INNOVATIONS IN WOOD-BASED PROCESS INDUSTRIES IN TRANSITION: MANAGEMENT & POLICY IMPLICATIONS

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EXTENDED ABSTRACT

As any mature industry the forest industries have gone through many transformations and structural changes. Historically, forest industries in the Northern hemisphere (North America and Northern European countries) have been rather successful by moving forward in the value chain in order to avoid market decline or raw material shortage (Hylander 2009). From timber exports and charcoal in the 17th-18th century; sawmill products in the 19th century; pulp and papermaking transformed by using sawmill residues in the early 20th century for production of graphic papers; and by inventing chemical pulping technologies in the early 20th century particularly for hygiene products and stronger paperboard which expanded in the mid-20th century.

However, in recent decades the pulp and paper industries located in the Northern hemisphere are confronted by manifold challenges while the incumbents has got stuck into its “big is beautiful” paradigm. Most of these challenges are connected to global transformation pressures, due to digitalization and multimedia (i.e. decline of printed media), competition from fast-growing economies in the Southern hemisphere, uncertain energy supplies, and environmental challenges (not least climate change) which increase the pressure on resource intensive process industries such as the pulp and paper industries in Western industry nations (UNECE/FAO 2009/2011).

In this short paper I will concentrate on the nature of innovation in pulp and paper industries (P&P), the largest biomass infrastructure on earth, and its implications for management and policymakers. The point of departure is the academic discourse on disruptive innovation followed by industry specific cases in order to explain the nature of innovation in process industries. Clayton Christensen (2000) settled an important distinction between disruptive and sustaining innovations. A disruptive innovation is an innovation that generates a new market and value chain, and finally disrupts an established market and value chain by shifting trajectory or replacing earlier technologies.

A sustaining innovation may be looked upon as either incremental (or evolutionary) or a more radical innovation. The incremental innovation contains gradual upgrading that improves a product in an existing market by means that customers are expecting, while the more radical innovation contains a major shift and
is perceived as unexpected within the industry. Both have in common that the market and business model do not transform in a significant way.

However, the outcome of global upscaling of pulping processes and the fact they have been tightly coupled with the papermaking paradigm rooted long ago (e.g. main production technologies and machines even have the same terms as a century ago!) made this industry even more inflexible and fixed to the paper mill layout. P&P is today the largest biomass industry on earth with a production capacity of almost half a billion tons per year. The cutting edge production units have since the 1950s doubled in production capacity every decade. Between 1950 and 1990 Swedish pulp and paper mills were back then on average among the most scale intensive, during this period Swedish mill on average went from roughly 15,000 to 225,000 tons per year (Skogsstatistiska Årsboken 1951; 1991). A couple of major sustaining innovations were more or less successfully integrated by the incumbents (e.g. automation control technologies in the late 20th century). In the 2000s the Nordic technology suppliers were vital to the sustaining innovation of eucalyptus plantation based Greenfield mills in the Southern hemisphere – innovating huge continuous digesters in kraft pulp mills – which today easily exceed production capacities over one million tons per unit annually.

Economically, new P&P machines have investment horizons of several decades and exceed the actual plant’s annual turnover, making it difficult to switch technological trajectory. In particular, innovations are tightly coupled with the physical lock-in issue in the sense that mills are highly integrated, internally and vertically in the technological system of pulp and paper. Any substantial change in any paper machine requires bottleneck, chain reactions in related parts of the system. Moreover, any change of one of the product features changes the production process chains and input materials. As an example, a Swedish paperboard producer in 2007 launched a paperboard with 50% whiter surface on the inside of the paperboard in order to have the same whiteness on both sides of the board. In this case a new product feature was not just a question of changing one or two parameters in the production process, it required a feasibility study of (almost) all production processes characterized by a continuous flow, of upgrading several production stages in the board machine – e.g. stock preparation, formation, pressing, drying, calandering and coating, wrapping machine, and preparing stages for converting, as well as feeding the board layer with stronger pulps in order to compensate for whiter, bleached board ply. The paperboard mill also set up a pilot machine for controlling numerous parameters in the paperboard production processes due to the difficulties to test the new product in the plant. The pilot machine also served its cause due to the mill’s only paperboard machine with a capacity of 300,000 tons annually and few occasions for running new product tests in the existing machine (Novotny 2007). Summa summarum: even an incremental product innovation in this kind of industry contains a chain reaction of simultaneous process innovations.

In the case of process industries, product features are strongly coupled to structure and the structure is strongly coupled to the processes (Linton and Walsh 2008). The number of co-evolved changes to the product and process will be greater than in assembly manufactured industries, since product innovation will result in a cascade of changes along the production process. This may even lead to opportunities for the product in the decline phase of its product lifecycle to enter a growth phase in an alternative market (Foster 1986).
Demonstration plants are particularly crucial in process industries because of the capital intensive and inflexible plant layout, on the one hand, and tightly coupled process and product innovations, on the other. The whole production chain ought therefore to be standardized and tested at large scale whenever an innovation is launched. This characteristic of large-scale process industries is even more augmented by the fact that production plants have high requirements on production availability and runnability with huge costs in case of production breaks, a trend that has been reinforced in recent decades of intense competition (Abdulmalek 2006; Novotny 2007). In addition, the R&D shift from P&P companies to technology suppliers makes demonstration plants even more crucial for innovations (Larsson 2006; Novotny and Laestadius 2014).

During the last decade the large corporations with mills located in the Northern hemisphere and positioned in declining graphic paper markets are literally dying in the chimney fire. Niche players and incumbents of chemical market pulp for new applications and bioproducts replacing fossil based products in packaging, textile, chemical and construction industries are growing in the 2000s. First movers with biorefinery products based on the sulfite process – Borregaard, Lenzing and Domsjö – are now followed on large scale by agents with other separating/fractionation technologies. An example of the latter is the Lignoboost technology which separates the lignin – the second most abundant organic compound on earth – to very high purity levels. This new process technology opens up completely new, diverging “product-tree” families of lignin-based chemicals. This in turn opens up new technological trajectories for the other two main compounds – cellulose and hemicelluloses which basically can replace any product in chemical industries and even steel/metal industries. The dismantling of the converging papermaking paradigm based on the gigantic capital intensive paper machine results in an opportunity to make use of the disruptive biomaterial diverging technologies/products (see figure 1).

Potentially, these sophisticated diverging technologies may also be disruptive for established pulping technologies in the longer run. Examples of difficulties in managing disruptive innovations are numerous in history as the Schumpeterian idea of “creative destruction” demonstrates. Schumpeter himself stated that it was not the stage-coach companies that initiated the transition for the new railway construction business in the 19th century. The incumbents were inclined to exploit incremental innovations and external, new entrants the disruptive innovations. Such transitions might turn incumbents’ existing resources out of date when new industries are emerging. A recent example is large integrated steel mills that struggled to respond to the mini-mills in the 1980s and 1990s (Christensen, 2000; Tushman & Anderson, 1997). For now, at least integrated P&P mills are losing out to unintegrated chemical pulp mills.

Another management/policy implication of studying a process industry like pulping is that market and technology shifts are rather about coupled process and product innovations where the outcomes are potentially disruptive and diverging, e.g. the Lignoboost technology that took ten years and several, upgraded pilot/demo-plants to commercialize. This is a different mind-set compared to innovation theories in general and specifically to those based on high-tech assembled manufacturing or ICT (cf. Utterback 1994), which converge instead of diverge. Steel, chemical, mineral and the pulping biorefinery case exemplified are
very much about separation technologies with a wide range of diverging product tree, cascade alike innovations, the opposite of assembly based manufacturing.

In the medium/long run this opens up for completely new development blocks of biomass refining industries which potentially can replace large part of today’s polluting and material intensive petro-chemical, metal and clothing industries. The nature of innovation in this kind of process industry however urges policy tools both on micro- and meso-levels. In the former case for more favourable conditions in setting up demonstration plants, to lower the barriers to entry for innovators that seldom have access to biomass feedstock, R&D infrastructure and venture capital. In the latter for policies in order to encourage diverging innovations in material technologies and different process industries - i.e. to encourage new development blocks in biomass based industries.

This paper is at quite an early stage and the author would probably need to develop the methodological and conceptual parts as well as to further explain the industry specific nature of innovations and the settings of exemplified technologies. Moreover, the management and particularly policy implications are still on a very rudimentary level and most probably would need a section of its own.

Figure 1: Chemical pulp biorefinery based on Axegård (2009) and Kamm et al (2010).
REFERENCES


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