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The transition to chlorine free pulp revisited: Nordic heterogeneity in environmental regulation and R&D collaboration

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ABSTRACT

The purpose of this paper is to analyze the development paths leading to the transition to cleaner bleaching technologies in the pulp industry. It devotes particular attention to the key features of the Swedish transition, but also compares this to the Finnish experiences. The empirical investigation builds on an analytical framework highlighting the conditions under which pollution regulations can provide efficient incentives for deep emission reductions at industrial plants. Existing and new archive material, including not least comprehensive license trial acts for Swedish pulp mills over an extended time period, are studied. Based on this historical analysis our findings contradict previous literature, the latter emphasizing that pressures from consumers and the public were the most significant driving forces behind the adoption of—and innovation in—alternative bleaching technologies during the late 1980s. Instead, this paper asserts, the green pulp transition was characterized by regulation-induced technological change and was made possible by long history of industry-wide cooperation in environmental R&D. Furthermore, while previous research has emphasized the leading role of the Nordic countries in green pulp innovation, we identify a number of profound differences between Finland and Sweden. These emerge from various national contexts in terms of, for instance, industry structures and strategies, political cultures, and regulatory styles. Finally, at a more general level the paper provides a few policy implications for supporting the ongoing transition towards a forest-based bioeconomy.

1. Introduction

This paper investigates the development and adoption of alternative bleaching technologies in pulp production, a research topic that has gained a lot of attention in previous literature. We study and compare the transition to Elemental Chlorine Free (ECF) and Total Chlorine Free (TCF) technologies among producers of bleached chemical pulp in Sweden and Finland in the 1980s and 1990s.[1] In brief, our results contradict the frequently cited conclusion that green consumerism and community pressure were the main driving forces behind this transition (e.g., Reinstaller, 2005, 2008; Rajotte, 2003; Popp et al., 2011). In addition, whereas previous studies emphasize the leading role of the two Nordic countries in green pulp innovation, we point to significant differences between the Finnish and Swedish transitions.

The diffusion and the development of new green technology are portrayed as key solutions to the environmental challenges facing society. Previous studies illustrate, however, that it may often be difficult to identify the determinants of green technology diffusion and innovation (e.g., Bergek et al., 2014; Allan et al., 2014). Much of the existing research has addressed the role of different policy instruments and regulations, but such assessments are complicated for a number of reasons. One difficulty lies in distinguishing between the impacts arising from consumer demand, community pressure, attitudes of CEOs on the one hand and the effects of specific policy instruments and government regulations on the other (e.g., Del Rio González, 2005; Kivimaa, 2007). Positive environmental outcomes at the firm-level may also be a by-product of productive investments aiming at cost savings.

Furthermore, there appears to be meagre evidence of one type of policy instrument being superior compared to others in promoting green technology adoption and innovation. Specific policy designs and the institutional contexts that typically have evolved

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[1] The distinguishing factor between these two processes is the use of chlorine dioxide, which is used in ECF but not in TCF. To compensate for the lack of chlorine dioxide, TCF will either imply the addition of higher dosages of peroxide or supplement the process with ozone (Jour et al., 2012).

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over several years may matter just as much (Flanagan et al., 2011; Kemp and Pontoglio, 2011; Kivimaa, 2007; Mickwitz et al., 2008). This notion has gained plenty of support in the so-called sustainability transitions literature (e.g., Markard et al., 2012; Meadowcroft, 2011), which recognizes that established technologies will be highly intertwined with prevailing business models, value chains, industry standards, as well as with the existing institutional and political structures. The more radical greening of, for instance, industrial processes will therefore be characterized by long development periods during which new technology-specific systemic structures, i.e., actor networks, institutions etc., need to be put in place and aligned. Inter-firm collaboration may play an important role in overcoming the high risks involved in committing capital to the yet unproven technologies (Moors et al., 2005).

The policies needed to achieve these processes will constitute of a mix of general and specific instruments, e.g., emission standards (and/or taxes) in combination with support to R&D and demonstration. The role of such support may be particularly important for facilitating the transition towards process-internal green technology in favor of end-of-pipe technology.[2] Internal process changes tend to involve intensive R&D activities on novel input material, technology and chemical reactions, but they also imply higher risks and costs in the short run (Yarime, 2009). However, process-internal technology has a greater potential for combining cost savings and emissions reduction, e.g., by avoiding the add-on cost of operating the end-of-pipe technology and offering opportunities for material and energy efficiency savings.

The interest in developing alternative bleaching technologies soared in the mid-1980s when the US Environmental Protection Agency (US EPA) detected dioxins downstream from pulp mills producing bleached pulp. This was news that dioxins would be formed also in the manufacturing of bleached chemical pulp,[3] and therefore implied an urgent need to reduce the emissions of chlorinated organic compounds (or AOX).[4] Eventually this resulted in the development and the adoption of ECF and TCF pulp. The academic community has devoted a lot of attention to the driving forces behind this transition (Smith, 1997; Norberg-Bohm and Rossi, 1998; Smith and Rajotte, 2001; Harrison, 2002; Reinstaller, 2005, 2008; Rajotte, 2003; Popp et al., 2011; Bergquist and Söderholm, 2015). An important reason for this research interest has been that both the ECF and TCF options represent process-internal technologies, and previous research on regulation-induced green technology development has typically had a strong bias towards the study of end-of-pipe technologies (Allan et al., 2014).

The existing literature shows that the alternative bleaching technologies diffused earlier and more rapidly in the Nordic countries compared to North America (e.g., Marcus, 1999; Smith and Rajotte, 2001; Harrison, 2002; Norberg-Bohm and Rossi, 1998; Bergquist and Söderholm, 2015). Whereas ECF eventually was the choice of North American pulp mills for replacing the chlorine bleaching, both ECF and TCF gained considerably higher market shares in the Nordic countries. In 1995 the ECF market share for total pulp production stabilized around 70 percent, while the corresponding share was 30 percent for TCF (e.g., Reinstaller, 2005; Popp et al., 2011). The two Nordic countries have also been recognized as forerunners in ECF and TCF innovation, e.g., in terms of patenting activity (Popp et al., 2011).

Previous research has also emphasized the important role that community pressure and green consumerism played for the phasing out of chlorine bleaching (e.g., Reinstaller, 2005, 2008; Rajotte, 2003; Popp et al., 2011). For instance, Popp et al. (2011) conclude that community pressure and consumer demand were the main driving forces. Nordic pulp mills, these authors argue, responded to this by launching the necessary development and modification processes well before any regulations were in place. Reinstaller (2005) argues that the increase in green consumer demand was in turn related to the ability of various policy entrepreneurs, not the least Greenpeace, to link the pulp bleaching issue to already perceived environmental threats in northern Europe. In other words, regulation, the argument goes, lagged behind, but was eventually encouraged both by public pressure and the availability of alternative bleaching technologies (Popp et al., 2011). Bergquist and Söderholm (2015) argue more strongly for the role played by environmental regulation in the transition to chlorine-free pulp, and compare the transition processes in Sweden and the USA. However, they do not contrast this with the community pressure argument, and they also devote little explicit attention to the importance of case-by-case licensing procedures of pulp mills in the 1980s.

The community-pressure explanation has gained a prominent place also in studies addressing the Finnish and Swedish transitions. Hilden et al. (2002) consider the diffusion of ECF and TCF as driven by market pressure to which new regulations subsequently were adapted (see also Auer, 1996). Reinstaller (2005) argues that a more 'elevated' political process in Sweden (compared to Finland) made Swedish firms perceive strong market opportunities, and were therefore more likely to take on the technological uncertainties associated with the less mature TCF technology. Auer (1996), Harrison (2002) and Popp et al. (2011) point to differences in government action and the implementation of regulations of AOX emissions, but nevertheless emphasize that pressures from consumers and the public drive the transition process prior to the introduction of any regulations.[5] Moreover, these studies have a narrow focus on the late 1980s and early 1990s; they therefore ignore the important role of case-by-case licensing of individual plants and not the least the role of the historical R&D efforts that eventually made the transition to chlorine-free pulp possible.

The purpose of this paper is to analyze the development paths leading to the transition to cleaner bleaching technologies in the pulp industry. It devotes particular attention to the key components of the Swedish transition, but also compares this to the Finnish experiences, in large parts relying on previously unexplored archive material covering the licensing of mills.

The paper challenges the results from existing research on the development of chlorine-free bleaching on two grounds. *First*, it puts in doubt the bundling of the Nordic countries' PPIs in this transition process. Both in Sweden and Finland the PPI has constituted a cornerstone in the respective economies (e.g., Fellman et al., 2008), and these two Nordic countries have international reputation when it comes to taking the lead in reducing

[2] End-of-pipe technologies remove or transform pollutants emitted from the production process to less harmful disposal, however without altering or in any way improving the process. Process-internal technologies instead reduce pollution by modifying the underlying production process.

[3] This resulted from a survey that the US EPA initiated following the national dioxin-related crises in the 1970s and 1980s (Norberg-Bohm and Rossi, 1998).

[4] AOX stands for absorbable organic halides. These compounds are generated in the pulp and paper industry during the bleaching process, and formed as a result of the reaction between residual lignin from wood fibres and chlorine/chlorine compounds used for bleaching.

[5] Previous research has also emphasized the importance of the geographical location of pulp mills with respect to the technological responses to the dioxin problem. Unlike Swedish mills, most Finnish mills were located near small and shallow inland water bodies, and according to Rajotte (2003) this contributed to the favoring of end-of-pipe technology in the Finnish industry.