



INNOVATION IN THE U.S. PULP AND PAPER INDUSTRY: LESSONS FOR BRAZIL

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Technological innovation, big and small, as well as domestic and global, has played critical role for the evolution of the modern United States pulp and paper industry since its origins in the early 19th century. New technological knowledge and its implementation, more than anything else, gave entrepreneurs, firms, industries, and whole regions, the ability to create or capture new markets or erect new production hubs, and to forge ahead competitors.²

The history of innovation in the U.S. pulp and paper industry offers some important lessons for the currently emerging Brazilian pulp and paper industry. Most importantly, it shows that sustained domestic capacity to produce innovations is a critical strategic resource for the long-term national and firm-level competitiveness, and for the industry's survival altogether. Given industry's global woes today, this is far from self-evident, as over-production and capital expenditures often dictate what companies set to do. This lesson reiterates the importance of building broad and embedded sectoral innovation system for the industry, which encompasses variety of actors, objectives and mix of private and public policies.

Other key insights shed light on the organizational behaviour of the industry, especially the way it expands in size, gives rise to new specialized sectors, and migrates from one region to another. In the U.S., successive waves of technological innovations in products and process gave rise to the different branches of the pulp and paper industry, and, combined, brought about industry's tremendous expansion over two centuries. Following similar pattern, but differing in scale and span, these waves were set in motion by pioneering technological departures and gained powerful - often global - momentum with business success.

Sometimes, new technological skills allowed entrepreneurs to seize or create new markets missed by others. At other times, perseverant technological research, development, and learning allowed whole regions to turn long-neglected natural resources into bonanza, basically spearheading a strategy later replicated by Brazil and Brazilian firms with eucalyptus. The largest waves of innovations enveloped powerful relocation dynamics in the U.S. Several times technological breakthroughs transformed neglected natural resources into valuable industrial raw material, literally

turning waste into money. Most important such events concerned northern spruce and southern pine, but touched upon also other regions and species. Upon a discovery of new regional source of pulp wood timber, the industry started migration by building new regional industrial system, and sometimes fundamentally altering the national structure of the industry.

The history of U.S. pulp and paper industry is particularly good case to learn from the industry, as the industry there has passed fully from being a nascent high-tech industry to large incumbent manufacturing base to finally its current state of decline and survival struggle. Indeed, when moving from nascent to mature industry, pulp and paper industries and their relation to innovation often follows similar paths. All too often a gold rush followed new promise, and sooner or later the new industry branch suffered from persistent and ever growing overcapacity, leaving capital expensive mills and factories with deteriorating profits. Typically, the U.S. industry responded with bureaucratic search for production efficiency and industry consolidation, which supplanted technological creativity and entrepreneurship - often already exhausted - as competitive strategies.

While this phase is yet to be seen in the Brazilian context, the resulting struggle to survive provided often important incentive to innovate in the U.S. More than few times, managers turned to disciplined research and development to combat challenges such as new political economy, grinding economic depression, or the gradual decline of demand for their existing products. In these cases, industry fended off a death-spell with its capacity for renewal, but rarely produced triumphant and lasting victories.

In what follows, I will provide condensed and stylized history of the U.S. pulp and paper industry, evaluate the role of technological innovation for its long-term evolution, and attempt to draw some lessons for Brazil.

Radical innovation in raw materials: the birth of modern pulp and paper industry

A recurrent theme in the history of pulp and paper industry is major radical innovation in raw material processing, often giving

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2. This article draws extensively on my more comprehensive and detailed article: Toivanen, H. 200; Toivanen, H. 2012.
For more detailed research on Brazilian pulp and paper industry, see: Toivanen, H; Barbosa Lima-Toivanen, M 2009.

rise to completely new technical and regional branch of the industry and offsetting the global pulp and paper industry too. Exactly such a remarkable innovation gave rise to the modern U.S. pulp and paper industry during the nineteenth century, and later the phenomenon has been repeated with industry's transition into U.S. South, growth of new regional industry clusters in Scandinavia, and, importantly from the perspective of this article, in Brazil.

The emergence of the modern pulp and paper industry in the U.S. consisted of three key phenomenon: the complete transition from rags to wood as raw material for pulp, embodied in the proliferation of sulphite pulp process as the main production technology. Secondly, wide adoption of vertically integrated mill and company organization introduced superior economies of scale. Thirdly, the adoption of the organizational structure of large-scale enterprise by industry leaders enabled them a sophisticated bureaucratic control of all aspects of papermaking, from forestry to marketing to critical technological knowledge and beyond.

Certainly, many other factors played role too. Improvements in the paper machine and other equipment were significant, and so were many other factors. But none of these amounted to something as potential as wood pulp technologies, vertical integration, and the organizational structure of large scale enterprise did.

The transition from rags to wood fiber during the last half of the 19th century marked the beginnings of modern pulp and paper industry. Departure from rag-based pulp occurred in overlapping phases and constituted broad U.S.-European wave of innovation. In the U.S., a particular problem fuelling search for wood-based fibers was acute problems in securing steady and affordable supply of rags.

Through various inventors and experiments, a new innovation was visioned in mid-19th century, which consisted of placing pieces of wood under pressure against a grindstone with a water source to take the fibers away to make the pulp for paper. Soon this revolutionary ground wood technology was put under careful patent protection by its inventors, who also licensed and commercialized it, only to discover that it did not work on industrial scale.

Growing demand for paper, mostly due to the rise of newspapers as mass media, prompted further technical innovation, which arrived in the form of chemical pulp process, namely sulphite pulp in the closing decades of 19th century. The sulphite process was a chemical, acid cooking process that consumed non-resinous wood in even larger quantities than the ground wood pulp process, but required relatively little energy. The demand for cheap power and a large supply of non-resinous wood, such as spruce, directed these processes towards the Northeast U.S. where hydropower and forests were ample in the vicinity of major markets.

The development of sulphite pulp marked a leap forward in the quality of wood pulp papers, and thus completed the transition away from rag pulp. Moreover, improvements and changes brought about by introduction of sulphite pulp process fuelled the surge of the whole

paper industry, as it proved capable of catering the needs of fast expanding newsprint industry and other markets. Again a feverish patent race in sulphite pulp technologies ensued, as entrepreneurs tried to reap the bonanza.

Although it was mostly Europeans who advanced the sulphite technology, the vast spruce stands of the North East U.S. and Canada, as well as the metropolitan U.S. newspaper markets, directed entrepreneurs attention there. Such market opportunity attracted entrepreneurs and investment, and quickly the industry leaped from nascent to mature industry. The competitive advantage of sulphite pulp and newsprint technology prompted significant structural and organizational changes in the turn of the century U.S. pulp and paper industry. The new technology swept through the industry rapidly, as new firms and incumbent ones rushed to invest in superior production technology and best mill sites. New mills were in rule vertically integrated, that is, they combined pulp processing and paper machine into single production line, often extending backwards to large pulp wood timber stands and forward to delivery networks, often railways.

Within a decade, the industry underwent fundamental transition, whose central feature was vertical integration of pulp and paper production. Combined annual U.S. production of paper doubled to 4,2 million tons between 1899 and 1909, as did the production of pulp. Most growth occurred within vertically integrated pulp and paper mills. Production of pulp at vertically integrated mills increased about 300 per cent in 1899-1909, and production of groundwood and sulphite pulp at vertically integrated mills 284 and 397 per cent. Thus, sulphite pulp and vertical integration played critical complementary role in the transformation of firm and industry level structures.

The innovation of large scale enterprise allowed managers an efficient way of dealing with the increased complexity of pulp and paper making, as well as better leverage over technology and critical knowledge. Several of the newly born large scale pulp and paper companies were also an answer to tightening antitrust climate, when accusations of cartels and government investigations intensified.

Radical innovation in raw materials II: the emergence of sulphate pulp and paper industry, 1930-1960

Radical innovation in raw material processing in mid-20th century gave rise to wholesale re-organization of the U.S. and the global pulp and paper industry. This innovation was the sulphate process that over few decades replaced the sulphite process as the dominant pulping technology. In the U.S., between 1914 and 1959, the annual production of sulphate pulp increased over 232-fold from 53 tons to over 12,000 - averaging thirteen percent annual growth over almost half a century. This growth accounted for most of the expansion of whole U.S. pulp and paper industry, as the share of sulphate pulp from the national annual production increased from about two per cent to almost 60 per cent within the same period. The new chemical

pulp technology enabled the paper industry to use resinous trees, such as southern pine, as raw material, and, when complemented with other innovations, practically erased the sulphite pulp process from the global industry.

The development of the sulphate pulp process technology was launched in mid-1930s in direct response to persistent economic woes of the industry, which stemmed from persistent overcapacity and depressed demand and prices. Some visionary inventors and companies recognized that with the right technology, neglected forests in the South and elsewhere could be used for papermaking, and opened the possibility to lower production costs significantly. A vision that echoed closely that of Brazilian pulp and paper pioneers in late 20th century.

The new innovation was championed by the International Paper Company and its Southern Division. After the expansion of southern sulphate industry by International Paper and other companies, American and global engineering community embarked on research and development effort that transformed the sulphate pulp and paper processes into industry standard, practically eradicating other pulp processes. American sulphate innovation had concentrated on overcoming problems to pulp highly resinous southern pine, but subsequent innovations focused on establishing economies of scale, applying the process to all kinds of fibre sources, and to produce new types of high value quality papers from sulphate process.

Sulphate pulp leveled most of the growth of U.S. pulp and paper industry since 1950s. It is illustrative that the production of bleached sulphate pulp increased 80,000-fold in the U.S. between 1931 and 1958, and almost 100,000-fold if one includes the semi bleached pulp, too. The share of sulphate pulp from the total U.S. pulp production increased from 42 per cent in 1939 to 45 per cent in 1947, and to 59 per cent by 1958. By 1960, the sulphate revolution in American pulp and paper industry was completed. It had unfolded in three waves, each triggering fundamental organizational changes in the industry. During maturation of the sulphate pulp process, technology gave rise to industry's emergence in the South, whose pine belt and newly built industrial infrastructures gave important economic advantages. In the second wave, after 1934, further maturation of sulphate pulp process and good experiences released massive relocation and investment to the South. Finally, the completion of continuous cooking provided further scale economies, and perfection of bleaching processes made the sulphate process viable for production of all types of papers. The last two innovations narrowed the advantage enjoyed by the South, and consolidated sulphate pulp as the industry standard in the U.S. and worldwide. In the later half of the 20th century, sulphate pulp simply marginalized all other pulp processes.

Learning in product innovation

Whereas radical innovation in raw material processing in the U.S. offers direct analogy with the Brazilian experience in innovation with

papermaking from eucalyptus, the U.S. industry's history in production innovation is quite different case. Few national industries have been able to replicate the long wave of product innovations that were developed from mid-19th to mid-20th century in the U.S., and in many aspects the U.S. based companies have lost this capability too.

The late 19th century witnessed feverish introduction of all kinds of paper production innovations, ranging from boxes to cups to envelopes to towels to toilet paper, and so forth. The context of these innovations was the expected emergence of huge demand for all sorts of paper products, but much of these activities were eclipsed by the rise of the newsprint industry. However, when the newsprint industry hit the usual troubles caused by over-investment in production capacity, and further hit by tough antitrust regulation and removal of protective import tariffs, the industry found itself in the need of reinventing itself.

Thus, a wave of unprecedented product innovation was launched around 1900. Within a couple of decades, much of industry migrated from newsprint into new paper products and markets, such as corrugated shipping containers and sanitary papers. This transition was fuelled by struggle to survive.

The surge of the sanitary paper product industry showcases best how the industry responded to the shock. The industry was pioneered by the Kimberly-Clark Company, which intensified its research and development program on cellulose, and succeeded to produce Cellucotton, a cotton like absorptive material derived from wood cellulose in 1915. The product suited especially for hygienic and sanitary use in hospitals and surgery, and U.S. participation to the First World War created enormous demand for the new innovative product, commercialized first as surgical dressings.

This product was followed by series of other products, including the famous cleansing tissue Kleenex, in the subsequent decades. These products were huge successes, leveraging Kimberly-Clark into one of industry's major companies, soon to be followed by others. These innovations laid basis for the expansion of pulp and paper industry into consumer nondurables market, a phenomenon that increased steadily demand for tissue papers and many other types of wood cellulose based products, such as baby diapers. The importance of these product innovations was great: in the case of tissue paper, its production tonnage doubled every decade since 1914 until 1947, when it surpassed newsprint. In value, it has passed newsprint much earlier, of course.

Another important nexus for product innovation was the paper container industry, which had evolved relatively slowly from the inventions of folding box and that of corrugated paper in the mid-nineteenth century. In the 20th century, innovation in corrugated paper and board concentrated to Ohio and some other major national mass distribution centers. The single most important factor for the growth of these two segments was the establishment of the paper box as the standard shipping container in the early

20th century. The paper box completed the emergence of American mass consumer markets and mass distribution infrastructure, and yet it took two decades to have it universally accepted. By the onset of the World War I, these early obstacles were overcome by entrepreneurs, and the paper shipping container industry boomed.

Boom times brought about also the familiar troubles of imitation, over-investment, and overcapacity, alike in newsprint industry few decades earlier. Leading paper container firms responded to these challenges by adopting clear corporate strategies of vertical integration, economies of scale, and internalization of research and development. Most importantly, leading firms turned to intensified production innovation, and attempted to prevent imitation and tone down competition with rigid intellectual property rights enforcement, as well as with continued pace of innovation. To some degree, this worked for about 2 decades, but the strategy collapsed during the war economy regulation introduced in 1940s.

The innovation of paper box in early 20th century was one of the fundamental innovations spearheading industry's expansion. Paper containers established paperboard as the most important industry branch by the teens, and despite of its leading position, its growth rates were second only to much smaller tissue paper segment. Its weight among the key paper grades increased steadily and it account for half of all production by 1929 and much more in 1939 and 1947. Most importantly, corrugated paper and other paper box inventions fostered also especially fruitful culture of innovation, and thereby helped the industry to venture into many new areas.

Lessons from looking back

I have offered above very condensed and stylized history of innovation in the U.S. pulp and paper industry, ignoring some important areas of innovation (such as magazine papers or LWC), as well as such critical issues as labor, environment, and political economy. However, my point here is to consider the lessons that we may draw from this history for the emerging global pulp and paper industry hubs, such as Brazil.

One evident lesson is that innovation in pulp and paper technology is determined by the overall economic structure

encompassing the industry. Waves of intense innovation in raw material processing or paper products have always been in response to either the promise of great bonanza, or threat of bankruptcy. Importantly, absence of innovation can often be explained by the economic structure as well. Persistent overcapacity and depressed prices have the capacity to take the wind out of the sails of innovation if companies lose faith in the possibilities of technological innovation and focus on narrow financial engineering as corporate strategy, as has often happened in the past and continues to be reality today. Similarly, protective tariffs and antitrust regimes all bear upon innovation, but in ways that are complex to understand. In other words, the risk of market failure and system failure are always present, necessitating careful and forward looking public policy for forests industries, and emphasizing that the senior management in pulp and paper companies must have deep understanding about the role of technological innovation for industry's future.

Brazilian pulp and paper industry is enjoying a tremendous boom due to its competitive advantage and innovation in eucalyptus fibre, and the national industry is becoming a key global hub for pulp production. To this end, the country and the industry have also built extensive sectoral innovation system (Toivanen and Barbosa Lima Toivanen, 2009), which secures frontier innovation in the sector.

Another key lesson from the history of U.S. pulp and paper industry is to look beyond the current wave of success, and similarly the Brazilian industry and government should actively to contemplate in what markets and technological areas the industry can actively growth and develop. If neglected, the risk of inheriting an industry struggling to survive among overcapacity and global cut-throat competition in pulp production is great.

It is obvious that economic and industrialization processes do not replicate themselves exactly at different points in time or place. Yet, the history of modern pulp and paper industry showcases that its challenges and boom times unfold in relatively analogous manner what comes to dynamic forces and structural determinants, and Brazilian companies and government can draw lessons from industry's history. ■

REFERENCES

1. Toivanen, H. 2004; *Learning and Corporate Strategy: Policy, Organization, and Innovation in the North American Pulp and Paper Industry, 1860-1960.* Unpublished Ph.D. dissertation, Georgia Institute of Technology.
2. Toivanen H. 2012; *Waves of Technological Innovation: The Evolution of the US Pulp and Paper Industry, 1860-2000.* In: Lamberg J-A, Ojala J., Peltoniemi M., Särkkä T. (eds). *The Evolution of Global Paper Industry 1800-2050.* Springer, 49-80.
3. Toivanen H.; Barbosa Lima Toivanen M. 2009: "*Learning, Innovation and Public Policy: The Emergence of Brazilian Pulp and Paper Industry*". In Malerba F.; Manil S. eds; *Sectoral Systems of Innovation in Developing Countries: Actors, Structure and Evolution.* Edward Elgar, 99-127.