that an understanding of the knowledge base and the technological development underpinning the environmental adaptation of industry would benefit from an approach that direct focus beyond the industrial R&D labs and production facilities. The case of the Swedish pulp- and paper industry illustrates that the state agencies played an important role in shaping the direction of technological development, not only through the emissions limits following regulatory action, but also through knowledge exchange and funding of R&D projects (Bergquist & Söderholm, 2010b; Bergquist et. al., 2011).

Below follows a brief survey over: (i) selected parts of the innovation system literature, especially with respect to system functions and to the role played by consults or other intermediaries of the system; and (ii) elements from the literature on Network governance
which deals with conditions for Network managements to function effectively and with sustained legitimacy. This is followed by a brief background to, on the one hand, the Swedish pulp and paper industry of the 20th century as well as the environmental protection system in the country, and IVL and IVL AB on the other. Thereafter we go into depth on the role of IVL and IVL AB in the environmental adaptation of Swedish industry, with a focus on the Swedish pulp and paper industry from the mid-1960s to the 1980s. The paper ends with a discussion.

The innovation system approach – points of departures

The notion of innovation systems includes institutions operating beyond the individual firm and networks of different organizations affecting both the rate and the direction of technological change.2 Put differently, “technologies cannot exist without institutions, except possibly in their very early and emergent stages (Saviotti, 2005, 29)”. The ‘innovation system’-approach is therefore useful for the interpretation of the social patterns of companies and other organizations in institutionalized innovation (Edquist, 1997).

It lies close at hand to picture this co-evolution of technology and institutions while interpreting environmental technology as an output of public institutional constraints on technology users and producers. However, the state shapes the technological capabilities not only through regulatory constraints, but also through a variety of other mechanisms. Lipartito and Sicilia (2004) suggest that the state plays an important role in the national innovation system, basically as a maker of rules, a creator of beliefs and attitudes, as a participant in the market, and as a channeler of financial flows, which in turn influences the technological capabilities of individual firms. Moreover, national innovations systems are marked by variations in institutional pattern, innovative output and technological style (Lipartito & Sicilia, 2004). In addition to public institutions, the technological capabilities of the individual firm is influenced by networks of different organizations, such as other technology-using and producing organizations affecting both the rate and the direction of technological change.

2 Innovation systems have been studied from different angels, from National innovation systems (Lundvall 1992; Edquist 1997), to Regional innovation systems (Braczyk et al. 1998) and Sectoral innovation systems (Carlsson and Stankiewitz, 1991; Breschi och Malerba, 1997). Also the term Technological system (Carlsson and Stankiewicz, 1991; Archibugi and Lundvall, 2001) has been referred to as a version of innovation system, but it should however not be confused with the notion of Large Technological Systems (LTS) introduced by the historian of technology Thomas Hughes (1983).
This recognition of the “embedded firm” opens up the innovation system approach to the analysis of the functions of the system,³ where the most basic function at the very core of the innovation systems analysis is the activity of learning or interactive learning (Lundvall, 1992; Edquist, 1997). Hekkert et al. (2007) propose a framework for systematically mapping the functions.⁴ They define important functions of the innovations system in terms of: (i) entrepreneurial activities; (ii) knowledge development; (iii) knowledge diffusion through networks; (iv) guidance of the search; (v) market formation; (vi) resource mobilization; and (vii) creation of legitimacy/counteract resistance to change.

Risky entrepreneurial activities are necessary to cope with the large uncertainties following new combinations of technological knowledge, applications and markets as experimenting contributes with more knowledge about the functioning of the technology under different circumstances. Thus, the very prerequisites of the innovation system, i.e., knowledge development and R&D, encompass both ‘learning by searching’ and ‘learning by doing’. Furthermore, knowledge diffusion through networks is particularly important in a heterogeneous context in which R&D meets government, competitors and the market, and where the exchange can result in policy decisions consistent with the latest technological insights and R&D agendas affected by changing norms and values. In addition, and as a consequence of government and market influence but also of the interactive and cumulative process of exchanging ideas between technology producers, users and other actors, guidance of the search for further investments in technological options must be carried through since resources are almost always limited. Other necessary functions of the innovation system are market formation or the creation of protected space for new technologies, resource mobilization and the creation of legitimacy for the new technology.

How organisations like IVL and IVL AB in contrast to other actors can facilitate the functions of the innovation system do, however, not come clear with the concept of functions approach of Hekkert et al. (2007). Bessant and Rush (1995) get a bit closer to the answer to this question while examining the process through which technology moves from ‘outside sources’ to the individual organisation or firm. They suggest the use of consultants⁵ as intermediaries to assist and advice firms, and list a number of ways in which these consultants can improve the operation of the innovation process, such as through direct transfer of

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³ For functions in literature overviews, see Johnson (2001) and Hekkert et al. (2007).
⁴ For further description of the functions, see Hekkert et al. (2007), pp. 421-425.
specialised, expert knowledge already obtained and assimilated by the consultants, i.e., the traditional model of consulting practice. By providing users with a single point of contact through which to access a wide range of specialist services (available from the consultant or provided by other organisations known to the consultant), the consultant can act as a channel and selection aid to the user and thus helps users articulate and define their particular needs in the innovation process. One additional important function of the consultant, suggested by Bessant and Rush (1995), involves implicitly or explicitly sharing experience, such as “cross-pollinating” between different contexts of the innovation system.

We also find it useful to supplement the above discussion with some theoretical elements from the Network governance literature in order to grasp the conditions for organizations like IVL and IVL AB to actually function in a network-facilitating manner given their rather large number of diverse users, both public institutions (e.g., the Environmental Protection Agency) and firms from a number of different manufacturing industries. Provan and Kenis (2008) suggest it is likely to be the Network Administrative Organization (NAO), in contrast to the Participant-governed Network (the network is governed collectively by the members themselves) or Lead Organization-Governed Network (the network is governed by a single network participant that takes on the role of a lead organization), that is the most effective in those networks having the largest number of diverse participants: “Because it has its own unique administrative structure, it will be able to handle larger numbers of diverse participants (Provan and Kenis, 2008, 239).” In difference to the two other forms of network governance, the network administrative organization (NAO) is externally governed, either voluntarily established by network members or mandated as part of the network formation process.

According to Provan and Kenis (2008) the NAO further facilitates network tasks requiring significant interdependence among members as these make great demands on governance for specialty skills, i.e., the facilitation of interdependent action, which the NAO form is more apt to than shared governance. Another competence, which according to Provan and Kenis

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6 “Many user firms lack the resources or experience to understand and prioritize their problems in such a way that external resources and opportunities can be effectively utilized. Consultants can provide a valuable input to this first stage of innovation, by creating a strategic framework for change; they can also move from identifying needs in this fashion to suggesting means whereby the identified problems can be solved,” (Bessant and Rush 1995, p. 102).

7 At one extreme, networks may be governed completely by the organizations that comprise the network. Every organization interacts with every other organization to govern the network, resulting in a dense and highly decentralized form (Provan and Kenis, 2008).

8 At one extreme, network governance would occur by and through a single organization, acting as a highly centralized network broker, or lead organization, regarding issues that are critical for overall network maintenance and survival (Provan and Kenis, 2008).
(2008), is required to achieve network-level goals has to do with external demands and the needs faced by the network, such as shifts in funding, new regulations, and needs of bridging. Also this competence is according to the authors facilitated by the NAO as it is the job of the network-level staff to develop the skills needed for network-level action.

The competences discussed by Provan and Kenis (2008) spring out of three basic tensions, or ‘contradictory logics’, presented by the authors as essential and problematic aspect of all kinds of network management. These are: (i) Efficiency versus Inclusiveness, which deals with the tension between the need for efficient operation and inclusive decision making; 9 (ii) Internal versus External Legitimacy, which deals with the tension in part between individualistic versus collectivistic legitimacy concerns 10 and in part between a focus on building internal network interactions versus building the credibility of the network to outsiders; 11 and (iii) Flexibility versus Stability, which deals with the tension between the importance of a flexible network management for ensuring rapid network responses in ways that meet changing stakeholder needs and demands, and a stable network management for developing consistent responses to stakeholders and for efficient network management over time. 12

In sum, we recognise the innovation system literature in combination with the Network governance literature to be useful for a proper understanding of the knowledge base and the technological development underpinning the environmental adaptation of the individual firm in the Swedish basic polluting industries from the 1960s to the 1980s. These theoretical approaches will – in combination – shed light on how and under what conditions IVL and IVL AB during this time facilitated the functions of the national innovation system for industrial environmental adaptation with a focus on the pulp and paper industry.

9 Here, Provan and Kenis (2008) find NAO providing the greatest balance compared to the two other forms as: “an NAO allows for structured and representative participation for key strategic issues while having a staff assume more routine administrative burdens,” (Provan and Kenis, 2008, p. 243).
10 “The role of governance for building external network legitimacy often involves actions and activities that may benefit the overall network, but not necessarily many of the individual participants or the internal needs of the network itself, such as building interactions (Provan and Kenis, 2008, p. 244).”
11 Here, Provan and Kenis (2008) establish the NAO mode to provide the greatest balance since: “[i]ts’ centralized administration can represent the network externally, whereas the need to legitimize interactions among participants can be addressed, at least in part, through its representative structure,” (Provan and Kenis, 2008, p. 244).
12 Provan and Kenis (2008) find neither of the governance forms to provide balance on this last matter.
The Swedish Pulp and paper industry and the Environmental protection system

The pulp and paper industry has played a significant role for the Swedish economy for over a century, with a record of being one of the largest but also most polluting industries. Already at the turn of the 20th century, pollution problems, essentially bad smelling odour from sulphate plants, were recognised as a restriction for the expansion of pulp and paper manufacturing in the country (Söderholm, 2009). Since the early 1900, the Swedish pulp and paper industry has therefore, as a cause of common problems, jointly established and financed research activities to address both air and water pollution problems (Bergquist and Söderholm, 2010a).

The collaborative arrangements for environmental R&D grew steadily during the 1940s and 1950s, and by that time, with a clear focus on efficiency aspects such as improved fibre extraction. The path of technological development in environmental R&D had during this period a bias towards rational resource utilisation, but also towards the analysis of waste water composition and on finding methods for reduced pollution (Bergquist and Söderholm, 2010a). However, effective collaborative efforts in environmental R&D became increasingly important in the late 1960s. As a new and much stricter environmental regulation was coming up, the costs and risks related to environmental adaptation increased. The pulp and paper industry therefore extended its collaborative R&D activities. Two new platforms were established; the state-industry financed Institute for water and air protection IVL in 1966, and The Forest Industries’ Water and Air Pollution Research Foundation (SSVL).

Before entering into more detail about IVL, we should provide some information about the activities of SSVL. SSVL was initiated in 1969 by the Swedish Pulp and Paper Mill Association, with the commission to conduct comprehensive environmental protection projects. The organisation consisted of representatives from a number of private companies, research institutions, consultants and equipment suppliers (Söderholm, 2007). Through this construction, an appropriate infrastructure for technology development and diffusion were set. It was in general not possible to actively develop new technology within the economic frames of the SSVL projects, but individual firms did, however, supplement the projects on a large scale and did, together with the suppliers, contribute to significant technological development (Bergquist and Söderholm, 2010a). During the 1970s and the 1980s, there was a constant and rather extensive focus on measuring, describing and valuing of discharges, respectively on programs of control methods for environmental monitoring. However, the most prominent focus areas of SSVL in the 1980s, were the environmental effects of, and measures against, the discharges of chlorinated organic substances, respectively of NOx and SO2 (SSVL, 1991).
One central and long-term driver for pollution reduction in the Swedish industry in general and the pulp- and paper industry in particular, was the implementation of the Environmental Protection Act (EPA) in 1969 (e.g., Lundqvist, 1980). Sweden, together with Japan and the US, has been seen as early pioneers in environmental protection, and Sweden was the first nation to establish an environmental protection agency in 1967. In contrast to the USA, Sweden developed a cooperative mode of the environmental protection system that became more successful in improving environmental quality (Jänicke, 1992). At the heart of the Swedish system was the above-mentioned Environmental Protection Act (1969), which was based on case-by-case judgments of every production unit (Lundqvist, 1980). The Act was broadly speaking built around two main principles. First, it aimed to achieve maximum pollution abatement given technical and economic feasibility and, second, it aimed to control the emissions of individual plants. As such it was the first uniform framework for regulation of emissions to air, water pollution, noise and other disturbing activities from industrial plants in Sweden (Lundgren, 1999). All production units engaged in polluting activities, as well as those who planned to engage in such activities, had to erect plans for the construction or alteration of plants, factories and other installations assessed according to several criteria specified in the Act. The licensing system was administrated by the Franchise Board of Environmental Protection (FBEP), which could prescribe any protective measures or limitations for the polluting activity that could be reasonably demanded in the view of criterion of “technical and economic feasibility” (SFS 1969: 38; Lundqvist, 1980). Failure in the assessment process meant that the activity had to be closed down or the expansion plans had to be cancelled.

In short, the Swedish environmental regulatory system was characterised by a high degree of centralisation, a low degree of public participation, and a policy style seeking cooperation and consensus between the regulator and the polluters (Lundqvist, 1971, 1980, 1997). Furthermore, the Swedish system was based on direct intervention as well as on precautionary principles. Reinstaller (2008) therefore suggests that firms perceived the system as serious and stringent, but was at the same time given a flexible handling not to threaten their existence. Another feature of the system was that internal process changes designed to reduce emissions were favoured at the expense of end-of-pipe solutions. This was aligned with the interests of the pulp and paper industry, who early favoured internal process changes in their R&D programs (Bergquist & Söderholm, 2010a). One reason for this was that the pulp and paper industry underwent a process of structural change towards larger units, starting in the 1960s,
with a potential risk of more serious local environmental damages, which the new regulation would not tolerate. The pulp and paper producers therefore concluded that pollutants had to be dealt with “inside the mills” by internal process measures, and not simply by end-of-pipe treatments (Wolfarht, et al., 1971).

**IVL and IVL AB – a background**

As noted above, the pulp and paper producers pooled resources to jointly facilitate environmental R&D programs, including environmental technologies, even before the “breakthrough” of the environmental issue in the 1960s. The development of this “green knowledge” became supported by the Swedish government who already in 1966 established the jointly financed Institute for Water and Air Protection (IVL) together with the Swedish pulp and paper producers and many other representatives from the Swedish manufacturing industries.

Behind the formation of IVL were a number of industry associations, apart from those of the Forest products industries also the Mining association, the Utility industry association and Sweden's Chemical industry office. Many of the water and air quality issues were considered common to the various branches of industry. Through a joint coordination and completion of special research programs, several business interests were considered to be met at the same time. With in-house specialists, the industry would further have the opportunity to actively participate in developing the area, and conditions emerged for a realistic assessment of the environmental problems of the industry (Bergquist and Söderholm, 2010b).

The service company, the Water- and Air Protection of the Industry AB (IVL AB), also established in 1966, was closely tied to IVL. While the primary task of IVL was to conduct research on the relationship between industrial production and environmental problems, and to find effective solutions to them, the tasks of the service company, IVL AB were to assist the industry with consulting services, reports, analysis and studies, and to advise and assist in negotiations between industry and government agencies.

IVL formed an important basis for knowledge generation and diffusion within the Swedish environmental protection system, foremost during the 1960s and the 1970s (Bergquist and Söderholm, 2010b). It was essentially through basic and applied research on the environmental effects of emissions that IVL supported the process of environmental
adaptation of industry. Besides this, IVL was also involved in developing technical measures aimed at lowering the emissions of hazardous substances. The assignments of the service company, IVL AB, were mostly focused on mapping the emissions from industrial plants, i.e., identifying discharges and their effects in the recipients. In this regard, the development inputs of IVL on the standardisation of methods of analysis and measurement instruments, constituted important prerequisites for the industrial environmental adaptation in Sweden (Bergquist and Söderholm, 2010b).

The knowledge mobilized within IVL and IVL AB was also of importance to the environmental authorities. The generated information concerning the levels and the effects of discharges partly formed the basis for the so-called individual emission permits that were granted by the above-mentioned FBEP, to polluting plants (starting in 1969). Adequate knowledge can in this regard be seen as a guarantee for giving correct priorities, i.e., to direct resources towards those problems that were most urgent.

Besides the acquired knowledge on pollution matters related to the basic polluting industry, IVL did obtain a broader role as national expert organisation. To a certain degree, IVL was also acknowledged abroad, and established a unique competence on the effects of oil spill and mercury. IVL was, for instance, employed by international organisations, such as the WHO and UNESCO in the 1970s (Bergquist and Söderholm, 2010b). Today IVL is referred to as IVL - The Swedish Environmental Research Institute. It is a limited company owned by a trust in equal shares composed of government and industry. In 2009, IVL had a turnover of SEK 200 million SEK (about USD 30 million), 180 employees and it is engaged in both research and consulting activities.  

**IVL and IVL AB as important intermeddlers of knowledge on industrial environmental adaptation**

The idea behind IVL was to pool financial and human resources under one roof in order to develop and diffuse knowledge and technology relating to the solution of industrial pollution problems. Here the most acute problems were identified and processed in the interaction of

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13 The research is on the one hand jointly funded by the government and the industry, and on the other hand by government research agencies, research foundations and the EU. The consulting activities consist of both short consultancy and more extensive national and international research and development assignments (www.ivl.se, March 2011).

14 The section is heavily based on Bergquist and Söderholm (2010b).
industry and government. By this model of pooled resources, not only the risk of any misguided investments in terms of knowledge and technology development were dispersed, but it also created an arena for knowledge-pollination, where R met D, where different lines of businesses met with each other, where technology producers met technology users and where R&D met government. Furthermore, this was an arena for the diffusion of knowledge in both directions, i.e., where R&D agendas got affected by changing societal norms and values and where policy decisions became consistent with the latest technological insights. Here a protected arena for the development of new knowledge and technology was formed, and it achieved its legitimacy from its origins, i.e., an arena in between, and linked to both, government and industry.

*The production of basic knowledge and technology for industrial environmental adaptation*

The operations of IVL and the service company came to constitute an important base for the Swedish industrial environmental adaptation from the 1960s and onwards in the sense that basic knowledge and technologies for measuring and assessing the quantity, content and environmental impact of industrial emissions were generated here. Early on, the focus of both IVL and the service company was directed towards identifying the quantity and content of industrial emissions, and of identifying and analyzing the environmental impacts of these emissions. Thus, in the late 1960s a large part of the operations of both IVL and the service company was situated at the individual mill, and the aim was to identify the flow and the amount of discharged contaminated substances. The former research manager at IVL, Arne Jernelöv, informs us about the character of these operations:

“The service department of IVL identified the emissions for much of the cellulose industry. It is hard to imagine today, but when we arrived at the old mills, it could be a total jumble of old pipes. There were seldom any drawings to speak of that could give us information about what was running in the pipes, in which direction and where, it was not at all clear. Usually, the best way to get information was to call in some old retired foreman who had worked there for 40 years. So, we spent a lot of time at the mills.”

Another large component of the operations at IVL and the service company consisted of so-called effect-research, i.e., of the assessment of environmental effects from industrial discharges, mostly on water but also on air and land. Other parts of the operation consisted of developing and installing methods for the treatment of industrial waste, especially wastewater. Some of the activities of IVL were also devoted to the restoration of the receiving water body. In connection to all the different parts of operation mentioned above, a continuous activity
also consisted of developing an IVL standard for routine analysis methods. It also consisted of developing instruments for the measurement of the character and extent of the emission, respectively impact on the receiving waters.

IVL and the service company constituted a kind of sanctuary for the development of basic knowledge and technology for the industrial environmental adaptation. Here the quantity, the content and the environmental impacts of industrial discharges were appreciated from research and experimental activities (‘entrepreneurial activities’ as according to Hekkert et al. 2007) in an arena in between government and industry. No individual firm thus alone had to take on the costs and risks connected to the development of such knowledge, and it was of course also a credibility issue for the company that a semi-governmental institution took on this task. At the same time, the positioning of IVL in between government and industry contributed to creating a protected space for the new knowledge and technologies, i.e. they were – along with the arguments outlined by Hekkert et al. (2007) – automatically given legitimacy from both the government and the industry. Through the service company, the individual firm further obtained one single point of contact through which to access a range of specialist services (see also Bessant and Rush, 1995). On the other hand, IVL and the service company, through their engagements in the individual mills, were not only able to distribute the new knowledge and technology produced by them, but also gained the opportunity to practice both learning-by-searching and learning-by-doing (as proposed by Hekkert et al., 2007). Of course, the commitments at the individual mills also helped IVL and the service company to identify development needs. Guidance of the search (Hekkert et al., 2007) or selection aid (Bessant and Rush, 1995) was also obtained in interaction with government agencies.

Identification, through interaction, of needed knowledge and technology

The various departments (research groups from the mid 1970s) at IVL, which were populated by both natural scientists and engineers, presented a proposal before the IVL expert committee over the direction of research within the co-funded framework program at IVL. The committee consisted of about 20 representatives from industry, preferably industry leaders, and a slightly larger proportion from government agencies, such as the Swedish EPA, but also from universities and research institutes. The proposal was thereafter endorsed by the IVL board consisting of about 10 representatives, half appointed by the government, such as the General Director of EPA, and the other half representing the industry. The direction of research within the framework program at IVL, i.e., identification of problems in need of
getting processed, was thus made in interaction between the government, the industry, different lines of businesses, as well as various natural scientists and engineers. Research within the framework program at IVL was generally directed towards the development of basic knowledge and technology on the measurement and assessment of the quantity, content and environmental impact of industrial emissions.

Especially the effect-research increased continuously in significance over the 1970s, which, for instance, is reflected in the considerably increased proportion of natural scientist employed at IVL over the period. It reasonably made sense to first prioritize the assessment of the effects of the emissions and thus obtain knowledge of basic importance to subsequently develop measures to reduce the most pressing effects. In parallel, the activity of IVL grew to an extent that could not be foreseen at the time of the founding of the Institute. Apart from through a dramatically increased framework program in the early 1970s, the increased activities of IVL were funded by grants and research grants from research councils and industry. However, the number of commissions also rose significantly over the years, and accounted for well over half of the operations at IVL in the late 1970s. IVL’s research manager in the 1970s, Arne Jernelöv, notes that it was very important that a significant portion was funded by the framework program as this: “more came to finance the start of things, when we quite did not know how it would go. Then, when we had got the first results, it was much easier to get research funded by other environmental research supporting organizations.” The statement reflects the importance of IVL and the partly government-funded framework program for the initiation of basic research.

Great demand at both sides – a joint mobilization on environmental protection

An important part of the growth of IVL in the 1960s and 70s was based on special research grants and commissions from industry, particularly the pulp and paper industry, but not the least also on research grants and commissions from government agencies, such as in particular EPA but also local and regional authorities (e.g., decontamination commissions). Many special projects were co-funded by the EPA and industrial entities in contexts where, for instance, the operation consisted of developing methods for the assessment of emission-impacts from a specific industry. The high proportion of commissions and research projects ordered from not the least the authorities reflects a gap in the Swedish society of specialist

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15 The total turnover increased during the same period from 44 people and 2.4 million SEK in 1970 to over 150 people and 30 million SEK in 1979 (over 15.6 million USD in today’s money value). In current prices the activity of IVL grew by an average of 30 and 45 percent annually during the 1960s and 1970s, respectively (Bergquist and Söderholm, 2010b).
knowledge in the environmental field, a void that IVL came to fill up. IVL was long the only Swedish organization with broad knowledge and research in the environmental field (environmental research was not yet well-developed at Swedish universities).

The broader environmental expert role is reflected in that IVL was a central consultation body for Swedish authorities, within a wide range of environmental issues. In addition, IVL organized and contributed to a large number of environmental courses at Swedish universities. These activities of IVL, in the service of the government, indicate its important role as an intermeddler of environmental knowledge also in the public sphere. The broader societal role of IVL is further reflected in the fact that an important part of the research was directed towards environmental effects of emissions not only from manufacturing industries, such as of sulfur dioxide, oil and detergents. The expertise was also in demand internationally: IVL was hired repeatedly by organizations such as the WHO and UNESCO in the 1970s.

As for the service company, its operations were completely driven by its market, i.e. primarily the industry (and local authorities who aimed at addressing the environmental impacts of wastewater systems). The operations comprised: (i) identifying industrial emissions; (ii) developing proposals for actions, programs and processes for the reduction of these emissions; (iii) project external purification plants; (iv) participating in and/or carrying out industrial research, development and redevelopment projects; and (v) advising and assisting in negotiations between industry and authorities. Initially, identifying industrial emissions made up for a large part of the activities. Soon, however, and as a natural consequence, function-control of purification plants became a growing business. As for the design of external purification plants and participation in (or enforcement of) industrial development projects, these too accounted for an ever-expanding part of the activities of the service company. This was not the least evident in the pulp and paper industry in which the service company in 1977 was engaged as main consultant for a major expansion of a pulp mill in northern Sweden. The service company rapidly increased its number of employees, from the initial 20 to 80 up to 1971. The turnover continued to increase during the 1970s, to about 20 million SEK (approximately two thirds of the turnover of IVL).

The growth of both IVL and the service company in the 1960s and 70s must be understood as an expression of a great demand at industry and government levels, for basic research and technology development on the measurement and assessment of the quantity, content and environmental impact of industrial emissions. It reflects a joint mobilization on environmental
protection where the ability to measure the scale and impact of emissions constituted the very basis for an environmental adaptation to take place. Other key features of IVL and the service company of great relevance for the early modern environmental adaptation of the Swedish industry is that the mobilized knowledge on industrial water and air pollution control came to partly form the basis of the so called individual emission permits that was granted by the earlier mentioned FBEP.

The cross-pollination and transfer of knowledge

When it comes to IVL and the cross-pollination and transfer of knowledge (Bessant and Rush, 1995), it is worth noticing that IVL in itself was an arena for this. Here, government met with industry, various lines of businesses met with each other, and R met D, both in the identification of focus areas and in the processes of knowledge and technology development. The ‘meetings’ took place both in the board rooms, within the expert group, the laboratory and at the individual firm, and then often together with the service company. This was also the fundamental idea behind IVL.

The service company, which represented the most direct link between IVL and the individual firm, was in many ways closely connected to IVL although it was not in any part state-governed. The two organizations shared the same administration and, for most of the time, also physical facilities. The service company was further hired for some of IVL’s field work and the service company hired IVL’s resources for investigations and assessments. As for the transfer and cross-pollination of knowledge and technology, the service company not only transferred the specialized expert knowledge of IVL to the individual firm, but, as suggested by Hekkert et al. (2007), it also contributed to the cross-pollinating between different contexts of the innovation system while taking on the entrepreneurial task of developing knowledge on the functioning of new technology under different circumstances. The service company further transferred and cross-pollinated experiences from one mill to another and sometimes over different lines of businesses, and at the same time brought information on knowledge needs of the industry back to IVL.

How IVL efficiently could respond to the needs of the users was something that was continuously discussed by the management. One central initiative to increase contact with the users was by organizing the annual so-called IVL conference, which attracted about 500 participants in the mid-1970s, from both industry (e.g., firms, trade associations, consultants) and authorities in Sweden and the other Scandinavian countries. The desire to increase contact
with users further contributed to several organizational changes of IVL in the second half of
the 1970s, such as to the engagement of service-company representatives in the management
of IVL.

With IVL focusing on the measurement and assessment of the industrial pollution and
predominantly external treatment measures, such as biological and chemical treatment of
waste water, it was natural for the pulp and paper industry at the end of the 1960s to continue
the already established tradition of jointly accomplished pollution reduction through internal
process changes. This should further be understood in light of the implementation of the
Environmental Protection Act, and the transformation pressure towards larger production
units to increase the productivity (Söderholm and Bergquist, 2010a). The above-mentioned
Forest Industries’ Water and Air Pollution Research Foundation (SSVL) did in this context
constitute an apt intermeddler of knowledge and technology to operate in parallel to IVL.
SSVL had a stronger focus on internal process changes and on the pulp and paper industry
exclusively, and it did not engage in the same information exchange with the authorities. As
the SSVL projects were elaborated by representatives from a number of private companies, as
well as from research institutions (in many cases IVL), consultants and equipment suppliers,
the individual paper and pulp mill became involved in a broad and efficient network of
knowledge. Knowledge was developed, cross-pollinated and transferred within the SSVL
project, and later by suppliers and consultants, which for obvious market reasons diffused the
new knowledge and technology they had helped to develop, to the next mill, and the next, and
next.

The rich knowledge built up through IVL, the service company and SSVL was further used
by environmental authorities in connection to licensing processes involving pulp and paper
firms (Kinneryd, 2010). As authorities in general were well informed about ongoing R&D
projects, the Franchise board could sometimes stipulate conditions based on technology not
yet fully developed and thus call for further development. This is an example of how the
innovationsystem was even reinforcing knowledge development.

“The Franchise board listened eagerly to the results of the investigations made by
both authorities and industry and if we could see the prerequisites for a certain
 technological development, we ordered probation periods and stipulated
 conditions based on expected technological development and thus in fact
 stipulated technological development.”

[Anonymous Franchise board-official with experiences of pulp and paper licensing processes of
the late 1980s and onwards]
The legitimacy of IVL

IVL was established on the initiative of industry, but on agreement between government and industry, who were unified on the value of the organization. The idea was to create one single point of contact through which both industry and government could get access to a wide range of specialist services for industrial environmental adaptation. Resources were allocated and an organization was founded in the sphere in between government and industry. The strong agreement of both ‘sides’, on the value of IVL and its position ‘in between’, created a protected space, or legitimacy for the knowledge and technology developed there.

Over the second half of the 1970s, IVL and the service company, however, began to demonstrate some problems in keeping up balance in the, referring to Provan and Kenis (2007), ‘basic tensions’ of network governance. The most obvious sign of this is the disconnection of the service company from IVL in 1978. To understand this matter of course we should recall that IVL was not only a kind of network governor but also a producer of knowledge essential to the network which in turn meant that the organization except from administrators consisted of both natural science- and engineering specialists. At time for the disconnection of the service company, the activities of the two organizations had further become quite diverse, with university-like natural-science research at IVL and industry-related activities in the service company. In addition, the major cleaning up of industry was over in the late 1970’s and early 1980s, which not the least is reflected in the large emission reductions of this period. For the industrial stakeholders of IVL, the natural-science research was thus probably no longer considered as vital as more applied engineering-led activities. This is indicated in statements, both through interviews and in documents from that time by industry participants in the higher management of IVL. The research manager at IVL at that time, Arne Jernelöv, and otherwise natural scientists, have in turn expressed it as a natural course for the service company to get disconnected from IVL, because of their diverse activities. He further considered it problematic for the legitimacy of IVL that the service company represented individual firms during licensing processes and thus as counterpart to authorities.

What we discern here is a growing problem for IVL in keeping up internal and perhaps also external (with reference to the statement by Jernelöv above) legitimacy. It was a great challenge from start for IVL and the service company to respond to the needs of the diverse users, and an issue which was continuously discussed by the management. Instead of bridging between the increasingly diverse activities of IVL and the service company, the latter was,
however, in the end disconnected from IVL. This choice does not only reflect the basic
tension between internal and external legitimacy of network management, but also between
flexibility and stability as suggested by Provan and Kenis (2007). The question is, though, if
IVL by disconnecting the service company was meeting changing stakeholder needs,
developing consistent responses to stakeholders, or did any of it. Anyway, IVL stayed in
business, but as an implementation element was missing a service department was re-
launched in the 1980s, with a fast growing number of assignments. Operations continued to
focus on the measurement and assessment of the industrial pollution and predominantly
external treatment measures.

Summary and conclusions
In this paper, we have addressed the issue of organizational networks and the diffusion of
green knowledge within the Swedish pulp and paper industry from the mid-1960s to the
1980s. During this period, the country’s pulp and paper industry underwent a period of rapid
environmental improvements, which were largely based on new knowledge concerning both
the industry’s impact on the environment as well as on clean technology development.
Underpinning this process was an inter-firm collaboration in environmental R&D, complemented by knowledge diffusion on the measurement and assessment of the quantity,
content and impacts of industrial emissions through the semi-governmental Institute (and its
service company) for Water and Air Protection (IVL). The jointly funded institute, where the
industry and the government constituted equal partners, was established in 1966.

Initially the initiative to establish IVL came from the pulp and paper firms, and can therefore
be seen as a pro-active measure for complying with anticipated environmental regulations in
the late 1960s. But at the same time this action was also a sign of self regulation. The Swedish
pulp and paper industry had already, since the early 1900s, jointly established and financed
research activities to address both air and water pollution problems. The acquired knowledge
and research traditions came to be of effective use during the 1960s. As a complement to the
measurement- and effect-focused R&D activities of IVL, the pulp and paper industry
expanded the R&D activities within projects of the Forest Industries’ Water and Air pollution
Research Foundation (SSVL) in the 1960s. Within these research efforts there was a stronger
focus on internal process changes and on problems facing the pulp and paper industry
exclusively.
Our studied case thus demonstrates that the environmental adaptation of the pulp- and paper industry cannot be understood from merely a corporate focus, i.e., as something accomplished by single firms or industries simply as a response to environmental regulation. By employing an innovation system approach, we find that the knowledge and technology development underpinning the environmental adaptation of the Swedish pulp- and paper industry in the 1960s to the 1980s involved a network of diverse actors representing different but complementary functions. This network included private companies, consultants, equipment suppliers, but also the state. In this context, IVL and its service company held important roles as intermeddlers or consults of knowledge in a national innovation system for industrial environmental adaptation, embracing also other manufacturing industries.

The notion of innovation systems includes networks of organizations developing knowledge encompassing both learning by searching and learning by doing. We find that the most central functions of IVL in the 1960s to the 1980s, as suggested by Hekkert et al. (2007), were related to the mobilization of resources (through pooled resources, the risks of any misguided investments in terms of knowledge development were dispersed), knowledge development, knowledge diffusion, and guidance of the search, and all within a protected environment “in between” government and industry. The consensus among state and industry representatives on the value of IVL, created a protected space, and legitimacy, for the knowledge and technology developed there. At the same time, this ought to have directed the scope of the research operations, which must respond to the needs common to several lines of business as well as those expressed by the government. Specialized knowledge, not the least through basic research, on the (standardized) measurement and assessment of the quantity, content and environmental impacts of industrial emissions, appears to have been justified by all involved parties, at least up to the 1970s. This new knowledge has indeed constituted general prerequisites for the industrial environmental adaptation in Sweden since the 1960s.

IVL further functioned as a very fruitful arena for cross-pollination of knowledge. Here, the different organizations of the national innovation system for industrial environmental adaptation could exchange and thus refine information; this is where both R met with D, where different lines of business met with each other, where technology producers met technology users and, not the least, where industry and R&D met government. Moreover, we find that the service company not only transferred the specialized expert knowledge of IVL to the individual firm, but, as suggested by Hekkert et al. (2007), also contributed to the cross-pollination between different contexts of the innovation system while taking on the
entrepreneurial task of developing knowledge on the functioning of new technology under different circumstances. The service company further transferred and cross-pollinated experiences from one mill to another and sometimes over different lines of businesses, and at the same time brought information on knowledge needs of the industry back to IVL. All in all, the rich knowledge built up by IVL, the service company and SSVL formed a substantial knowledge base and an important network for supporting not only individual firms, but also the government through the environmental adaptation process.

One central actor within the Swedish national innovation system for industrial environmental adaptation was indeed the state. As suggested by Lipartito and Sicilia (2004), the state has an important role in forming national innovation systems, not the least as maker of rules. Indeed, this case proves that environmental regulation constituted an important driver for the development of the technological capacities within the pulp and paper industry. The Environmental Protection Act implemented in 1969 demanded the pulp and paper producers to undertake any protective measures or limitations that were defined as technical and economic feasible – and ecologically motivated – which triggered a massive search for environmentally related knowledge. This included knowledge and technology on the measurement and assessment of the quantity, content and environmental impact of industrial emissions, as well as the development of external treatment measures and internal process changes. By continuously defining stricter emission standards for different pollutants, the state, through the environmental authorities, influenced direction and extent of technological development.

Furthermore, we find that the state did not only influence the innovation system through the implementation of environmental regulations, even though this was central. As suggested by Lipartito and Sicilia (2004), the state also gave voice to beliefs and attitudes of importance for the system. One central element in the Swedish environmental protection system developed in the late 1960s was the idea of the advantages of co-operation and consensus seeking procedures put forward by the environmental authorities. We find that the innovation system was in many parts both a product and a symbol of this ideology. The co-operation with industry in the form of IVL was rewarding for the state and the Institute did indeed, as suggested by Linderström (2001) as well as Bergquist and Söderholm (2010b), function as a cornerstone within this policy setting. Not only did the development inputs of IVL constitute basic prerequisites for the industrial environmental adaptation in Sweden, but they were also of direct importance to the environmental authorities in that information generated at IVL
partly formed the basis for the individual emission permits granted by the Franchise Board of Environmental Protection, to polluting plants (starting in 1969). Besides the acquired knowledge on pollution matters related to the basic polluting industry, IVL did further obtain a broader role as a national expert organisation.

Finally, the integration of environmental perspectives in business history provides many opportunities to shed new light on how businesses have interacted with its external environment. Our case proves a multifaceted picture of intensive R&D activities in collaborations through networks as a response to institutional change. Our case essentially highlights the complexities related to corporate environmental adaption, and the rationale for sharing resources and competences to accomplish technological change. It also highlights the role of the state in shaping the technological capacity of the firms. However, one of many important challenges for future research would be to compare how different national institutional settings have shaped the formation of “green” innovation systems. Such an approach would also benefit from including national features of corporate stakeholder relations, as these will influence firms’ interplay with other firms as well as with other actors of the innovation system.
References


