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Toivanen, Hannes
Georgia Institute of Technology

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LEARNING AND CORPORATE STRATEGY: THE DYNAMIC
EVOLUTION OF THE NORTH AMERICAN PULP AND PAPER
INDUSTRY, 1860-1960

A Dissertation
Presented to
The Academic Faculty

By

Hannes Toivanen

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy in History and Sociology of Technology and Science

Georgia Institute of Technology

April, 2004

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LEARNING AND CORPORATE STRATEGY: THE DYNAMIC
EVOLUTION OF THE NORTH AMERICAN PULP AND PAPER
INDUSTRY, 1860-1960

Approved:

Steven Usselman, Chair

August Giebelhaus

John Krige

William Winders

Stuart Graham

Date Approved: 16 April, 2004

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SUMMARY

This study analyzes the long-term evolution of the North American pulp and paper industry, and offers a new synthesis of the dynamic forces that spearheaded the expansion and transformation of this large manufacturing industry. The evolution of the North American pulp and paper industry between 1860 and 1960 was driven by successive waves of technological learning that spawned structural change. Such waves transformed and expanded the sulphite and sulphate pulp, envelope, paper container, paper bag, magazine and printing paper, coated paper, board, and many other pulp and paper industries between 1860 and 1960. These waves repeated a pattern of co-evolution of technology and industrial organization that enveloped dynamic forces of change, such as innovation, corporate strategies, industrial relocation, and policy. As distinct branches of the pulp and paper industry passed from the early nascent phase to full maturity, the sources of innovation, nature of technological change, strategy and structure of leading firms, and industrial organization underwent throughout transformation. As these waves of industrial change passed from a nascent phase to maturity, the reciprocal dynamics between organization, corporate strategy, policy, and technological learning co-evolved, and established the evolutionary path of the North American pulp and paper industry.

CHAPTER 1

INTRODUCTION

This study analyzes the long-term evolution of the North American pulp and paper industry, and offers a new synthesis of the dynamic forces that spearheaded the expansion and transformation of this large manufacturing industry. I argue that the dramatic growth of the industry between 1860 and 1960 was driven and punctuated by distinct, sustained, and successive spectacular waves of innovation. Radical technological departures enabled managers of specialized firms to create new markets and pursue aggressive strategies of corporate growth. As these waves of industrial change passed from a nascent phase to maturity, the reciprocal dynamics among organization, corporate strategy, policy, and technological learning co-evolved, and established the evolutionary path of the North American pulp and paper industry.

Accurate historical understanding of the long-term evolution of a technology intensive industry sheds lights on the sources of economic growth, and this is what this study intends to accomplish. Innovation and firms are the major agents of industrial evolution, Joseph Schumpeter famously posited in his studies that still guide much of

economic and business literature.¹ By employing the concept of organizational capabilities, Richard Nelson and Sidney Winter proposed a framework to analyze the role of learning and organizational behavior for economic change. Their path-breaking study was premised on the central role of technical advancement for economic growth, and it urged scholars to reconsider how technological learning in practice influenced economic change.²

An effort to understand where technological learning resides in an economy, and to identify its characteristic dynamics, has been central for subsequent scholarship. Individual talented people are, of course, the primary source of technological ingenuity, but the organizational context influences heavily the diffusion of innovation and its economic effects. Historians of American science, technology and business have in great detail chronicled how the nation evolved from adopting European technology to being the leading source of technological innovations.³

In his study of the emergence of American system of manufacturing, David Hounshell demonstrated how individual, skilled mechanics moved from one industry to another during the late nineteenth century, and importantly contributed to nation-wide

¹ Joseph Schumpeter, *The Theory of Economic Development*. Cambridge, Mass.: Harvard University Press 1934; Joseph Schumpeter, *Capitalism, Socialism, and Democracy*. 3rd ed. New York: 1950: Harper.

² Richard R. Nelson and Sidney G. Winter, *An Evolutionary Theory of Economic Change*. Cambridge, Mass.: Belknap Press 1982; Another important contribution was the analytic framework advanced in Nathan Rosenberg, *Inside the Black Box. Technology and Economics*. New York: Cambridge University Press 1982.

³ Thomas P. Hughes, *American Genesis. A History of the American Genius for Invention*. New York: Penguin Books 1989.

technological learning.⁴ American innovation in iron and steel reflected leading firms' ability to respond flexibly to the changing needs of their customers, and this user-producer interaction propelled the rise of the modern U.S. steel industry, Thomas Misa has concluded.⁵ David Noble and Thomas Hughes have demonstrated how increasing innovation by American firms created a demand for technologically advanced work force, and prompted the transformation of the American university system.⁶ In the early twentieth century, the most important change in the organization of technological learning occurred when the large American firms divorced technological innovation from manufacturing operations, and established specialized research and development departments.⁷

⁴ David A. Hounshell, *From the American System to Mass Production, 1800-1932*. Baltimore: Johns Hopkins University Press 1984; See also: Nathan Rosenberg, "Technological Change in the Machine Tool Industry," *Journal of Economic History*, 23: 414-443.

⁵ Thomas J. Misa, *A Nation of Steel. The Making of Modern America, 1865-1920*. Baltimore: Johns Hopkins University Press 1995. For theoretical formulation of the role of user-producer for innovation in firms and industries, see: Eric von Hippel, *The Sources of Innovation*. New York: Oxford University Press 1988.

⁶ It should be noted that Noble's study was highly critical of the effect of large corporations on American institutions of science and technology. David F. Noble, *America By Design. Science, Technology, and the Rise of Industrial Capitalism*. New York: Knopf 1977; Thomas P. Hughes, *Networks of Power. Electrification in Western Society, 1880-1940*. Baltimore: Johns Hopkins University Press 1983; See also: David Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth*. New York: Cambridge University Press 1989, 21-97.

⁷ The best overview of American research and development is: David A. Hounshell, "The Evolution of Industrial Research in the United States," in Richard S. Rosenbloom and William J. Spencer (eds), *Engines of innovation: U.S. Industrial Research at the End of an Era*. Boston: Harvard Business School Press 1996, 13-85. Another useful overview is David C. Mowery and Nathan Rosenberg, *Paths of Innovation: Technological Change in 20th Century America*. New York: Cambridge University Press 1998. Detailed studies of the origins of research and development at major U.S. firms are: Leonard R. Reich: *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1926*. New York: Cambridge University Press, 1985; Ronald R. Klein, *Steinmetz: Engineer and Socialist*. Baltimore: Johns Hopkins University Press 1992. David Hounshell and John Kenly Smith, Jr, *Science and Corporate Strategy: DuPont R&D, 1902-1980*. New York: Cambridge University Press 1988; Ross Knox Bassett, *To The Digital Age. Research Labs, Start-Up Companies, and The Rise of MOS Technology*. Baltimore: Johns Hopkins University Press 2002.

Economic historian Gavin Wright has argued that technological learning in firms, industries, and regions in the nineteenth century America was a network phenomenon.⁸ In the early 1990's, economists introduced the notion of national systems of innovations as a systematic framework to analyze, and to enhance nation-wide technological learning.⁹ These studies provide a substantial body of evidence that the organizational context importantly shapes the direction, character, speed, and impact of technological learning. This is also foundational for the way I apply the concept throughout this study.¹⁰

⁸ Gavin Wright, "Can A Nation Learn? American Technology As A Network Phenomenon," in Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Temin, *Learning by Doing in Markets, Firms, and Countries*. Chicago: The University of Chicago Press 1999, 295-320. For similar analysis of the twentieth century U.S. economy, see: Richard R. Nelson and Gavin Wright, "The Rise and Fall of American Technological Leadership: The Postwar Era In Historical Perspective," *Journal of Economic Literature*, Vol 30 (Dec. 1992): 1931-1964. For the notion of technological spillovers, see: Adam B. Jaffe, Manuel Trajtenberg, and Rebecca Henderson, "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations," *Quarterly Journal of Economics* 108: 577-598. Similar dynamics are also analyzed at regional level: AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard University Press 1994.

⁹ Richard R. Nelson (ed), *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press 1993; Bengt-Åke Lundvall (ed), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London : Pinter Publishers 1992; These volumes offer a model of systems of innovation in late-twentieth century industrialized countries that strikingly resembles the classic schumpeterian interpretation of economic history in David S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe From 1750 to the Present*. London: Cambridge University Press 1969.

¹⁰ There are several attempts to define specific forms of technological learning. Broad literature on social construction of technology avoids using the notion of learning, but important elements of its theoretical premises are borrowed from Nelson and Winter. Best introduction to this literature is: Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (eds), *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology*. Cambridge, Mass.: MIT Press 1987; For the notion of technological momentum, see: Thomas P. Hughes, *Networks of Power*, 140-174; An influential effort to apply the notion of "scientific paradigms" proposed in Thomas S. Kuhn, *The Structure of Scientific Revolutions*. 2nd Ed. Chicago: The University of Chicago Press 1970 (1962), is Giovanni Dosi, "Technological Paradigms and Technological Trajectories," *Research Policy* 11 (1982): 147-162. On path-dependency of technology, see: Paul A. David, "Clio and the Economics of QWERTY," *American Economic Review* 75 (1985): 332-336. On learning by using, see: Nathan Rosenberg, *Inside the Black Box*, 16, 120-140; This view is also advanced in Walter G. Vincenti, *What Engineers Know and How They Know It: Analytical Studies From Aeronautical History*. Baltimore: Johns Hopkins University Press 1990. Interesting investigation of the epistemological and sociological foundations of engineering knowledge is: Louis L. Bucciarelli, *Designing Engineers*. Cambridge, Mass.: MIT Press 1994. For technological learning in firms, see especially essays in Lamoreaux, Raff, and Temin, *Learning by Doing*; For a review of institutional incentive structures and learning, see: Douglass C. North, *Institutions, Institutional Change and Economic Performance*. New York: Cambridge University Press 1990, 73-82.

For the purposes of the study, it is also appropriate to define what I mean by corporate strategy. Alfred D. Chandler, Jr., argued in his influential study, *Strategy and Structure*, that managerial considerations of efficiency and competitiveness determined the organizational structure of leading American enterprises in the early twentieth century.¹¹ Michael E. Porter has argued in his influential textbook on corporate strategy that corporate managers direct and organize their enterprises based on what they have reason to believe to produce competitive comparative advantage over their competitors.¹² Such a process of strategic decision making by firms determines organizational change at the industry level.¹³

In order to reduce the effects of market competition and be able to better predict future developments, corporate managers also attempt to gain control of the competitive environment.¹⁴ Chandler has argued that the large-scale vertically integrated structure of firms enabled corporate managers to improve the efficiency of production and distribution through centralized coordination.¹⁵ As Steven Usselman has shown in his study of the railroads, the administrative control of technological innovation was a central

¹¹ Alfred D. Chandler, Jr., *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. Cambridge, Mass.: The MIT Press 1962.

¹² Michael E. Porter, *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: Free Press 1985.

¹³ For a industry study that demonstrates this point: David G. McKendrick, Richard F. Doner, and Stephan Haggard, *From Silicon Valley to Singapore. Location and Competitive Advantage in the Hard Disk Drive Industry*. Stanford: Stanford University Press 2000. See also: Alfred D. Chandler, Jr., *Visible Hand. The Managerial Revolution in American Business*. Cambridge, Mass.: Belknap Press 1977; Alfred D. Chandler, Jr., *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge, Mass.: Belknap Press, 1994; Naomi R. Lamoreaux and Daniel M. G. Raff (eds), *Coordination and Information. Historical Perspectives on the Organization of Enterprise*. Chicago: Chicago University Press 1995.

¹⁴ Louis Galambos and Joseph Pratt define this as a “control of risks in markets and in the political system” in *The Rise of the Corporate Commonwealth. Unites States Business and Public Policy in the 20th Century*. New York: Basic Books 1988, 28-36.

element in the coordination mechanisms deployed by managers in order to manage the forces of economic change.¹⁶ In particular, intellectual property rights enabled firms to coordinate technological change.¹⁷ In a more polemic way, “New Left” historians have argued that corporate interest importantly shaped the early twentieth century reforms of American political economy.¹⁸ Thomas McCraw has pointed out, however, that the impact of American regulation of business on different industries has depended largely on their distinct underlying structure, and described the leading regulators as much more independent of corporate interest.¹⁹ Thus managers are forced to consider a complex, ever changing mix of economic, technological, and political factors when they craft corporate strategies.²⁰

¹⁵ Chandler, *Visible Hand*.

¹⁶ Steven W. Usselman, *Regulating Railroad Innovation. Business, Technology and Politics in America, 1840-1920*. New York: Cambridge University Press 2002.

¹⁷ Steven W. Usselman, “Patents, Engineering Professionals, and the Pipelines of Innovation: Internalization of Technical Discovery by Nineteenth-Century American Railroads,” in Lamoreaux, Raff, and Temin, *Learning by Doing*, 61-91. For a rather clear analysis of the intentions of the Patent System, see: William M. Landes and Richard A. Posner, *The Economic Structure of Intellectual Property Law*, Cambridge, Mass.: Belknap Press 2003;

¹⁸ See in particular: Gabriel Kolko, *The Triumph of Conservatism; A Re-Interpretation of American History, 1900-1916*. New York: Free Press 1963; Noble, *America By Design*; Martin J. Sklar, *The Corporate Reconstruction of American Capitalism 1890-1916. The Market, The Law, and Politics*. New York: Cambridge University Press 1988.

¹⁹ Thomas K McCraw, *Prophets of Regulation*. Cambridge, Mass.: Belknap Press 1984. Analysis of the influence of public policies on corporate science and technology is: David M. Hart, *Forged Consensus. Science, Technology, and Economic Policy in the United States, 1921-1953*. Princeton: Princeton University Press 1998; A good discussion of the conflicts between American antitrust policies and the Patent System during the twentieth century is: David M. Hart, “Antitrust and Technological Innovation in the US: Ideas, Institutions, Decisions, and Impacts, 1890-2000,” *Research Policy* 30 (2001): 932-936.

²⁰ A persuasive effort to provide analytic framework for the long-term evolution of American business is: Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Temin, “Beyond Markets and Hierarchies: Toward a New Synthesis of American Business History,” *The American Historical Review* 108 (April 2003): 404-432.

This study is primarily an effort to provide a historical analysis of the long-term evolution of the North American pulp and paper industry, but theoretical literature on industrial leadership and competitiveness has influenced my interpretation of historical evidence. Michael E. Porter's theory of competitiveness emphasized the micro-economic foundations of industry evolution, and has encompassed much of subsequent scholarship.²¹ In 1989, the MIT Commission on Industrial Productivity employed a similar framework to analyze the lagging performance of American manufacturing industries.²² In their review of sources of leadership in seven different industries, David Mowery and Richard Nelson noted that although elements of different central theories of industry dynamics corresponded with virtually any of the case studies, no single pattern fit all of the cases. Industries evolve over different evolutionary paths, and we have no general theoretical framework to explain industrial change. Yet, these studies have in common an emphasis on the co-evolution of organizational structures and technological learning.²³

I began this introduction by arguing that this study offers a new synthesis of the long-term evolution of the pulp and paper industry, one that emphasizes radical technological departures and sustained waves of technological learning. Most historians of the industry emphasize the absence of radical technological departures, and characterize technological change in the industry as a slow, incremental, and accumulative process. This may be because historians of the North American pulp and

²¹ Michael E. Porter, *The Competitive Advantage of Nations*. New York: The Free Press 1990.

²² Michael E. Dertouzos, Richard K. Lester, Robert M. Solow, *Made in America. Regaining the Productive Edge*. New York: HarperPerennial 1989.

paper industry have primarily examined the mature phases of capital intensive segments of the industry. In so doing they have ignored how individual segments of the industry have evolved from the nascent phase to full maturity over a long period of time.²⁴ A typical characterization of innovation in pulp and paper is provided Gary Magee in his comparative analysis of the British and American industries between 1860 and 1914: "[Pulp and paper industry is]...dominated by a capital-intensive flow production technology and a process of innovation characterized by gradual technological accumulation rather than major leaps."²⁵ In a similar vein, claiming to have listed all the major process innovations in the pulp and paper making in the U.S. between 1915 and 1940, Avi Cohen concluded that "Yet none of these innovations were major departures from existing technology."²⁶

²³ David C. Mowery and Richard R. Nelson (ed), *Sources of Industrial Leadership. Studies of Seven Industries*. New York: Cambridge University Press 1999, 11.

²⁴ The best overview of the history of pulp and paper industry in the North America is: David C. Smith, *History of Papermaking in the United States* (1691-1969). New York: Lockwood Publishing Company 1970; Very detailed history for developments before 1916 is: Lyman Horace Weeks, *A History of Paper-manufacturing in the United States, 1690-1916*. New York: B. Franklin 1969 (1916); Classic case study of technological change in a nineteenth century paper town is: Judith A. McGaw, *Most Wonderful Machine. Mechanization and Social Change in Berkshire Paper Making, 1801-1885*. Princeton: Princeton University Press 1987. An account of the early horizontal combinations that relates to theory of firm is: Naomi R. Lamoraux, *The Great Merger Movement In American Business 1895-1904*. Cambridge: Cambridge University Press 1985. Other major studies by historians include: Thomas Heinrich, "Product Diversification in the U.S. Pulp and Paper Industry: The Case of International Paper, 1898-1941," *Business History Review* 75 (Autumn 2001): 467-505; Gary B. Magee, *Productivity and Performance in the Paper Industry: Labour, Capital, and Technology in Britain and America, 1860-1914*. Cambridge, Mass.: Cambridge University Press 1997; Barry E. C. Boothman, "High Finance/Low Strategy: Corporate Collapse in the Canadian Pulp and Paper Industry, 1919 – 1932," *Business History Review* 74 (2000):4, 611-656; Avi J. Cohen, "Technological Change as Historical Process: The Case of the U.S. Pulp and Paper Industry, 1915-1940," *Journal of Economic History*, Vol. XLIV (Sept. 1984): 775-799; Trevor O. Dick: "Canadian Newsprint, 1913-1930," *Journal of Economic History*, XLII (Sept. 1982), 659-87. There are hardly any historical studies devoted solely to the pulp industry. Instructive on the developments in the wood pulp is: Royal S. Kellogg, *Pulpwood and Wood Pulp in North America*. New York: McGraw-Hill, 1923.

²⁵ Magee, *Productivity and Performance in the Paper Industry*, 2.

²⁶ Avi J. Cohen, "Technological Change as Historical Process., 785.

The following chapters detail a very different kind of dynamics of innovation in pulp and paper. Each of the chapters analyzes in detail the historical development of distinct waves of industrial growth that coalesced around specific bodies of technological knowledge. The second chapter examines the nascent sulphite pulp and paper industry, as it leaped from non-existent to be the largest sector, and the driver of substantial industry wide expansion during the last decades of nineteenth century. Patent monopoly on revolutionary sulphite pulp technology enabled managers to coordinate this rapid and dramatic period of industrial growth. The third chapter examines the role of intellectual property rights for cartels in other nascent segments of the pulp and paper industry. Chapter four offers detailed analysis of the long-term evolution of the American paper container industry, which propelled paperboard into most consumed line of paper in the U.S.

Radical technological departures, intellectual property rights, and product standardization punctuated the development of the paper container industry. The fifth chapter details how the sulphate pulp industry emerged from obscurity to become the dominating sector of the pulp and paper industry between 1920 and 1950, and facilitated important industry-wide expansion. The last chapter offers a history of the invention of machine coated paper, and it's development from a non-existent product in 1930 to the basis of an industry with over half a billion dollar in annual sales volume in 1960.

The dynamic development of these different industry segments repeated a common pattern of co-evolution of technological learning and industrial organization. At the nascent phase of the industry, a narrow group of firms gained control of revolutionary manufacturing technology through intellectual property rights, which facilitated the

creation of monopoly and oligopoly in specialized paper markets. Over time, imitation, innovation, standardization, expiration of patents, diffusion of technology or public policy have undermined such barriers of entry, and enabled competitors to learn the revolutionary technology. The leading specialized firms responded by adopting aggressive strategies of scale and scope, and drive down the unit cost. At this phase of industry development, an important shift in the locus of technological learning occurred. The leading pulp and paper firms specialized in operating large-scale, vertically integrated production process of pulp and paper, and procured manufacturing technology increasingly from specialized equipment suppliers. At the macro level of the North American pulp and paper industry, this study documents an historical evolution whereby the primary locus of productivity improving technological learning shifted from the pulp and paper firms themselves to specialized equipment suppliers.²⁷

²⁷ This has been conceptualized as the divergence of operational and technological clusters in McKendrick, Doner, and Haggard, *From Silicon Valley to Singapore*, 42-46.

CHAPTER 2

TECHNOLOGICAL LEARNING IN THE GROUNDWOOD AND SULPHITE PULP AND PAPER INDUSTRY, 1860-1920

A long sustained wave of learning in the wood pulp technologies culminated around 1900 in the dramatic restructuring of the North American pulp and paper industry. Within a few years the industry witnessed a merger mania, and the building of a number of vertically integrated, capital intensive record size pulp and paper mills that flooded the market with new, low cost ground wood-sulphite papers (see Table 2-1.). Ground wood was manufactured by mechanically grinding wood cords in small chips, which were then digested under pressure into cellulose pulp without chemicals. Chemical wood pulps, soda and sulphite, were manufactured by digesting the small wood chips in chemical solution. These wood pulps processes differed substantially technologically, and enabled the production of very different kind of papers.

The rapid diffusion of revolutionary technologies underpinned this transition into industrial capitalism and the new organization of the industry. A central element of this process was the eclipse in the number of available, alternative, sulphite process

technologies during the 1890's, and the creation of a patent monopoly by the industry's first large scale enterprise, the International Paper Company (henceforth IP).²⁸

Table 2-1. Production of Selected Paper Grades in the U.S., 1899-1909. (Tons of 2,000 lbs.).

Paper Grade	1899	1904	1909
Newspaper	569,000	913,000	1,176,000
Wrapping paper	535,000	644,000	763,000
Board	389,000	460,000	812,000
Book paper	304,000	454,000	677,000
Fine paper	119,000	147,000	198,000
Total Production	2,168,000	na	4,217,000

Source: *Manufactures 1909*. Washington, D.C.: Government Printing Office 1913, 758-9.

The emergence of a sulphite patent monopoly contrasts sharply with the efforts to control ground wood and soda pulp processes with intellectual property rights, as such attempts were repeatedly frustrated by the immaturity of technology or competing innovations. Discovered in the 1860's, the sulphite process was developed slowly and painstakingly into a commercially viable mass production technology during the 1890's. The sulphite process was a strategic innovation, however, because it critically complemented other wood pulps. Application of sulphite pulp with ground wood pulp allowed firms to improve significantly the quality of paper, introduce a wide array of new products, and simultaneously dramatically reduce the unit cost.

IP secured its sulphite monopoly through innovation, imitation, extensive litigation, pooling of technology, and horizontal combination. Yet, following a broad-

²⁸ Naomi R. Lamoreaux, *The Great Merger Movement*, 86-117; Very good statistical overview of the great merger wave is: Ralph L. Nelson, *Merger Movement in American Industry, 1895-1959*. Princeton:

based effort to discover a superior wood pulp process, the subsequent patent monopoly remained vulnerable to challenges, and the managers of the company recognized extensive and inclusive licensing as a way to strengthen its basic patent. The administrative control of technological innovation was a central element in the coordination mechanisms deployed by IP in its attempts to manage the forces of economic change.²⁹ This dual character of contracting of intellectual property rights had wide ranging implications for the competitiveness of the industry.³⁰

By examining half a century of technological learning within the pulp and paper industry, this chapter seeks to illustrate how maturity and ownership of technology, together with the institutional framework in which firms are situated, affects the ability of firms and industries to acquire new organizational capabilities.

Early Development of Wood Pulp Technologies

A small and tight community of entrepreneurs and inventors, who maintained a sustained wave of technological learning, pioneered mass production and vertical integration in the North American pulp and paper industry. These people innovated always in a strictly proprietary context, and the ownership of the critical wood pulp technologies – ground wood, soda, and sulphite - allowed them to merge firms, and induce vertical integration across the industry. This group of entrepreneurs developed new chemical sulphite pulping processes, which by critically complementing the older

Princeton University Press 1959.

²⁹ See cases discussed throughout: Usselman, *Regulating Railroad Innovation*.

³⁰ Lamoreaux, Raff, and Temin, *Beyond Markets and Hierarchies*.

mechanical ground wood pulping process, allowed unprecedented economies of scale in quality newsprint, book, and writing paper when the pulping process was fully integrated in the paper making machine.

As the frontier of technological knowledge on wood pulp technologies expanded and accelerated during the late nineteenth century, leading entrepreneurs consolidated critical intellectual property rights under their administrative control. This culminated in the pooling of intellectual property rights for the sulphite technology, an effort that eventually prompted the formation of the first large-scale pulp and paper enterprise, the IP, in 1898. Its managers controlled patents for the path-breaking sulphite digester through a special holding entity, the American Sulphite Company, and sold over 200 tactically priced patent licenses by 1903. This arrangement allowed IP managers to coordinate the diffusion of new technology and structural change in the North American pulp and paper industry. Because International attempted to gain control through a decades long, broad based effort to innovate in the wood pulp processes, its monopoly claims were intensely contested.³¹

In the nineteenth century, population growth, and institutional change that included urbanization, increased education, as well as the impact of Civil War, engendered an increased demand for paper that induced the discovery of new sources of cellulose. The maturing of wood pulp techniques depended critically on entrepreneurial strategies forged within small technological communities. Since the 1850's, the supply of rags used for pulp had steadily fallen further behind the increasing demand and eventually, in the aftermath of the Civil War, the shortage culminated with the "American

Paper Panic.” The shortage of Southern cotton rags, and booming demand for newspapers prompted the opening of the two first ground wood mills in the United States. The pioneering wood grinding machine had been patented in 1841 by the German, Friedrich Gottlob Keller, and acquired in 1846 by another German, Heinrich Völter, who improved the machinery and commercialized it with relative success. The Germans Albrecht, Rudolph, and Albreto Pagenstecher applied the patents and machinery of Völter in 1866, when they opened the first commercially viable paper and ground wood pulp mill in the United States in Massachusetts. Warner Miller, who opened a vertically integrated mill in New York the next year, had also learned of the German technology during his travels in Europe. The early commercial success of the ground wood pulp technology was limited because it produced mainly very poor quality paper, and more importantly, because the difficulty and cost of separating pulp from the water frustrated attempts to scale up production. Miller and Albrecht Pagenstecher cooperated closely to improve the machinery and were eventually able to pioneer the mass production of ground wood pulp. The owner of the neighboring mill to the Pagenstecher establishment, Benjamin Franklin Barker, received in the early 1870’s four patents for wood grinders that further facilitated economies of scale in ground wood pulp. While the expiration of the Völter patent in 1884 made the ground wood pulp process freely available, pulp and paper firms continued to depend upon suppliers of specialized and proprietary grinding and pulp treating machinery.³²

³¹ The license network is detailed in *American Sulphite Pulp Company v. De Grasse Paper* 193 F. 653 (1912).

³² Dard Hunter, *Papermaking. The History and Technique of an Ancient Craft*. 2nd Ed. New York: Dover Publications 1981(1947), 376-380; Warner Miller, “Introduction of Ground Wood Pulp in U.S.,” *Paper Trade Journal*, 22 Feb. 1917, 44, 48, 62 (hereafter *PTJ*); *PTJ* 1 March 1917, 18; McGaw, *Most Wonderful*

The wood pulping processes had definitive technological requisites that determined their economic application and the geographical location of the industry. The mechanical grinding of wood into ground wood pulp took place under pressure, was very power intensive, and consumed a tremendous amount of timber. The sulphite process was an 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 United States where hydropower and forests were ample in the vicinity of major markets. Yet the development and introduction of wood pulp technologies followed definitive entrepreneurial action that was prompted by the worsening shortage and booming price of the traditional dominant source of pulp fiber, cotton rags.³³

A small technological community believed that wood pulp could yield good quality paper if an appropriate chemical process - soda and sulphite - could be found. Hugh Burgess and Charles Watt secured an English patent for the production of pulp by boiling wood in caustic alkali at high temperature in 1851. The soda process, as it was named, did not become a commercial success in England, but the inventors secured an American patent in 1854, and opened a mill in Pennsylvania. Relying on the patent monopoly, they incorporated in 1863 the American Wood Paper Company and constructed a large-scale pulp and paper mill in Manayunk, Pennsylvania. Technological difficulties and high costs prevented the wide adoption of the soda process, but the early

Machine, 195-197; Magee, *Productivity and Performance*, 179-180; Smith, *The History of Papermaking*, 128-139.

experiments with it provided impetus for the sulphite process. The inventor of the sulphite pulp process, Benjamin Tilghman, claimed that it was while visiting mills in Manayunk that he recognized the potential of his earlier experiments with fats in sulphurous acid, which he had conducted in Paris in 1857. Tilghman began experimenting by cooking wood chips in a solution of sulphurous acid under high pressure and temperature, and acquired British patents for the sulphite process in 1866-67. The new process dissolved wood in a superior way and produced fine red-colored fiber pulp that was suitable for the manufacture of quality papers after bleaching.³⁴

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. The ground wood-sulphite mix resulted in a strong white paper instead of the yellow and weak ground wood paper. The increased hardness of the ground wood-sulphite paper also made it a superior alternative for the demands of newspaper printing. Emphasis on this mass product market set the course for the subsequent developments of the technology. Besides improving the qualities of paper, the sulphite pulp induced economies of scale and speed. The right mix of ground wood and sulphite pulp formed such a strong web on the paper-forming felt of the paper machine that it enabled the transition into more efficient and larger paper making machinery. Thus, sulphite pulp was the critical complementary technology to the ground wood pulp, new power intensive techniques of wood grinding, and the faster and larger paper making machinery that typically are

³³ David C. Smith, "Wood Pulp and Newspapers, 1867-1900," *Business History Review* 38 (Autumn 1964): 328-45.

³⁴ Hunter, *Papermaking*, 390-391.

proscribed as the causes of the structural change in the North American pulp and paper industry between 1880 and 1920.

Ground wood pulp technology fell under exclusive patent rights when introduced in the United States, but these monopolies lapsed in the 1880's. In the absence of significant improvements, the technology became freely available in principle. In practice, however, specialized machinery suppliers controlled and perfected the grinding, washing, beating, and screening technologies that were required for the mass production of ground wood pulp. Judith McGaw has detailed how the late nineteenth century paper firms rarely developed organizational capabilities in the machinery, but rather chose to rely on specialized shops such as the Black Clawson Company, the J.Horne and Sons Company, and many others. The existence of specialized machine shops and the relative simplicity and technological maturity of the ground wood pulping made it a reliable process and thus viable investment for many paper firms.³⁵

The sulphite pulping process was barely at experimental stage in 1867 and the need of continued improvement placed it squarely under tight patent monopolies over the next four decades. Benjamin Tilghman attempted to cash in with his invention only to be frustrated and accumulate burgeoning debt. After months of efforts to cook sulphite pulp in digesters he was forced to give up because leaks and cracks in the digester shell continued to damage the pulp batch. The sulphite process consisted of cooking wood chips in a solution of bisulphite of lime under high heat and pressure as long as was needed for the dissolution of the chips and to bleach the pulp –often more than 7 hours. The acidic chemical reactions damaged the metal digester shell, triggering undesired

³⁵ McGaw, *Most Wonderful Machine*, 108-116, 158-173.

chemical reactions that disturbed the batch. Tilghman had successfully described the sulphite cooking process as the application of bisulphate of calcium to sulphurous acid, but was unable to build an acid resisting interior lining of the digester shell and incurred \$20,000 in debts instead of reaping the bonanza of his invention. Other inventor-entrepreneurs learned from his failure a valuable lesson, and a community of inventors continued to pursue what they believed might give birth to a new industry.³⁶

The hope of a breakthrough in sulphite technology fueled the efforts of a few experimenters whose work was widely circulated in the trade journals. Europeans especially took up with the new technology and commenced where Tilghman had stopped. The Swede Carl D. Ekman and Englishman George Fry developed a magnesium sulphite process and established a pulp and paper mill in England in 1874. Since the pulp was not fully bleached, the paper retained a yellow color and poor quality. German Alexander Mitscherlich experimented with calcium sulphite and identified the practical success of the process with the structure and composition of the digester shell and its interior lining. His work between 1883 and 1886 resulted in patents that described, in addition to the sulphite process, an improved digester lining. Mitscherlich called for continuous lining of cement that he applied directly upon the hard metal shell, a layer of thin sheets of lead embedded in and upon the lining of cement, and next to these either one or two courses of vitrified brick laid in cement. The patented inventions of Ekman and Mitscherlich definitively improved the sulphite process but did not establish it as an economically viable technology. Charles S. Wheelwright attempted to employ the Ekman-Fry process in the early 1880's at his mill at Providence, Rhode Island, but

³⁶ "Obituary: Benjamin Tilghmann," *PTJ* 4 July 1901, 37, 48. For detailed descriptions of the Tilghman

without commercial success. August Thilmany purchased the American rights to the Mitscherlich patents in 1887 and commercialized them through the International Paper and Fiber Company, which opened a sulphite pulp and paper mill in Michigan. Despite these advances, the commercial success of the new sulphite process continued to be frustrated by technological problems.³⁷

By the early 1880's, other inventors had identified the interior lining of the sulphite digester as the critical problem they must solve in order to stabilize the process and decrease the cooking time. The potential economic bonanza fueled a feverish international race for the complete patent. The French Pierredon patents from 1883 described a heavy continuous lining of Portland cement mortar that was directly applied upon the metal surface of the digester shells. A patent by Austrian Wilhem Wenzel described a mortar that was composed of Portland cement and quartz sand mixed with a solution of silicate of soda, and applied on the digester shell. Additional patented constructions included the Austrian Ritter-Kellner process and the British Partington process.³⁸

Although Europeans advanced the sulphite technology, quite a few inventors and entrepreneurs realized that the potential of the sulphite process could be released through the utilization of the vast spruce stands of the North East United States and Canada. The newspaper, printing, and publishing industries of the United States established the world's largest markets for newsprint and book paper, the primary products made from

process, see: Julius Grant, *Wood Pulp*. (Leiden, Holland, 1938), 20-21.

³⁷ Hunter, *Papermaking*, 393.

³⁸ H.W. Stebbins, "The Sulphite Process," *PTJ* 6 Feb. 1908, 75-89; F. Fittica, "The Invention of Sulphite," *PTJ* 20 Oct. 1904, 5.

sulphite pulp. Therefore it is of little surprise that William Chisholm, a lumber manufacturer from Halifax, Nova Scotia, acted upon learning of the success of the Partington sulphite process by contracting the firm for digesters and skilled men in 1885. With his partners, Chisholm incorporated the Halifax Wood Fibre Company, which had large timber tracts and an advantageous seaboard location to ship sulphite pulp to the newsprint mills of the United States. Chisholm's sulphite pulp mill on the East River in Sheet Harbour, Canada, attracted wide attention among North American pulp and paper makers. William A. Russell, a member of an established pulp and paper family of entrepreneurs from Lawrence, Massachusetts, sent one his employees to learn the craft of lead-burning from the Englishman who managed the digester lining in Sheet Harbour. William Russell had established one of the first ground wood pulp mills in the United States in Bellows Falls, Vermont, in 1869 and pioneered its large scale use in the newsprint. He incorporated with politically influential partners the American Sulphite Pulp Company for the purpose of acquiring and holding the Partington sulphite patent rights in the United States. Having secured the rights in 1887, Russell installed the Partington digesters at the mills of his family company, the Russell Paper Company.³⁹

The introduction of sulphite-ground wood pulp changed dramatically the economics of newsprint mills and created immediate incentives for firms and entrepreneurs to construct fully integrated pulp and paper mills. Alfred D. Remington had pioneered large-scale paper production in Watertown, New York, in the late nineteenth century, and upon learning of the sulphite pulp traveled to Sweden and Germany in the 1880's. Remington began to import sulphite to his mills that used a pulp mix that

³⁹ Howard Coady, *Sheet Harbour History: From the Notes of and Old Woodsman*. Hantsport, N.S.:

combined a one-part sulphite and three parts of ground wood pulp to produce newsprint. In 1890 he completed the construction of a sulphite mill and perfected a modern fully integrated newsprint mill. The technological learning incurred over a decade constituted the platform for his expansion plans, and he established the St. Regis Paper Company that specialized in newsprint in 1900.⁴⁰

Realizing the potential of the new technology, William A. Russell aspired to gain control of the rapidly expanding newsprint industry by establishing a virtual monopoly on the sulphite process in the United States. However, none of the existing patents in the late 1880's described a commercially viable technology. The International Sulphite Fibre and Paper Company, which controlled the North American rights to the Mitscherlich patents, was bankrupted in the mid-1890's because the process did not work properly. The tactic of William Russell was to secure the proprietary rights of promising new technology and simultaneously organize a continued effort for improvement. The pinnacle of this effort, obviously, was to obtain a patent for a superior sulphite process. William Russell acted then as a manager, and delegated the scientific and technological work to his brother George Fred Russell, who was in charge of experimental work on sulphite digesters at the family mills.

Attempting to gain economies of scale, George Russell focused his efforts on the digester lining and decreasing the cooking time. He began experimental work with the lead-lined Partington digesters but within a few years moved toward lead-free solutions. Around 1889 Russell traveled to Europe to learn the latest technology and art of sulphite

Lancelot Press 1988, Ch. 2.

⁴⁰ Eleanor Amigo and Mark Neuffer, *Beyond the Adirondacks. The Story of the St. Regis Paper Company*. Westport, Conn.: Greenwood Press 1980, 8-12.

cooking. As a result, he filed in 1890 a patent application that described continuous interior lining of a sulphite digester with Portland cement, silicate soda, and sand instead of the established constructions that relied on Portland cement alone or lead sheets. The new structure drastically improved the acid resistant character of the digester, was fully continuous inside the digester, and reduced the cooking time per batch volume. Most importantly, the claims of the lead-free Russell patent were so general and technologically advanced that over the next two decades any manufacturer hoping to make a profit from sulphite cooking had to take them into account.⁴¹

Decline in the Availability of Technological Alternatives

The broad claims of the Russell patent were an effort to bring the widely diffused sulphite technology under the administrative control of William Russell. The eventual significance of the patent resulted from conscious work by the managers of the American Sulphite Company and the IP to marginalize competing technologies, rather than from its inherent technological novelty. In the 1880's and 1890's the Russell patent defined only one competing sulphite digester construction, but by 1900 all alternative technologies had declined in importance.

The flourishing number of alternative sulphite digesters in late nineteenth century North America is readily evident from the pulp and paper entrepreneurs who emigrated from Europe. In the hands of these inventors the lead digester had short-lived moments of success in the North America. William Luke, a descendant from a long line of Scottish papermakers, organized an attempt to improve the lead-burning digesters in Piedmont,

⁴¹ U.S. Patent No. 445,235. (1891, reissued 1892).

West Virginia. With the help of his son David, a chemistry graduate from the University of Pennsylvania, and brother John, William Luke raised \$250,000 to produce 10 tons of sulphite pulp daily for the production of book paper. The Lukes incorporated the West Virginia Pulp and Paper Company in 1888, which quickly became one of the leading book paper firms in the United States. This success was based on the original version of the lead-sulphite digester, but within a few years from the incorporation the company obtained a license to the lead-free Russell sulphite digester.⁴²

William Luke basically emulated in book paper what others did in newsprint, that is, he employed his knowledge of the sulphite technology to introduce low-priced wood pulp product innovations that replaced or captured market share from the rag-content papers. This opportunity induced Moritz Behrend, an innovative pulp and paper entrepreneur from Prussia, to immigrate with his family to the United States, in an attempt to profit from his knowledge of the wood and sulphite pulping. Behrend had scored an important victory in Germany by successfully challenging the Mitscherlich sulphite patent, arguing that the British patent Benjamin Tilghman had received in 1867 covered the same discovery. Invalidation of the Mitscherlich patent allowed Behrend to establish a thriving sulphite mill in Prussia with influential partners who included the Reichskanzler Otto von Bismarck. The entrepreneur-innovator immigrated to the United States in 1897 to supervise the construction of a new sulphite mill in Nekoosa, Wisconsin. Encouraged by the factor endowments available for the new pulp technology and American demand, he raised with his brother one million dollars in capital to construct a fully integrated sulphite bond paper mill. Established in 1898 in the city of

⁴² Anonymous, *History of the Company and Sales Policies*, 2. Carl A Kroch Library, Rare Manuscript

Erie, the new Hammermill Paper Company featured two Fourdrinier paper machines and six rotary sulphite digesters at the great lake with advantageous transportation connections in 1899.⁴³

Hammermill based its business strategy on the pioneering knowledge of the sulphite technology that allowed its managers to coordinate change in the structure of demand for fine papers. Over the years of experimentation, the Behrend brothers had learned to build and run sulphite digesters economically. They focused on efforts to replace the high priced quality rag-content papers with a new product innovation, sulphite bond paper. Their lower pricing slowly captured market share from rag-content papers. When Ernst and Otto Behrend made an additional innovation in the watermarking technology, the business improved. Quality papers typically carried a visually impressive watermark imprint that required traditional batch production done in a craft mode. The Behrend brothers experimented with a rubber roll process to mechanize watermarking of quality bond papers and perfect mass production. In 1902 they secured a patent for a process that allowed the imprinting of a watermark without disturbing economies of scale in a fully integrated pulp and paper mill. Mastering over sixty different watermarks while running long runs of production, the company aggressively expanded by capturing markets from the rag-content bond papers.⁴⁴

Though lead-based sulphite digesters posed a viable, economical alternative in specialty papers, perhaps into the late 1880's, they entered a terminal decline in

Collection, Cornell University. West Virginia Pulp and Paper Collection #3118, Box#7.

⁴³ Michael J. McQuillen and William P. Garvey, *The Best Known Name in Paper: Hammermill. A History of the Company*, Erie, Penn.: Hammermill Paper Company 1985, 18-24, 31.

⁴⁴ McQuillen and Garvey, *The Best Known Name*, 33-40.

importance during the 1890's. Alexander Mitscherlich, despite having his patents invalidated in Europe, managed a messy licensing policy in the United States. In addition to the license granted to Thilmany, Mitscherlich granted licenses, probably for others of his numerous patents, to competing companies. His inventions attracted the attention of Don M. Dickinson, the Postmaster General of the cabinet of President Grover Cleveland, president's secretary Daniel Lamont, and Secretary of Navy William C. Whitney, who all partnered to establish the Manufacturing Investment Company to exploit the Mitscherlich patent. The company experimented with the process at the Fletcher Paper Company mill at Alpena, Michigan, and then built a newsprint mill of its own in Madison, Maine, in 1888 with Whitney as its manager, and another one in Appleton, Wisconsin. The new sulphite paper received a first medal at the Columbia Exhibition in Chicago in 1893, but problems with the process and an inability to enter the high quality paper markets forced the company into bankruptcy in early 1899.⁴⁵

Use of lead-based sulphite digesters translated to business success only if the company deployed the new technology specialized to replace high quality and high priced rag-content papers, such as book paper or fine bond papers. In the more competitive low grade paper markets the only viable competitor to the Russell digester lining was patented in 1894 by Eugene Meurer, whose digester was commercialized by the Non-Antem Sulphite Digester Company and its president Albrecht Pagenstecher.⁴⁶ Non-Antem digester lining was an improvement in the lead lining invented by

⁴⁵ F. S. Rollins, 29 Jan. 1941. *Memo Re: Manufacturing Investment Company*. Great Northern Paper Company Papers, 1896-1960. University of Maine, Fogler Library (hereafter cited as GNP Collection), Box #840. Folder #9.

⁴⁶ U.S. Patent No. 514,374. (1894).

Mitscherlich, though contemporaries judged it economically and technologically inferior to Russell lining.⁴⁷ The New York and Pennsylvania Paper Company, a leading firm specializing in book and fine paper, contracted in 1896 for the Non-Antem digesters that cost almost nine thousand dollars a piece, but Pagenstecher failed to convince newsprint manufacturers of the applicability of his lead-based digester.⁴⁸ There did exist competing digester technologies and suppliers in the 1890's, but by 1900 William. A. Russell had completed extensive legal maneuvers and pooling of competing patents that created a virtual monopoly in the sulphite digesters.

Process of Monopolization

The lead-free digester lining discovered by George Russell perfected mass production of sulphite pulp, but its economic viability came to depend critically on managerial coordination of technology. Through his control of innovation William Russell looked to trigger and coordinate rapid structural change within the pulp and paper industry. The George Russell patent made such wide claims that it established potentially a sulphite monopoly, and thus it was destined to be upheld or abolished by the courts. Competitors challenged the patent by arguing that the Russell digester lining only modified the prior, broadly diffused knowledge of sulphite prices, and had a particular antecedent in the patent of Wenzel. The first case to test the validity of the Russell patent,

⁴⁷ For detailed comparisons of the relative merits of different digester lining constructions between 1896 and 1900, see the testimonies by George A. Hall, the superintendent of the J & J. Rogers Mill, and Hugh Connors, the superintendent of the International Paper Company during: *Hentschel v. Carthage Sulphite Pulp Company et al.*, 194 F. 114 (1909).

⁴⁸ *Articles of Agreement* [Between Non-Antem Sulphite Digester Company and the New York & Pennsylvania Paper Company], 18 April 1896. GNP Collection, Box # 840, Folder #12.

American Sulphite Pulp Company v. Howland Falls Pulp Company, declared the patent invalid in 1895.⁴⁹

The court examined in detail to what degree George Russell was familiar with the similar approach developed by Wilhem Wenzel in 1889 in Austria, and its international diffusion. Finally the District Court of Maine was persuaded by the defendant's argument that Russell had effectively only modified the prior art discovered by Wenzel, and interpreted narrowly. American Sulphite Pulp Company appealed the case, bringing forward new evidence, most importantly detailed correspondence between the Russell brothers and personal notes of George Russell in order to prove novelty and originality of the digester lining. In effect, the plaintiffs argued that Russell had laid down his digester lining construction in Cologne in 1889 before he received the information of the similar, but prior, solution invented by Wilhem Wenzel. Persuaded by these arguments, the Circuit Court of Appeals reversed the earlier decree in 1897 and granted the American Sulphite Pulp Company patent monopoly on sulphite technology in the United States. The court ruling was a severe shock to the nascent newsprint industry whose rapid expansion depended on the availability of the new technology. The *Paper Trade Journal* reported in the early 1899:⁵⁰

The manufacturers affected were banded together to resist any attempt on the part of the American Sulphite Pulp Company which owned the Russell patent, to collect royalties or, to exact the damages for infringement, which the court gave it

⁴⁹ *American Sulphite Pulp Company v. Howland Falls Pulp Company*, 70 F. 986 (1895).

⁵⁰ *American Sulphite Pulp Company v. Howland Falls Pulp Company*, 80 F. 395 (1897).

the right to do. Subsequently a truce was declared pending the outcome of negotiations making to merge the principal news mills into combination. It was said that the Russell interest were given assurance they would be ‘taken care of’ in case the combination went through.⁵¹

Instead, William Russell took care of his interests himself in 1898 by incorporating the “band” of New England mills into the first large-scale pulp and paper firm, the IP. As the president of the new company, Russell’s first action was to consolidate and organize the sulphite monopoly he aspired to control. In November 1898 the IP used a secret agent to purchase the patent rights to the Mitscherlich process at the public auction organized by the receivers of the bankrupt International Sulphite Fiber and Paper Company. By including the mills of the president of the Non-Antem Sulphite Digester Company, Albrecht Pagenstecher, in the merger and appointing him a director of the IP in 1898, Russell further extended his control over sulphite technology through personal networks.⁵²

When William A. Russell suddenly died before the completion of these arrangements, the new president of IP, Hugh C. Chisholm, claimed that the company should receive the Russell patents with his other interests from the American Sulphite Pulp Company. After a short controversy, International purchased the patent rights for \$20,000 and announced publicly in February 1899 that it had obtained a controlling interest in the Russell digester lining patent. The company had now secured control of the

⁵¹ *PTJ* 4 Feb. 1899, 81.

⁵² *PTJ* 6 Dec 1900, 708.

new sulphite technology and could enjoy its advantages free while charging competitors a license fee.⁵³

The corporate strategy of IP rested on the sulphite monopoly. Having conquered the newsprint industry through its dominant size and patent monopoly, the company began to exert its influence on the industrial organization of other high volume segments of the pulp and paper industry. The Russell patents were again destined for litigation. In 1900 the American Sulphite Pulp Company found the validity of its digester lining patents challenged when it sued the Burgess Sulphite Fibre Company, the world's largest producer of sulphite pulp, and three other firms for patent infringement. As the judicial process commenced during summer 1900, the parties eventually reached a settlement that sealed the validity of Russell patents. According to the *Paper Trade Journal* the other twenty infringing mills only wasted money on legal battles and were best off in the new situation by simply paying licenses and damages. An editorial of the *Journal* summarized the situation:

The regulation of the sulphite market is now practically in the hands of the International Paper Company. Thy [sic] this is meant that that company being the principal owner of the Russell patent, has the power to refuse licenses for new plants, and can also prevent additional digesters from being put in the mills now in existence... One thing is now put down as a certainty of the future by sellers of

⁵³ *PTJ* 5 Nov. 1899, 899; *PTJ* 10 Dec. 1898, 999; *PTJ* 21 Jan. 1899, 41; For the details of the transfer of patent rights to the International Paper Company, see: *American Sulphite Pulp Company v. De Grasse Paper* 193 F. 653 (1912).

sulphite, and that is that the price to be paid for licenses will have its effect on the price of sulphite, making that article dearer than at present.⁵⁴

Naturally competitors did everything they could to frustrate the ambitions of Russell and the International Paper. The most noted case involved the resignation of Garret Schenck, the manager of insurance and taxes, from the newly formed International Paper Company. Schenck had obtained patents on process for reclaiming liquids from the pulp digesters, and commercialized it in cooperation with the National Sulphite Boiler and Fibre Company in the 1880's. Schenck was generally recognized as a successful pulp and paper engineer and manager, and had created in 1897 the Great Northern Development Company to produce newsprint in the neighborhood of Bangor, Maine. The emerging Russell sulphite monopoly threatened to frustrate this, and Schenck focused his efforts to circumvent the patent.⁵⁵

In July 1898 the Development Company changed its name to the Great Northern Paper Company, with over four millions dollars of capital. Under the leadership of Schenck, its managers reviewed the newly formed newsprint cartel, and argued that the IP was not sustainable competitively because most of its mills were not fully integrated. Indeed, many of the sulphite mills absorbed by the International were only in the vicinity of its paper machines, not fully integrated. The managers of the Great Northern proposed to build a fully integrated sulphite newsprint mill in Millinocket at a favorable location

⁵⁴ *PTJ* 27 Sept. 1900, 387.

⁵⁵ *Warner Miller to Garret Schenck*, 28 July 1898. GNP Collection, Box #842, Folder #12; L. D. Post, *Achievements of a Great Silent Man, Garret Schenk. The Northern*, Feb. 1928, 10-11; Smith, *Papermaking in the United States*, 172.

along the mighty Penobscot River, surrounded by vast spruce stands, and with a railway connection. The Great Northern managers believed that these factors, together with license free sulphite technology, would enable it to produce newsprint at lower prices than any other firm.⁵⁶

Central to the strategy of the Great Northern was Schenck's belief that he could circumvent the Russell sulphite monopoly. His old friend Fred W. Ayer from Bangor had obtained patent for lead-free cement lining of a sulphite digester, and was eager to assign the patent to the Great Northern. Schenck explained the advantages and potential problems of the Ayer patent to his managers:⁵⁷

The only parties, I may say, that would raise a question, are the International Paper Co. and the American Sulphite Pulp Co, controlling the so-called Russell patents. If we can safely use the lining, without infringing, it makes a saving of a great many thousand dollars to the Great Northern Paper Company, and it is equally as good or better than the lining that we contemplate using, at a very large expense.⁵⁸

The Great Northern Paper Company was forced to either contract a costly license for the Non-Anthem lead digester from Albrecht Pagenstecher, or the lead-free Ayer digesters. Schenck's lawyers argued that the Ayer patent did not infringe the Russell

⁵⁶ *Proposed Pulp and Paper Mills at Millinocket, 1898*. GNP Collection Box #841 Folder #14.

⁵⁷ U.S. Patent No. 624,608. (1899).

⁵⁸ *Garret Schenck to Lewis Cass Ledyard, 1 Sept. 1899*. GNP Collection, Box #841 Folder #10.

patent if followed strictly, and enabled him to circumvent the IP monopoly. The Great Northern managers contracted the patents, and proceeded with the construction of the Millinocket mill, which, when completed in 1900, was arguably the world's largest. The strategy of the Great Northern Paper Company was based on its ability to circumvent the Russell sulphite cartel. Although the case reiterates how dramatic an effect the control of innovation had on corporate strategy and structure in the pulp and paper industry in the 1890's, it remained of marginal importance for the unfolding structural change of the pulp and paper industry.⁵⁹

The success by which IP maintained managerial control over sulphite technology effectively limited the potential of any viable alternatives, such as the Ayer patent. Legal tactics attached revolutionary advantages only to the Russell sulphite technology, and the managerial coordination of the International and American Sulphite Company recast corporate strategies of the leading newsprint and book paper firms. In a sweeping change around 1900, these companies adopted or intensified a vertically integrated corporate structure and embraced economies of scale. The Champion Coated Paper Company of Ohio, for instance, abandoned its old book paper mill and opened the world's largest coated paper mill in Hamilton in 1901. During the following decade the company tripled the size of its only paper mill and pioneered the relocation into the South by acquiring large timber tracts and constructing a 200 ton capacity sulphite mill in North Carolina to supply Ohio operations. Through these actions it wanted to cease dependence on the supply of sulphite pulp by the West Virginia Pulp and Paper Company, and establish an

⁵⁹ *Garret Schenck to Fred W. Ayer*, 23 Oct. 1899; *Fred W. Ayer to Garret Schenck*, 28 July 1899; *Opinion*, 28 Sept. 1899. Betts, Betts, Sheffield Betts, Counsellors at Law. GNP Collection, Box #841, Folder #10.

independent vertically integrated production.⁶⁰ All the leading newsprint and book paper firms followed the suit, including the St. Regis Pulp and Paper Company, the Kimberly & Clark Company, the West Virginia Pulp and Paper Company, the Great Northern Company and many others.⁶¹

Table 2-2. Number of Sulphite Mills, Digester and Annual Production of Sulphite Pulp in the United States, 1897-1907 (Tons of 2,000 lbs.)

Year	Mills	Digesters	Reported Production
1897	49	205	432,140
1900	71	265	643,250
1907	86	320	1,128,720

Source: H.W. Stebbins, *The Sulphite Process. Economic and Other Developments Affecting it Since 1897.* *PTJ* February 6, 1908, p.75-89.

Control of the sulphite patents enabled IP to facilitate vertical integration in the pulp and paper industry. Between 1897 and 1907, the production of sulphite sky rocketed and achieved enormous scale economies (Table 2-2). Over a three-year period from 1897 the number of the sulphite digesters increased by almost one third. More stunning is the fact that between 1900 and 1907 the capacity of individual digesters grew by almost fifty per cent. Indeed, the entire sulphite production in the U.S. increased 82 per cent between 1899 and 1904 and accounted for 40 per cent of the all wood pulp production (Table 2-3 and 2-4). The production of sulphite at vertically integrated pulp and paper mills increased about 162 per cent while the production of all other sulphite pulp grew only

⁶⁰ Elwood R. Maunder and Elwood L. Demmon, "Traiblazing in the Southern Paper Industry," *Forest History* 5:1 (Spring 1961): 6-12.

⁶¹ Anonymous, *History of the Company and Sales Policies*, 2; Amigo and Neuffer, *Beyond the Adirondacks*, 26.

about 40 per cent. As a consequence, the vertically integrated mills' relative share of total sulphite pulp production increased. Whereas in 1900 one third of all sulphite pulp was produced in fully integrated mills, the share increased to half by 1905, and to over 56 per cent by 1909. These statistics do not reveal the full extent of vertical integration in the pulp and paper industry, because they count as vertically integrated only pulp and paper mills located within the same county and owned by the same company. The South Carolina pulp mill and the Ohio paper mill of the Champion Coated Paper Company, for instance, are accounted for as disintegrated mills.

Table 2-3. Wood Pulp Made for Sale or For Use in Establishment Other Than Those in Which Produced in the United States (tons of 2,000 lbs.)

Pulp	1899	1904	1909
Ground	280,052	273,400	310,747
Soda	99,014	130,366	155,844
Sulphite	271,585	376,940	444,255
Combined	650,651	780,706	910,846

Table 2-4 Wood Pulp Produced Including That Used in Mills Which Manufactured in the United States (tons of 2,000 lbs.)

Pulp	1899	1904	1909
Ground	586,374	968,976	1,179,266
Soda	177,114	196,770	298,626
Sulphite	416,037	756,022	1,017,631
Combined	1,179,525	1,921,768	2,495,523

Sources for both tables: *Manufactures 1909*. Washington, D.C.: Government Printing Office 1913, 759.

In many cases the vertically integrated structure of pulp and paper firms followed from the licensing policy of IP, which abhorred the emergence of an independent and large sulphite pulp market, and reluctantly licensed disintegrated sulphite firms. The

company favored firms that produced sulphite pulp mostly for their own consumption and produced product other than newsprint, or supplied regions where International was inactive. The control of sulphite technology also allowed IP to single out an exceptional corporate strategy to reap the advantages of rapid technological change occurring in all pulp and paper machinery. While other pulp and paper firms invested evenly in ground wood pulp, sulphite pulp and paper machinery, IP focused exclusively on the sulphite technology.

Horizontal Combination and Innovation

Immediately upon its formation, IP was labeled as a newsprint cartel by critics who focused on its dominance of the North American newsprint capacity. During its first five years the firm did not install a single new paper machine. Instead of increasing its output, the company trimmed internal efficiencies and attempted to shift paper production capacity from newsprint into more specialized grades, such as bible, book and bag paper. Most importantly, International increased daily production capacity of sulphite pulp from 490 tons in 1898 to 858 tons in 1900, and achieved the capacity of about 1,000 tons 1909 where it remained until 1919.⁶²

Upon its formation in 1898 IP hired an experienced constructor of digester interior linings, superintendent George A. Hall, to manage an extensive program of cutting out old digester interior linings and installing new ones, as well as building new digesters. The work was completed at IP sulphite mills at Fort Edward, Piercefield,

⁶² Totals are calculated by including the reported capacity of each mill of the International Paper Company in the *Lockwood's Directory of the Paper, Stationery, and Allied Trades*. 25th, 26th, and 34th Editions. New York: Lockwood Publishing Company 1899, 1901, 1909).

Watertown, Niagara Falls, South Gardiner, Rumford Falls, Berlin, Bellows Falls and Palmers Falls, New York.⁶³ In addition to improving all of its existing sulphite mills, the company built additional daily capacity of 110 tons at three new locations.⁶⁴

While IP invested massively in the sulphite technology and the acquisition of pulp wood stands, it did nothing about its existing paper machines. Apart from pulp-treating machinery, such as beaters, washers and screens, the sulphite technology represented the only investments in technology the IP made during its early years. Its daily ground wood pulp capacity remained unchanged at 2,390 tons for years after the incorporation, and it took a decade to increase it to about 3,000, where it remained through 1919. The failure of the IP to install a single new paper machine during its first five years and its success in reducing its newsprint production were interpreted by the U.S. Attorney General as symptoms of cartel, but they also revealed extent to which the company managers relied on the economic and competitive advantages of the Russell patent.⁶⁵

The central role of sulphite technology in IP strategy as well as the structure of the North American pulp and paper industry begs the question as to what extent patent rights enabled the firm to control markets? The answer is that the company had built an extensive licensing network through which it was able to rig the price of paper. By March 1903, the American Sulphite Pulp Company had sold over 200 licenses for the Russell

⁶³ The mills are as accounted for in the testimony by the superintendent of the International Paper Company, Hugh Connors, during an unrelated digester patent trial: *Hentschel v. Carthage Sulphite Pulp Company et al.*, 169 F. 114 (1909).

⁶⁴ *Lockwood's Directory*. 25th and 26th Editions.

⁶⁵ *PTJ* 25 Feb. 1904, 315.

digesters, and charged a license fee per cubic feet of the digester, “measured on the inside of the vessel to which the lining was to be applied.”⁶⁶

Despite of IP’s denials, the courts established that the pricing of licenses varied a great deal between different licensees. Most firms paid between 86 cents and \$1.35 per cubic foot per digester inside volume, but two other classes of licensees existed too. Some firms paid a fixed fee, and the leading U.S. book paper producer West Virginia Pulp and Paper Company paid a one-time fee of \$10,000, an amount that IP’s Hugh Chisholm later argued was “accidentally small.” Firms that were members of the IP “family” paid as low as 15 cents per cubic feet. The cost of the license certainly increased the price of sulphite pulp, but it is extremely difficult to estimate precisely how much. The court cited in the *American Sulphite v. Howland Falls* case of 1897 a digester with the volume of roughly 10,000 cubic feet, for which the license fee could have been anything between \$1,600 and \$14,000.⁶⁷ The only uniform rule of these license agreements was that they were signed through the expiration of the Russell patents in 1909. The law that provided little or no restrictions on discriminating licensing practices now allowed the IP a substantial, yet far from complete, mechanism to coordinate the nascent sulphite pulp, newsprint and book paper industries.⁶⁸

⁶⁶ *American Sulphite Pulp Company v. De Grasse Paper*, 190 F. 39 (1911)

⁶⁷ *American Sulphite Pulp Company v. Howland Falls Pulp Company*, 80 F. 395 (1897).

⁶⁸ *American Sulphite Pulp Company v. De Grasse Paper*, 193 F. 653 (1912).

Table 2-5. Year End Quoted Bid/Asked U.S. prices For Sulphite Pulp in U.S. Cents, 1889-1909

Year	Foreign Bleached	Foreign Unbleached	U.S Bleached	U.S Unbleached
1889	4.50/5.00	2.85/3.65	na	na
1899	3.25/3.75	2.20/2.50	na	2.25/2.50
1900	3.25/3.75	2.30/2.50	2.75/3.00	2.10/2.50
1904	3.35/3.45	2.25/2.40	2.50/3.25	1.85/2.10
1905	3.10/3.25	2.25/2.40	2.50/2.80	1.85/2.10
1909	2.60/2.70	1.75/2.20	2.60/2.80	2.00/2.15

Sources: *PTJ* 28 Dec. 1889; *PTJ* 28 Dec. 1899; *PTJ* 27 Dec. 1900; *PTJ* 29 Dec. 1904; *PTJ* 28 Dec. 1905; *PTJ* 30 Dec. 1909.

IP's decision to charge a one-time fee per digester encouraged maximum throughput at the licensee mills. Ironically, this had the additional effect of undermining demand for European sulphite imports that constituted a challenge for the sulphite monopoly. The price difference between more expensive foreign and cheaper domestic sulphite pulp translated directly to the advantage of IP, as it facilitated greater consumption of American sulphite pulp. The weekly open market quotations of the *Paper Trade Journal* reveal that the price difference between the imported and domestic sulphite pulp was non-existent in the unbleached sulphite pulp, but significant in the bleached sulphite pulp (See Table 2-5.). Eventually after 1900 the price of imported and domestic bleached sulphite pulp converged at accelerated rate, and reached parity in 1909. The scope and extent of the efforts of IP suggest that the sulphite monopoly did contribute to the relative price stability of the U.S. bleached sulphite pulp. In the absence of direct sources on the effect of licensing on the price of pulp, however, such judgment remains ultimately precarious.

My account of the beginnings of the IP has emphasized the dynamic forces of innovation and entrepreneurship, whereas the previous literature on the firm has traditionally cited over-capacity, low prices, and unsuccessful attempts of firms to combat these evils through cooperation as the causes of the merger.⁶⁹ In respectively influential studies Naomi Lamoreaux and Neil Fligstein have cited independent mills' fear of bankruptcy as having triggered the merger that enabled the IP to control newsprint prices through its dominant size.⁷⁰ The interpretation does correctly identify that contractual agreements between firms helped to stabilize the newsprint price, and the critical role played by the IP, but does not recognize credibly the distinct mechanisms deployed by the firm to achieve these ends.

To the extent the collusion argument focuses exclusively on consolidation of market share and does not integrate the critical role played by technology in achieving stability in prices and industrial organization, it remains an insufficient explanation for the timing and shape of horizontal combination. Only by considering the sulphite process patent monopoly can we explain why the individual firms that were mired in the structural problems of the pulp and paper industry in the 1890's chose the structure of a tightly integrated large enterprise that became the IP.

The centralized structure of IP was an exception among the newsprint firms that attempted to gain market control through cooperation and consolidation during the great merger movement. Although many other newsprint firms had identical integrated

⁶⁹ L. Ethan Ellis, *Print Paper Pendulum, Group Pressures and the Price of Newsprint*, 14. In L. Ethan Ellis, *Newsprint: Producers, Publishers, Political Pressures*. (New Brunswick, 1960 (1948)), Appendix.

⁷⁰ Lamoreaux, *The Great Merger Movement*, 105; Neil Fligstein, *The Transformation of Corporate Control*. Cambridge, Mass.: Harvard University Press 1990, 63.

structure with the IP, the dramatic difference was in the size of the firm. International simply dwarfed other newsprint manufacturers, and the difficulty of organizing in a large integrated firm was exposed when rival newsprint firms grouped together. Typically, newsprint firms attempted to gain market control through loose combinations and centralized sales agencies and rarely ventured to centralize the management or manufacturing operations. Under the competitive pressures brought by IP, nearly thirty Mid-West newsprint manufacturers established a common sales agency, the General Paper Company, in June 1900 and gave it exclusive sales rights for the next five years. The General Paper Company was the only firm that equaled IP in size, but its organizational structure turned out to be ill advised. Newspapers and federal antitrust authorities were quick to single out the new giant firm as an illegal sales pool and after years of investigations filed an antitrust suit in December 1904. Within 18 months the defendants accepted a consent decree that dissolved the General Paper Company.⁷¹

Following the guilty plea, the leading member of the General Paper Company, Kimberly & Clark Company, decided to tighten its structure and consolidated with its subsidiaries, the Atlas Paper Company and the Telulah Paper Company, into a new centralized structure as the Kimberly-Clark Company in 1907.⁷² The remaining other former members of the General Paper Company explored the possibility of emulating the structure of IP, too, but chose instead to organize under the Fibre and Manila Association. It was quickly charged with violation of the Sherman antitrust law and its members

⁷¹ Simon N. Whitney, *Antitrust Policies. American Experience in Twenty Industries*. New York: Twentieth Century Fund 1958, 334-335.

⁷² *PTJ* 10 Jan. 1907, 14.

pleaded guilty to price fixing in 1908.⁷³ Many similar newsprint pools experienced a varying fate, such as the defensive consolidation of the Eastern mills left outside the IP in 1900 that never bore fruit.⁷⁴ These regional consolidation plans were typically attempts to re-vitalize the economic viability of an historical industrial district that had flourished during the epoch of proprietary capitalism.⁷⁵ However the sweep of antitrust cases demonstrated to the pulp and paper managers that the degree of vertical centralization predicted how a merger would survive legal challenge.⁷⁶

If regional attempts to merge were often unsuccessful, national consolidation plans that did not involve contracting of critical technologies fared no better. In the second largest branch of the industry, book paper, the leading firms Virginia Pulp and Paper Company, New York and Pennsylvania Company, Ticonderoga Pulp and Paper Company, the Duncan Paper Company, the Morrison & Cass Paper Company, the Jessup & Moore Paper Company, and P.H. Glatfelter Company and others entertained a merger in December 1898 that never came to realization.⁷⁷ The intent to stabilize book paper market through the formation of a dominant national giant survived three years and increased significantly in size when Hugh Chisholm's own Oxford Paper Company

⁷³ Whitney, *Antitrust Policies*, 334-335; *PTJ* 4 July 1907, 5; *PTJ* 5 Sept. 1907, 8; *PTJ* 17 Oct. 17 1907, 5

⁷⁴ *PJT* 23 Aug. 1900, 227; *PTJ* 13 Sept. 1900, 332.

⁷⁵ For the definition of industrial district and argument for their sustained competitiveness, see: AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard University Press 1994; Michael J. Piore and Charles F. Sabel, *The Second Industrial Divide: Possibilities of Prosperity*. New York: Basic Books 1984.

⁷⁶ Tony Freyer, *Regulating Big Business. Antitrust in Great Britain and America, 1880-1990*. New York: Cambridge University Press 1992, 133, 141.

⁷⁷ *PTJ* 3 Dec. 1898, 979

joined the plan, but it never amounted to incorporation.⁷⁸ The sheer consolidation of market power, then, rarely if ever amounted to a winning strategy in the high volume pulp and paper industries.

Technological learning and control of innovation were always part of the successful recipe of cartelization in all segments of the pulp and paper industry between 1860 and 1909. This was the case in the coated book, bag, folding box, corrugated board, news board, envelope, drinking cup, sanitary, and tissue paper industries, in which firms successfully created smaller or larger cartels. In these industries, managers consolidated administrative control of technology by cross-licensing patents, merging firms, and litigation. The absence of such efforts characterized the failed trusts in the writing, wall, straw and basic board paper industries. This striking difference between the failed and successful cartels in the pulp and paper industry suggests that technology constituted a major mechanism to coordinate complex industrial organizations.⁷⁹

When IP faced the expiration of the Russell patent in 1909, increasing competition in its major lines of business, and antitrust scrutiny, it was forced to forge a new competitive strategy. The company's experience with the sulphite technology, which consumed the most wood in relative and absolute terms of all the pulping processes, predictably geared the firm towards forestry, as its capital intensity pushed it to improve

⁷⁸ *PTJ* 17 Oct. 1901, 482.

⁷⁹ C. W. Bell, "Board 'Combinations'. The Changes That Have Taken Place In the Market—Present Production—An Enumeration of the Various Pools Etc.," *PTJ* 9 Feb. 1905, 115; "Consolidations in the Trade," *PTJ* 6 Feb. 1908, 151-153; Harry J. Bettendorf, *Paperboard and Paperboard Containers. A History*. Chicago: Board Products Publishing Company 1946; Grover J. Daly, *The Corrugated Container Industry – A History and Analysis*. Chicago: Board Products Publishing Company 1971; Charlotte Heath, *Dennison Beginnings, 1840-1878*. Framingham, Mass.: Dennison Manufacturing Company 1927; Wilbur F. Howell, *A History of the Corrugated Shipping Container Industry in the United States*. Camden, N.J.:

the efficiency of production. Thus IP formulated a strategy that emphasized almost exclusively scale economies.

In December 1905 the president of the company, Hugh C. Chisholm, announced an aggressive strategy of expansion that focused almost exclusively on economies of scale, and came to create a new technological core for the firm. While the company had installed during its eight years only one small cardboard machine, it now installed 10 new paper machines that replaced older machinery and increased the company's production capacity. The move was accompanied by the development of new technological capabilities in machinery and forestry. IP reduced its dependency on outside machinery suppliers in 1908 by acquiring the plant of Turner Falls Machinery Company in Massachusetts that provided services to all of its mills. Most importantly the company increased its timberlands from 840 thousand acres in 1903 to 1,2 million in 1908, and respectively its timberland limits from 1,8 million to almost 3 million. As a first pulp and paper firm the company also announced a designated forestry policy that followed Gifford Pinchot's "scientific forestry." This was realized through extensive tree nurseries, employment of foresters, and introduction of new forest management techniques. International Paper's new strategy of growth emphasized the competitive advantages of continuous improvement of capital efficiency, and paid little or no regard to strategic innovation.⁸⁰

Samuel M. Langston Company 1940; Charles McKernon, "The Story of the Writing Branch," *PTJ* 6 Feb 1908, 11; *PTJ* 5 July 1900, 3; *PTJ* 17 June 1909, 6.

⁸⁰ *PTJ* 7 Dec. 1905, 3, 16; *PTJ* 30 Jan. 1908, 22; *PTJ* 16 April 1908, 50; *PTJ* 7 Jan. 1909, 7.

Relocation of Newsprint to Canada and Product Diversification in the U.S Paper Industry

IP specialized in economies of scale largely in response to the changing political economy. Tariff barriers up to 20 per cent duty had protected the U.S. sulphite newsprint industry since its origins, but in 1909 the government lowered these tariffs. Newspapers continued to cry for the total abolishment of tariffs on newsprint, and in 1913 this was done with the Underwood-Simmons tariff passed as a Woodrow Wilson reform. A rapid period of growth in the Canadian newsprint industry followed. The expansion of the Canadian pulp and paper industry accounted for the growth of imports of newsprint into the U.S. from 2,000 tons in 1904 to 220 in 1913, and eventually to 730,000 tons in 1920. Between 1913 and 1920, Canadian newsprint capacity grew from an annual 350,000 tons to about 880,000 tons. During this period of transition, technological routines in the Canadian pulp and paper industry were geared almost exclusively towards large-scale production of newsprint.⁸¹

Much of the Canadian growth resulted from the massive investment of U.S. firms in new production capacity there. IP responded to the changed conditions by eventually relocating all of its newsprint capacity to Canada, and diversifying U.S. newsprint production into specialty paper grades. Philip Dodge, the president of the company had outlined this strategy in 1911, when he predicted that the removal of tariffs from

⁸¹ Barry E. C. Boothman, "High Financy/Low Strategy: Corporate Collapse in the Canadian Pulp and Paper Industry, 1919-1920," *Business History Review* 74 (Winter 2000), 611-656; Trevor J. O. Dick, "Canadian Newsprint, 1913-1930. National Policies and the North American Economy," *Journal of Economic History*, Vol. XLII, No. 3 (Sept. 1982), 659-687; Ellis, *Print Paper Pendulum*, Ch. 6; John A. Guthrie, *The Newsprint Industry. An Economic Analysis*. Cambridge, Mass.: Harvard University Press 1941, 234; Heinrich, "Product Diversification"; Royal S. Kellogg, *Pulpwood and Wood Pulp in North America*. New York: McGraw-Hill Book Company 1923, 24; Thomas R. Roach, *Newsprint. Canadian Supply and American Demand*. Durham: Forest History Society 1994, 1-8.

Canadian newsprint would sound the death knell for smaller U.S mills. IP would respond with “a large physical expansion in Canada,”⁸² Dodge argued. A year later the company announced that it would shift 20 per cent of its U.S. production capacity from newsprint to specialty papers, such as tag and box papers. In addition the company deepened its vertical integration with the Continental Paper Bag Company, which converted paper into specialty paper bags.⁸³

The effects of the tariff revision on IP, and the whole U.S. paper industry, were amplified by intensified antitrust scrutiny. Government executed extensive investigations on the price of newsprint and trade practices of the industry in the midst of the war effort. The Federal Trade Commission concluded its studies in 1917, and soon the book and newsprint industries were both indicted. The government dissolved many central industry associations, as well, and even regulated the price of newsprint for few years.⁸⁴

Combined, these regulatory pressures diminished the significance of newsprint in the strategy of U.S. paper firms, and its share of total paper production declined steadily. IP’s evolving structure exemplified the changed dynamics. IP’s Dodge reflected on the effects of political economy on the profit structure and future of his firm in 1919:

It is notable that substantially one-half of the profits resulted from manufacture of special papers small in volume as compared with news print ... Certain of the

⁸² *PTJ* 17 Aug. 1911. Vol. LIII, No. 7. 8.

⁸³ *PTJ* 10 Oct. 1912. Vol. LV, No. 15, 9; *PTJ* 17 March 17, 1913. Vol. LVI, No. 13, 30; Continental, in turn, made renewed effort diversify its production by introducing new product innovations, such as sanitary napkins. *PTJ* 10 April 1913. Vol. LVI, No.15, 30.

U.S. mills can continue the production of news print paper on a competitive basis for many years. Some have been changed for the production of other and more profitable papers. As to others, changes are being made and will be made to put them on a profitable basis outside of the newsprint field...The world-wide dislocation of industry and commerce has confronted this business like all others with new conditions, which must be met with optimism and tempered by cold conservatism⁸⁵

Ten years later, statistics affirmed Dodge's assessment. In 1910, IP had produced 365,800 tons of newsprint at its mills in the U.S., but by 1932 the production had declined to 127,057 tons. Simultaneously, the company's production of other grades had increased from 64,438 tons to 527,008 tons. Twenty years after Americans had laid the technological foundation for the modern mass production of sulphite newsprint, the industry entered a gradual but terminal path of decline in the U.S. by relocating production capacity to other countries and retooling mills into other paper grades.⁸⁶

Conclusions

Ironically, the long sustained wave of learning in the wood pulp technologies, put in motion in the early 1860's, culminated in legal decrees and contracts around 1900 instead of technological breakthroughs. The technological watershed was the 1889

⁸⁴ Simon N. Whitney, *Antitrust Policies. American Experience in Twenty Industries*. New York: The Twentieth Century Fund, 334-339; The tariff history is detailed in L. M. Lamm, *Tariff History of the Paper Industry of United States, 1789-1922*. New York: The American Paper and Pulp Association 1927.

⁸⁵ *PTJ* 10 April 1919. Vol. LXVIII, No. 15, 8.

discovery of the lead-free sulphite digester that enabled true economies of scale. The true peak of the wave was reached with the Appeals Court decree in 1897, and the license settlement between IP and Burgess Sulphite Fibre Company in 1900, which together completed the efforts of William A. Russell to transform the relatively freely available critical sulphite technology into a private monopoly. Having secured this, the managers of IP acquired in technology a central mechanism to coordinate the unfolding expansion and structural change in the pulp and paper industry.

Trying to control competition in its major lines of business, IP chose to limit free trading of the sulphite pulp. The company executed this tactic through an extensive licensing network that facilitated vertical integration of the sulphite and paper mills, as well as vertical specialization of firms into newsprint, book, and other commodity paper grades. Like in any other industry, productivity improvements in the pulp and paper industry depended on the availability of new technology. Yet, the administrative control of sulphite technology enabled managers of IP significant power to construct the extent and scope of these efficiencies in the industry.

The combination of rapid diffusion of innovation and patent monopoly undermined the incentives for all U.S. pulp and paper firms to innovate in sulphite technologies.⁸⁷ Such effects were amplified by the public policies that affected the industry leader. Antitrust authorities prevented the formation of a competing national newsprint giant in 1905, and induced International to diversify production capacity from

⁸⁶ J. L. Fearing, *American Newsprint*. New York: International Paper Company 1933, 4.

⁸⁷For a parallel development in the radio industry, see: Leonard S. Reich, Research, "Patents, and the Struggle to Control Radio: A Study of Big Business and the Uses of Industrial Research." *Business History Review* Vol. 51 (Summer 1977): 208-235.

newsprint into more specialized products. Policy makers also abolished protective tariffs at a time when the U.S. newsprint industry was particularly vulnerable for such a change, and did facilitate relocation of manufacturing operations to Canada. The changed incentives quickly dampened industry wide coordinated efforts to improve the basic sulphite pulping processes with radical technological departures that had characterized the industry for almost half a century.

CHAPTER 3

SPECIALIZATION, INNOVATION, AND CARTELS

Traditionally, specialization into exclusive markets had enabled proprietary firms to avoid competitive pressures typical in undifferentiated high volume paper markets, but as the nineteenth century drew to a close, the amounting technological change enabled mass production of almost all kinds of papers. The resulting competitive pressures forced the specialty production firms to opt for survival through consolidation or move into new products, and many firms mixed successfully both strategies. Failure to recognize the new technological fundamentals of specialty production was dangerous. A typical experience was the incorporation of the Holyoke writing paper firms into the American Writing Paper Company in 1899. The “writing paper trust” spiraled down from its beginnings and struggled at the brink of bankruptcy. The firm coordinated sales but left the twenty-seven participating mills to continue operations largely independently, and possessed no definitive strategy of competitive advantage besides dominant market share in specialized writing papers. While Holyoke’s writing paper firms had enjoyed some success back in the nineteenth century and turned towards consolidation only as a last

defense against deepening price decline, other pulp and paper segments had dealt with over-capacity for decades.⁸⁸

Mergers in the pulp and paper industry between 1895 and 1905 that did not involve contracting of technologies typically fell prey to competitive pressures embodied in price decline, over-capacity and ease of entry, as well as to the intensifying legal pressures that outlawed horizontal pooling. The problem for specialty production paper firms, such as the Holyoke proprietors, was that when confronted with the new mass production technologies they possessed little or no capabilities to erect barriers of entry into their businesses formerly protected by novel craft skills. Ironically, simultaneous with the erosion of the strategies of specialization in the paper making, a wave of innovation and novelty in paper converting industries, such as the folding box and envelope industries, took shape.⁸⁹

Specialty production afforded firms a central mechanism of erecting barriers of entry and controlling markets. Such dynamics were particularly evident in the paper converting industries, where firms bought ready sheets and rolls of paper, and converted them into specialized paper products, such as envelopes, boxes, and many other products. Strong specialty production strategies allowed converting firms potentially to prevent the forward integration of their paper suppliers. An analysis of the relationship between paper suppliers and paper converting firms demonstrates how intellectual property rights influenced greatly managers' opinions of vertical integration.

⁸⁸ For a brief but detailed description of the writing paper industry between 1898 and 1908, see: Charles McKernon, "The Story of the Writing Branch," *PTJ* 6 Feb. 1908, Vol. XLVI, No. 6, 11.

⁸⁹ For insightful definitions of specialty production, see: Philip Scranton, *Endless Novelty. Specialty Production and American Industrialization, 1865-1925*. Princeton: Princeton University Press 1997, 17-18.

These experiences of pulp and paper industry correspond with the detailed studies of Philip Scranton, in which he has demonstrated how different managerial strategies of specialty production continued to be economically viable despite of the rise of the large-scale enterprises that focused on mass production. The history of important segments of the pulp and paper industry sheds additional light to the dynamic forces that determined the relative competitiveness of specialty and mass production strategies.⁹⁰

Dynamics of Cartelization in the Absence of Intellectual Property Rights

Organization of technological learning was a key determinant for the success of consolidation and cartels in the pulp and paper industry during the late nineteenth and early twentieth century. Intellectual property rights enabled managers to suspend competitive forces that facilitated over-capacity and price decline, but consolidation of market share alone rarely constituted a recipe for successful cartelization in the different segments of the pulp and paper industry.⁹¹

The experience of the wall paper industry highlights how the introduction of mass production eroded traditional strategies of specialty production, and facilitated cartelization of the industry. The wall paper firms coordinated efforts to combat declining prices for the first time in 1880, when they formed the American Wall Paper

⁹⁰ Scranton, *Endless Novelty*; Philip Scranton, *Figured Tapestry: Production, Markets, and Power in Philadelphia Textiles, 1885-1941*. New York: Cambridge University Press 1989; See also essays in Charles. F. Sabel and Jonathan Zeitlin, *The World of Possibilities. Flexibility and Mass Production in Western Industrialization*. New York: Cambridge University Press 1997.

⁹¹ The importance of consolidation of market power in other industries is argued in Naomi R. Lamoreaux, *The Great Merger Movement in American Business 1895-1904*. Cambridge, Mass.: Cambridge University Press, 1985; Neil Fligstein, *The Transformation of Corporate Control*. Cambridge, Mass.: Harvard University Press 1990, 63: For rather comprehensive list of consolidations in the late nineteenth and early

Manufacturers' Association to schedule prices and harmonize terms of credit. The association proved ineffective in its efforts, and it lost its members by 1888. A renewed attempt followed the economic downturn of 1893, when firms with over 65 per cent control of the U.S. market consolidated into the National Wall Paper Company. The giant continued to be beset with new entrants and spiraling prices, and as a last resort the majority of the industry incorporated a joint sales agency, the Continental Wall Paper Company. The president of the National Wall Paper Company, Henry Burn, explained to the Industrial Commission of the U.S. Congress in 1900 that the industry could remain profitable only through attaining economies of scale and coordinated sales operations. On the other hand he argued elsewhere that "It has also been demonstrated that the manufacture of wall paper involves elements of so peculiar nature that it cannot be as successfully conducted through the medium of a combination as it can through independent and isolated plants. Individual taste and the personality of the manufacturer play an important part, which, in a combination consisting of numerous plants, is but to be overlooked."⁹²

His exclamation about competition was largely tactical rhetoric since the company itself admitted that it controlled over 98 per cent of all wallpaper manufactured and sold in the United States around 1900. The firms' problem was that none of the alternatives entertained by Henry Burns -coordinated sales, economies of scale, and specialization- amounted to a winning strategy in the absence of proprietary technology.

twentieth century American Pulp and Paper Industry, see: Lyman Horace Weeks, *Paper Manufacturing in the United States, 1690-1917*. New York: Burt Franklin 1969 (1917), 288-313.

⁹² The quote is from: *PTJ* 5 July 1900. Vol. XXXI, No. 1, 3; *PTJ* 25 April 1901. Vol. XXXII, No. 17, 520.

The problems caused by this managerial ambivalence were amplified when the firm was confronted with the shifting legal interpretations of the Sherman antitrust laws.⁹³

In 1902 the Continental Wall Paper Company sued its client, Louis Voight and Sons Company, for not having paid in full wall paper deliveries. The defendant argued that it was forced to buy from the combine, but since it had no assurance it was paying as low rates as anyone else, it decided not to pay in full. Louis Voight and Sons Company argued that as an illegal combination the Continental Wall Paper Company had no standing in the court, and its contracts did not deserve the protection afforded by the law.⁹⁴ The defense in *Continental Wall Paper Company v. Louis Voight and Sons Company* rested on a claim that potentially undermined the enforcement of legal contracts by any loose horizontal combination. In December 1906 the U.S. Circuit Court declared that “the Continental Wall Paper Company was the most complete and ingeniously organized trust that has come to the knowledge of the court,”⁹⁵ and as an illegal entity did not have a standing in the court. After an U.S. Supreme Court ruling in the case in 1909, the Continental Paper Company was dissolved. In the absence of effective legal mechanisms to stabilize prices, however, the wall paper industry continued pooling, and was repeatedly investigated and indicted by antitrust officials.⁹⁶

In the wall paper industry specialty producers appeared to respond more flexibly, or efficiently, to changes in the fragmented, ever evolving consumer demand than did mass production firms. Such corporate strategy presented managers with the challenge to

⁹³ *PTJ* 8 June 1905. Vol. XL, No. 23, 14

⁹⁴ *PTJ* 30 Oct. 1902. Vol. XXXV, No. 18, 554.

⁹⁵ *PTJ* 6 Dec. 1906. Vol. XLIII, No. 23, 26.

innovate continuously, because their firms, too, were vulnerable for rapid diffusion of innovation that enabled imitation and entry. These competitive forces caused over-capacity and deteriorated profit margins in newsprint and book paper. The late nineteenth century paperboard industry suffered from these troubles, but over time industry managers came to assign innovation more weight in their stabilization plans than the wall paper managers did. In 1880, the majority of produced 2,700 tons of board was strawboard, whose cheap source of fiber was abundant straw. Broad patents allowed a handful of firms to monopolize the manufacture of paperboard during the 1830's, and significant improvements in the process were patented during the 1850's. These patent monopolies lapsed by 1880, and the basic process technology became freely available.⁹⁷

Factories converting board into paper boxes consumed almost the entire strawboard production. The introduction of paperboard into a wide array of new uses between 1880 and 1920 catapulted it from a niche segment to the most consumed line of paper in the U.S. As Susan Strasser has aptly described, much of the new board consumption resulted from the introduction of paper containers into a wide range of new uses in the American economy and the convergence of mass distribution and marketing in the paper package.⁹⁸

As specialty paper container firms purchased more and more standardized paperboard to be converted, the lack of mechanisms to coordinate board production established a familiar pattern of problems. Production capacity was repeatedly increased

⁹⁶ *Continental Wall Paper Company v. Louis Voight and Sons Company*, 21 U.S. 227 (1909).

⁹⁷ *Week, Paper Manufacturing*, 222-224.

in advance of demand and profit margins deteriorated. In 1888, these problems prompted the organization of the Union Straw Board Company, a selling agency that controlled the market for a time. Its dominant position was undermined by the opening of new natural gas fields in the West that induced the entry of strawboard mills. In addition to fuel to cook straw in high temperatures, natural gas provided a cheap and good adhesive, formaldehyde, which was required to manufacture solid board from straw fibers. Attracted by the ample supply of straw and natural gas in the West, the Akron industrialist O. C. Barber entered the manufacture of strawboard to supply his match business with paper boxes. Barber's previous success had earned him the title of "America's Match King," and he looked to emulate his strategy of monopolization in the match business.⁹⁹ During the 1880's Barber acquired eventually all of the Western strawboard mills and organized them under the American Straw Board Company. Later he acquired the Union Straw Board Company, and thereby assuming control of the total U.S. manufacturing capacity. But after the opening of new natural gas fields fuelled entry in the industry and finally, in the aftermath of the depression of 1893, the American Straw Board Company definitively lost its dominant position.¹⁰⁰

⁹⁸ Susan Strasser, *Satisfaction Guaranteed. The Making of American Mass Market*. Washington: Smithsonian Institution Press 1989, 32, 34-35; OEEC, *The Pulp and Paper Industry in the USA. A Report by A Mission of European Experts*. Paris: OEEC 1951, 28, 33.

⁹⁹ Alfred D. Chandler, Jr., *The Visible Hand. The Managerial Revolution in American Business*. Cambridge, Mass.: Belknap Press 1977, 292-293.

¹⁰⁰ C. W. Bell, "Board 'Combinations'. The Changes That Have Taken Place In the Market—Present Production- An Enumeration of the Various Pools Etc.," *PTJ* 9 Feb., 1905. Vol. XL, No. 6, 115.

Table 3-1. Production of Board by Grade in the U.S., 1899-1919 (Tons of 2,000 lbs.)

Year	1899	1904	1909	1914	1919
Straw	157,534	167,278	171,789	175,424	228,248
Pulp	44,187	60,863	71,036	116,419	179,747
News	32,119	38,560	74,606	127,966	88,839
Other	131,777	253,950	565,957	871,996	852,208
Total	367,516	522,555	885,297	1,293,719	1,350,961

Sources: *Manufactures, 1905*. Washington, D.C.: Government Printing Office 1908, 667-668; *Manufactures, 1919*. Washington, D.C.: Government Printing Office 1923, 561.

Falling paperboard prices resulted not only from over-capacity in strawboard, but to a great extent from new paperboard grades, such as the bristol, leather, binder's, chip board and many others. Most significant of these was the pulp board, where attempts to gain market control and set-off competition from other board grades induced the consolidation of the National Pulp Board Company. This move, interpreted as hostile by the strawboard manufactures, prompted the consolidation of the Standard Straw Board Company, which acquired the American Straw Board Company. These pulp- and strawboard giants dominated their respective industries but were short-lived. Attempts to stabilize the paperboard industry through consolidation proved fruitless because the basic manufacturing technology was freely available from specialized machinery suppliers. Nor did access to raw material or energy supplies present opportunities to erect barriers to entry.¹⁰¹

It took a radical innovation to carve out a business strategy in the paperboard industry that held the potential to maintain prices and control production. The cornerstone of this strategy was the patent rights received by the brothers Robert, Jessie and Richard

McEwan for their pioneering process to manufacture paperboard from recycled newspapers.¹⁰² Newsboard, which became its sales name, allowed the manufacture of board within close proximity of the majority of folding box companies, which were concentrated in metropolitan areas. The resulting savings in transportation costs gave it a definitive competitive advantage over Western strawboard producers. The McEwans created a patent monopoly through a series of litigation cases in the 1890's, then turned their attention to designing a licensing system that eliminated over-capacity and guaranteed price stability.¹⁰³

The McEwan brothers who were practically able to shape the organization of the emerging newsboard industry, initially preferred to license the technology to independent board mills and abstained from entering large scale production themselves. They quickly realized that competition among their licensees and the relative ease by which a mushrooming number of mills infringed their patents deteriorated license returns to the McEwans Brothers Company. In order to secure license revenues, the brothers promoted the incorporation of the National Board and Paper Company, which merged all the legal newsboard mills. They assigned to this firm an exclusive right to license their technology, and charged it with the responsibility for collecting license revenue and maintaining an active infringement litigation policy in order to sustain the incentive for legal mills to continue paying. Predictably, the McEwans did not assume tight centralized control of the company, and an increasing number of participating mills refused to pay license fees.

¹⁰¹ Bell, Board "Combinations".

¹⁰² Robert B. McEwan, Jessie L. McEwan, and Richard W. McEwan, U.S. Patent No. 492,927 (1893).

In the face of mounting crisis the brothers were forced to withdraw their license from the National Board and Paper Company in April 1900.¹⁰⁴

The unfortunate patent strategy of the McEwan brothers not only weakened their license revenues. It also unleashed the very same competitive forces that kept profits at bay in segments of the pulp and paper industry without proprietary technologies. Within a short time competition in newsboard had picked up a momentum that was difficult to slow down, not to mention bring under centralized control. As the McEwans witnessed the disintegration of what had once been a potentially viable monopoly of annual value beyond \$1 million, they resolved to take more drastic measures. In August 1900 Robert McEwan, who had assumed responsibility of the business, centralized patent rights under his tight control in the National News Board Company, intensified the policing of the patent, announced a dramatic price hike, and reduced the legal licensees to only eleven companies.¹⁰⁵ These actions went without success and newsboard prices remained practically flat during the ensuing years, while the price of straw and pulp boards increased respectively 30 and 20 per cent – a phenomenon even more noteworthy because of the 40 per cent increase of pulp board production.¹⁰⁶

The failure to devise an organizational structure that efficiently enforced legal contracts and coordinated manufacturing capabilities frustrated Robert McEwan's

¹⁰³ *PTJ* 2 Aug. 1900. Vol. XXXI, No. 5, 131; *McEwans Brothers Company v. White*. 63 F. 570 (1894); *McEwans Brothers Company v. William W. McEwan, George W. Downs, Matthias Plum and Matthias Plum Jr.*. 91 F. 787 (1899).

¹⁰⁴ *PTJ* 19 April 1900, Vol. XXX, No. 16, 491.

¹⁰⁵ *PTJ* 2 Aug. 1900. Vol. XXXI, No. 5, 131; *PTJ* Sept. 6, 1900, Vol. XXXI, No. 10, 290; *PTJ* Oct. 4, 1900, Vol. XXXI, No. 14, 419.

attempts to control a niche market, and pushed him towards a loose price fixing combination that covered the whole paperboard industry. McEwan's aggressive style appeared only to aggravate his problems as licensees, clients, and rivals severed relations with him. He sued former licensees for infringement only in order to find that they had new leverage over the desperate monopolist. Instead of pursuing these cases to the point of indictment, Robert McEwan induced firms to participate in his consolidation plan by surrendering interest in his patent rights.¹⁰⁷ He also continued efforts to enforce the patent monopoly through extensive litigation, only to keep the patent valid through extensive appeals processes and settlements.¹⁰⁸ The varied success of infringement litigation and the troubles of maintaining prices eventually led McEwan promote consolidation of the whole paperboard industry in 1902. The formed United Box Board and Paper Company was re-capitalized at almost \$30 million, and now produced over 90 per cent of all strawboard and 95 per cent of newsboard in the United States. The concentration of the board industry was deepened as some 30 mills outside Union formed a common sales agency, Paper Products Company, in 1903.¹⁰⁹

The two companies set out to follow an orthodox market control strategy, but soon realized its ineffectiveness. The first action of the new combines was to tighten the grip on clientele in the folding box industry. The United Box Board and Paper Company announced new harsh credit terms and increased prices of strawboard from \$11 to \$14

¹⁰⁶ *Manufactures, 1905*. Washington: Government Printing Office 1908, 667-667; *Census of Manufactures: 1919*. Washington: Government Printing Office 1923, 560.

¹⁰⁷ *PTJ* 27 Dec. 1900. Vol. XXXI, No. 26, 808.

¹⁰⁸ These cases included *National News Board Company v. Elkhart Egg Case Company*, *McEwan v. Philadelphia Paper Manufacturing Co*, *National News Board Company v. Fort Orange Company*.

and newsboard by \$10.¹¹⁰ Attempts to curtail production constituted the key tactic of both the United Box Board and Paper Company and the Paper Products Company strategies, but it was precisely difficulties arising from such plans that weakened and eventually disintegrated the combinations. In 1904, the management of Paper Products Company attempted to enforce production curtailments, and the members of the cartel responded by resigning. The more tightly integrated United Box Board and Paper Company experienced somewhat more success in enforcing curtailment plans, but was forced to sell a number of individual mills back to their original owners who disagreed with production cuts. Over the next few years the company steadily lost its market share in the face of competition by independent board mills and because of the increasing backward integration by the paper container industry. Innovation and specialty production enabled firms in the paper box industry to secure market control and enter the capital intensive paperboard manufacture. This was a decision that low capitalized paper converting factories without intellectual property assets could not afford. In turn, these powerful patent monopoly strategies frustrated attempts of the board manufacturers to integrate forward, too, as their only points of entry remained at the highly competitive manufacture of undifferentiated basic paper folding boxes.¹¹¹

¹⁰⁹ *PTJ* 31 July 1902, Vol XXXV, No. 5, 131; *PTJ* 8 Oct. Vol. XXXVII, No. 15, 451.

¹¹⁰ *PTJ* 25 Dec. 1902, Vol. XXXV, 743; *PTJ* 11 June 1903, Vol. XXXVI, No. 24, 739.

¹¹¹ *PTJ* 11 Feb. 1904. Vol. XXXVIII, No. 6, 244; *PTJ* 5 May 1904. Vol. XXXVIII, No. 18, 635; *PTJ* 7 July 1904. Vol. XXXIX, No. 1, 3.

Role of Patents for the Evolution from Specialty Production into Mass Production

In the late nineteenth century, a relatively consolidated paperboard industry had supplied a fragmented folding box industry, yet around 1900 the balance of bargaining power between them shifted. Paper folding box and bag firms had successfully erected barriers of entry for their particular market niches by patents. They had also developed new capabilities in marketing, manufacturing, and finance, which allowed them potentially to integrate backward into paperboard manufacture. As the organizational capabilities necessary for specialty production in the pulp and paper industry shifted from paper makers to paper converters within the few decades around 1900, a new force of vertical integration came into existence in the pulp and paper industry.¹¹²

Specialization and innovation in machinery characterized business strategies in the paper folding box industry, where firms attempted to protect small market niches from competition. This had been evident since Colonel Andrew Dennison pioneered the manufacture of paper boxes in the United States in 1844 by supplying the Boston jewelry industry. While the manufacture of folding paper boxes in the mid-nineteenth century typically involved only nominally mechanized operations and was chiefly executed through a series of labor intensive gluing, pasting, and cutting operations, from the 1860's onwards a number of specialized machines were patented that converted a single sheet of paperboard into a folding box. Technological change in paper containers began

¹¹² For a theoretical formulation of this point, although one that explores rather reasons for disintegration, see: Paul. L. Robertson and Richard N. Langlois, "Innovation, Networks, and Vertical Integration," *Research Policy* 24 (1995), 543-562.

to culminate around 1900 with the emergence of firms and pools with patent portfolios that monopolized specialized markets.¹¹³

None of the new patents on paper folding box machinery resulted in a dominant patent, but individual patents were broad enough to monopolize important niche markets. By the 1890's, accelerating technological change in the art caused almost every converting factory to operate under some patent. A typical strategy to carve out and dominate a niche market was that of Thomas Cornell and Edward Shelton, who had established a pioneering U.S. paper folding box factory in Birmingham, Massachusetts in 1875. The factory specialized in pressing manilla paper into boxes with an impressive picture or text imprint. The manufacture of the box took place by the means of cutting and creasing rules that were locked in printers' chase and pressed tight with printers' blocks and furniture, requiring the labor intensive use of two machines. About fifteen per cent of the production was substandard quality, until Edward Shelton patented landmark folding box and printing machinery in 1876. The Cornell and Shelton box was well adopted by clients. The appealing print design enabled new marketing tactics, and the box itself was rather practical for end-users, such as retailers. It was delivered flat in bundles, and easy to "knock down" in an instant, once needed. Realizing the economic potential of specialized "knock down boxes", Cornell and Shelton acquired related patents, and eventually organized a much larger firm, the National Folding Box & Paper Company.¹¹⁴

¹¹³ Charlotte Heath, *Dennison Beginnings, 1840-1878*. Framingham: Dennison Manufacturing Company 1927, 17.

¹¹⁴ Edward D. Shelton, U.S. Patent No. 183,423 (1876).

After 1892, National Folding Box & Paper Company litigated relentlessly against patent infringers, instigated over thirty cases during the next decade. These tactics enabled the firm to control the relatively small but lucrative market of the “knock-down box” that comprised mostly stores selling women’s dresses. The box was the first of its kind in the U.S. markets, and court rulings frustrated the attempts of other leading paper box firms, such as the Robert Gair Company and Dayton Paper Novelty Company, to enter the market with imitations.¹¹⁵

Specialty production alone was an insufficient business strategy in many niche markets of the pulp and paper industry, and managers repeatedly consolidated intellectual property assets to vitalize and enhance business models based on novelty. In the summer 1898, the ten largest envelope manufacturers in the U.S. consolidated in the United States Envelope Company with headquarters in Springfield, Massachusetts. The combination controlled about 90 per cent of annual national production of about 19 million envelopes. The consolidation of patents that covered the converting of paper into envelopes was an important element of the plan.¹¹⁶

During the following decade, the U.S. Envelope Company was perhaps the most successful paper firm in the North America, outperforming in relative terms annually other pulp and paper firms. Its success resulted largely from its ability to control existing and expanding markets, while introducing new product innovations. It launched the

¹¹⁵ Most significant among these cases were: *National Folding Box & Paper Company v. Elsas et al*, 86 F. 917 (1898); *National Folding Box & Paper Company v. Robertson*, 112 F. 1013 (1902); *National Folding Box & Paper Company v. Stecher Lithographic Company et al*, 81 F. 395 (1897); *National Folding Box & Paper Company v. Gair* 97 F. 819 (1899); *National Folding Box & Paper Company v. Gair* 105 F. 191 (1899); *National Folding Box & Paper Company v. Munson & Company* 99 F. 86 (1900); *National Folding Box & Paper Company v. Elsas et al*, 86 F. 917 (1898); *National Folding Box & Paper Company v. Dayton Paper Novelty Company et al*, 97 F. 331 (1899); See also: *PTJ*, 25 Jan. 1900, 126.

window envelope that critically improved mass mailing technology for large bureaucratic organizations, such as the national enterprises and government agencies. Samuel Slater, an employee of the U.S. Envelope Company, patented a machine that mechanized the manufacture of the window envelope, and the firm secured another monopoly of annual value of over half a million dollars.¹¹⁷

With varying success, similar strategies of innovation and monopolization of new markets were emulated in almost every segment of the pulp and paper industry. When public sanitary concerns pushed for the removal of the traditional public drinking cup, specialized paper cup firms introduced patented disposable alternatives and tried to block competition from the rapidly expanding market.¹¹⁸ In the towel and tissue paper industry firms formed the “tissue paper trust” during the 1890’s. In the absence of intellectual property assets it failed quickly, and firms were forced to devise alternative strategies of market control. Most tissue firms introduced patented paper dispensing machines that were incompatible with competitors’ standard sizes.¹¹⁹

The effects of the cartelization of technology were most evident in the bag paper industry, where pooling of patents prompted the consolidation of the industry’s leading firms into the tightly centralized Union Bag and Paper Company in 1899. Innovation had

¹¹⁶ *PTJ* 21 May 1898 Vol. XXVII, No. 21, 419-421.

¹¹⁷ *PTJ* 21 May 1898, 419-421.

¹¹⁸ *PTJ* 25 March 1915, Vol. LX, No. 12, 10. For the drinking cups, see: *PTJ* 17 June 1909 Vol. XLVIII, No. 24, 6; *PTJ* 22 June 1911. Vol. LII, No. 25; *Individual Drinking Cup Co. v. United States Drinking Cup Co.*, 220 F.331 (1914); *Individual Drinking Cup Co. et al. v. Public Service Cup Co.* 226. F. 465 (1915); *Individual Drinking Cup Co. v Errett And Individual Drinking Cup Co. v Hudson River Day Line* 300 F. 955 (1916); *Individual Drinking Cup Co. v Public Service Cup Co.* 261 F. 555 (1919); *Individual Drinking Cup Co. v Sanitary Products Corporation* 267 F. 196 (1920).

constituted the dynamic force of industrial change and market control ever since the first U.S. paper bag machine was installed in Bethlehem, Pennsylvania, in 1851, and patented by Francis Wolle the next year. The mechanical paper bag machine executed an elaborate series of folding and pasting operations on simple sheets of paper. By replacing the traditional hand mode of the manufacture, the machine dramatically reduced the unit cost of paper bags, and expanded tremendously its markets. In 1869, eight leading U.S. paper bag firms consolidated into the Union Paper Bag Machine Company that produced annually 371 million bags. The members divided regional markets, and agreed to collectively “buy and fight patents.”¹²⁰

The timing of this merger can in part be explained with developments in the paper bag converting machinery. Competing patents and product innovations diminished the value of aging patents on paper bag machinery, and fuelled a patent race for new type of standard grocery bags. Thus, the eight leading bag firms recognized the utility of consolidating their complementary intellectual property assets. A turning point in the race was the patenting of the so-called “satchel-bottom” paper bag by Daniel Appell in May 1882, which was assigned to a member of the bag machinery patent pool, the Eastern Paper Bag Company of Connecticut. The Appell machine successfully improved machines that were common in the paper bag business, and competitors were compelled

¹¹⁹ *Morgan Envelope Company v. Albany Perforated Wrapping Paper Company*, 152 US. 423, 433 (1894); *PTJ* 4 Sept. 1913. Vol. LVII, No. 10, 10; *PTJ* 8 July 1915. Vol. LXI, No. 2, 10; Weeks, *Paper Manufacturing*, 313.

¹²⁰ “Consolidations in the Trade,” *PTJ* 6 Feb. 1908, Vol. XLVI, No. 6, 151-153.

to imitate it. The Eastern Paper Bag Company was forced to have courts enforce its patent or lose it.¹²¹

Eastern Paper Bag and its allies successfully defended the “satchel-bottom bag” patent for the first time in 1887. The patent pool members also continued to acquire patents and introduce product innovations in order to gain dominant position in the rapidly expanding paper bag business.¹²² New bags particularly designed for the needs of grocery stores constituted a lucrative market for the paper industry. Additional development by the leading paper bag firms, including the the Eastern Paper Bag Company, Cleveland Paper Company, Standard Paper Bag Company, New York Paper Bag Machine Company, and the Union Paper Bag Machine Company, standardized the new paper bag as the so-called “self-opening” bag. Its utility was defined in 1887 by a judge when he upheld valid certain key patents of the Union Paper Bag Machine Company:

The invention is an ingenious and very useful one. The bag can be folded into a flat piece of paper, and thus a large number can be included in a bundle, occupying but a small space, in a convenient form for transportation, and ready for immediate use; and the grocer has merely to grasp it at the upper side, and ‘give it a flip through the air’ as he lifts it from the counter, and it at once becomes a square box, which will stand upon its bottom.¹²³

¹²¹ Daniel Appell, U.S. Patent No. 258,272 (1882).

¹²² *Eastern Paper-Bag and others v. Standard Paper-Bag and others*, 30 F.63 (1887).

¹²³ *Union Paper-Bag Machine Company et al v. Waterbury et al*, 39 F. 389 (1881).

The “self-opening bag” firms erected barriers of entry by litigating patent infringers, and numerous cases facilitated the cartelization of the industry.¹²⁴ Coordination of technology maintained prices in the “self-opening bag” business by controlling entry and manufacturing, whereas the lack of such coordination mechanisms hindered the standard paper bag business. The bag paper industry was split effectively into two very different markets along the lines of intellectual property assets until 1899, when 90 per cent of U.S. paper bag manufacturing capacity was consolidated into the Union Bag and Paper Company. The company was an attempt to centralize the coordination of two very different bag markets. It absorbed all the major standard bag manufacturers and owners of the “self-opening bag” technology. Its one million-dollar patent portfolio contained about 400 patents on paper bag machinery.¹²⁵

The Union Paper and Bag Company was a large-scale, tightly centralized, and vertically integrated firm. It’s capitalization at twenty seven million dollars made it to one of the largest firms in the pulp and paper industry, and equaled half of the size of the International Paper Company. Upon its incorporation the company built unprecedented large and vertically integrated pulp, paper, and paper bag converting mill in Wisconsin that produced annually some 4 billion bags. Besides manufacturing operations, economies of scale were achieved in logistics. The new integrated Kaukauna mills manufactured finished products whereas the company had previously shipped paper from

¹²⁴ *New York Paper-Bag Machine Company v. Union Paper Bag-Machine Company* 32 F.783 (1887); *Eastern Paper-Bag Company v. Nixon et al*, 35 F. 752; *Union Paper-Bag Machine Company et al v. Waterbury et al*, 39 F. 389 (1889).

¹²⁵ *PTJ* 4 March 1899. Vol. XXVIII, No. 9, 179; *PTJ* 11 April 1901. Vol. XXXII, No. 15, 450; “Consolidations in the Trade,” *PTJ* 6 Feb. 1908, Vol. XLVI, No. 6, 151-153.

its Wisconsin paper mills to a converting plant in Batavia, Illinois. The consolidation created a giant in the paper bag industry, and erected barriers of entry to others. Indeed, the consolidation was also a pre-emptive response to the threat of forward integration into bag converting by the International Paper Company.¹²⁶

In 1899, the rumors that the International Paper Company was planning to enter the new paper bag segment materialized as the Continental Paper Bag Company was incorporated in Maine. The company acquired patents for the “self-opening bag” machine from Herman Elsas, a successful New York City paper converter, who also became its first president.¹²⁷ The Continental self-opening paper bag machine produced 25,000 bags a day, and the company completed the experimental work to perfect the machine’s continuous operation during the spring 1900. By April, the Continental Paper Bag Company was already finishing the construction of a bag factory with 125 machines that equaled roughly one quarter of Union production capacity. The new mill was fully integrated with the “monster pulp and paper mill”, as the *Paper Trade Journal* described, the International Paper Company at Rumford Falls in Maine¹²⁸

The exact character of the relationship between the International Paper Company and the Continental Paper Company around 1900 remains unclear, but contemporary observers perceived the two to be intimately linked. Besides circulating rumors of formal merger and openly coordinated production, the managers of the International Paper Company frequented the board of directors of Continental. Eventually, after decades, the

¹²⁶ *PTJ* 22 March 1900. Vol. XXX, No. 12, 428; “Consolidations in the Trade,” *PTJ* 6 Feb. 1908, Vol. XLVI, No. 6, 151-153.

¹²⁷ “Continental Paper Bag Company,” *PTJ* 18 Feb. 1915. Vol. LX, No. 7, 139-146.

¹²⁸ *PTJ* 25 April 1900. Vol. XXXII, No. 17, 515.

two firms formally merged. In any case, in 1900, the Union Bag and Paper Company and Continental Paper Company towered over an industry that produced about twenty-five million paper bags every day.¹²⁹

The Union Bag and Paper Company responded by launching a price war and famously withholding technology from the markets.¹³⁰ The latter tactic dominated the defensive strategy of Union, and it attempted to halt the operations of Continental by asking courts to confirm its right to block technology in 1901. Litigation in the matter lasted almost a decade, and eventually defined importantly how large enterprises can use patent portfolios without violating the antitrust laws.¹³¹

The case was peculiar, because the parties were fighting about outdated technology. The Continental Paper Bag Company machines at the Rumford Falls factory relied on a specific technological solution to fold paper bags flat that had been patented by Edward E. Claussen in 1898. Union argued that the Claussen patent was invalid, and infringed its patent on the “self-opening bag” that had been granted to William Liddell in 1896. The Circuit Court ruled in favor of Union, and forced Continental to undertake an extensive program of retooling.¹³²

Continental decided to appeal the case, and shifted its legal tactics. It argued that Union did not deserve protection afforded by law, because it was an abusive patent

¹²⁹ *PTJ* 31 May 1900. Vol. XXX, No. 22, 697.

¹³⁰ *PTJ* 26 May April 1900. Vol. XXX, No. 17, 521.

¹³¹ *PTJ* 24 Oct. 1901, Vol. XXXIII, No. 17, 524.

¹³² Edward E. Claussen, U.S. Patent No. 598,497 (1898); William Liddell, U.S. Patent No. 558,969 (1896); *Eastern Paper Bag Company v. Continental Paper Bag Company*, 142 F. 479 (1905); *Eastern Paper Bag Company v. Continental Paper Bag Company*, 150 F. 741 (1906); *PTJ* 4 Jan. 1906, Vol. XLII, No. 1, 3; *PTJ* 12 Oct. 1905, Vol. XLI, No. 15, 12.

monopoly. Continental argued that Union had never installed a single Liddell machine or commercialized the technology, and for this reason the patent did not deserve protection. Union argued that it made better profit by using its existing Lorenz & Honiss and Stilwell paper bag machines than it had reason to expect after bearing the cost of installing the Liddell machines. Yet the company could not be obliged to make the cost saving Liddell technology available to its competitors. This argument landed the case at the Supreme Court in 1907, which used the case to examine the relationship between the antitrust laws and patent system. Justice McKenna defined the character of Union in his majority opinion in 1908: “We have no doubt that the complaint stands in the common class of manufacturers who accumulate patents merely for the purpose of protecting their general industries and shutting out competitors.”¹³³

Such behavior alone, however, was not sufficient reason to deny protection for Union’s patent. McKenna pointed out that the case did not demonstrate decreased supply or increased prices, and therefore the antitrust laws did not apply. The Eastern Paper Bag Company, or more precisely Union Bag and Paper Company, could demonstrate credible competitive reasons why it did not apply the Liddell patent. As the case was presented to the Supreme Court it involved purely the question of the right of the patentee to withhold technology from public. Historians, economists, and lawyers have rightly interpreted *Eastern v. Continental* to have made patent portfolios an important part of corporate

¹³³ *Eastern Paper Bag Company v. Continental Paper Bag Company*, 210 U.S. 405 (1908).

strategy, but paid less attention how the ruling defined the relationship between the patent system and antitrust.¹³⁴

Eastern v. Continental was only one of many high-profile cases, in which the courts attempted to define whether large combines employed the patent system to circumvent the Sherman Act legally or not. The issue gained importance in early twentieth century American politics, when so many people complained that too often the patent system slowed down technological progress and allowed monopolistic behavior. A demonstrative example is a manufacturer's attempt to fix retail prices through patents deemed insignificant, which created a public outrage. W. K. Kellogg claimed famously that he could fix the price of corn flakes because it was distributed in a patented paper carton box.¹³⁵ In the *Heaton-Peninsular Button Fastener Company v. Eureka Specialty Company* in 1896 the courts held legal a practice to create monopoly in unpatented article through restrictive patent license contracts. Heaton-Peninsular sold a patented button-fastener machine on the condition that the purchaser used only unpatented fasteners manufactured by the seller. The practice of creating a monopoly through licensing contracts continued to be tried in the courts. In 1902, the Supreme Court ruling *Bement v. National Harrow Company* held legal price fixing patent licenses imposed by National Harrow Company, a holding company owned by majority of spring-tooth harrow makers, on its customers.¹³⁶

¹³⁴ See David C. Mowery and Nathan Rosenberg, *Paths of Innovation. Technological Change in 20th Century America*, 17-19, and literature cited there.

¹³⁵ Strasser, *Satisfaction Guaranteed*, 277-280.

¹³⁶ Ward S. Bowman, *Patent and Antitrust Law. A Legal and Economic Appraisal*. Chicago: The University of Chicago Press 1973, 146-151.

Eventually, a four to three Supreme Court decision *Henry v. A.B. Dick Company* legalized extensive tying practices with the sale of patented articles in 1912. A.B. Dick Company sold its patented stencil-duplicating machine, a rotary mimeograph, with license restriction that customers used only staples sold by the patentee. The decision triggered renewed outrage, and a political effort to resolve the conflict between the antitrust and patent system.¹³⁷ Responding to increasing public concern and congressional bills, President William H. Taft called for an investigation of the relationship between the antitrust and patent system. Taft cited the shelving of technology and the implications of the *Henry v. A.B. Dick Company* as critical issues to be revisited.¹³⁸

According to Susan Strasser, the manufacturers' victory in the A.B. Dick case was short-lived. In 1913, the Supreme Court handed down a decision that prohibited manufacturers to fix the price of patented or trademark protected goods, and effectively outlawed tying practices.¹³⁹ The political effort to reform the antitrust laws and patent system continued, though. Prolonged investigations in the nature of law and efficiency of the Patent Office were carried out. In 1914, these efforts culminated in the passage of the Clayton Act that concerned mostly antitrust, but contained sections that defined the relationship between antitrust and patents, too. No significant new legislation that related directly on the patent system was passed until the 1930's.¹⁴⁰

¹³⁷ *Henry v. A.B. Dick Company*, 224 U.S. 1 (1912).

¹³⁸ House Document No. 749, 10 May 1912. *Congressional Record – Senate*. 62nd Congress, 2nd Session, 6206-6207.

¹³⁹ Strasser, *Satisfaction Guaranteed*, 283.

Conclusions

The maturation of mass production technology during the late nineteenth century presented a tremendous challenge to many pioneering American pulp and paper firms. Leading firms in various segments of the pulp and paper industry responded by consolidating into large enterprises that towered over their competitors. When such strategies did not include the control of new mass production technology, they struggled or failed. Sheer consolidation of market power did not enable firms to survive a critical period of transition that spanned from the nineteenth century into twentieth, and was underpinned by innovation in manufacturing technologies.

Firms with experience in specialty paper production were particularly apt to coordinate structural change by controlling key technologies. Specialty production dominated the paper converting industry that purchased ready sheets and rolls of standard paper. It is suggestive of the significance of the intellectual property rights that consolidation in the paper converting industry was often accompanied by backward integration. The only significant case of forward integration by a large manufacturer of standard papers into paper converting was that of International Paper Company. However, its forward integration into bag converting depended on strategic acquisition of intellectual property rights.

The technological core of successful cartels is best explained by the fact that intellectual property rights enabled them to circumvent antitrust. However, this chapter suggests that institutional change significantly diminished this aspect of patents in the early twentieth century America. In response to allegations of patent misuse by cartels,

¹⁴⁰ David F. Noble, *America By Design. Science, Technology, and the Rise of Corporate Capitalism*. New

landmark court rulings and the Clayton Act established limits for firms' ability to create monopolies through patents. This institutional change facilitated a shift in the locus and meaning of innovation in large-scale pulp and paper enterprises during the following decades.

CHAPTER 4

CO-EVOLUTION OF TECHNOLOGICAL LEARNING AND ORGANIZATION IN THE PAPER CONTAINER INDUSTRY, 1870-1960

Technological learning co-evolved with the organization of the paper container industry between 1870 and 1960. Industry managers emphasized the role of proprietary specialty products for competitive corporate strategies, and acknowledged that such tactics required firms to move continuously abreast of the technological frontier. Technological change, expiration of intellectual property rights, and public policy, under certain circumstances, too, weakened managers' ability to control over long periods of time specific bodies of technological knowledge that constituted the foundation for specialty production. The maturation of specialty products into standard ones prompted firms to evolve into new products and technologies. The paper container industry's organizational evolution between 1870 and 1960 was characterized by such cycles of maturation of technological knowledge, and punctuated by critical periods of transition, during which the most innovative firms emerged as the leaders of the industry.

Such technological evolution prompted managers to couple it intimately with consolidation, too. Mergers and acquisitions provided managers with another central

response to the difficulty of sustaining control over specialty products. Large scale vertically integrated national enterprises had several advantages over smaller rivals in markets for standardized paper containers because of their ability to coordinate mass production. In addition, consolidation arrested imitation by rivals.

The industry concentrated steadily during the twentieth century, and it experienced massive merger waves during the 1920's and 1950's. The co-evolution of technological learning and industrial organization shaped firms' ability to achieve competitive advantage through specialization, and converged the strategy and structure of the leading paper container enterprises by the 1950's. Indeed, if the early paper container firms were highly distinctive and original, ninety years later no North American firm was able to follow a unique strategy of differentiation. Mergers and acquisitions in the U.S. created eventually a handful of firms with almost identical organizational capabilities. A long period of industrial evolution had come to end, and next many of these large specialized paper container firms were absorbed by even larger forests products corporations, and organized into one of many corporate divisions.

Dynamics of Innovation in the Early U.S. Corrugated Paper Industry

The modern paper container industry evolved relatively slowly from the invention of corrugated paper in the mid-nineteenth century. Strong intellectual property rights and cooperation of the leading manufacturers impeded innovation in the basic manufacturing processes and products until the 1890's. The first patent on the manufacture of corrugated paper was given to Edward C. Healy and Edward E. Allen in 1856 in England. Their patent covered a fluted paper that was applied as a sweatband in hats. Corrugated paper

was introduced into the packaging of goods in the United States in 1871, when New Yorker Albert L. Jones obtained a pioneering American patent on “improvement in paper for packing” that defined a method to corrugate cardboard.¹⁴¹ Jones argued that the elastic “corrugated packing” was a novel way to protect glass bottles, and hoped to replace the practice of wrapping bottles in thick layers of paper. Jones obtained in 1873 a patent for an improved simple corrugated paper sheet, and argued that his unlined corrugated paper replaced sawdust and straw as cushioning materials in shipping containers. Henry D. Norris acquired both of Jones’ patents in order to enter their production in New York City.¹⁴²

In 1874 another New Yorker, Oliver Long, obtained a patent for his improvement of the Jones method, and introduced the corrugated paper that was lined from one side. Long had perfected a reliable technique of fluting a continuous web of single and double-faced corrugated paper. The flexible corrugated paper was then further converted into a number of specialized cushioning materials for bottles, china, glassware, and other fragile articles. Henry D. Norris purchased the Long patent too.¹⁴³

The Jones and Long patents covered broadly the methods to manufacture corrugated paper, and the organization of intellectual property rights had a great impact on the nascent industry. Norris had pioneered the production of corrugated material in New York, but learned that a major competitor to his factory was Robert H. Thompson

¹⁴¹ Albert L. Jones, U.S. Patent No. 122,023 (1871).

¹⁴² *Corrugated Box Manufacture’s Handbook*. 3rd Ed. S. S. Corrugated Paper Machinery Co., Inc. 1965, 1; Harry J. Bettendorf, *A History. Paperboard and Paperboard Containers*. Chicago: Board Products Publishing 1946, 61-65.

who produced a similar line of paper containers in the city. Thompson specialized in cork-lined corrugated paper that was used for the packing of beer bottles, glass and other articles. In 1875, Norris and Thompson decided to merge their operations into the Thompson & Norris Company that controlled very broad rights on the corrugated paper technology. Upon learning of the merger of Thompson and Norris, the impoverished Oliver Long claimed he had never received the agreed payment for his patent, and disputed the transfer of the patent rights. Long resold interest to his patent to Robert Gair, who looked to diversify his New York folding box firm into the corrugated paper business.¹⁴⁴

A lengthy legal dispute ensued between the Thomson & Norris and Gair about intellectual property rights, and they attempted to invalidate each other's patents. The inventor of the revolutionary sulphite digester lining, George F. Russell, was sent to Europe to investigate the validity of the corrugated paper patents, and in the United Kingdom he unearthed evidence that questioned the priority of American corrugated patents. Russell's findings prompted the parties to settle the issue in 1888. Robert Gair acknowledged the validity of the Long and Jones patents, and admitted that Thompson & Norris lawfully controlled them. In return he received an exclusive license to manufacture corrugated paper to fixed prices.¹⁴⁵

¹⁴³ Oliver Long, U.S. Patent No. 154,498 (1874), reissued as No. 9948 (1881); A detailed chronological history of the paper containers in the North America is the special issue: *Boxboard Containers*. Oct. 1950, Vol 68, No. 634.

¹⁴⁴ Wilbur F. Howell, *A History of the Corrugated Shipping Container Industry in the United States*. Camden: Samuel M. Langston Company 1940, 16-18.

¹⁴⁵ Howell, *A History of the Corrugated Shipping Container Industry*, 16-18.

The patent pool of Gair and Thompson & Norris on the manufacture of corrugated paperboard impeded production innovation and growth of the industry. This resulted particularly from the strategy devised by Thompson, who secured personal patents for improvements and acquired competing patents. Thompson & Norris and Gair focused on manufacturing corrugated paper in sheets that were sold mostly as a cushioning material, and paid little attention to product diversification. The expiration of the Long patent in 1897 induced a small wave of innovation in the corrugated paper products and machinery, and facilitated the divergence of respective trends of technological learning.¹⁴⁶

Although paper box firms continued to innovate in the corrugated machinery, specialized firms entered the field for the first time during the 1890's. Jefferson T. Ferres of the Sefton Manufacturing Company developed in secrecy a machine that could produce either single-face or double-face corrugated board in 1895. The same year, Charles Langston built a corrugated board machine in Philadelphia. He had been master locomotive mechanic for the Baldwin Company, and had extensive machine-tool experience. Charles Langston's son, Samuel, studied mechanical engineering at Cornell University, and established in 1901 a firm that specialized in corrugated paper machinery.¹⁴⁷

The expiration of basic manufacturing patents and relatively rapid diffusion of new manufacturing equipment lowered barriers of entry, and prompted corrugated paper firms to focus on product innovation. Until 1890 corrugated paper had been used only as

¹⁴⁶ Howell, *A History of the Corrugated Shipping Container Industry*, 16.

bottle wraps, cushioning, dividers, and partition in wood boxes. The disintegration of the patent pool prompted firms to develop new corrugated paper products, and the single most important one was the corrugated paper box. Thompson & Norris manufactured the first corrugated paper box in 1894. The so-called “Cellular Board” boxes were intended for use in the express shipments of light goods, such as lamp chimneys, flowers, hats, or feathers. New York Wells Fargo & Company’s Express drivers repeatedly refused to accept the unfamiliar container, acquiescing only after the company’s managers required them to do so.¹⁴⁸

The Thompson & Norris Company and Gair Company introduced a great variety of patented specialized corrugated paper containers, but faced an increasing competition. Mass production of all kinds of consumer goods induced demand for mass production of paper containers, and a number of new entrants flocked to the business. One of these imitations was the Climax Bottle Wrapper, a corrugated paper tube that protected individual glass bottles. In 1898, J. J. Hinde and J. J. Dauch acquired the patent rights to the bottle wrapper, and began its production at their small strawboard mill in Sandusky, Ohio. Two years later, they incorporated the Hinde and Dauch Paper Company that adopted an aggressive strategy of growth. Jacob J. Hinde, in particular, recognized that the emerging mass distribution business presented a very potent opportunity for the little paper container firm.¹⁴⁹

¹⁴⁷ Robert W. D’Ambry, *Langston. Leadership by Design, 1901-1951*. Camden, NJ: Samuel M. Langston Company 1951, 21-23

¹⁴⁸ Bettendorf, *Paperboard and Paperboard Containers*, 65-69

¹⁴⁹ H.H. Squire, *A Brief History of the Hinde & Dauch Paper Company with a Sketch of the Development of the Corrugated Fibre Industry*. The Hinde & Dauch Paper Co, Sandusky, Ohio, 1926. No pagination.

Within fifteen years of its incorporation, the Hinde and Dauch Company was the world's largest manufacturer of corrugated paper specialties. Its growth reflected the tremendous expansion of the paperboard and paper converting industries in the United States during the early twentieth century. The single most important factor for the growth for these two segments of the North American pulp and paper industry was the establishment of the paper box as the standard shipping container between 1900 and 1919. 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.¹⁵⁰

Standardized Innovation: The Creation of Markets

The best measure of the growth of the corrugated paper industry was the rapidly increasing production of paperboard in the U.S., as all corrugated paper was converted from it. Paperboard passed newsprint as the most consumed line of paper in U.S in the late teens, and its annual production increased from 357 thousand metric tons in 1899 to 1,678 in 1919, and 5.392 in 1939.¹⁵¹

The early dynamics of this structural change of the American pulp and paper industry was influenced heavily by regulation, which reduced competition in the nascent paper container industry. The growth of the paper container industry was based on its

¹⁵⁰ For the rise of mass distribution, see: Alfred D. Chandler, Jr, *Visible Hand. The Managerial Revolution in American Business*. Cambridge, Mass.: Belknap Press 1977; and mass consumer markets: Susan Strasser, *Satisfaction Guaranteed. The Making of American Mass Market*. Washington: Smithsonian Institution Press 1989.

ability to substitute prevalent shipping containers with low cost imitations, as an industry leader explained in 1920:

There is one particularly outstanding feature of the box board enterprise which has unquestionably revolutionized the distributing of this product, and that is, through the consumption of the heavy tonnage created by the development of the fibre container business, which is a substitute for the lumber or wooden box, and where manufacturers of box board formerly depended almost solely for distribution of their product upon the set-up, folding, and corrugated box consumers, the fibre containers substituted the wooden box, has become successful accomplishment and is today the largest consuming feature of common box board and raw material that exists.¹⁵²

Thompson & Norris and Robert Gair had created new markets with innovative paper containers in large metropolitan cities, where customers were free to consider the relative costs and advantages of wooden, metal, glass, and paper containers. Around 1900, the leading corrugated paper container firms, such as the Hinde and Dauch, regarded the railroads as the largest potential new market. In effect, they looked to capture the giant national shipping container markets from the prevalent wooden boxes.

¹⁵¹ OEEC, *The Pulp and Paper Industry in the USA. A Report by A Mission of European Experts*. Paris: OEEC 1951, 28, 33.

¹⁵² "Box Board Industry has Unusual Year," *PTJ* 15 April 1920, Vol. LXX, No. 16. (American Paper and Pulp Association, Annual Convention Issue).

To their surprise and frustration, the advocates of the “packaging revolution” encountered the resistance of the administration of a massive technological system that formed the American railroads. Railroads fell under the heavy-handed regulation of the Interstate Commerce Commission that skewed how costs and efficiency were calculated, as Steven Usselman has demonstrated. Railroad regulation was situated in the center of much larger and intense contemporary American political debate on the character of big business. In 1910, these tensions peaked famously in the Advance Rate Case, when Louis Brandeis accused railroads of notorious inefficiency. Such heated political debate and detailed regulation slowed the diffusion of shipping container innovations in the railroads.¹⁵³

The corrugated paper box firms responded to these challenges by a coordinated effort to reform the shipping container regulations. The industry looked to demonstrate the reliability of paper box by standardizing it, and introducing it as a credible and certified railroad shipping container on parity with the wooden ones. The paper package was first introduced to railroads in the form of cereal boxes in 1903, when some Northeast cereal manufacturers succeeded in making an exception to railroads’ Official Freight Classification. The potential of the new market activated paper managers in standardization issues, and in 1905 the leading firms, including Thompson & Norris and Hinde and Dauch, formalized their cooperation by establishing the Progress Club that

¹⁵³ Steven W. Usselman, *Regulating Railroad Innovation. Business, Technology, and Politics in America 1840-1920*. Cambridge, Mass.: Cambridge University Press 2002, Ch. 9. Thomas K. McCraw, *Prophets of Regulation*. Cambridge, Mass.: Harvard University Press 1984, Ch. 3.

began to advocate the new package innovations.¹⁵⁴ Due to these efforts, the Official Classification Committee of the railroads authorized in 1906 the general use of specified corrugated paper boxes in most types of freight. Immediately, the member firms of the Progress Club introduced specialized paper containers that replaced glass in the shipping of starch, soda, baking powder, confectionery, grocery, drugs and dried fruits. In addition, specialized paper containers were introduced to hardware, stationary, rubber tires and other rubber goods, shoes and leather goods, soap, washing compounds and other heavier commodities.¹⁵⁵

Cooperation between the leading corrugated paper firms facilitated continued efforts to reform the regulation of the railroad shipping containers. The industry introduced testing protocols to standardize the quality control of paper boxes. In so doing, they borrowed ready sets of established scientific tests and specifications that had been created by German paper engineers in the late nineteenth century, and later importantly modified by Americans. In 1908, these efforts prompted the railroad authorities to prescribe the American “Mullen test” for determining the strength of boxes. The testing apparatus had been invented in 1887 by John W. Mullen for the testing of strength of any fibrous material. In 1910 the Official Classification ruling on fibre containers was expanded to cover a range of established test practices. Similarly to the first official paper quality standards, the late nineteenth century German Normalpapiere Klassen, it

¹⁵⁴ Other members were: The J.W. Sefton Mfg. Company, The McPike Paper Company, The Charles Boldt Company, The Hunt & Crawford Company, The J.N. Hahn Company, and The Modes-Turner Glass Company. Squire, *A Brief History of the Hinde & Dauch Paper Company*.

¹⁵⁵ Squire, *A Brief History of the Hinde & Dauch Paper Company; Correspondence Course*. Ohio: The Hinde and Dauch Paper Co. 1940, 10. Westvaco Papers, Collection #2830, Box #68.

formalized the testing procedures and certification process by requiring manufacturers to mark the quality of boxes with corresponding official stamps.¹⁵⁶

The paper package quickly gained market share in railroad freight, but the railroad rate setting mechanisms constituted another troubling barrier to market the expansion of paper package industry. Paper boxes reduced the dead weight of a car, but often paper boxes were subjected to a higher rate than wooden boxes. In 1909, only few specified articles in paper containers were charged the same rate as if shipped in wooden boxes, and all others more. Typically the shipping costs for paper containers averaged 10 per cent penalty when compared with official wooden ones in the Western, Eastern, and Southern Official classifications. Within such arrangement, railroads absorbed the economic advantages of lighter packages instead of shippers or corrugated paper container firms.¹⁵⁷

In response to such rate setting mechanisms, the Southern Mail Order Liquor Association filed a petition to the Interstate Commerce Commission in 1911. The association's members had begun in 1904 to shift from shipping liquor bottles in wooden boxes to paper cartons instead. As a consequence, they argued, the railroads began to charge on arbitrary weights instead of actual weight. The ICC argued that the paper package reduced over 20 per cent of the weight of liquor shipments, which totaled annually about 360 thousand tons nationally. The investigation established that all shipments in paper packages were to be charged at the actual weight. Yet the firms

¹⁵⁶ H.H. Squire, *A Brief History of the Hinde & Dauch Paper Company*, 9; John W. Mullen, U.S. Patent No. 358,056, (1887).

¹⁵⁷ The rates are detailed in Bettendorf, *A History. Paperboard and Paperboard Containers*, 76.

continued to complain that the railroads and ICC regulations discriminated against paper containers, and prevented their increased usage.¹⁵⁸

The manufacturers of solid fibre boxes attempted to create new markets through almost identical and simultaneous efforts with the corrugated paper industry. Chicago paper folding box firms were frustrated by the definition of “boxed” by the railroad classification committees as “enclosed on all sides in wood.”¹⁵⁹ E. W. Bonfield of the Illinois Fibre Company filed an official petition to have solid “fibre or pulp boxes” accepted on cost parity with wooden boxes as standard railroad shipping containers in 1906. In response to his petition, the Western Classification Committee established the rule 14-B that defined the use of solid and some corrugated paper containers in the railroads, standard tests, and certification by official stamps. The Eastern and Southern Classification Committees followed soon, and modified respectively their classifications of solid paper containers.¹⁶⁰

Standardization was a highly strategic instrument for both wooden and paper box firms as they attempted to protect their markets. Official railroad classifications treated the two products very differently, and placed the burden of proof on paper manufacturers. Paper boxes were subjected to detailed quality standards, and wooden boxes to none. Managers in both industries deployed specifications to influence the rate of diffusion of paper boxes in the railroads, and predictably differed greatly in their assessments of it.

¹⁵⁸ Interstate Commerce Commission, *R.W. Pridham Company v. Southern Pacific Company Et Al. Docket No. 5273*, decided 6 April 1914. In Interstate Commerce Commission, *Decisions of the Interstate Commerce Commission of the United States. Vol. XXI, May, 1911, to December, 1911*. Washington 1912, 199-203.

¹⁵⁹ Quoted in Bettendorf, *A History. Paperboard and Paperboard Containers*, 88.

The manufacturers of wooden boxes argued that paper boxes had captured between 30 and 40 per cent of railroad shipping container business by 1911. The paper box industry, on the other hand, acknowledged only 5 per cent market share. U.S Forest Service experts studied the organization of the paper container industry. They portrayed a highly concentrated industry that specialized in converting, and purchased about one third of all U.S. produced paperboard.¹⁶¹

The efforts of the solid and corrugated paper container manufacturers to reform the railroad regulation and displaced wooden boxes were closely linked, and yet distinct in the sense that they were largely two different industrial organizations. Nevertheless, a landmark ICC ruling changed the regulatory regime for both paper container products, and established the paper box definitively as the standard freight package in the railroads. In the early teens, a Californian paper box manufacturer, R.W. Pridham, contested the legality of an exemption that allowed railroads to charge canned foods shipped in paper boxes up to 400 per cent more than those shipped wooden boxes on routes eastbound from California. The railroads continued to favor wooden boxes at the cost of paper boxes, because lumber created such a large freight volume, Pridham complained. Again, the controversy over shipping container regulations concentrated on quality standards. Lumber and wooden box industry associations argued in the case hearings that paper boxes were subjected to higher rate because of their inferior quality. Paper box

¹⁶⁰ The standardization of solid fibre boxes is detailed in Bettendorf, *A History. Paperboard and Paperboard Containers*, 74, 84-93.

¹⁶¹ Henry Maxwell and H.S. Sackett, "Wooden and Fibre Boxes Compared," *PTJ* 27 July 1911. Vol. LIII, No. 4, 54, 60; Henry Maxwell and H.S. Sackett, "Wooden and Fibre Boxes Compared," *PTJ* 20 July 1911. Vol. 53 No. 3, 42.

specifications were too complex to be applied or enforced by railroad employees, they argued, and therefore wooden boxes provided a much safer choice.¹⁶²

After brief examination, the ICC decided that paper containers were as good as wooden ones if constructed, packed, and sealed according to existing specifications of the Official Classification in 1914. The Pridham case removed the last significant obstacles of true market competition between paper and wooden packages. A telegram celebrating the decision circulated among the manufacturers of paper boxes as they prepared for a period of rapid growth and large profits.¹⁶³ Immediately following the decision, the railroad witnessed rapid increase in vegetables and fruit cans shipped in paper boxes instead of wooden ones. In 1916, another change in the regulations admitted the shipment of cigarettes and cigars in paper boxes on parity with wooden boxes. Within a few years, regulations concerning the shipments of most commodity classes on both U.S and Canadian railroads were changed similarly. The consolidation of different railroad regulations into one in 1919 represented the concluding point for the paper firms' efforts to reform the shipping container regulation. The new regulatory guidelines established broad and inclusive standards that enabled railroads and shippers to choose freely between a wide range of competing shipping containers.¹⁶⁴

¹⁶² Interstate Commerce Commission, *R.W. Pridham Company v. Southern Pacific Company Et Al.* Docket No. 5273. decided 6 April 1914. In *Interstate Commerce Commission, Decisions of the Interstate Commerce Commission of the United States*. Vol. XXI, May, 1911, to Dec., 1911. Washington 1912, 199-203; The case was reported in detail and widely in the trade press: "Fibre versus Wooden Containers," *PTJ* 3 July, 1913. Vol. LVII, No.1, 14; *PTJ* 14 May 1914. Vol. LVIII, No. 20, 9; J. M. Ford, "The Pridham Case and Fibre Boxes," *PTJ* 11 June 1914. Vol. LVIII, No. 24. 26.

¹⁶³ Telegram, 2 May 1914. Carl A Kroch Library, Rare Manuscript Collection, Cornell University. West Virginia Pulp and Paper (henceforth Westvaco) Collection #2830, Box #62, Folder #3.

¹⁶⁴ *Correspondence Course*, 6-7; Interstate Commerce Commission, *Consolidated Freight Classification No.1.* (Official Classification No. 44, Southern Classification No. 43, Western Classification No. 55). Chicago: The Blakely Printing Company 1919; It is suggestive of the dynamics involved in the Pridham

Technology Cartels, Antitrust, and Innovation

The admittance of the corrugated paper box as an alternative standard railroad shipping container opened a potentially vast market for a product manufactured by a small number of firms. The leading corrugated paper products and machinery firms responded to the prospect of emerging markets by erecting barriers of entry. They pooled patents, divided regional markets, and followed other price-fixing practices. These efforts were in part frustrated by technological innovation, as some machinery suppliers refused to cooperate and willingly supplied any paper box manufacturers with imitations and innovations. In addition, antitrust policies gave a final blow to such tactics during the 1910's.

Around 1900, a handful of firms controlled the basic patents on the manufacture of corrugated paper converting machinery, and these firms looked to prevent competition by pooling their patents. Following meetings organized to lobby the railroad classification committee in 1904 and 1905, the owners of central patents formed the Corrugated Paper Patents Company. The trust was briefly changed into the Progress Club, before organized again into the Corrugated Paper Patents Company in 1907. The individual members of the trust either sold or assigned all of their patents related to corrugated paper and machinery to the trust, and received in turn licenses that specified prices and required the reporting of production.¹⁶⁵

case that railroad attempted to increase the freight rates on paper boxes even after the ICC decision. See PTJ July 22, 1915. Vol. LXI, No. 4, 8, 18.

¹⁶⁵ The members of the trust included the Charles Boldt Co. of Cincinnati, Ohio, the Hinde and Dauch Paper Company of Sandusky Ohio, the Thompson & Norris Company of Brookville, Indiana, the Modes-Turner Glass Company of Terre Haute, Indiana, the J.N. Hahn Company of Cleveland, Ohio, the Hunt-Crawford Company of Coshocton, Ohio, Lawrence Paper Manufacture of Lawrence, Kansas and the

All the members of the patent trust were firms whose main business was the manufacture of corrugated paper containers, and who extensively built their own machinery. The Thompson & Norris Company was perhaps the largest member of the club, followed by the Hinde and Dauch, which had built its first corrugating machines independently in 1897 and 1898. Jacob Hinde himself was a renowned inventor, and he fostered machinery innovation at his firm and purchased competing patents. Another member, the McPike Paper Company from Alton, Illinois, was managed by J. H. McPike, who had invented a pioneering corrugating machine, too.¹⁶⁶

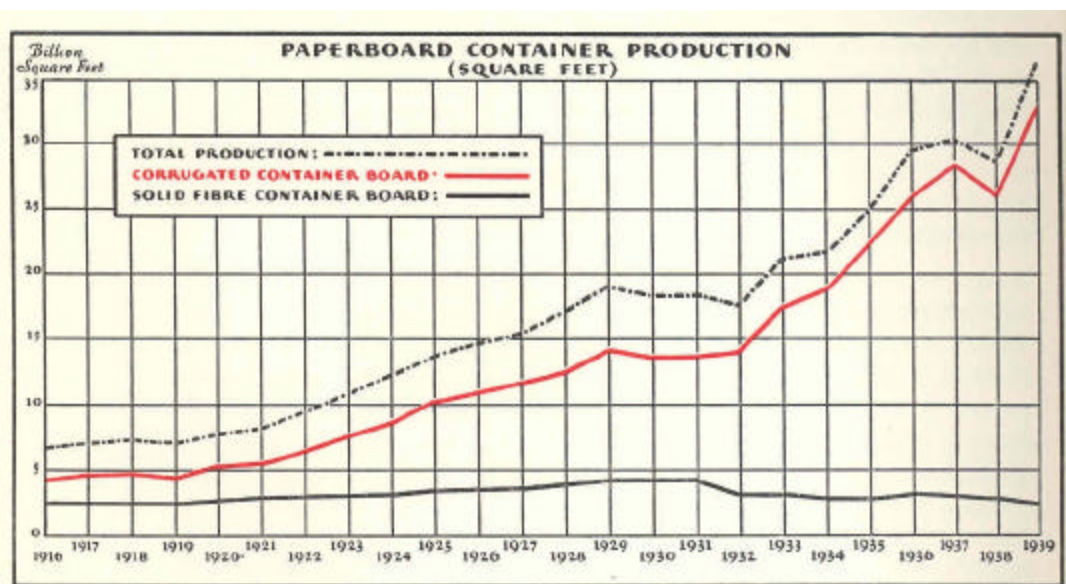


Figure 4-1. Paperboard Container Production between 1916 and 1939. Source: Wilbur F. Howell, *A History of the Corrugated Shipping Container Industry in the United States*. Camden: Samuel M. Langston Company 1940, 47.

McPike Paper Company of Alton, Illinois. *Declaration of Trust*. Oct. 15, 1907, Westvaco Collection, #2830, Box #62.

¹⁶⁶ *Brief Upon the Validity of the Corrugated Paper Patents Company of Dayton, Ohio*. No date but written in early 1910. Westvaco Collection, #2830, Box #62, Folder # 3; Howell, *A History of the Corrugated Shipping Container Industry*, 23-30

The goal of the of Corrugated Paper Patents Company was to erect barriers of entry for the rapidly expanding industry. Corrugated paper captured the lion's share of U.S. paper container markets, and the technology was controlled largely by the patent cartel. Within a few years after the establishment of the Corrugated Paper Patents Company, a similar arrangement was considered in the Fibre Box Association that covered solid paper containers. However, the effort never amounted to anything significant, probably because the manufacturing technology was not covered by a reasonably small number of fundamental patents.¹⁶⁷

Specialized corrugating machinery suppliers presented a challenge for the corrugated paper patent cartel. An important agent of such pressures was Tobias E. Raffel, who built several machines for firms outside the Corrugated Patents trust between 1904 and 1906. He quickly earned a reputation as an ingenious engineer, not least because he belonged to a family of acclaimed converting machinery builders. The known inventor Samuel Samuels of the American Corrugated Paper Products Company was Raffel's cousin. Upon his success Raffel established the Paper Working Machines Company, and focused exclusively on supplying firms outside the trust.¹⁶⁸

Around 1909 and 1910, antitrust policies presented a challenge to the Corrugated Paper Patents Company, too, and its members were forced to revisit the structure of the trust. In a legal analysis of the corrugated patent trust in early 1910, an attorney argued that price fixing, regulation of production, and division of regional markets could be held legal under the Sherman antitrust laws only if they were based on a single patent. There

¹⁶⁷ *J. Sprigg McMAhon to Hinde and Dauch*, 17 Jan. 1910. Westvaco Papers, Collection #2820, Box #62, Folder# 3.

did not exist such a dominant patent for the corrugated paper, and therefore the Corrugated Paper Company restricted the manufacture and sale of an unpatented article in an illegal way, he argued. Following up his brief in a personal letter to Jacob Dauch, the attorney doubted if the trust would run a risk of prosecution at the moment, but encouraged him to explore alternative organizational structures because of the way judicial interpretations of the antitrust laws were changing.¹⁶⁹

Unexpectedly, an invention by Samuel Langston presented potential relief for the corrugated patent trust. Earlier Langston's successful firm had presented a serious challenge to the patent pool, but the Corrugated Paper Patents acquired from the inventor what was potentially the much searched for fundamental patent. In 1908, Langston received a patent for a new type of converting machine that was regarded as the trailblazer of modern capital intensive mass production of single and double faced corrugated paper. Corrugated Paper Patents managed to acquire the rights to the patents that covered this invention. The contract also forbade Langston from engaging in making or selling the corrugated machines, and limited his business to other converting machinery.¹⁷⁰

Langston's radical technological departure induced other machinery suppliers to imitate it. In 1911, firms outside the Corrugated Paper Patents Company formed the Corrugated Paper Manufacturer's Association, which strove efforts to invalidate the Langston patent monopoly. George Swift circumvented the Langston patents and

¹⁶⁸ Bettendorf, *A History. Paperboard and Paperboard Containers*, 81.

¹⁶⁹ *RKR-N to J.J.Hinde*, 19 Feb. 1910. Westvaco Collection, #2830, Box #62, Folder # 3.

¹⁷⁰ The contract is discussed in *Corrugated Paper Patents Company v. Paper Working Machine Company* 237 F. 380 (1913); Samuel L. Langston, U.S. Patent No. 878,403 (1908).

commercialized a very close imitation, delivering what was probably the most severe technological blow to the patent trust. Meanwhile, Arnold Pacyna of the Chicago Folding Box Company obtained two additional patents on Langston imitations in 1911. Tobias Raffel attempted the same, but failed to circumvent the Langston patent claims. The Corrugated Patents Company litigated Raffel's Paper Working Machines Company for patent infringement. A lengthy and expanding legal battle, fuelled in part by the personal antagonism of Langston and Raffel, continued until the death of the latter in 1920. Langston was relatively successful in his litigation, but came inadvertently to rather accelerate imitation and eventually undermine his own patents.¹⁷¹

When Raffel's Paper Working Machines Company went bankrupt in 1916, largely due to the extensive patent litigation, its experienced former employees established machine shops that specialized in Langston imitations. The S & S Corrugated Paper Machinery Company was a direct offspring of Raffel's firm, and continued to be a leading corrugated machinery supplier long after Langston himself exited the business during the 1940's. Another firm established by Raffel's former employee was the Progressive Corrugated Paper Machinery Company. It also commercialized Langston imitations. The Corrugated Machinery Association that consisted of 15 firms that competed fiercely with the members of the Corrugated Paper Patents Company acquired the patent portfolio of the bankrupt Raffel. The supply of corrugated machinery increased because of these firms, but also because Langston's patents weakened during the lengthy legal disputes. An appeal in the *Corrugated Paper Patents v. Peter Heibel & Sons & Manufacturing Company* in 1917 invalidated important claims of the 1908 Langston

¹⁷¹ Bettendorf, *A History. Paperboard and Paperboard Containers*, 81.

patent. The court ruled that earlier patents by Jefferson T. Ferres, and some others, anticipated clearly the Langston patent. The aggressive infringement litigation by Langston backfired severely, then, and he not only facilitated a nascent imitation-industry, but eventually lost his patent control, too.¹⁷²

It is difficult to estimate how the disintegration of patent cartels influenced the rate of innovation in the corrugated machinery industry. Yet, when the early twentieth century experience in the corrugated paper industry is contrasted to that of late nineteenth century, the most striking difference is the rate of innovation and its impact on economies of scale. Jefferson T. Ferres' 42 inch wide converting machine in 1895 produced ten feet of corrugated board a minute. By 1910 the corrugating machines averaged 30 feet a minute, and by 1917 machines of 63 inch widths averaged speed between 60 and 75 feet a minute.¹⁷³

The effects of technological innovation and intellectual property rights on the organization of the industry, and its technological learning were amplified by antitrust. In 1921 the antitrust authorities charged the Corrugated Paper Manufacturer's Association with price fixing and other unfair trade practices. The association consisted of ten corrugated converting firms that served exclusively the New York City market, and were not integrated backward into paperboard production. Grover Daly has argued that the case echoed Supreme Court rulings on American Hardwood Manufacturer's Association

¹⁷² The first series court hearings were *Corrugated Paper Patents Company v. Paper Working Machine Company* 237 F. 380 (1913); Case relating to Raffel's subsequent infringement of another Langston patent is: *Corrugated Fiber Company v. Paper Working Machines Company et al.* 259 F. 283 (1919); *PTJ* 13 July 1911. Vol. LIII, No. 2, 48; *PTJ* 20 July 1911. Vol. LIII, No. 3, 40, 48; Bettendorf, *A History. Paperboard and Paperboard Containers*, 81; Grover J. Daly, *The Corrugated Container Industry – A History and Analysis*. Oak Park, Ill.: Harry J. Bettendorf 1971, 25-26.

¹⁷³ *Peter Heibel & Sons & Manufacturing Company v Corrugated Paper Patents* 247 F. 332 (1917).

and the so-called Linseed Oil –decision, which intensified the competitive environment in the U.S.¹⁷⁴

Technological innovation and public policy together, then, prompted change in the corrugated paper container industry. During the 1920's, individual paper container firms responded to these challenges by adopting clear corporate strategies of vertical integration, economies of scale, and internalization of research and development. The Hinde and Dauch Paper Company pioneered the new tactics. The company also expanded its paperboard manufacturing capabilities in Ohio, added new converting factories within the vicinity of major metropolitan areas, established vertically integrated subsidiary in the Canada, and acquired major interest in the Frohman Chemical Company that supplied critical paper chemicals. Other leading corrugated firms soon followed suit, thereby changing the basic dynamics of the industry's evolution.¹⁷⁵

Emergence of Strategies of Scale and Scope

The paper box was established as a standard shipping container just as the U.S. war mobilization effort had begun. The booming demand for all kinds of paper containers prompted managers of paper converting firms to revisit strategies of vertical integration. Traditionally the industry had focused on paper converting operations and purchased necessary paperboard from specialized suppliers. The dynamics of this supplier relationship were shaped by allegations that the paperboard industry was benign to collusive practices. In 1911, the members of Easter Boxboard Club were indicted for

¹⁷⁴ Daly, *The Corrugated Container Industry*, 28-29.

¹⁷⁵ *A Brief History of the Hinde & Dauch Paper Company*, 7.

attempting to increase prices in the New York City markets by fixing prices, dividing markets, restricting production, and other unfair trade practices prohibited by antitrust. The Chicago Folding Box Company charged thirty-nine local box board manufacturers with similar violations in 1912. These cases exhibited forces that anticipated the backward integration of box converters.¹⁷⁶

Naturally the paperboard firms followed strategies intended to impede those of their major clients. The leading box board manufacturer, American Strawboard Company was reorganized into the larger United Box Board Company with over 6 million dollar capitalization. Its managers hoped to gain price setting power through its impressive size and market share. Similar considerations prompted the entry of the largest pulp and paper enterprise into box board business. In 1912, the International Paper Company retooled in newsprint capacity into specialty production, and increased four-fold its production of box board. The paperboard industry was enticed into price fixing both because of potential over-capacity, and by booming demand during the war mobilization.¹⁷⁷

Another Chicago paper box firm charged 54 firms of antitrust violations in 1916, and alleged that the Paperboard Association was nothing but an arena for price fixing. Sixty to seventy Chicago box converting factories converted annually about 200,000 tons of paperboard into 300 million paper boxes of different types. Contemporary observers

¹⁷⁶ *PTJ* 29 June 1911. Vol. LII, No. 23, 16; *PTJ* 6 July 1911. Vol. LIII, No. 1, 30; *PTJ* 21 Aug. 1913. Vol. LVII, No. 8, 8; Grosvenor B. Clarkson, *Industrial America in the World War. The Strategy Behind the Line, 1917-1918*. Boston: Houghton Miffling Company 1924 (revised ed.), 216-217; David C. Smith, *History of Papermaking in the United States (1691-1969)*. New York: Lockwood Publishing 1970, 238-9.

¹⁷⁷ *PTJ* 18 July 1912. Vol. LV, No. 3, 5; *PTJ* 10 Oct. 1912, Vol. LV, No. 15, 9; For the effects of the war mobilization on Hinde and Dauch, see: Smith, *History of Papermaking*, 400-405.

concluded that the paperboard firms attempted to force box converting firms to pass on profits due to the increasing demand for paper containers.¹⁷⁸

As the war effort increased demand for paper containers, the box converting firms began to experience shortage of paperboard. New York City paper box firms responded by attempting to coordinate their supply of paperboard, and considered integrating into paperboard production collectively in 1916. Such initiative demonstrated how different the capital intensity in paper box converting and paperboard production was. The former business was relatively easy to afford, whereas the paperboard production required the installation of expensive paper machines, and necessitated often backward integration into pulp production and logging.¹⁷⁹

The leading paper box firms adopted aggressive strategies of backward integration in order to control the price of paperboard and ensure its steady supply. Robert Gair Company acquired in 1921 the Haverhill Boxboard Company in Massachusetts, Piermont Company in New York, and Thames River Specialty Company in Connecticut. These paperboard mills supplied Gair's converting plants in nearby metropolitan areas. In addition, the company increased its capital. All the leading paper box firms followed suit during the 1920's.¹⁸⁰

The Hinde and Dauch Paper Company was by 1920 already the world's largest paper box manufacturer, and its aggressive policy of growth impeded entry of others into

¹⁷⁸ Paper Box Making in Chicago, *PTJ* 7 May 1914. Vol. LVIII, No. 19, 10; *PTJ* 11 Feb. 1915. Vol. LX, No. 6, 9; *PTJ* 10 Feb. 1916. Vol. LXII, No. 6, 18.

¹⁷⁹ The collective attempt of New York City box firms is detailed in *PTJ* March 23, 1916. Vol. LXII, No. 12; A typical description of paperboard shortage during the war mobilization is: *PTJ* 25 May 1916. Vol. LXII, No. 22, 8; The role of paper containers for the war effort is briefly assessed in *PTJ* 30 Aug. 1917, Vol. LXV, No. 9.22.

the industry. Its managers followed strategy of scale and scope in part because they had to cope with increasing production capacity and declining prices. During the 1920's, the paper container industry grew rapidly, and shipments averaged almost ten per cent annual growth between 1923 and 1933, while prices plummeted. Managers of Hinde and Dauch emphasized productivity, and focused upon vertical integration and scale economies.¹⁸¹

At the heels of the war boom in 1918, Hinde and Dauch management discussed difficulties with transportation and labor supply that prevented the company from running its mills at full capacity. These difficulties reflected the war boom that facilitated managerial strategies of growth. Over 90 per cent of Hinde and Dauch containers and shipping boxes were delivered to either the United States Government or those of its allies. More capacity meant more profits its managers reasoned. The arrival of the post-war depression in 1920 surprised the industry, and reversed the logic of these growth strategies.¹⁸²

What began as a slow down developed into a decade of depression that forced firms to revisit corporate strategies and deeply shaped the industry's evolution. From early on, the managers conceptualized the problems plaguing the paper container industry as over-capacity. Although the cancellation of the war effort caused a temporary decline in demand, there was a significant increase in consumption of paper in the U.S. during

¹⁸⁰ *PTJ* 6 Oct. 1921, Vol. LXXIII, No.14, 18; *PTJ* Oct. 6, 1921, Vol. LXXIII, No.14, 30.

¹⁸¹; Daly, *The Corrugated Container Industry*, 7.

¹⁸² *KBK* (Unidentified, HT) *To Harry A Brinkley of Southern Fibre Company*, Aug. 27, 1918. Westvaco Collection #2830, Box #62, Folder #3. Southern Fibre was one of the most important suppliers of board, straw paper etc to box makers, and Hinde and Dauch demanded their entire output in summer 1918; *Minutes of the Regular Meeting of the Board of Directors of the Hinde and Dauch Paper Company*, 7 March 1922. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 188. Westvaco Collection, #2830, Box #1

the 1920's. Over-capacity caused decline in prices, and the industry could hardly make profits despite of increasing demand. This conceptualization of problems caused managers to pay attention to the organization of the industry, as they looked to increase prices through consolidation of production capacity.¹⁸³

The changed economic conditions during the early 1920's prompted Hinde and Dauch managers to define a strategy that emphasized increase in production capacity and entry into different regional markets. In an attempt to integrate backwards, Hinde and Dauch contracted to buy all paperboard produced by the Brown Company in 1920. Within a year it acquired the whole company, including mills along the Mississippi River with ample supply of straw, abundant water and drainage facilities. Railroads provided good transportation to large Mid-West centers of manufacturing, such as Chicago, St. Paul, Omaha, Kansas City and St. Louis. Completing a move of corporate expansion, Hinde and Dauch invested into its new subsidiary, and among other improvements increased the daily production of straw paper at the Iowa plant from 20 to over 95 tons. Further advancing its shift to the Mid-West, Hinde and Dauch soon thereafter acquired the American Strawboard Company from Mid West Box Company, which was offered for sale because the latter's indebtedness.¹⁸⁴

The new conditions prompted Hinde and Dauch to revisit its corporate strategy, and in 1922 it appointed a managerial committee for that purpose. Despite over-capacity

¹⁸³ Minutes of the Quarterly Meeting of the Board of Directors of the Hinde & Dauch Paper Company, May 1, 1918; Minutes of the adjourned Meeting of May First Nineteenth Hundred and Eighteen, of the Board of Directors of the Hinde and Dauch Paper Company, 24 May 1918. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 101, 103.

¹⁸⁴ For the Brown Company, see Minutes of the Semi Annual Director's Meeting, 5 July 1921; Mid West Company, Minutes of the Regular Meeting of the Board of Directors of the Hinde & Dauch Paper

in the industry, the committee warned, Hinde and Dauch should not enter price-cutting. Instead, the insistence on good margin of profit should dictate the long-term strategy of the company. The firm resolved to continue its strategy of growth, but decided to focus upon the corrugated paper industry. A proposed merger with River Raisin Company was abandoned because it produced solid fibre products. The merger would not have resulted in improved cost-efficiency or helped the company to gain price-setting power in its primary corrugated markets.¹⁸⁵

In the depressed markets of the early 1920's, the capital efficiency of production determined the success of individual firms and was decisive for the success of Hinde and Dauch. Its managers carefully reviewed the downtime of each of its machines. For the first half of 1922 mills and factories showed radically different figures. Whereas the best machines of the company were running close to 90 per cent of the time in Fort Madison and Gloucester, others in Ohio and Delphos stood still. The production efficiency of fabricated paper machines could be improved 75 per cent, a company review suggested.¹⁸⁶ While technology, in particular boilers, provided some remedy to the downtime,¹⁸⁷ the main issue for corporate headquarters was to manage capital efficiency

Company, 3 Jan. 1922. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 156-158, 166.

¹⁸⁵ Minutes of the Regular Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 4 April 1922; For River Raisin Company consideration, see: 7 March 1922 and 2 May 1922. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 191-195, 187, 198.

¹⁸⁶ Minutes of the Regular Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 7 July, 1922. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 203-206.

¹⁸⁷ For a detailed discussion of relationship between downtime and boilers, see Minutes of the Regular Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 7 July 1922 and 7 March 1923. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 205, 238;. See also the statement by the company president, Minutes of the Regular Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 12 Sep. 1922. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 252.

though securing orders at profitable prices. Indeed, Hinde and Dauch managers prided themselves in the early 1920's for not accepting low priced bids for its products.¹⁸⁸

Over-capacity facilitated standardization of the industry. It created conditions that favored certain kinds of firms but also other facets of industrial life. Paradoxically demands of labor unions and government for a five-day labor week fit with managers' desire to curtail overproduction. In September 1926, the president of Hinde and Dauch, Sidney Frohman, complained about over-capacity again: "We can hardly expect any mill profits for December or January, but that it was hoped that universal adoption of the five day operation approved at the Washington conference with the Labor Department would in a measure correct this condition."¹⁸⁹ In January 1927, Frohman assessed that the shorter week had the effect of taking 270,000 tons of board off the market. This had a stabilizing effect on the prices because of the relative size of the corrugated paper industry.¹⁹⁰

¹⁸⁸ Reviews and memos written by company employees or executives often asserted that Hinde and Dauch was the leading manufacturer of corrugated paper and did not sacrifice quality for price. See: Minutes of the Regular Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 7 July 1922. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 206; In 1927, the president of Hinde and Dauch assessed that a new boiler at Sandusky Mill #2 would pay itself by saving in fuelled d within the next four years time. Meeting of the Directors of the Hinde and Dauch Paper Company, 21 April 1927. For a detailed follow up of the installation see Meeting of the Directors, 7 July 1927. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917 – April 1, 1937*, 106, 110..

¹⁸⁹ Meeting of the Directors of Hinde and Dauch Paper Company, 7 July, 1927; For a detailed discussion of how managers assessed demands for a shorter labor week, see also Special Meeting of the Hinde and Dauch Paper Company, April 1, 1925; Meeting of the Directors of Hinde and Dauch Paper Company, 7 July 1927; For the same in relation to kraft liner, see Meeting of Directors, June 25, 1929. *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 55, 104, 202.

¹⁹⁰ Meeting of the Directors of Hinde and Dauch Paper Company, July 7, 1927; For a detailed discussion of how managers assessed demands for a shorter labor week, see also Special Meeting of the Hinde and Dauch Paper Company, April 1, 1925; Meeting of the Directors of Hinde and Dauch Paper Company, July 7, 1927; For the same in relation to kraft liner, see Meeting of Directors, 25 June 1929. *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 55, 104, 202.

Together, vertical integration and increased size afforded the managers of Hinde and Dauch new tactics to foster specialized customer relationships. They developed mechanisms to keep customers at disadvantage in order to maintain good margin of profit, and on the other hand to reduce dependence on particular markets. Managers of Hinde and Dauch considered the geographical distribution of production capacity as an extension of this tactic.¹⁹¹ St Louis could be supplied from the Alton plant, the Illinois Glass Company in Indiana from the Muncie plant, and the excess production of Bridgeton, New Jersey should be used for Eastern markets to check large consumers there from developing their own corrugating plants.¹⁹² Another form of this strategy was the cultivation of intimate user-producer relationships. Hinde and Dauch installed box plants on plants of its large customers, such as Hazel Atlas Glass Company.¹⁹³

Such considerations were critical when Hinde and Dauch decided to acquire the Kansas City Packing Box Company and the Kansas City Fibre Box Company in 1926, perhaps its largest acquisitions ever. The firm's plants were located in Kansas City, in the center of the Packing House District, and delivered to customers such as Swift, Armour, and Procter & Gamble. A straw paper mill was immediately projected at Kansas City in

¹⁹¹ Minutes of the Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 12 Sept. 1923. *Minutes of Stock Holders and Directors October 1913 – December 1924*, 252-3.

¹⁹² Meeting of the Directors of Hinde and Dauch Paper Company, 7 July 1929 *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 55, 110.

¹⁹³ Hinde and Dauch managers frequently discussed their relationship to large customers. For a discussion of Hazel Atlas and DuPont, see Meeting of the Directors of Hinde and Dauch Paper Company, 17 Sept. 1926; for Hazel Atlas, 25 June 1927 *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 104-105, 202.

order to run down the marginal cost, and similarly the managers paid close attention to the railroad shipping opportunities.¹⁹⁴

The fear of additional competition from its own customers reiterated to paperboard managers that only through profitable marginal cost could they command the organization of the industry. Hinde and Dauch managers began to analyze advantages of vertical integration and geographical distribution in greater detail. Transportation costs from a kraft mill in Watertown to a projected box plant in Cleveland were too high, the president of the company argued in October 1927. Rather than shipping kraft board to plants, mills and plants should be built adjacent, the president argued. Another aspect of this concern was the frequent complaints that Hinde and Dauch filed at the Interstate Commerce Committee in order to bring railroad freights down.¹⁹⁵

The acquisition of Thompson & Norris Company marked the completion of the geographical expansion of Hinde and Dauch in 1927. The new subsidiary had plants in Brooklyn, Boston, Brookville, Indiana, and a Canadian subsidiary. The merging of two leading corrugated paper specialty firms presented a great challenge for Frohman, but he was encouraged by the projection of his New York sales manager who projected

¹⁹⁴ Special Meeting of the Directors of the Hinde and Dauch Paper Company, 27 Sept. 1926. *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 83-89.

¹⁹⁵ Meeting of the Directors of Hinde and Dauch Paper Company, 19 Oct. 1927; For ICC proceedings see for example Meeting of the Directors of Hinde and Dauch Paper Company, 25 June 1929. *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 117, 202.

doubling sales within two years.¹⁹⁶ In addition, Hinde and Dauch acquired the J.M. Raffel Company that specialized in corrugating machinery.¹⁹⁷

Other leading U.S. corrugated paper companies followed aggressive strategies of growth, too. The Container Corporation had grown during the 1920's through a series of mergers and vertical integration, as did the Robert Gair Company, National Container, and some others. These leading firms operated in several major markets in the U.S. and Canada, and were vertically integrated.

As they completed their aggressive strategies of vertical integration in the late 1920's, the emergence of Southern kraft paper called the strategy in to question. Mass produced Southern kraft paper and board undersold all other paper grades by a great margin, and provided unexpected advantage for disintegrated paper converting plants. Particularly small independent converters that served metropolitan areas benefited from this, whereas the large scale paper container firms had to struggle to keep their board operations profitable.¹⁹⁸

Maps of the U.S. board mills and converting plants demonstrated the new industrial organization. Of all U.S. box converting firms in 1928, the Robert Gair Company, Container Corporation of America, and Hinde and Dauch are the only ones that have significantly integrated backwards. Gair owned five paperboard and one specialized corrugated board mills; Container Corporation five paperboard mills; and

¹⁹⁶ Meeting of the Directors of Hinde and Dauch Paper Company, 19 Oct. 1927. *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 55, 116.

¹⁹⁷ Meeting of the Directors of Hinde and Dauch Paper Company, 19 Oct. 1927; 20 Dec. 1927. *Record of the Proceedings of the Stock Holders & Directors, February 15, 1917 – April 1, 1937*, 55, 119-120.

Hinde and Dauch three paperboard and three specialized corrugated board mills. All were strategically located to supply converting operations in the vicinity of major markets. The leading paper container firms differentiated themselves from the smaller ones. The strategy of vertical integration and economies of scale was crafted by managers during the 1920's. Yet, as the price decline of paperboard began to undermine it, the managers of the leading corrugated firms responded by assigning product innovation more central role in the corporate strategy.¹⁹⁹

Product Innovation and Evolution of Technological Learning

If paper box converters could integrated backwards, paperboard manufactures could do so forward. A leading U.S. newsprint producer, St. Regis Paper Company, installed paper box converting machinery at its paperboard mill in Herrings, New York, in 1921, but divested the plant. The Waldorf Box Board Company of St. Paul acquired in the early 1920's the Collins Converting Company, and the Standard Paper Company of Kalamazoo, Wisconsin, installed machinery to convert board from its three papermachines. The Ohio based Gardner Board and Carton Company integrated forward, too, and acquired a number of smaller paper converting plants. Such moves seldom paid dividend during the 1920's. No such venture equaled the operations of the incumbent

¹⁹⁸ These mergers are studied in detail in *Harry L. Wollenberg to M. A. Wertheimer* 14 June 1928. David Clark Everest Papers, Mss 279, Wisconsin State Historical Society (henceforth DCE Papers), Box 54, Folder #12.

¹⁹⁹ Paperboard Industries Association. Maps of U.S. boxboard mills, solid and corrugated fiber plants, and folding box plants in 1928. DCE Papers, Box #67, Folder #14.

corrugated paper firms, and it is suggestive that St. Regis divested its box converting plant rather quickly.²⁰⁰

The corrugated and other specialty converting firms deployed intensive defensive tactics in order to frustrate the forward integration by their paper suppliers. As the basic converting machinery technologies came publicly available, the paper container industry focused upon product patents. The most famous example of these tactics was perhaps the “Bliss Boxes,” a family of standard corrugated paper boxes patented by Herbert R. Bliss and his two brothers, and licensed to converting firms through the expiration of patents in 1938. Such rapid diffusion of product innovation in the corrugated paper industry presented a challenge to the largest firms, and they responded by claiming large intellectual property rights to specialized product areas. Hinde and Dauch centralized product development and management of intellectual property rights to company headquarters in Sandusky, Ohio, by 1919. During the subsequent years, these routines were increasingly systematized as the company grew in size. The company expanded actively its already large paper product patent portfolio, organized innovation into a department of experimental box design, and added specialized patent engineers who monitored North American and international corrugated paper box patents that should be considered for acquisition by the company. The company’s expert patent attorneys also

²⁰⁰ *This is Gardner. Fiftieth Anniversary, 1900-1950.* Gardner Board and Carton Company 1950, 12-13; Eleanor Amigo and Mark Neuffer, *Beyond The Adirondacks. The Story of St. Regis Paper Company.* Westport, CT: Greenwood Press 1980, 70.

examined rival products and vigorously pursued potential infringers to settle out or in the court.²⁰¹

Industry wide, these efforts were, to say the very least, intensive enough to slow down the entry of new firms into the corrugated paper industry. During the 1920's many of the large-scale pulp and paper firms attempted to diversify into more profitable specialty products. Thomas Heinrich has demonstrated the difficulties of the International Paper Company to diversify into new products during the 1920's and 1930's. Although the company did emerge as the world's largest producer of paperboard during this period, it did not integrate forward into paper box converting until 1940. A study of similar efforts of a Wisconsin pulp and paper firm, the Marathon Paper Mills, suggests that the organization of intellectual property rights constrained its ability to enter new markets.²⁰²

Marathon Mills was controlled by an ambitious papemaker, Clark D. Everest, who proposed the merger of his sulphite board operations and the Menasha Printing and Carton Company, whose food paper containers were a big success in the Mid-West. Everest initiated intensive merger talks –materialized in a stream of letters- with his long time friend George S. Gaylord of Menasha Printing and Carton Company in 1920. Steven B. Karges has shown that both men assessed in amazing detail the benefits of the merger, and yet failed to proceed with it. The merger of the two firms took place only after seven years of negotiations. Everest was desperate to diversify standard board production into more profitable converting products during the 1920's, and regarded entry into the

²⁰¹ *Correspondence Course*, 13-14, Squire, *A Brief History*; *Hinde and Dauch Paper Company Annual Report 1919*. Westvaco Collection #2830, Box #46; Bettendorf, *A History. Paperboard and Paperboard Containers*, 81.

corrugated paper products a good choice. He pursued close negotiations on a joint venture with the Sefton Manufacturing Company, too, but the converter hesitated and was eventually acquired by the Container Corporation of America. Everest's problem was that his attempts to diversify production were repeatedly frustrated by intellectual property rights, and after nine years of depressed business he exclaimed: "...90 % of the business and all the profitable business is covered by what some one claims to be an infringement. Just how we come out on this, I don't know."²⁰³

In 1928, the Hinde and Dauch and Container Corporation acquired large competing converting firms, further troubling Everest and his associates. They argued that such concentration in the industry worsened the effects of the recent disintegration of the Corrugated Box Division of the Paperboard Industries Association, and predicted more competitive times for the Marathon Mills. Everest responded to these concerns by intensifying his attempts to integrate forward, and eventually in 1929 he was close to entering the corrugated paper industry by acquiring two specialty firms with large patent portfolios. Clarence Schoo of Massachusetts General Fibre Box Company explored the industry and intellectual property rights on the behalf of Everest, and informed him of the potential of the Wayne Paper Goods Company. Managers of the company argued that there was no fundamental patent for set-up or corrugated boxes. The company secured

²⁰² Thomas Heinrich, "Product Diversification in the U.S. Pulp and Paper Industry: The Case of International Paper Company, 1898-1941," *Business History Review*, 75 (Autumn 2001): 467-505; *International Paper Company After Fifty Years, 1898-1948*. New York 1948, 89.

²⁰³ The quote is from *Clark D. Everest to George S. Gaylord*, 28 Nov. 1929. DCE Papers, Box #63, Folder #1; *George S. Gaylord to Clark D. Everest*, 29 Sept. 1921. DCE Papers, Box #21, Folder #3; Steven Burton Karges, *David Clark Everest and Marathon Paper Mills Company: A Study of A Wisconsin Entrepreneur, 1909-1931*. Unpublished Ph.D. Dissertation. University of Wisconsin 1968, Ch. 6 and 7; The merger talks between Everest and owners of Sefton lasted at least four years between 1925 and 1929. See: *Clark D. Everest to George S. Gaylord*, 14 May 1925.

patents in great volumes, much like the Radio Corporation of America or General Electric, which generated large license revenues from patents on small technical details, the manager boasted.²⁰⁴

Such defensive patent strategies of the leading paper converter firms were strengthened with the onset of the Great Depression. Declining demand and prices of standard paper boxes prompted Hinde and Dauch to attempt to diversify its paperboard production. In the midst of the deepest recession in nation's history in 1933, Sidney Frohman reported to his Board of Directors about innovation with tremendous success. Orders for special insulation for electrical refrigerators had increased so much that the company's Sandusky mill was working 24 hours a day. To secure this profitable business, Hinde and Dauch must obtain exclusive rights to this product, Frohman continued. The company had begun to manufacture corrugated paper heat insulation for electrical refrigerators and building insulation under a General Electric Company licenses, but was in the process of applying for its own house insulation patent.²⁰⁵ The electric giant had filed an application for a stronger patent and Hinde and Dauch had to enter negotiations with it, Frohman said.²⁰⁶

²⁰⁴ Harry L. Wollenberg to M. A. Wertheimer 14 June 1928; H. J. Miller to Clarence J. Schoo, 19 March 1929. DCE Papers, Box #62, Folder #1. Letters in this particular folder shed light on Everest's efforts to diversify into corrugated paper products; M. A. Wertheimer to Karl E. Stansbury 25 Feb. 1928. DCE Papers, Box #54, Folder 15. For Everest's similar efforts to diversify into food packaging through mergers, see: Karges, *Clark D. Everest*, 183-184.

²⁰⁵ Hinde and Dauch Patent Attorney examined at length if the difference between the patents of Hinde and Dauch and GE was patentable in 1932, and concluded that this was the case. *Opinion re Patentability. "Thermocraft" of General Electric Co – Ideal Insulation: of Hinde and Dauch Paper Company*. 2 Jan. 1932. Westvaco Collection #2830, Box 62.

²⁰⁶ Minutes of the Meeting of the Directors of the Hinde & Dauch Paper Company, 29 May 1933. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 293-4.

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Figure 4-2. Most of these Hinde and Dauch Paper Company corrugated paper products in 1925 were patented. Source: Hinde & Dauch Paper Company Annual Address of the President to the Stock Holders, 1925. West Virginia Pulp and Paper Company Collection. Number 2830, Box 46. Courtesy of the Division of Rare and Manuscript Collections, Cornell University Library.

Everest attempted to diversify his paperboard production into insulation materials too, but an analysis of the patent situation threw cold water on these aspirations. A Marathon Mills engineer, Allen Abrams, affirmed in 1929 that the Marathon Mills was developing a good insulating material, but concluded: “However, because of the previous experimentation done by other persons and because of the patent situation on the Balsam Wool process we are temporarily discontinuing the work.”²⁰⁷

Everest, an experienced manager of innovation, had successfully diversified into a number of different kinds of forest products, and thus developed a persistent routine of research and development. Yet his efforts to enter the paper insulation business were impeded by the leading specialized paperboard converting firms. Everest asked his technical research department to find out if the insulation knowledge could be adapted to the so-called rapid frozen foods. In subsequent reports, Abrams concluded that Robert Gair Company’s research laboratories possessed the best knowledge on the subject. Everest contracted specialized engineers to further study the subject. The extensive search confronted the proprietary knowledge of Hinde and Dauch in 1933, when an engineer informed Everest that they did not have insulation board that fit the GE refrigerators.²⁰⁸

The GE insulation business was good for Hinde and Dauch. In 1933, GE produced 85,000 sets, and the company projected to reach its maximum production capacity, about 160,000 sets next year. GE’s “Knight Patent,” which covered most paper

²⁰⁷ Allen Abrams, *Report on Redwood Bark For Fiber Insulation Material*. 18 Oct. 1929. Technical Department. Report No. 19. Marathon Paper Mills. DCE Papers, Box #60, Folder #2.

²⁰⁸ Allen Abrams, *Report on Freezing of Foods*. 18 April 1930. Technical Department. Marathon Paper Mills. DCE Papers, Box #60, Folder #2; Robert M. Boehm to David C. Everest, 15 Feb. 1933. DCE Papers, Box #105, Folder #12; Karges, *David C. Everest*, 126, 128-130, 182, 271

insulation products, was critical for this projection.²⁰⁹ Worried, Frohman told the board that GE, which had to rely on external manufacturers of refrigerator insulation sets, played its cards well. GE had placed orders in competing paper firms “at prices considerably below those quoted by our company,” he said. The solution, Frohman argued, was to secure an exclusive license from GE before Container Corporation, Ashtabula Paper Company or any other competitor. Three months later, in August 1933, Hinde and Dauch had secured this. The agreement enabled the control of prices through the fact that Hinde and Dauch could depict them in sublicense contracts. Yet, numerous infringements undermined the patent’s value, and in 1935 Hinde and Dauch and GE redrafted the license agreement in favor of the papermaker. Hinde and Dauch secured full power to police proprietary rights and to order price in paper insulation products. In addition, GE agreed to reduce the royalty percentage in half. By 1936, the insulation business was so good that Sidney Frohman proposed the establishment of a separate division for it.²¹⁰

His proposal searched to clarify innovation’s organizational place within the firm. While undifferentiated product markets, such as newsprint, featured simple user-producer

²⁰⁹ James L. Knight, US Patent No. 1,914,207 (1933).

²¹⁰ Minutes of the Meeting of the Directors of the Hinde & Dauch Paper Company, 19 May 1933; 9 Aug. 1933; 23 July 1935, *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 293-4, 300, 407; On the infringement of GE’s patent and the licensing arrangements, see the extensive correspondence between Hinde and Dauch and General Electrics in Westvaco Collection #2830, Box 12, Folder #17.

²¹⁰ Minutes of the meeting of the Board of Directors, 23 July 1935. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 407; These new products included: improved turret top, top deck, dash pads, side panels, corrugated and embossed panels for trunks, rear compartments, floor boards and cowl in automobiles. Insulation products were applied to truck refrigeration, freight car refrigeration, air-conditioned railroad coaches, and for the improvement of old houses and construction of new ones. Minutes of the meeting Shareholders of Hinde and Dauch Company, 4 March 1936. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 450-1.

relationships, the relationship was often more complex in special products. The managerial overview of business relationships assumed heightened importance on a par with innovation. Intellectual property rights enabled Hinde and Dauch to coordinate such complex user-supplier relationships. A licensee of Hinde and Dauch, the Detroit Paper Products Company, sold its entire production to the Kelvinator Company that depended solely on it. In 1938, Kelvinator threatened to build its own plant and the Detroit Paper would lose large volume of business. Charging Kelvinator with infringement of its Knight patents, Hinde and Dauch was able to stop such an initiative.²¹¹

Innovation and intellectual property rights constituted key components in the strategy of Hinde and Dauch during the 1930's. In 1938, the company completed the development of specialized machinery for manufacture of insulation for electrical refrigerators. The considerable cost reductions of new machinery gave Hinde and Dauch an additional advantage. The Gibson Company of Greenville, Michigan, requested the new machinery to be installed at its plant, causing further savings in transportation charges.²¹²

Cost efficiencies like this contributed to economies of scale, as Hinde and Dauch was able to invest in increased production capacity. In 1939, the company had assembled five of the new type of machines for manufacturing paper insulation sets that each cost

²¹¹ Minutes of a Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 24 Sept. 1938. *Minutes of Board of Directors, June, 1937 – January 18, 1946*, 75-76. Westvaco Collection #2830, Box 1; For Kelvinator's infringement, see Minutes of Board of Directors, 5 Dec. 1938. *Minutes of Board of Directors, June, 1937 – January 18, 1946*, 84.

²¹² Minutes of a Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 24 Sept. 1938. *Minutes of Board of Directors, June, 1937 – January 18, 1946*, 75-76; The raw material for insulation products came from Wisconsin, and the company calculated that it cost about the same to ship the material directly to Michigan than to Sandusky. This move abolished the transportation cost of \$1.25 per one hundred pounds. The savings were considerable, because Gibson had placed order for 200,000 hundred sets

\$12,000. Two of these were placed at the Gibson plant in Michigan, while two remained at Sandusky supplying an order placed by Westinghouse for 1939. Because more machines were being assembled, Hinde and Dauch searched to win contracts by other manufacturers of electrical refrigerators as well.²¹³

As the Hinde and Dauch managers fostered specialty production, niche innovation, and intimate user-supplier relationships, they significantly re-shaped the company's knowledge base. The company was most willing to invest and install machinery and equipment when it could secure markets and clients through innovation, and control competition through intellectual property rights. Moreover, the intimate user-producer relationships informed investment strategies about demand. In addition to insulation products, this strategy was replicated at Hinde and Dauch in specialized boxes for furniture, mid-soleing for shoes, and most notably in specialized products for the automobile industry.²¹⁴

Based on its experience with GE, Hinde and Dauch began in 1935 to develop insulation and instrument boards for automobiles in cooperation with the Ford Motor Company. In January 1936, Ford placed an order of over 120,000 panels of corrugated body fillers, and subsequent orders would be placed -depending upon Hinde and Dauch's

for year 1939. Minutes of Board of Directors, 5 Dec. 1938. *Minutes of Board of Directors, June, 1937 – January 18, 1946*, 83.

²¹³ These included, General Electric Company, Frigidaire Company, Ohio, Crosley, Ohio, Rex, Ohio, Westinghouse, Ohio, Gibson, Michigan. Minutes of a Meeting of the Board of Directors of the Hinde and Dauch Paper Company, 24 Sept. 1938; For cost consideration of new machines and allocation of production capacity, see Minutes of Board of Directors, 5 Dec. 1938. *Minutes of Board of Directors, June, 1937 – January 18, 1946*, 75-76, 83.

²¹⁴ A specialized machine was installed in Lenoir, North Carolina to serve the local furniture industry; A wholly owned subsidiary of Hinde and Dauch, Sterlite Fibre Products Inc. manufactured midsoleing for shoes in South Coventry, Connecticut, selling the entire production to local shoe manufacturers. Minutes of Board of Directors, 5 Dec. 1938. *Minutes of Board of Directors, June, 1937 – January 18, 1946*, 85. Collection #2830, Box 1

ability to deliver- from Ford's Canadian, South African, River Rouge, Los Angeles as well as Eastern plants. This potential prompted Hinde and Dauch to invest \$15,000 in improvements of one of its Sandusky paper machines, as well as the acquisition of new machinery and equipment.²¹⁵

In 1936, Hinde and Dauch used about 65 per cent of its total mill production capacity.²¹⁶ Because innovation enabled improvement in run-time of production machinery, the company pursued cooperation with Ford. Predictions of demand were critical for Hinde and Dauch's decision to pursue innovations for the automobile industry. During a demonstration of the new product to Ford management, Edsel Ford told Frohman that in paper insulation and dash board: "they had found something they had been looking for during the past several years as a better substitute for what they have heretofore been using."²¹⁷

In addition to Ford, Hinde and Dauch considered as Chrysler Corporation, Federal Motors and Murray Corporation potential markets for its insulation products. Preparations for larger production capacity followed immediately. Machinery at Sandusky was retooled, and a mill at Muncie, Indiana that had been down for several years was reconditioned throughout. The directors of Hinde and Dauch expected the business to amount to \$600,000 annually. As the business grew in volume, the organization of production became an issue again. New customers, like the Budd Wheel

²¹⁵ Minutes of the meeting of the Board of Directors, 17 Dec. 1935; 18 Jan. 1936. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 420-422, 440.

²¹⁶ Minutes of the meeting Shareholders of Hinde and Dauch Company, 4 March, 1936. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 450-1.

²¹⁷ Minutes of the meeting of the Board of Directors, 9 Oct. 1936. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 479-480.

Company, proposed to license manufacturing rights and build a production lines that supplied only itself. Ford wanted to take over the production too. Because Hinde and Dauch had invested in machinery that supplied Ford, it did not consent, and wanted instead to negotiate a long-term contract.²¹⁸

Specialized product innovations enabled the leading paper converting firms to enter new markets. The new products required very different types of capabilities than simple paper box manufacturing, and therefore prompted the transformation of the knowledge base of the incumbent paper converting firms. Moreover, the importance of intellectual property rights for basic corrugated paper box business declined. In 1938, the central patents that covered the best-selling “Bliss boxes” expired. These dynamics were in part reflected when the International Paper Company finally entered the mass production of paper converting products. IP and Hinde and Dauch built jointly a fully integrated pulp, paper, and converting plant to Florida that produced boxes for oranges. Hinde and Dauch granted an exclusive license to IP to manufacture these boxes under its patents. Although the paper giant was limited by intellectual property rights in this venture, its experience of running the Florida plant facilitated its entry into mass production of non-proprietary corrugated products in 1940. The world’s largest producer of paper bags, the Union Bag and Paper Company, followed a similar course. The company abandoned its strategy of purchasing all the paper it converted into specialized paper products and integrated backward into pulp and papermaking. It built a giant kraft pulp and paper mill in Savannah, Georgia in 1939. The company had extensive

²¹⁸ Minutes of the meeting of the Board of Directors, 10 Feb. 1936; 9 Oct. 1936; 11 Dec. 1936. *Record of the Proceedings of the Stock Holders & Directors February 15, 1917-April 1, 1937*, 479-480; 484-485, 490-492.

experience in bag converting machinery, and it installed a large converting plant at the Savanna mill. The maturation of the paper container technologies frustrated attempts to cover major lines of business with patents, and lowered barriers of entry.²¹⁹

The declining importance of intellectual property rights in the major lines of paper container business induced cooperation and concentration in the industry during the 1940's. Collusive practices were largely banished from the industry by a landmark antitrust case in the late 1930's, when the antitrust authorities charged 28 leading firms of illegal trade practices. The defendants controlled 56 per cent of the U.S. markets, and the nine largest firms one third. In contrast, the 178 smallest, typically local firms shared 44 per cent of the U.S. markets. The charges alleged that the industry had continued cooperative practices, such as price fixing and production quotas, after the dissolution of the New Deal National Recovery Administration, during which such practices had been granted immunity from antitrust. The defendants agreed with a consent decree in 1940.²²⁰

The decree reinforced firms' reliance on economies of scale, and the onset of the Second World War amplified the dynamics of concentration, as the demand for paper boxes surged. During the wartime mobilization, 80 per cent of military shipments were in standard paper containers. The new demand facilitated mass production technology in the basic standard products. The speed of basic corrugating machinery increased from 300 feet per minute in 1940 to 600 by 1955. During the same period, the annual shipments of

²¹⁹ *John F. Rollins to Sidney Frohman, 24 May 1939; Plan for manufacture and sale of kraft board orange boxes.* Westvaco Collection #2830, Box #61, Folder #8; ; *Transcript of Remarks by Donald J. Hardenbrook, Vice President of Union Bag and Paper Corporation to the Investments Analysts Society of Chicago.* 14 Oct. 1954. DCE Papers, Box #262, Folder #2; *International Paper Company After Fifty Years, 1898-1948.* New York 1948, 89.

corrugated board increased from 33,000 tons to 93,000, while the utilization of paperboard production capacity increased from 73 per cent to 88. The industry boomed again.²²¹

Such developments prompted managers to emphasize economies of scale, and a wave of mergers followed during the 1950's. Over fifty leading specialized corrugated paper containers firms were reduced to fifteen national, vertically integrated firms in thirteen combinations. Vertical integration characterized seven of these mergers, four were horizontal mergers of converters, and in two cases a manufacturer of metal and glass containers diversified into paper containers. The fifteen industry leaders dominated U.S. markets with annual value of 2.7 billion dollars. These firms had similar organizational capabilities and overlapping geographical operations. Thus, their managers' ability to deploy strategies of differentiation was inherently constrained.²²²

Conclusions

The co-evolution of industrial organization and technological learning is striking in the North American paper container industry between 1870 and 1960. Innovative firms employed intellectual property rights to protect their specialized markets, but over time new entrants always gained market share. The maturation of technology, imitation,

²²⁰ *Anonymous lawyer to Sidney Frohman* 11 June 1937; *Exhibit 1*. Westvaco Collection, #2830, Box #58, Folder#10; *United States of America v. National Container Associations et al.* Civil Action No. 8-318. District Court of the United States for the Southern District of New York. 23 April 1940.

²²¹ Daly, *The Corrugated Container Industry*, 100-102. *Robert Gair Today. A Big Company in a Very Large Industry*. New York: Robert Gair Company 1953, 6; A review of manufacturing technologies around 1950 is offered in OEEC, *The Pulp and Paper Industry in the USA. A Report by a Mission of European Experts*. Paris: OEEC 1951, 303-314.

²²² Daly, *The Corrugated Container Industry*, 74-75; *Robert Gair Today*, 13.

expiration of intellectual property rights, and the law were the central dynamic forces that undermined firms' attempts to maintain barriers of entry over a long period of time. As the leading specialized firms lost their ability to control specific market segments through patents, they often responded by creating new markets with innovative new products.

The history of the North American paper container industry between 1870 and 1960 is a story of continuously diminishing role of differentiation for corporate strategy. Although the paper container industry displayed tremendous capacity for new product innovations over a long period of time, by the 1950's its industrial organization did not foster radical technological departures. The specialized, large, vertically integrated paper container firms resembled each other, and were more likely to compete by improving production efficiency than product differentiation. In contrast, radical technological departures propelled two European firms, Swedish Tetra-Pak and English Smurfit-Stone, into global paper packaging giants by the late twentieth century.

CHAPTER 5

DIFFUSION OF INNOVATION AND THE EVOLUTION OF THE SULPHATE PULP AND PAPER INDUSTRY, 1850-1960

The most significant structural and technological change in the North American pulp and paper industry in the twentieth century was the replacement of the sulphite process as the dominant pulping technology by the sulphate process. 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 within the same period. This particular industrial evolution involved complex dynamic forces, such as innovation, relocation, consolidation, and vertical integration and disintegration, which are fundamental for our understanding how industries behave over a long period of time.

Technological breakthroughs punctuated the long-term growth of the sulphate industry, and distinct periods of industry transition exhibited different mechanisms and speeds of diffusion of innovation. The history of the North American sulphate industry

offers an analysis of reciprocal relationships between dynamics of diffusion of technological innovation and its sources. Indeed, during rapid bursts of growth the locus of innovation shifted constantly within the complex and large industrial organization that included the community of specialized manufacturers that built the pulp and paper machines, and the ones that ran them.²²³

Table 5-1. Wood Pulp Production in the United States by Grade, 1909-1959 (Thousand tons of 2,000 lbs.)

Grade	1909	1914	1919	1929	1939	1947	1959
Ground Wood	1,179	1,294	1,519	1,638	1,445	2,050	2,883
Sulphite	1,018	1,151	1,420	1,689	1,946	2,773	2,442
Soda	299	348	411	521	442	491	410
Sulphate	na	53	120	911	2,963	5,355	12,317
Total*	2,496	2,893	3,518	4,863	6,993	11,917	20,933

Sources: *Manufacturers, 1919*. Washington, D.C.: Government Printing Office 1923, 558; *Census of Manufactures 1947. Vol. II*. Washington, D.C.: Government Printing Office, 1949, 318; *Biennial Census of Manufactures 1931*. Washington: Government Printing Office 1931, 487; *Census of Manufactures 1958. Vol. II.* Washington, D.C.: Government Printing Office 1960, 26A-12.

*Note that Total Wood Pulp includes specialty wood pulps, such as semi-chemical and defibrated pulp, not given here.

Perhaps the most characteristic feature of the industry's long-term evolution, until the late 1930's, was the absence of sustained effort to coordinate technological learning. In this sense, the organization of technological learning formed a stark contrast to other major segments of the pulp and paper industry. Managers and industry leaders did

²²³ Theoretical conceptualization of these communities as "technology clusters" and "operational clusters," and discussion of literature is offered in David G. McKendrick, Richard F. Doner, Stephan Haggard, *From Silicon Valley to Singapore. Location and Competitive Advantage in the Hard Disk Drive Industry*. Stanford: Stanford University Press 2000, 37-65. The evolution of sulphate and hard disk drive industry share surprisingly many features, such as diffusion of innovation, role of mass production, relocation, and many others, and for this reason this chapter applies, as well as confirms, several insights of the careful examination of co-evolution of industry-wide learning and relocation by McKendrick et al.

attempt to coordinate many aspects of the expanding sulphate industry, but failed to consider the internalization and control of underlying technology. The managers of leading North American pulp and paper firms had done so successfully in the case of other technologies, such as sulphite pulp, napkins, feminine hygiene products, newsboard, paper boxes, bags, and many others. Instead, the leading sulphate pulp and paper firms relied largely on external sources of innovation, and the industry became mired in enduring over-investment into new capacity and price depression.

Throughout the early twentieth century, the North American sulphate industry was patterned by strong regional differences and inter-regional competition. The nascent industry arrived originally from Scandinavia to the continent through Canada, but practically disappeared from there while reaching a considerable size in the U.S. Lake States by 1920. The growth of the U.S. industry took off with the emergence of Southern mass production in the late 1920's. As a result, sulphate firms constituted very different industrial organizations in the Lake States, South, and Pacific Coast in terms of technological capabilities and factor endowments. Within this setting, regional industrial organizations influenced greatly how managers chose to cope with simultaneous expansion and over-capacity.

Inter-regional competition was underpinned by innovation, and continental concentrations of sulphate mills embodied very different systems of innovation until the 1950's. Although radical technological departures retired other pulp processes and older sulphate equipment rapidly and repeatedly, different regional industrial organizations embodied relatively distinct technological styles, and therefore adopted innovations selectively and asymmetrically when seeking competitive advantage. First when a small

pool of highly specialized sulphate process machinery supplier firms assumed managerial control of the underlying technological knowledge after World War II, new innovations diffused rapidly and evenly throughout the global industry. The leading North American sulphate firms responded by developing similar continental strategies and structures relatively rapidly, and ended the era of regional differences.

Early Development of Sulphate Wood Pulp Technology

The discovery of “artificial” soda, sodium carbonate, by Nicolas LeBlanc laid the foundation for the modern sulphate pulping processes in the late nineteenth century. In 1775, a reward offered by the French Academy of Science prompted LeBlanc to patent a process for making caustic soda ash from common salt. The patent described a process consisting of mixing of one part sodium sulphate, one part limestone or chalk, and one-half part charcoal that was introduced to a separately fired reverberatory furnace. The mass was raked through the furnace, and the resulting thick material was cooled and solidified to a “black ash” containing nearly one-half of sodium carbonate. In subsequent refinements, the carbonate was recovered by countercurrent leaching in a series of tanks, and from the resulting solution the crude “black salt” could be obtained by evaporation. The soda could be purified by recrystallization, or sodium hydroxide could be obtained by causticizing the carbonate solution with lime. The LeBlanc process constituted the basic method to manufacture soda ash with high sodium sulphide content until the 1880’s, after which the ammonia-soda process and subsequently developed direct production of caustic in electrolytic chloralkali cells replaced it. The availability of the

LeBlanc soda process provided impetus for new chemical industries that employed soda, among them the wood pulp industry.²²⁴

As the rag shortage increased the price of paper in mid-nineteenth century Europe, quite a few entrepreneurs began to examine how to apply centuries old method of using alkalines to separate cellulose fibers from other nonwoody plants to wood pulp processes.²²⁵ Hugh Burgess and Charles Watt first discovered how to use alkalies in the pulping of wood. Their English patents in 1851 described a soda pulp process that consisted of boiling wood in caustic alkali at high temperature, and made specific use of the soda ash produced by the LeBlanc process. The soda pulp process did not become a commercial success in England, however. The inventors secured an American patent in 1854, and opened a mill in Pennsylvania. Burgess and Watt used aspen to make soda pulp that contained neither a long or strong fiber, but when mixed with rag pulp produced good quality writing paper with a pricing advantage. Relying on a patent monopoly, they incorporated the American Wood Paper Company and constructed a large-scale pulp and paper mill in Manayunk, Pennsylvania, in 1863. This prompted the emergence of soda pulp-writing paper industry in Pennsylvania, but difficulties with the pulping process arrested its expansion.²²⁶

The most severe impediment for the diffusion of soda pulp process was the high cost of soda ash, the source of alkaline for the process. In order to improve the

²²⁴ Roy P. Whitney, "Introduction," in Roy P. Whitney (ed), *Chemical Recovery in Alkaline Pulping Processes*. TAPPI Monograph Series No. 32. New York: TAPPI 1968, 1-14.

²²⁵ Roy P. Whitney, "Introduction," 3.

²²⁶ Dard Hunter, *Papermaking. The History and Technique of An Ancient Craft*. New York: Dover Publications 1978 (1947), 390-391; Royal S. Kellogg, *Pulpwood and Wood Pulp in North America*. New

productivity of the process, entrepreneurs focused their efforts on the recovery of chemicals from the pulping process waste liquor. The soda process produced chemical waste called the weak black liquor, and it could potentially be processed into reusable soda ash. Initial attempts towards this end at American soda pulp mills followed closely the LeBlanc technology. Fluid weak black liquor was processed with external heat into a “black ash,” which was cooled and leached to give a sodium carbonate solution. This process consumed external energy to recover sodium carbonate, and a 60 per cent recovery of original chemicals was considered good yield. These improvements were not sufficient to increase the adoption of the soda process significantly. The main reason limiting its acceptance continued to be the high price of sodium carbonate, as well as the energy intensity of the chemical recovery process.²²⁷

The idea of improved economics of the soda process induced a broad-based effort to develop improved chemical recovery system during the nineteenth century. Many of the improvements were borrowed from other chemical industries. Soda pulp mills replaced the old reverbatory chemical recovery furnaces with rotary ones that had been pioneered in the LeBlanc soda industry. Of equal importance was the transfer of new evaporation technology from the sugar industry to the pulp industry in the late nineteenth century, as these direct contact evaporators improved the recovery yield significantly. These improvements mattered little in the U.S., where the relatively mature ground wood and sulphite pulp technology attracted the attention of the leading pulp and paper firms. In the U.S, the soda pulp industry was largely confined to Pennsylvania, where mill

York: McGraw-Hill Book Company 1923, 35; Lyman Horace Weeks, *A History of Paper-Manufacturing in the United States, 1860-1917*. New York 1969 (1917), 227-231.

²²⁷ Whitney, “Introduction.”

owners struggled to improve the efficiency of the recovery process. The wide adoption of a new innovation, direct production of caustic in electrolytic chloralkali cells, in the 1890's was critical for the industry's continued competitiveness.²²⁸

Relative immaturity of technology and high cost of chemicals limited the diffusion soda pulping process, but a small technological community of inventors believed in the possibility of commercially viable alkaline wood pulp process and continued to innovate. American Asahel K. Eaton obtained in 1870 a patent for remarkable improvement of his earlier 1864 patent for the soda process. Eaton substituted more expensive sources of alkali with oxysulphide of calcium or sulphide sodium that were considered a waste, and therefore relatively cheap. The patent claimed to disclose for the first time the sulphide sodium as a solvent in wood pulp, but its description of chemical details of the pulping process were rather vague. This discovery went unnoticed by the North American pulp and paper industry, whose managers were preoccupied with the adoption of the groundwood and sulphite pulp processes. Besides potential technological problems, the Eaton process could not be adapted to the production of white newsprint, writing, or book paper, and there was simply little or no demand for it.²²⁹

In Europe, the disclosure of similar invention triggered rapid structural change and expansion in the pulp and paper industry in the 1880's. In an attempt to get around previous patents on boiling process with sodium sulphate, Carl F. Dahl invented in 1879 in Danzig, Germany, an alkaline wood pulp process that drastically reduced the cost,

²²⁸ Thomas M. Grace, "Perspectives on Recovery Technology," 45-47. In Thomas M. Grace (ed), *Forum on Kraft Recovery Alternatives*. Appleton, WI: The Institute of Paper Industry 1957, 27-57.

expanded the range of adaptable tree species, and produced a new kind of extremely strong paper. The process substituted traditional sources of alkaline in the pulping process with sodium sulphate, which was considered essentially as a waste. Dahl's American patent from 1884 described in great detail the whole process, the recovery of sodium salts from the waste liquors, and made very broad and fundamental claims for having disclosed a distinct sulphate process.²³⁰

The basic sulphate wood pulp process discovered by Eaton and Dahl could be adapted to the cooking of range of a different kinds of wood pulps, most importantly wood species with high resin content that did not adapt to the groundwood or sulphite process, such as the pine. The immediate success and rapid diffusion of Dahl's pulp process was due to its innovative characteristics. The patented pulp process became known as the "Kraft process" according to the German word for "strong." The process involved the intentional undercooking of pulp in order to produce a very dark, unbleachable, but extremely strong stock that enabled the manufacture of papers with superior strength. The kraft pulp consisted of the heaviest possible individual fibres, which were hydrated into extreme condition, making the pulp very "wet" or "slow" in the language of paper makers. Such pulp readily found many applications in the Europe, such as industrial wrapping papers.²³¹

These wood pulp process highlighted the divergent evolutionary paths of the North American and European pulp and paper industries. The kraft process diffused

²²⁹ Asahel K. Eaton, U.S. Pat. No. 106,143 (1870) and U.S. Pat. No. 119,224 (1871).

²³⁰ Carl F. Dahl, U.S. Pat. No. 296,935 (1884).

²³¹ George Carruthers, *Paper-Making*. Toronto: The Garden City Press Cooperative 1947, 221-227; Edwin Sutermeister, *Chemistry of Pulp and Paper Making*. New York: John Wiley & Sons, Inc. 1920, 141.

rapidly in the European pulp and paper industry, where soda pulp mills were widely retooled into the new technology. Such structural change was in particular rapid in the pine rich Scandinavian countries, and Germany. In North America, on the contrary, discovery of the kraft process went unnoticed. Although a host of reasons, including the competitive structure of groundwood and sulphite industry, contributed to this, the most fundamental reason was the organization of the Pennsylvania soda pulp industry. These firms supplied almost exclusively writing paper markets, and the kraft process allowed only the production of dark, colored, and stiff papers, such as cover and industrial wrapping papers. The absence of large pine and spruce stands may have contributed, too, although plenty of other adaptable tree species, such as hemlock, were available in the region. Thus in the North America, firms and industries with pre-existing capabilities that would have supported the early adoption of the kraft process, did not do so.²³²

Once the North American pulp and paper industry begun to adopt the sulphate process in the early twentieth century, it constituted a distinct and new nascent industry. Characteristically, the role of individual entrepreneurs and engineers was central, as the skills and knowledge circulated most efficiently with people. In 1907, Norwegian Olai Bache-Wiig constructed the first North American kraft mill at East Angus, Quebec for Brompton Paper & Pulp Company. Three years later, Wiig introduced the industry to Wisconsin by establishing Wausau Sulphate Fibre Company. American Joseph H. Wallace traveled and learned the kraft process in Sweden in 1906, and subsequently organized a commercial size experimental run with the Southern pine there. Encouraged, he incorporated the Southern Paper Company in 1912, and built the pioneering Southern

²³² Royal S. Kellogg, *Pulpwood and Wood Pulp in North America*. New York: MacGraw-Hill Book

kraft pulp mill at Moss Point, Mississippi, that was acclaimed for producing kraft paper at lowest cost in the world. Largely due to distance to major markets and Northern competition, the Southern kraft industry did not take off until roughly a decade later. Although the production of sulphate pulp increased rapidly during the following decade, in the context of giant sulphite and groundwood operations it amounted to a small vibrant industry at best. The emerging industry concentrated to Quebec in Canada, and in the United States in particular to Wisconsin and other Lake States.²³³

In Canada the annual production of sulphate increased from 33,000 tons in 1912 to 188,000 tons in 1920. In the United States the annual production more than doubled between 1914 and 1919 to 120,000 tons, but this was a tiny slice of over three and half million tons of annual wood pulp volume. In the context of an industry dominated by capital intensive large-scale enterprises, such as International Paper Company, these high growth rates of the minuscule sulphate industry carried little importance.²³⁴

Managers of the leading pulp and paper firms followed corporate strategies built around economies of scale, and recognized little or no incentives to examine or invest in the kraft process. A number of North American authors argued that the production of kraft pulp that would equal the quality of European pulp was impossible, and it was more convenient to import it. The relative quality of kraft pulp did not constitute a fundamental issue for managerial decisions about pulp processes, whereas practical reasons, such as potential markets and efficiency of production, were decisive. Problems with the kraft

Company 1923, 37-42.

²³³ For an autobiographical account of the first pulp and paper engineers to consider Southern pine, see: "The Beginning of the Kraft Paper Industry in the Southern States," *PTJ*, 23 July 1936, 21, 24.

²³⁴ J. H. H. Alexander, "Eighty-Four Years Ago Wisconsin Had But One Paper Mill," *The Paper Industry*, December 1932, 670-673; Kellogg, *Pulpwood*, 37-42.

technology in the early twentieth century severely constrained attempts to achieve true economies of scale. In 1908, one of the most prominent paper engineers in the early twentieth century North America, J. A. De Cew, argued that the great potentiality of the kraft process was frustrated by lack of economies of scale in the machinery:²³⁵ “An American objection to the kraft process is the apparent necessity for the use of the Kollergang [machine used for the final separation of the fibres and the first stage of fibre hydration], which apparatus is not in favor on this continent on account of its small capacity in proportion to the power required.”²³⁶

The European origin of kraft machinery was manifest in vocabulary and technological style of the industry. While necessary machinery for almost every phase of the kraft process embodied the European style, limiting economies of scale, this was most evident in the heart of the kraft process, the chemical recovery cycle. Rapid early diffusion of the kraft process had provided European papermakers with a sustained lead in the knowledge of sulphate pulping, and they produced most new machinery. The expiration of fundamental patents gave an important boost for technological learning in the kraft pulp technology by 1900. A continued effort to improve the sulphate process followed the expiration of the Dahl patents, but inventors were not able claim broad intellectual property rights on the process anymore. Technological learning in the sulphate process focused upon the recovery of chemicals, and indeed engineers conceptualized the whole sulphate process as revolving around the recovery cycle.

²³⁵ In a rule the product of the pioneering North American kraft mills was compared to the European kraft products. See for example: “‘Mitsch-Kraft’ a Detroit Sulphite Company’s Product,” *PTJ* 28 May 1908, 42. Often repeated contemporary claim was that it was impossible to produce good quality kraft pulp in the North America. For specific efforts to counter these claims see: Josef E. Hedin, “The Manufacturing of Sulphate Pulp and Kraft Pulp,” *PTJ* 20 April 1911, 46-48, 54.

Around 1900, the kraft process had two distinct advantages over the prevalent chemical pulp technology, the sulphite process. The possibility reclaiming chemicals from the sulphate process presented potentially a very considerable saving, and fueled invention and adoption. Second, the sulphate process lent itself to woods with high resin content, and expanded widely the range of tree species - most importantly the pine - that could be pulped economically. The sulphite process was limited to the non-resinous woods, spruce being the major source of cellulose for the industry. Territorial expansion of the kraft industry was not a mechanical replication of existing basic production processes, however, and engaged firms into a comprehensive learning experience as they adapted basic sulphate pulping technologies into different biological environments.²³⁷

A severe disadvantage of the sulphate process was its intense odor, described typically as “intolerable.” The smell was formed during the cooking and recovery process, and polluted large areas close to a mill. Indeed, this was considered a serious enough nuisance to attempt to limit the industry to sparsely inhabited regions. Environmental concerns also included stream pollution, as the discharged chemicals often had destructive effect on downstream ecology of rivers, but this applied to sulphite and soda mills, too. Improved treatment of chemical waste liquors potentially reduced these severe social costs, and established the other important incentive –along with the

²³⁶ “First Principles of Making Kraft,” *PTJ* 28 May 1908, 38.

²³⁷ For the territorial expansion of American agriculture, diffusion of innovation, and learning in biological adaptation, see: Alan L Olmstead and Paul Rhode, “Induced Innovation in American Agriculture: A Reconsideration,” *Journal of Political Economy*. Vol 101 (February 1993): 100-118.

improved economic efficiency– to focus research and development efforts on the recovery cycle of the kraft pulp process.²³⁸

The chemical recovery cycle and its energy efficiency constituted the critical economical bottlenecks of the kraft process. The Kraft industry had improved the energy efficiency of the process by replacing older reverberatory furnaces with rotary ones, but these required heavy maintenance. The chemical processes deteriorated equipment quickly, and necessary maintenance of the brickwork alone destroyed the economics of low-capacity standard rotary recovery units. The flow of recovery process was also relatively slow and labor intensive. Black ash discharged from a rotary recovery furnace was mixed manually with salt cake and slabwood before being shoveled into the smelter.²³⁹

The energy efficiency of turn of the century rotary furnaces was poor, too. These rotary furnaces consumed auxiliary fuel, and substantial losses were suffered during the discharge of black ash from the furnace. Rotary furnaces could not burn all carbon in the black liquor, and discarded black ash with considerable content of unburned carbon. The relatively uncontrolled infiltration of air into the discharge worsened the loss of heat. Lastly, rotary recovery furnaces were vulnerable to destructive, violent explosions that disrupted mill operations, and injured and killed labor.²⁴⁰

²³⁸ Sutermeister, *Chemistry of Pulp and Paper Making*, 142.

²³⁹ Whitney, "Introduction," 8-9.

²⁴⁰ Grace, "Perspectives on Recovery Technology," 48-49.

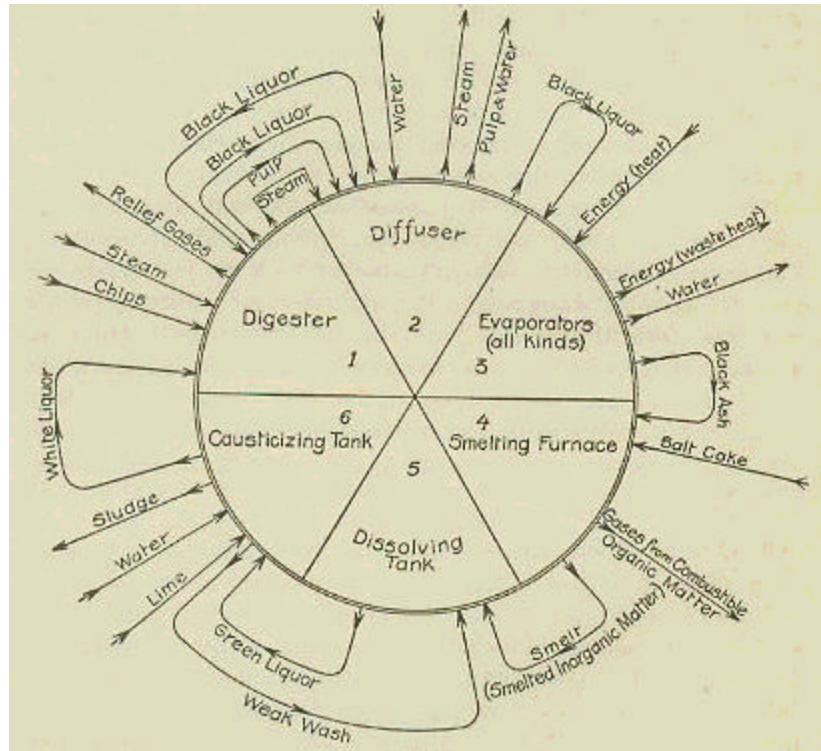


Figure 5-1. Technological structure of the sulphate pulping process cycle. The pulp digesting process itself occurs during the phases one and two, and the recovery cycle during the phases three and six. This textbook was prepared under the direction of the Joint Executive Committee on Vocational Education Representing the Pulp and Paper Industry of the United States and Canada, and summarized North American technological learning in the industry. Source: Karl M. Thorsen, "Manufacture of Sulphate Pulp," 4. In J. Nevell Stephenson (ed), *The Manufacture of Pulp and Paper. A Textbook of Modern Pulp and Paper Mill Practice. Vol. III.* 2nd Ed. New York: McGraw-Hill Book Company 1927, Section 6.

Efforts to reduce maintenance, eliminate the use of auxiliary heat and explosions, and to improve liquor evaporation and heat recovery constituted the major lines of engineering work in the kraft pulp industry during the early twentieth century. Europeans possessed evidently superior capabilities in the kraft process, and occupied the frontier of technological learning. Technological learning in kraft process in the early 1900's centered upon the improvement of evaporation in the recovery cycle, since this held the key to energy and chemical efficiency. Black liquor –which contained all the chemicals used in the cooking– was manufactured from weak black liquor by evaporation. Early installations followed the idea of direct evaporation, in which the liquor was held in a pan under hot gas. In an effort to improve heat efficiency, Carl Dahl had constructed a steam-boiler arrangement that used auxiliary fuel for the evaporation. In the 1890's, chemical engineers realized that it was technologically possible to recover fuel in addition to the chemicals, if the evaporator was run like a gas generator. Such improvements required papermakers often to learn from the experience of other industries.²⁴¹

The North Americans had the advantage of learning of evaporator techniques developed in the nineteenth century sugar industry, where economies of scale were emphasized. American Homer F. Yaryan had invented a multiple effect evaporator to concentrate sugar liquors, and construction based on his patent became almost universal in the North American soda, and early kraft pulp industry. Developed into steam-heated multiple-effect evaporators, the Yaryan was a horizontal, rotary liquor-in-tube construction that enabled almost energy self-sufficiency of the recovery cycle. The

²⁴¹ Karl M. Thorsen, "Manufacture of Sulphate Pulp," 63. In J. N. Stephenson (ed), *The Manufacture of Pulp and Paper. Vol III*. New York: McGraw-Hill Book Company 1927, Section 6.

technology peaked in the years immediately following 1900, when Americans turned their attention to the European evaporator technology again.²⁴²

The Europeans hardly ever employed the Yaryan evaporators. Instead, the leading Norwegian and Swedish mills relied on rotating disc evaporators. Josef E. Hedin summarized his experience of running them in his North American kraft mill when he stated that the Scandinavian evaporators “have high efficiency, need very little repairing, and work practically without the use of coal.”²⁴³ His bold claims that disc evaporators were far superior to the conventional Yaryan were situated within the broader phenomena of technological learning in the kraft pulp technology around 1910. After years of experimentation, engineers agreed that vertical rotary digesters of 1,000 cubic feet represented best practice in the industry. They were more expensive than other designs, but paid back several times a year by giving better black liquor, better pulp, and by saving time, Hedin concluded in his important review.

Such assessments summarized the early North American learning experience from running kraft mills, and importantly presaged the efforts to innovate during the next decade. Improvements in the evaporator technology were matched by a number of other significant innovations in the kraft process. Concurrent maturation of many, if not all technologies involved, induced a more comprehensive chemical engineering approach to the kraft pulp process around 1910. During the following decade, North American managers and engineers effectively Americanized the kraft pulp technology, as they focused upon throughput and efficiency. However, increased technological learning in

²⁴² Grace, “Perspectives on Recovery Technology,” 49.

²⁴³ Hedin, “The Manufacturing of Sulphate and Kraft Pulp.”

the North American kraft pulp industry occurred in the absence of any significant managerial coordination as experimentation occurred mostly at scattered mills and relatively small pulp and paper firms.

Regional Learning in the Kraft Process, 1910-1927

Technological learning in the kraft process technologies remained dispersed at various North American locations between 1910 and 1927. This organization of research and development shaped deeply the diffusion of innovation and direction of inventive activity until the late 1930's. The engineering community embodied the most important mechanisms to coordinate technological learning at the early stages of emerging kraft pulp industry in the North America between 1910 and 1927. The Technical Association of the Pulp and Paper Industry (TAPPI hereafter) was established in 1914, and it early on appointed a small committee on sulphate technology to review and diffuse innovations. The committee did not engage in a systematic research and development program, as other TAPPI committees did in the case of technologies deemed more important for the industry's competitiveness, such as standardization and sulphite pulp. In this context an industry outsider from chemical engineering conceived an invention that triggered a renewed wave of learning in the kraft pulp process during the 1910's.²⁴⁴

The chemical engineering approach to the kraft process and its recovery cycle reached an important threshold during the winter of 1909 and 1910, when Hugh K. Moore, Ph.D. was invited to renovate and reconstruct a sulphate mill in La Tuque, P.Q., Canada. Moore had no prior experience in the sulphate process, but had built a reputation

²⁴⁴ Grace, "Perspectives on Recovery Technology."

with his work and publications within the American chemical engineers. Cooperating eventually almost for a decade with the Brown Company, he began his work by improving and perfecting the efficiency of the process. Moore's most lasting and significant contribution to the kraft process was the patented construction of a new type of recovery furnace that marked a radical departure from the standard rotary furnace. Moore and his collaborators discovered a method to spray black liquor into a stationary furnace, and greatly improved the chemical recovery and heat efficiency of the process.²⁴⁵

Moore detailed his experiences at the La Tuque mill in an article eight years later in *Metallurgical and Chemical Engineering*. Although an obvious marketing pitch for the Brown Company's proprietary kraft technology, the article demonstrated a stylized chemical engineering approach to the process. Moore claimed that fifteen specific technological problems in the recovery cycle had attracted his attention in 1909, including the loss of alkali, turpentine, and sludge, and the poor energy economy of the process that culminated in every digester batch discharging 18,000 lb. steam in the atmosphere. The graphic descriptions of the potential losses, labor intensive phases of the process and maintenance of equipment echoed frustrations at every North American kraft mill. The Brown Company equipment promised a remedy, and Moore claimed as the "tangible results" of his process:²⁴⁶

²⁴⁵ The chemical engineering approach was manifest in the landmark textbook on pulp processes in 1920: Edwin Sutermeister, *Chemistry of Pulp and Papermaking*. New York: John Wiley & Sons, Inc, 1920. See chapter V for extensive analysis of the sulphate process.

²⁴⁶ Hugh K. Moore, "Chemical Engineering Aspect of Renovating a Sulphide Mill," *Metallurgical and Chemical Engineering* Vol.17, No. 3 (1 Aug. 1917), 117-125.

We have been enabled to produce over 1600 horse-power from our liquor in addition to recovering the heat generated in the gas producer. We saved all hour hospital bills and damages arising from explosions, we reduced the repair bills in the furnaces enormously, we saved all the repairs on incinerator and disk evaporators and the power required to run the same, we saved about 60 men's labor in various departments and, above all, got an even, uniform production quality never obtained before. In addition to the above it alone was the means of increasing the production many times.²⁴⁷

Moore managed at Brown Company a research and development effort between 1911 and 1916 that constituted a technological watershed for the kraft pulp process. His patent in 1915 defined a complete sulphate pulp waste liquor treatment system, whose technological heart consisted of the so-called "explosion process." In this process lignin liquor, recovered from the sulphate waste, was sprayed into extremely hot furnace and "exploded." As a result of the occurring efficient burning, the sulfate of soda fell on the furnace floor and was combusted. The discovery certainly improved the economy of the recovery cycle, but it was plagued by many technological problems. Moore's promises of an immediate bonanza proved exaggerated, but his discovery certainly redirected efforts to improve the recovery process.²⁴⁸

The "explosion process" emphasized that the key to economically efficient kraft pulp mill was improved chemical recovery, typically characterized by experienced

²⁴⁷ Moore, "Chemical Engineering Aspect."

²⁴⁸ U.S. Patent No. 1,137,780 (1915).

papermakers as the “weak spot of the sulphate industry, where money can be made and just as easily lost.”²⁴⁹ Potential improvement of the recovery cycle of kraft pulp process relieved North American industry’s dependence on European imports, and in particular from the disturbances caused by the World War I. The war had cut off German supply of kraft to the North America, and greatly decreased Scandinavian imports, too. The kraft pulp consumption had peaked in the Germany, where the search for strengthened material independence had fueled a range of product innovations in kraft papers. For these reasons the price of kraft pulp had boomed, and by 1917 it traded some 20 per cent higher than sulphite pulp that was much more expensive process. The First World War, by redirecting traditional sulphate trade flows, established new incentives and reinforced old ones for the North American kraft pulp firms to intensify efforts to improve the chemical recovery technology.²⁵⁰

Such incentives awoke the interest of leading large-scale pulp and paper enterprises into the kraft pulp process, and they began to examine its potential. Managers of the leading firms, such as IP, attached new strategic meaning to the kraft pulp process between 1915 and 1925. Structural change was precipitated by IP's decision to retool three plants of its wholly owned Continental Paper & Bag Mills to use kraft pulp purchased from the open markets. In 1919, IP acquired a small sulphate pulp mill in Maine that used northern timber. The decision triggered a long and gradual process of

²⁴⁹ Jacob O. Lundberg, “A Quarter Century of Sulphate Pulp,” *Paper* Vol. XVIII, No. 15. 31 June 1916, 11-12.

²⁵⁰ Hans Lagerlof, “The Future of Sulphate and Kraft Pulp,” *Pulp and Paper Magazine of Canada*. 25 January 1917, 94-95.

industrial change between 1925 and 1940, by which large scale vertically integrated firms occupied the sulphate pulp and paper industry.²⁵¹

The combined efforts of paper makers evidently accelerated the rate of innovation and matured kraft pulp technology. Moore's invention was critical in this sense, but it also paradoxically set the kraft technology on two very different paths of development. The North American kraft pulp industry became split into the proponents of stationary recovery furnace, and those who looked to improve the old rotary furnace. This technological division was manifest between 1916 and 1935, when the North American kraft paper industry was divided into these two schools of chemical recovery technology. They shared a belief in reduced environmental pollution and improved efficiency of the process, but provided very different technological solutions.²⁵²

The major difference between the rotary and stationary furnaces was their adaptability to economies of scale, and the pre-existing capabilities of firms predicted how their managers regarded the potential of the two alternatives. From the beginning Moore and his followers argued that the maintenance of the rotary furnaces was too costly, and that its size and capacity was limited by inherent technological factors. Rotary furnaces required the use of too dense black liquor, they argued, whereas in stationary furnaces efficient burning was achieved with more liquid liquors. Stationary furnaces, however, suffered from severe technological problems of their own. Among the chief shortcomings of the design was that the method of spraying liquor created poor heat

²⁵¹ *International Paper Company After Fifty Years, 1898-1948*. New York 1948, 65.

²⁵² For an early review of Moore's claims and their potentiality, see: Olai Bache-Wiig, "Report on Sulphate Pulp," *Technical Association Papers –Series II*. New York: Technical Association of Pulp and Paper Industry, 32-33; Carl Moe, "Report of the Sulphate Pulp Committee," *Technical Association Papers, Series III*. New York: Technical Association of Pulp and Paper Industry 1920, 12-13.

economy. This was made worse by an inadequate boiler design that proved difficult to improve. For these reasons stationary recovery furnaces received only relatively little attention before 1935, and were advanced in relative secrecy by only a few committed people.²⁵³

Between 1923 and 1927, Charles E. Wagner improved significantly the stationary furnace by controlling the supply of air, and thereby developing the heat economy of the process. He is regarded as having fundamentally improved the stationary furnace, and for having established that a proper boiler arrangement was the key to a successful recovery cycle. Wagner himself was unable to install a boiler successfully, however, until he began collaboration with George H. Tomlinson in 1926. Together the men built a stationary recovery furnace at the soda pulp mill of Howard Smith Paper Mills Ltd., in Cornwall, Ontario. Later Tomlinson argued that Wagner's design led to a "complete and absolutely failure."²⁵⁴ The men parted, but Tomlinson continued to improve the stationary furnace, and eventually built several improved ones for Howard Smith Paper Mills.²⁵⁵

The Cornwall mill was the first to embody the fundamental principles characteristic of modern stationary recovery furnaces eventually introduced successfully in the late 1930's, and which quickly became the industry standard. The early Tomlinson

²⁵³ Frank W. Roberts, "The Evolution of the Modern Recovery Unit for Soda and Sulfate Pulp Mills," *Paper Trade Journal*, Vol 131 No. 22 (30 Nov. 1950) 191-202.

²⁵⁴ Quoted in Roberts, "The Evolution of the Modern Recovery Unit."

²⁵⁵ For somewhat stylized autobiographical accounts by Wagner and Tomlinson on their contributions to the recovery process, see: C. L. Wagner, "Modern Recovery in Sulphate and Soda Mills," *PTJ*, Vol 89 (3 Oct. 1929), 82-83; C. L. Wagner, "Alkali Recovery from Pulp Liquors by a Chemical Engineering Process," *Industrial and Engineering Chemistry* Vol 22. No. 2 (Feb. 1930), 122-127, George H. Tomlinson, "Recent Developments in Kraft and Soda Pulp Manufacture," *Pulp and Paper Magazine of Canada*, Vol. 34, No. 1 (Jan. 1933), 77-79. Best available description of the collaboration between Wagner and Tomlinson is written by the son of the latter: George H. Tomlinson, II, "Black Liquor Recovery – An

furnaces suffered from heavy maintenance costs and poor heat economy, and sulphate and soda firm managers preferred established stationary furnace design. Tomlinson remained at the employment of Howard Smith Paper mills that guarded improvements in its processes. In contrast, Wagner was employed by the New York City contract engineering firm J. O. Ross Engineering Corporation, and worked for the relative free diffusion of his type of stationary furnace. Despite his efforts, stationary furnaces were adopted only on rather limited scale in the North America.²⁵⁶

The eventual emergence of stationary furnaces as the industry standard depended on learning from innovations introduced first in rotary furnace design. Most important of these was a new spray method that facilitated the tremendous improvement of the energy efficiency of the recovery cycle between 1900 and 1930, when it was improved from consuming external energy of 5 million Btu/ton to a surplus of equal size. In 1923, William M. Carey invented a method to spray very concentrated liquor into rotary furnaces while installing a unit for Gulf States Paper Company at Braithwaite, Louisiana, thereby enabling significant new economies of scale. The efficiency of burning increased with the degree of density of lignin liquor, and this discovery was adapted to stationary furnaces, too. The liquor was fed into stationary furnaces through a spray nozzle, and allowed potentially larger volumes than stationary furnaces, into which the liquor was introduced in more solid form. In 1926, the Braitwaite mill was relocated to Tuscaloosa, Alabama, and there Carey built improved rotary recovery furnaces that used a

Historical Note,” in Thomas M. Grace (ed), *Forum on Kraft Recovery Alternatives*. Appleton, WI: The Institute of Paper Industry 1957, 15-26.

²⁵⁶ Roberts, “The Evolution of Modern Recovery Unit.”

concentration of 70 per cent liquids.²⁵⁷ The pace of innovation in the kraft recovery cycle accelerated during the early 1920's, and critically underpinned the tremendous expansion of the U.S. production of kraft pulp after 1925.²⁵⁸

Organization of the kraft pulp industry shaped the direction of research and development in chemical recovery processes. The industry was populated with small units when compared to the leading sulphite and groundwood pulp mills, and this industrial organization fueled a continued belief in the viability of rotary recovery furnace, as well as led managers to downplay that its scale economies were inherently limited. Between 1915 and 1935, most North American kraft mills trusted improved rotary furnaces. In the United States Adolph W. Waern improved the Swedish style rotary furnaces at the mill of D. J. Murray Manufacturing Company in Wausau, Wisconsin.²⁵⁹ Other improvements to rotary furnaces in the early 1920's included the Sandberg-Sundblad, de Verdier, and Carey rotaries. This sustained and industry-wide wave of technological learning was the main reason for relatively quick improvement of the efficiency of chemical recovery cycle. The task posed a formidable technological challenge, noted by the leading pulp wood expert in the North America, Royal S. Kellogg, in his 1923 authoritative textbook. Kellogg argued that the sulphate recovery

²⁵⁷ This particular installation is described in detail: C. R. Seaborne: *Report of Trip of Inspection By Seaborne and Weinkauf*, 23 March 1930. Clark D Clark Everest Paper, Mss. 279, State Historical Society of Wisconsin. (Hereafter DCE Papers), Box #80, Folder #1.

²⁵⁸ For details of this work, see: Otto de Lorenzi (ed), *Combustion Engineering. A Reference Book Fuel Burning and Steam Generation*. New York: Combustion Engineering, Inc. 1953, Ch.28, page. 10.

²⁵⁹ de Lorenzi, *Combustion Engineering*, Ch.28, page. 11.

systems were universally known to be expensive, and “few have proved commercially profitable.”²⁶⁰

Table 5-2. Number of Sulphate Pulp Digesters, Average Digester Capacity, and Total Digester Capacity (Tons of 2,000 lbs.) in the United States, 1914-1954*.

Year	Digesters	Average Unit Capacity	U.S. Production Capacity
1914	23	3,383	77,820
1919	59	4,288	252,995
1921	70	3,755	262,821
1923	101	4,115	415,628
1925	114	4,365	497,647
1927	122	5,709	649,490
1929	113	7,517	849,400
1931	183	7,155	1,309,400
1937	268	12,569	3,368,460
1947	387	15,081	5,836,464
1954	622	32,275	11,151,218

Sources: *Census of Manufactures 1914. Vol II.* Washington, D.C.: Government Printing Office 1919, 618. *Biennial Census of Manufactures 1927.* Washington, D.C.: Government Printing Office 1930, 568; *Biennial Census of Manufacturers 1931.* Washington, D.C.: Government Printing Office 1935, 488; *Census of Manufacturers: 1947.* Washington, D.C.: Government Printing Office 1949, 321; *Census of Manufactures 1954. Vol. II.* Washington, D.C.: Government Printing Office 1955, 26A-31.

*Note that Total U.S. Capacity is calculated maximum throughput, and differs from the actual annual sulphate pulp production.

The average capacity of sulphate digesters increased significantly during the 1920s, manifesting the stabilization of pulp process technology and diffusion of innovations. Although the rated capacity experienced a slight decrease around the post-World War I depression, the maturation of technology boosted over 30 per cent increase in the average capacity of sulphate digesters between 1919 and 1927. As is evident from

²⁶⁰ Royal S. Kellogg, *Pulpwood And Wood Pulp In North America.* New York: McGraw-Hill Book Company 1923, 16; Grace, Perspectives on Recovery Technology.

the Table 5-2, new scale economies occurred in the sulphate pulp process first after 1925, however. In 1929, 114 digesters produced 72 per cent more sulphate pulp than 113 in 1925. The size of sulphate mills increased as the necessary technology, most importantly the chemical recovery cycle, matured.

In North America, Wisconsin evolved to be the main site of technological learning in the sulphate process technology between 1915 and 1925. The early kraft pulp industry had concentrated into Wisconsin, which produced roughly half of the annual U.S. production of about 50 short tons in 1914, and one third of the 120 short tons in 1919.²⁶¹ Wausau Sulphate Fibre Company was one of pioneering kraft firms, and had installed a second paper machine at its vertically integrated kraft mill by 1913.²⁶² The U.S. Forest Service had an experimental station for the study of pulp processes at Wausau, and the Pulp and Paper section of its Forests Products Laboratory in Madison was headed by Dr. Otto Kress, one of the leading paper scientists of his time and later instrumental for the establishment of Institute of Paper Chemistry in Appleton. These research institutes carried out research and development in cooperation with the University of Wisconsin that supported the local nascent kraft pulp industry, where most firms lacked necessary capabilities for such work.²⁶³

Reflecting the increasing local investment into the kraft technology, a few key members of the Wisconsin pulp and paper industry established the By-Products Research

²⁶¹ *Manufactures 1919*. Washington: Government Printing Office 1923, 562.

²⁶² Burt Williams, *Wausau – Its Great Paper Manufacturing Interest*. 29 June 1913. DCE Papers, Box #7, Folder #1.

²⁶³ For an early description of this collaboration, see: Sydney D. Wells, “Some Experiments on the Conversion of Longleaf Pine to Paper-Pulp on Longleaf Pine to Paper-Pulp by the Soda and Sulphate

Association to investigate and advance sulphate pulp processes in October 1923. The association contracted professor Alfred H. White from the University of Michigan to study recovery processes, and arranged an experimental site at a mill in Ann Arbor. Following other similar projects, a new chemical recovery system was installed at the kraft mill in Stevens Point, Wisconsin, in 1924. The recovery of by-products from black liquor was initially the central goal of the project, but the vice president of Stevens Point Pulp and Paper Company, E. G. Goodall, noted how the improved smelting and heat economy of the recovery cycle quickly replaced it. Learning by running the experimental recovery cycle, Goodall and his associates replaced the original style smelters by a new method of low temperature reduction.²⁶⁴ Goodall explained: "Every one concerned recognizes the big advantage of this latter possibility, for the reason that we all know that one of the big draw-backs with the sulphate system is the excessive cost of upkeep in smelting and incinerating departments, due entirely to the excessive high temperatures developed in present day smelting furnaces."²⁶⁵

The pioneering \$25,000 recovery plant was lost through accidental fire in 1924. This forced the association to attract new members, and diffuse the new practices beyond the originally rather closed Wisconsin group. In Wisconsin, industrial organization and the presence of specialized federal and university research and development units supported a broad wave of learning in kraft technology. These factors created the situation noted by Thomas M. Grace that the research and development on rotary

Process," *Pulp and Paper Magazine of Canada*, 15 Sept. 1913, Vol XI, No. 18, 629-630; Otto Kress, Experimental Work in Kraft Pulp. *Paper*, Vol. 18, No. 20 (26 July 1916), 11-12

²⁶⁴ Goodall himself developed a system of completing all liquor-drying outside the furnace in a separate spray-drying tower. De Lorenzi, *Combustion Engineering*, Ch. 28, p. 11.

²⁶⁵ E. G. Goodall to Clark D. Everest, 31 Aug. 1925. DCE Papers, Box #2, Folder #3.

chemical recovery furnace was relatively public in contrast to the secrecy surrounding stationary recovery furnace.²⁶⁶

Rapid diffusion of kraft pulp innovations propelled industrial relocation in the North American pulp and paper industry. The cost and availability of pulp wood in traditional industrial regions was a persistent subject of debate. This had been also another chief justification for the massive relocation of newsprint capacity from the U.S. into Canada. The kraft process was the first pulping technology that could potentially utilize on large scale the vast stands of Southern pine, often characterized as “waste,” and thus prompted managers to consider a Southern strategy.²⁶⁷

Exemplifying this trend and the underlying dynamics, F. L. Moore prepared on behalf of northern investors the building of a kraft mill at Houston, Texas in 1922. He noted in particular how kraft papers were utilized in many ways not imagined ten years earlier, and trusted that they would increasingly replace the Northern sulphite papers. Moore himself confessed to be a lay man in papermaking, so he had contracted the engineering services of pioneering Joseph H. Wallace. Wallace had followed the example of another industrial chemist from the pulp and paper industry, A.D. Little, and launched a successful career in contract engineering in the New York City.²⁶⁸

The emergence of an independent and distinct industry supplying sulphate pulp machinery, technology, and knowledge accelerated the diffusion of innovations, and unleashed new competitive forces in the early 1920's. These changed conditions were

²⁶⁶ Grace, “Perspectives on Recovery Technology.”

²⁶⁷ “The Beginning of the Kraft Paper Industry in the Southern States,” *PTJ*, 23 July 1936, 21, 24.

recognized by the managers of pioneering American kraft pulp firms, such as the Chesapeake Pulp & Paper Company. The company had been incorporated in 1913, and built a kraft pulp mill with 22 ton daily capacity at West Point, Virginia. The pulp was sold and shipped to buyers, and a Fourdrinier paper machine was integrated into the mill first in 1930. Despite its early success, the mill soon demonstrated how rapid technological breakthroughs could retire much of the older kraft pulp equipment, and foster intensified competition between incumbents and new entrants. Most of the early specialized American kraft pulp mills had been established in the early 1910's, and just ten years later they were locked in with equipment of limited capacity and economies of scale.²⁶⁹

Chesapeake exemplified such a development, and its managers responded by launching a dramatic expansion and modernization plan in the early 1920's. The core of these actions was the purchase of latest kraft process innovations. In 1922, a \$50,000 Swedish Kamyk pulp dryer was installed at West Point, and according to the company historian, drier pulp returned the investment within fifteen months in reduced freight costs. Also critical for profitability was modernization of the chemical recovery system. In 1923, the company improved the yield of its rotary recovery furnaces by installing a \$50,000 quadruple-effect evaporating plant supplied by the Massachusetts firm Ernest Scott & Company. The adoption of latest technological innovations increased production

²⁶⁸ F. L. Moore to A. W. Standing, 15 Aug. 1922. DCE Papers, Box #11, Folder #6; Pine Waste Products, Inc., *A Potential Industrial Empire. The Manufacture of Paper and By-Products From Southern Pine Refuse*. DCE Papers, Box #14, Folder #12.

²⁶⁹ Alonzo Thomas Dill, *Chesapeake. Pioneer Paper Makers. A History of Company and Its Community*. Charlottesville: The University Press of Virginia 1968, 36-38.

and productivity for Chesapeake, which reached a daily capacity of 75 tons in 1925, bringing the company back into the black after five years of losses.²⁷⁰

The managers of leading North American pulp and paper firms became increasingly aware of opportunities enabled by innovations in the kraft process and products around this time. They had observed first hand the surge in use of kraft paper in paper boxes and sacks during the World War I. In addition, new process innovations enabled economies of scale in kraft pulp production, and thus made it more attractive for vertically integrated large scale enterprises. Most importantly, the critical process innovations were increasingly commercialized by industry outsiders and thus diffused relatively freely. These factors prompted the leading pulp and paper firms to revise the place of kraft pulp and paper in their corporate strategies, and to give it a more prominent role after 1925.

While kraft paper firms across the North America forecast increased demand, they differed markedly in their strategies. The potential of Southern kraft pulp and paper production constituted the most difficult strategic choice for managers without significant mills there. IP, with major operations in the North East and Canada, and the leading Wisconsin firms considered this strategic question throughout the 1920's, and arrived at contrasting conclusions. IP decided to follow up its early experiments in the South by steadily increasing investment into the region, whereas Wisconsin firms played down the potential of Southern kraft. William H. Bissell, president of large Wisconsin lumber firm, rejected an offer to invest in the South by saying:

²⁷⁰ Dill, *Chesapeake*, 93-94.

I want to correct the misapprehension that seems to obtain with so many of our Southern friends, evidenced by their repeated statements that there is a shortage of raw material in the North for producing pulp and paper. While eventually our home supply will doubtless be exhausted, certainly so unless reforestation measures are adopted, yet the standing supply of paper and pulp timber in Wisconsin and Northern Michigan we feel is amply sufficient to keep all the mills going at their present rate of production for more years than any of us can hope to survive... As an investment proposition I personally do not look with favor upon attempting to establish industries of this kind in the South, or far from our present operations. We have here ample water power, an abundant supply of raw material, a well trained and efficient supply of labor (both skilled and common) that has grown up in this industry. We have also ready access to our important markets at a reasonable freight cost, and do not understand that returns from similar investments in the South approximate the results we are getting in our home state.²⁷¹

This encapsulated the attitude of Wisconsin forests industry managers effectively. Such views emerged from the state's industrial organization and the character of kraft process technology in 1924. Managers of small and medium sized firms preferred proximity to Mid-West customers, and were skeptical of potential scale economies of kraft mills. In addition the kraft wrapping paper business, which was the main product of Wisconsin kraft mills, experienced a deepening slump in the mid-1920's. Statistical

²⁷¹ *W. H. Bissell to John M. Bissell*, 20 October 1924; For other such views, see *William H. Bissell to Clark*

surveys by the Wrapping Paper Manufacturer's Service Bureau confirmed rapidly increasing inventories at the 27 member companies in 1924, and that together their mills continued to produce over 200 tons a day above orders at hand. Wisconsin pulp and paper managers revived cooperation as an attempt to arrest over-investment into new capacity.²⁷²

Firms performed differently, and therefore regarded the potential of cooperation differently. Clark D. Everest controlled and managed the powerful Marathon Mills paper group with the largest kraft tonnage in Wisconsin, and he was quite confident of his operations in 1924. Ridiculing the calls for cooperation by the other members of Wrapping Paper Service Bureau, he claimed:²⁷³

We have pounded down the cost to a point where I do not believe there is a concern in the United States that can make similar grades of paper on a basis of cost comparable with ours. At the same time, we have manufactured a little over 15% more paper over the first sixth month than in 1923... The whole secret of the thing is that we have run the mill to production at all times.²⁷⁴

D. Everest, 27 Sept. 1923. Both in DCE Papers, Box #16, Folder #3.

²⁷² *Stanley C. Bayless* (President of the Bayless Manufacturing Company) to *A. J. Stewartson* (Secretary of the Wrapping Paper Manufacturers Service Bureau), 1 June 1924. DCE Papers Box #24, Folder #13.

²⁷³ My analysis of Everest is indebted to the careful study by Steven Burton Karges. His dissertation, *David Clark Everest and Marathon Paper Mills Company: A Study of A Wisconsin Entrepreneur, 1909-1931*. Unpublished Ph.D. Dissertation. University of Wisconsin 1968, situates the Mid-West paper managers' strategies in the context of unfolding structural change.

²⁷⁴ *Clark D. Everest* to *A. J. Stewartson* 12 July 1924. DCE Papers Box #24, Folder #13.

Like other managers of the Wisconsin community, Everest dismissed the idea that the Southern kraft paper industry could compete with the established capabilities of his firm. The Wisconsin logic had made a full circle. Other managers gave the general weakness of business and mills as reasons not to invest in the South, and Everest did so because of the strength and productivity of his business.

When Wisconsin industrialists did invest in the South, as Clark D. Everest ultimately did on a modest scale, the point was to diversify production and learn new product technologies. Everest oversaw the erection of a pulp mill at Laurel, Mississippi, that was a stage for feverish search for new cellulose based products. After many years of trial and experimentation, George H. Mason introduced at the mill Masonite board, a type of pulpwood board. Renamed as Masonite Corporation, the Laurel mill monopolized through patents a lucrative share of the construction product business. IP instead recognized the South as a site for new competitive mass production of cheap basic grade pulp and paper. The organizational evolution of technological learning in the kraft process, as well as the unexpected Great Depression, rewarded IP's strategic choices between 1925 and 1940.

Emergence of Southern Mass Production and Industrial Relocation, 1925-1931

Maturation of technology enabled the introduction of mass production of kraft pulp and paper between 1925 and 1931. The rated annual pulp capacity of U.S. sulphate digesters increased during this period from half a million tons to 1.3 million (see Table 5-2. above), and most of the new capacity was built by new entrants to the industry. The

North American kraft pulp and paper industry entered a phase of rapid expansion after 1925, and most of the new capacity was located in the South.

This shift in the geographical organization of kraft industry revealed and released dynamic forces that depicted structural change in the whole North American pulp and paper industry. Recovery from the World War I depression and technological innovation fueled investment into new equipment and capacity by entrants, as well as incumbent kraft firms. The investment boom turned into a self-feeding cycle, as the entry of large scale enterprises accelerated the rate of sulphate process and product innovation, which in turn gave rise to new economies of scale and markets that attracted new investments by rivals. Thus new investment flowed into the industry between 1925 and 1931, financing mass production of kraft pulp and paper on an unprecedented scale. As production of U.S. kraft wrapping paper increased about 80 per cent between 1925 and 1931 (see Table 5-3.), the price of Southern kraft wrapping paper declined from five cents per pound for F.O.B. paper in 1926 to two and half for delivered paper in 1932.²⁷⁵

As over-capacity and the Great Depression began to grind down industry profits, the focus of technological learning shifted from scale economies to product differentiation. Between 1925 and 1940, the share of sulphate pulp from the combined U.S. wood pulp production skyrocketed from about five percent to over forty, and this occurred in the context of total production of wood pulp increasing from 3.4 million metric tons to 6.3. As a result of this boom, a persistent condition of over-capacity emerged by the late 1920's that eased first during the World War II mobilization. In a desperate search for an exit from the depressed basic commodity kraft paper grades,

managers attached growing importance to product innovations that enabled entry into specialty markets less susceptible to imitation, standardization, and downturn in the general economic cycle. This shifting managerial strategy innovation by the leading firms helps to explain why the kraft boom continued throughout the Great Depression.²⁷⁶

Table 5-3. Production of Kraft Wrapping Paper in the United States, 1909-1931 (Tons of 2000 lbs.)

Year	Total
1909	12,661
1914	109,753
1919	192,583
1925	479,975
1931	867,743

Sources: *Manufacturers 1919*. Washington, D.C.: Government Printing Office 1923, 560; *Census of Manufacturers: 1927*. Washington, D.C.: Government Printing Office 1930, 557.

Much of the new capacity was erected during the early stages of Great Depression, which amplified the effects of technological innovation. Incumbent individual mills with old production technology lost share to new entrants enjoying the competitive advantages of new technology that enabled low cost mass production. On the other hand this presented classic “catch-22” problem for the industry, because if all mills and firms followed this logic, a price destroying over-capacity would ensue.

The Great Depression, rapid process and production innovation, regional factor endowments, and the particular situations of individual firms established the complex

²⁷⁵ 1940 *Statistical Review of the Kraft Paper Association*. 10 Feb. 1940. West Virginia Pulp and Paper Company Collection #1781, Carl A. Kroch Library, Cornell University, Box #122, Package #10.

²⁷⁶ OEEC, *The Pulp and Paper Industry in the USA*. Paris: OEEC 1951, 41.

framework in which corporate managers attempted to balance short term gains with long term strategic choices. The Wisconsin industrialists worried about becoming underdogs in the kraft industry, and followed closely developments in the South. Forced to reconsider their earlier strategy, the managers of leading Wisconsin firms considered the possibility relocating their kraft production. The Kaukauna firm, Thilmany Pulp and Paper Company, and Clark D. Everest were first to respond. In 1927, they organized Longview Fibre Company, which built an integrated sulphate mill at Longview, Washington, with 100 ton daily capacity of pulp and board. It was the third kraft mill in the Pacific Coast, following Crown Zellerbach's 60 ton daily capacity sulphate mill in Port Townsend, and the integrated 50 ton pulp and 55 ton paper mills of the St. Helens Pulp & Paper Company. Three years after proudly assuring the long term competitiveness of the Wisconsin kraft paper industry, Everest importantly revised his analysis in 1927:²⁷⁷

I am of opinion that except for wrapping paper purposes, within the next five years you will see the South hemmed in about the same relative position as the Northern kraft mills and I think the West Coast people will have the same relative advantage over the South as the South has now over the North. This will force the Northern people into the manufacture of higher grades and specialties where strength and folding qualities are a necessity and where deliveries are made on comparatively short freight rates... I do not think you will see any further development in Kraft either in the Central Western states or on the East Coast.

²⁷⁷ Hugh G. Parker, *Report on the Pulp and Paper Industry of the Pacific Coast*. 1927. DCE Papers, Box

There may probably be some additional developments in the South and particularly on the part of International [Paper Company].²⁷⁸

The potential of the Pacific Coast for the expansion of Wisconsin kraft pulp depended critically on technological learning, besides the usual factor endowments. Analyzing these questions in 1927, Dr. Hugh P. Baker repeated well known facts before discussing the need for research and development: Ample supply of cheap timber and energy, and labor that equaled costs in the Mid-West and East. Among the Pacific tree species the Red Fir best applied to the sulphate pulp process, but its use required considerable refinement of the basic technical processes. While Southern kraft mills constituted a major competitor, their experience and research work in the sulphate pulping of the Southern Pine lent little or no technical support to the Pacific mills. Baker's analysis demonstrated how vulnerable the technological stability of pulp and paper making process was. Although firms had relatively symmetric access to basic manufacturing technology, specificity of regional biological environments required the adaptation, or differentiation, of pulp and paper processes.²⁷⁹

In the late 1920's, Everest was deeply engaged in revising his corporate strategy in the rapidly changing North American pulp and paper industry. His mills produced evenly sulphite and kraft pulp and papers, and he worried increasingly of Canadian competition in the sulphite pulp and papers. Canadian newsprint and book paper mills

#40, Folder #2.

²⁷⁸ *Clark D. Everest to Hugh P. Baker*, 30 Sept. 1927. DCE Papers, Box #40, Folder #2. Exemplifying how rapidly the competitive environment in the kraft paper industry was changing, Everest proposed himself in 1929 a joint Southern kraft pulp and paper venture to the pioneering Brown Paper Company of Louisiana. *Clark D. Everest to H. L. Brown*, 29 July 1929. DCE Papers, Box#61, Folder #19.

undersold easily their U.S. rivals, and it is suggestive of these dynamics that IP had relocated all of its newsprint capacity to Canada by the early 1920's. Everest had originally responded to the Canadian mass production by focusing on scale economies, and by fostering product innovation for specialized markets. In the late 1920's, he began to emulate this strategy in the kraft paper industry.²⁸⁰

Reorganization of capital was one central mechanism Everest employed to improve efficiency and create strategic capabilities. He controlled a large and diverse group of pulp and paper firms, and planned the consolidation of five of his box making firms into single holding company to finance the modernization and expansion of the Ontonagon Fibre Company kraft mill. Proximity to principal markets and good quality were other major competitive advantages of the Wisconsin paper industry. Quality required constant improvement, however. An industry analyst warned Everest that although the Southern kraft paper continued to be of poor quality, and therefore could not substitute the higher priced Wisconsin kraft papers, the Southerners were intensely working on the issue.²⁸¹

²⁷⁹ Parker, *Report on the Pulp and Paper Industry*.

²⁸⁰ There is a considerable literature on the relocation of the sulphite newsprint from the United States to Canada, as well as on the expansion of the Canadian sulphite industry since 1920. Among the most analytic examinations are: Barry E. C. Boothman, "High Finance/Low Strategy: Corporate Collapse in the Canadian Pulp and Paper Industry, 1919-1932," *Business History Review* 74 (Winter 2000), 611-56; Trevor J. Dick, "Canadian Newsprint, 1913-1930: National Policies and the North American Economy," *Journal of Economic History*, Vol XLII No. 3 (Sept. 1982), 659-687; Heinrich, "Product Diversification." Illustrative of the larger political economy of the process is: L Ethan Ellis, *Print Paper Pendulum. Group Pressures and the Price of Newsprint* (1948). Reprinted in his: *Newsprint: Producers, Publishers, Political Pressures*. Rutgers University Press 1960, Chapter 5-6. A statistical overview is provided in Thomas R. Roach, *Newsprint: Canadian Supply and American Demand*. Durham, N.C., Forest History Society, 1994.

²⁸¹ *Brown Katzenbach to Clark D. Everest*, 6 Sept. 1928. DCE Papers, Box #52, Folder #22; Frazer and Torbet, *Survey of Paper Mills in Lake Region*. 1 Oct. 1928. DCE Papers, Box#52, Folder #22. For similarly orchestrated consolidation plans, see: *Harry L. Wollenberg to M. A. Wertheimer*, 16 May 1928, 23 May 1928, 1 June 1928, 14 June 1928. DCE Papers, Box #54, Folder #6.

Strategic and technological challenges associated with kraft production processes were amplified by a product innovation, kraft paperboard, in the late 1920's. Kraft paperboard substituted for higher priced paperboards, and over time its success split the kraft industry into two distinct industries, paper and paperboard, with different clientele, organization, and dynamics. Kraft paperboard gave an important strategic advantage to entrants in kraft industry, as they were able to choose to supply different kraft paper or paperboard markets.

The perfecting of kraft paperboard took a considerable effort of research and development by specialized firms, and the difficulty of its production prevented many from entering its production. Typically, this board was manufactured from straw, jute, recycled fiber, and unbleached sulphite pulp. The incentives were strong, however, since paperboard had emerged in the 1910's as the most consumed line. A Milwaukee firm, Hummel-Ross Fiber Corporation, pioneered the manufacture of kraft board with a cylinder machine in the United States in 1924. The developer of stationary kraft recovery furnaces, Brown Paper Company, pioneered the mass production of kraft board on a Fourdrinier machine at its mill in Monroe, Louisiana, in 1927.²⁸²

Commenting on these and other developments in pulping technology, Everest complained to a fellow manager: "With all the new developments in the chemical processes, I am beginning to believe that almost any business is in danger of being disrupted overnight. While I do not fear any trouble with cornstalks, or any of those

²⁸² Dill, *Chesapeake*, 109.

things, someone may blunder on to something in the conversion of wood into pulp which will put a good many mills to serious disadvantage.”²⁸³

The mounting over-capacity in basic wrapping paper and other kraft papers further facilitated transition into the production of kraft paperboard. Kraft paperboard resembled closely the higher priced established grades of paperboard, thus offering considerable savings for the shipping container industry at the time of decreasing demand. Perhaps for these reasons, the partly Everest controlled Longview Fibre was one of the pioneering kraft paperboard mills in the North America. Soon many others followed the suit, such as Chesapeake Pulp & Paper Company, and IP.

An aggressive investment program increased Chesapeake's 75 ton daily capacity of kraft pulp in 1925 to over 120 by 1930. At that time the company managers deemed forward integration into papermaking necessary for sustained competitiveness. After experimenting with the production of both kraft paper and board with their Fourdrinier machine, they decided for the latter. This choice presented difficult technological problems, and required heavy salesmanship to introduce the new product for users accustomed to sulphite or straw board. After considerable engineering and sales work, Chesapeake successfully entered the paperboard market.²⁸⁴

Introduction of kraft paperboard enabled IP to fulfill its Southern strategy just when it appeared to be frustrated by the deepening depression.²⁸⁵ IP followed up its initial experiments with kraft pulp and paper by acquiring Bastrop Pulp and Paper Company

²⁸³ Clark D. Everest to A. J. Stewartson, 9 Jan. 1929. DCE Papers, Box #68, Folder #14.

²⁸⁴ Dill, *Chesapeake*, 102, Appendix H; *International Paper Company After Fifty Years*, 66.

²⁸⁵ For a detailed analysis of International's Southern strategy, see: Thomas Heinrich, "Product Diversification."

that had a kraft pulp and paper mill in Bastrop, Louisiana, in 1925. Two years later, the company acquired the Louisiana Pulp and Paper Company mill, also at Bastrop. With the last acquisition IP assumed the employment of Richard J. Cullen, who had experience of managing the building of several Southern kraft mills. When IP organized its Southern operations in 1930 into a fully owned subsidiary, Southern Kraft Corporation, Cullen became its president, reflecting his central role for IP's Southern strategy. Following the division's success, Cullen eventually became the president of IP itself in 1936.

After 1925, IP accelerated its expansion in the South, and sent the price of kraft downwards. This was facilitated by the dissolving of Southern Kraft Paper Association just before the onset of Great Depression, too, as it discontinued cooperative efforts to stabilize prices. The market breaker, IP, relied on economies of scale and built in 1928 a vertically integrated kraft mill at Camden, Arkansas, and acquired another mill at Moss Point, Alabama. The company captured probably one third of the U.S. kraft paper markets by 1928, and its managers wanted more. The company projected another large kraft pulp and paper mill at Mobile, Alabama, by 1929, and rest of the kraft industry watched in despair.²⁸⁶

²⁸⁶ *Clark D. Everest to O. M. Porter*, 30 June 1928. DCE Papers, Box #49, Folder#10; *Clark D. Everest to Edwin C. Crosset*, 20 June 1928. DCE Papers, Box#51, Folder #17.

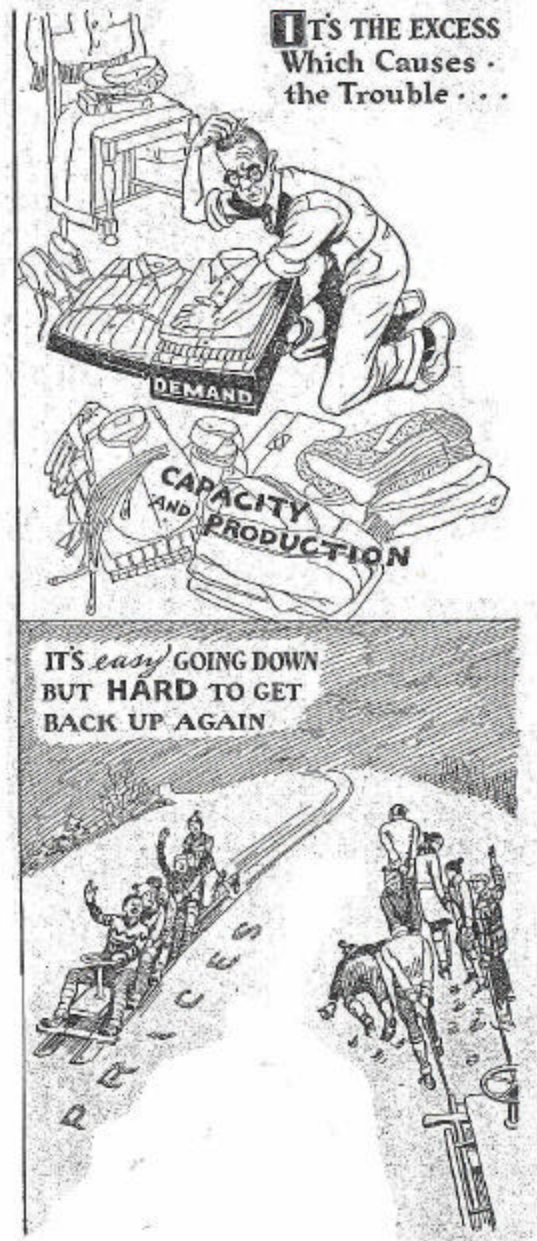
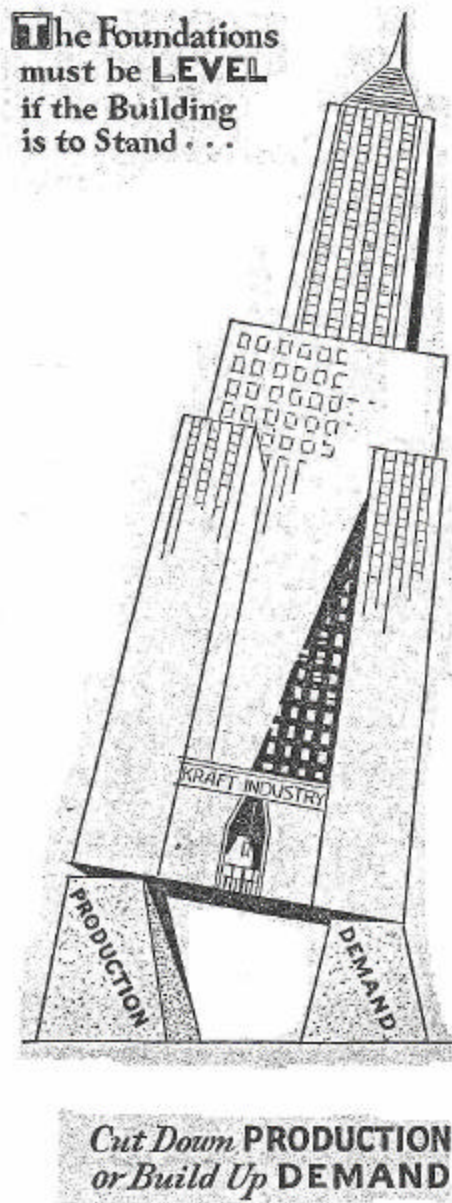
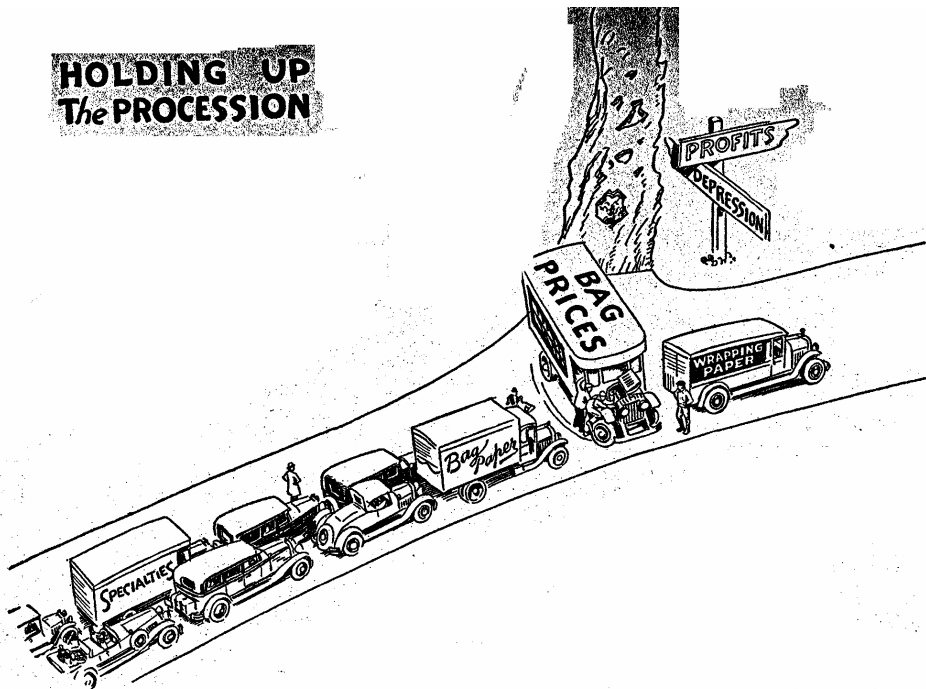
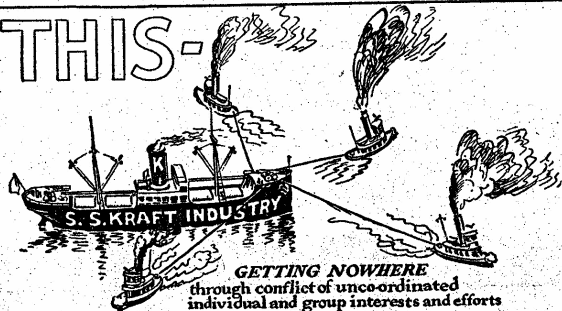


Figure 5-2. Over-capacity and the despair of industry leaders. Source: News Letter of the National Kraft Paper Manufacturers' Association. No. 6, 5 Nov. 1930. David Clark Everest Papers, Box #77, Folder #9. Courtesy of the State Historical Society of Wisconsin.

**HOLDING UP
The PROCESSION**

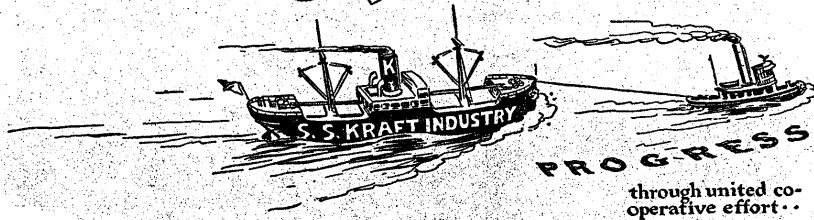


THIS-



GETTING NOWHERE
through conflict of unco-ordinated
individual and group interests and efforts

OR



through united co-
operative effort . . .

THIS!

Figure 5-3. Benefits of coordination and vertical integration. Source: News Letter of the National Kraft Paper Manufacturers' Association. No. 6, 5 Nov. 1930. David Clark Everest Papers, Box #77, Folder #9. Courtesy of the State Historical Society of Wisconsin.

Before this investment, many industry insiders believed that the pulp and paper giant had reached its limits. IP pursued between 1920 and 1940 an ambitious product diversification program into power utility, specialty papers, Canadian newsprint, and Southern kraft. The last one constituted a cash cow that resuscitated the other suffering ventures, Thomas Heinrich has concluded in his analysis.²⁸⁷ The situation of the leading firm enabled rivals an excellent opportunity of strategizing. Trying to assess the effect of the Mobile mill on kraft markets, Wisconsin paper managers believed in the summer 1929 that Canadian losses prevented IP from lowering any further prices for the Southern kraft.²⁸⁸

IP's situation also prompted other kraft paper firms to attempt to revitalize industry cooperation. Looking to prevent the kraft paperboard industry repeating the recent experience of kraft wrapping paper, the Paperboard Industry Association appointed a committee to negotiate a cooperative plan among the leading kraft paperboard firms on 18th September, 1929. The preventive character of these negotiations followed from recent technological breakthroughs in kraft paperboard production that had created strong incentives for investment and entry. Paper container industry consumed yearly about 1,4 million tons of paperboard, of which roughly 800,000 tons was jute board. Kraft paperboard equaled in quality jute board, and sold much cheaper. For this reason the annual production of kraft paperboard increased from about 37,000 tons in 1925 to 165,000 in 1928. The kraft firm managers predicted immediate rush of new

²⁸⁷ Heinrich, "Product Diversification."

²⁸⁸ *Clark D. Everest to Harry L. Wollenberg*, 25 June 1929. DCE Papers, Box#65, Folder#1; Heinrich, "Product Diversification."

investment in Southern kraft board, and the central aim of negotiations was to establish a mechanism to coordinate how the new capacity was brought to markets.²⁸⁹

As the president of American Pulp and Paper Association, Everest had unsuccessfully attempted to stabilize the kraft pulp and paper industry in 1927. Two years later the industry's managers regarded price stabilization as a more viable option. This was because much of the pressure on the paperboard market followed from the increasing tendency of kraft paper mills to shift production from depressed wrapping paper into paperboard. All the participating firms: Albermarle Paper Company, Bogalusa Paper Company, Fibreboard Products Company, Hummell-Ross Company, Longview Fibre Company, Mead Paperboard Company, Minnesota & Ontario Paper Company, Ontonagon Fibre Company, Brown Paper Mill Company, and IP had done so. However, Brown and IP differed in critical aspect from the other firms.²⁹⁰

IP and Brown were the only major kraft paper companies with significant and immediate expansion plans in 1929, a fact that put the rest of industry in a defensive position. As participants questioned the sincerity of IP's intentions during the negotiations, its managers stepped around the issue. Some assured colleagues of their willingness to participate in price stabilization, but this was dismissed as misleading rhetoric. Rivals based their analysis on the fact that IP had not even begun the production of kraft paperboard on a significant scale by 1929, and was potentially considering

²⁸⁹ *Paperboard Industries Association. Report of Meeting of Contact & Program Committee With Manufacturers of Kraft Linerboard.* 6 Oct. 1929. DCE Papers, Box #67, Folder #15.

²⁹⁰ *Paper Board Industries Association. Report of the Fourth Meeting of Committee Appointed by Paperboard Group of Paperboard Industries Association, with Manufacturers of Kraft Linerboard.* 13 Dec. 1929. DCE Papers, Box #67, Folder #14.

entry.²⁹¹ Eventually in December 1929, J. H. Allen, a manager of IP, stated the true position of his firm: “We believe each industry trying to straighten out its own situation... We are just getting into production in this line. We are not much association-minded so far.”²⁹²

The industry leader strategy of IP threw cold water at the hopes of the other kraft paper firms to be able to cooperate on production and prices, and yet the managers of the smaller kraft firms continued to pursue such a possibility because of the miserable business conditions. Clarence J. Schoo, a manager of a box converting plant owned by the Longview Fibre Company, rationalized such plans in a letter to Everest in 1930:

The only sound basis, if any, upon which to predicate a curtailment of production, as I view it, is to decidedly reduce the total amount of board being produced, each participant taking his proportionate share, and in the case of a mill making both paper and board on the same machine, the total reduction in production should be in terms of quantity of board, and not paper... In other words, there is no justice in the Brown Company decreasing the production of wrapping paper for the benefit of the wrapping paper industry and in that way defeating the real purpose of the movement which is to decrease production of board.²⁹³

²⁹¹ For a detailed analysis of the effects of the Southern kraft industry, and in particular the International Paper Company and the Brown Paper Company, by the management of the world’s largest manufacturer of corrugated paper containers, see: *Minutes of the Meeting of the Directors of Hinde and Dauch Paper Company*, 17 June 1930 and 31 March 1931. West Virginia Pulp and Paper Collection #2830, Carl A. Kroch Library, Cornell University, Box #1.

²⁹² *Report of the Fourth Meeting of Committee Appointed by Paperboard Group of Paperboard Industries Association, with Manufacturers of Kraft Linerboard*. 13 Dec. 1929.

²⁹³ *Clarence J. Schoo to Clark D. Everest*, 13 Nov., 1930. DCE Papers, Box #73, Folder #1.

Despair is the appropriate characterization of the state of mind of most North American kraft paper managers at this time, with the exception of those who were pushing an aggressive Southern strategy. Hundreds of letters and dozens of minutes of different kind of meetings attest to an intense attempt to coordinate the existing over-capacity and the future expansion that was deemed inevitable. The emotional character of these attempts arose from the speed and totality of the transformation of underlying fundamentals of the industry. New Southern kraft mills threatened the viability of the old kraft industry plants in the New England and the Lake States. When IP announced price cuts against Everest's predictions in the early 1930, he interpreted the move as a direct attempt "to drive Northern mills out of existence." At an extreme case this anxiety led to negotiations between the leading Northern and Southern mills in 1930 about the conditions on which IP, Brown Paper Company, and Bogalusa Paper Company would suspend the building of any additional kraft mills.²⁹⁴ The emergence of Southern kraft paper mass production had an effect on the Pacific market, too, but was limited by transportation costs, aggressive expansion of local mass production, as well as the reluctance of local paper business people to allow the entry of a market breaker. To a great extent these attitudes arose from the intensified competition between the different regional U.S. kraft industries.²⁹⁵

²⁹⁴ *Clark D. Everest to Harry L. Wollenberg*, 2 March 1930; *Harry L. Wollenberg to Clark D. Everest* 20. Jan. 1930; *Monroe A. Wertheimer to Harry L. Wollenberg*, 5 May 1930. DCE Papers, Box #74, Folder #14.

²⁹⁵ For a detailed and rather lengthy description and analysis of competition between Southern kraft and leading Pacific firms, see in particular: *Clark D. Everest to Marvin M. Preston*, 28 July 1930. DCE Papers, Box #74, Folder #15. The managers of International Paper Company boasted in private conversations around 1930 that the company would enter the Pacific Coast. The president of the Longview Fibre Company argued that the International Paper Company had neither the capabilities, nor the want to enter

Table 5-4. Per Cent of Major Manufacturing Regions From the Total U.S. Kraft Paper Production, and Total National Capacity Utilization, 1926-1931 (Tons of 2,000 lbs.)

Region	1926	1929	1931
New England	29	23	16
Middle Atlantic	9	10	20*
South	22	32	36
Lake States	34	23	18
Pacific Coast	5	11	10
Total Capacity	507,785	945,124	1,296,730
Actual Production	400,727	697,112	850,000

Source: *Statistical Survey of the Kraft Paper Industry, 1926-1929*. National Kraft Paper Manufacturer's Association. DCE Papers, Box #77, Folder #7; *The Kraft Situation and What to Do About it*. The Kraft Institute, 3 Nov. 1932. DCE Papers, Box #95, Folder #14.

*Includes Pennsylvania, Ohio, and Illinois.

The geographical organization of the U.S. kraft industry shifted significantly within only five years between 1926 and 1931, as demonstrated in the Table 5-4. The Southern mills increased their share of annual national production from 22 per cent to 36, while the share of the Lake States kraft industry declined from 34 per cent to 18 within the same period. A statistical report by the Kraft Paper Manufacturer's Association confirmed that the annual capacity of New England and Lake State kraft mills had remained unchanged around 100 and 50 tons between 1926 and 1931, respectively, whereas the annual capacity in the South had increased with 80 per cent to 164 tons

the Pacific Coast. See the exchange in *Clarence J. Schoo to Harry L Wollenberg*, 28 May 1930; *Harry L. Wollenberg to Clarence J. Schoo*, 5 June 1930. DCE Papers, Box #73, Folder #1.

during the same period. The South appeared to absorb a lion share of investments into new production capacity.²⁹⁶

Industry leaders identified IP as the single most important cause of the deepening regional differences. Those contemporaries who had vested interests in cooperation, such as the secretary of the kraft paper association, Oliver M. Porter, were sometimes unable to identify the underlying dynamic forces, such as technology, and explained industrial change with attitudes. Porter wrote to Everest in 1930:

Do you see any immediate likelihood of the kraft paper industry as a whole, or the Northern mills as a group, pulling out of the present situation? Is there any possibility, in your opinion, of permanent improvement being effected until there is a change in the executive personnel and production and selling policies of the International Paper Company and, therefore, in the attitude of their competitors towards them?²⁹⁷

The corporate strategy of the IP stemmed from its distinct organizational capabilities, however, and its managers considered carefully technology, production, and relocation. They were determined to seize the advantages opened by technological innovation in the kraft pulp and paper processes, and therefore IP continued to embody the dynamic forces driving structural change in the North American pulp and paper industry. While the whole American paper industry cried to suspend such forces through

²⁹⁶ *Statistical Survey of the Kraft Paper Industry, 1926-1929*. National Kraft Paper Manufacturer's Association. DCE Papers, Box #77, Folder #7.

cooperation, IP announced a record sized kraft pulp and paper mill to be built at Panama City, Florida, by 1931. In addition, the Brown Paper Company accounted installation of two new kraft paper machines, too.²⁹⁸

Voicing the outrage, and astonishment of the pulp and paper industry, the editorial of the *Paper Industry* asked: “What’s the big idea? That’s the question that the whole astounded paper trade is asking. Why will any corporation promote huge additional kraft paper tonnage in the face of known forty per cent over-production? Look at the price situation!”²⁹⁹

The “big idea” of Cullen and his associates was a radical departure in the chemical recovery cycle that enabled new scale economies. The economic and technological core of the Panama City mill was the first continuous chemical recovery plant. The recovery cycle consisted of known and established components, most notably of rotary furnaces and the Swenson and Murray evaporators, but its process design was pioneering. Benefiting from a decade of learning by doing, IP was capable of engineering and constructing a fully continuous recovery cycle that supplied the required chemicals to kraft digesters, thus reaching record throughput at the mill. Yet the mill deployed a number of recovery furnaces, as the individual size of each rotaries was limited. In this sense, the organization of IP's continuous recovery cycle presented substantial

²⁹⁷ *Oliver M. Porter to Clark D. Everest*, 23 Sept. 1930. DCE Papers, Box #77, Folder #9.

²⁹⁸ For the Brown Paper Company expansion, see: *Harry L. Wollenberg to Clarence J. Schoo*, 5 June 1930. DCE Papers, Box #73, Folder #1

²⁹⁹ “What’s the Big Idea?,” *The Paper Industry*, April 1930, 17; Such views circulated widely in the industry trade journals in the early 1930’s. While rather rare in the industry’s leading journal, *The Paper Trade Journal*, self-victimization of the industry was highly visible in the colorful editorials of the *Paper Industry*. See: “Brother! Shed a Tear for the Kraft Industry,” *Paper Industry*, Oct. 1931; “The Economic Opportunity of the Paper Industry,” *Paper Industry*, May 1931; “A Move for Stabilization,” *Paper*

improvement in the rotary technology, but not a radical technological departure that enabled significant new economies of scale³⁰⁰

The Panama City mill represented a technologically new stage in IP's economies of scale-strategy. Vertical integration characterized these efforts, and by 1931 the company had acquired over 1.25 million acres of Southern timberland. Scale economies in the pulp wood supply depended on the introduction of sustainable yield management into the South, and here too IP was able to draw on its prior experience in the Northern sulphite pulp and paper industry. The new network of scientific foresters engineered the Southern timber belt, and adapted importantly the biological ecology and manufacturing technology to each other on an unprecedented scale.³⁰¹

IP was not immune to problems caused by industry-wide over-capacity, and its managers struggled to figure out what was the "big idea" of the Panama City mill, too. In dramatic move, Mullen and his associates shifted its production from kraft paper into kraft paperboard, and during the last stages of construction the production process was

Industry, Oct. 1932. Eventually the enactment of the National Industrial Recovery Act made such exclamations rather rare.

³⁰⁰ The Panama City mill and its technology are described in detail: "New Efficiency Record Established In Chemical Reclaiming," *Chemical & Metallurgical Engineering*, Vol. 38, No. 8 (Aug. 1931), 440-444. Everest and his closest associates had contracted specialized engineers to analyze the status of Southern recovery units in 1930. The detailed report documents that prior to the Panama City mill, Wisconsin was the leading site for technological learning in the rotary recovery furnaces. C. R. Seaborne: *Report of Trip of Inspection By Seaborne and Weinkauf*, 23 March 1930. DCE Papers, Box#80, Folder #1.

³⁰¹ Early twentieth century North American efforts to modernize, or more precisely introduce scientific forestry practices differed strongly by regions. In contrast to the developments in the Northeast, Pacific Coast, or the Lake States, modern forestry gained very slowly foothold in the South. For demonstrative descriptions of the state of Southern forestry and differences within the Southern states, see meticulous study by: William G. Robbins, *American Forestry. A History of National, State, & Private Cooperation*. Lincoln: University of Nebraska Press 1958, 62-63, 144-146. The relationship between forestry and the expansion of the Southern pulp and paper industry is analyzed in detail: David C. Smith, *History of Papermaking in the United States, 1691-1969*. New York: Lockwood Publishing Company 1970, 414-420; Detailed analysis of forestry's role for the modern Southern pulp and paper industry is: William Boyd, "The Forest is the Future? Industrial Forestry and the Southern Pulp and Paper Complex," in Philip

retooled. The Panama City mill capacity equaled 65 per cent of the national production of kraft board in 1928, and its profitability depended on its ability to capture markets from jute and sulphite board. In response to over-capacity, IP also integrated forward into specialty production and paper converting. The company installed an "enormous" converting plant of its fully owned subsidiary, Continental Bag & Paper Company, at the Mobile mill, and thereby prompted change in the paper bag industry.³⁰² The success of these tactics made the Southern Kraft Corporation the most profitable division of IP in the 1930's.³⁰³

The first wave of the Southern strategy of IP was timed to meet the competition by incumbent kraft firms in the South and Wisconsin, and its tactic was to bring North American kraft paper and board prices under pressure. In the South its success was evident. Early pioneers of the kraft process had erected 20 small or medium size mills across the Southern pine belt by 1920, but a decade later the investment rush had decreased the number to 17, as new record size vertically integrated mills simply wiped out the older mills. Controlling one third of the Southern mills, IP became the dominant firm in the kraft industry in the U.S.³⁰⁴

The organization of the Southern kraft industry underwent a deep transformation, then, whereas the old organization of the Lake States kraft industry persisted. In 1932,

Scranton (ed), *The Second Wave: Southern Industrialization From the 1940s to the 1970s*. Athens : University of Georgia Press 2001, 168-218.

³⁰² Harry L. Wollenberg to Monroe A. Wertheimer, 28 Aug. 1930. DCE Papers, Box #74, Folder #14

³⁰³ Heinrich, "Product Diversification." At this time the Southern kraft and specialty kraft paper production created also most income for the St. Regis Paper Company, which had only diversified into kraft pulp and paper in 1929 from newsprint and book paper. Eleanor Amigo and Mark Neuffer, *Beyond the Adirondacks. The Story of St. Regis Paper Company*. Westport, Connecticut: Greenwood Press 1980, 84, -77, 85.

Wisconsin had about half a dozen companies that manufactured kraft pulp or paper, and the leading firms attempted to increase economies of scale. Tomahawk Kraft Paper Company, Thilmann Pulp and Paper Company, and Nekoosa-Edwards Paper Company all followed the lead of Everest's Marathon Mills group. Everest maneuvered skillfully with vertical integration, product innovation, and industrial relocation to offset the effects of the IP.³⁰⁵

The Southern mass production gave rise to a sustained, coordinated defensive strategy of the Northern kraft manufacturers. In late 1931, the managers of leading Lake States firms met to discuss, again, how to respond to the recent actions of IP. They agreed to meet the new lower prices announced by IP, but not to go below. Northern managers acknowledged that plain price cooperation could not turn around the forces of unfolding industrial change, and such conferences offered most importantly a venue to discuss strategies that potentially could. In order to sustain and improve the competitiveness of Northern kraft industry, deep strategic choices in the production and products had to be made.³⁰⁶

Attempts to achieve economies of scale were central for the Wisconsin kraft firms' defensive strategy, and this was successfully achieved in capital, marketing, management, freight, and production. Surprisingly, a central element of the improved competitiveness of the Wisconsin and other Lake States kraft industry was strategic,

³⁰⁴ George Brown Tindall, *The Emergence of the New South, 1914-1945*. Louisiana State University Press 1967, 84-85.

³⁰⁵ J. H. H. Alexander, "Eighty-Four Years Ago Wisconsin Had But One Paper Mill," *The Paper Industry*, Dec. 1932, 670-673; Kellogg, *Pulpwood*, 37-42.

³⁰⁶ K.E.S. (unidentified, HT), *Memorandum of Telephone Conversation with George Stansbury*. 10 Oct. 1931. DCE Papers, Box #86, Folder #12.

moderate vertical disintegration. In many cases mills could purchase Scandinavian sulphate pulp below the cost of their own or Southern production. More important was the question of quality, however. Scandinavian pulp was considered the best kraft pulp available, and enabled Northern kraft mills to shift capacity into specialty production. In quality specialty kraft product markets, such as envelopes and premium packages, the lesser quality Southern kraft was not a competitor.³⁰⁷

The pre-existing capabilities of the Wisconsin paper industry enabled renewed emphasis on specialty production, because the production of most kraft specialties required its mixing with different kind of pulps. In Wisconsin a great variety of different pulps were manufactured within a relatively small region, creating economies of scale for such specialty papers. The vice president of Everest's Tomahawk Kraft Paper Company, Sven B. Bugge, managed the development and product differentiation of such brand envelopes as the "Somo Envelope Kraft" and "Mailwell Envelope Kraft." Their specific characteristics depended on the use of right mix of kraft and sulphite pulp.³⁰⁸ Similarly certain container boards required a mix of specific kraft and groundwood pulp, as did paper used in the manufacture of waxed cartons.³⁰⁹ Another example was the

³⁰⁷ This point is powerfully demonstrated in an analysis of the competitiveness of the different North American pulp and paper industry regions: George N. Ostrander, *Statements Presented At Hearings Before the Timber Conservation Board, Washington D.C.* 10 June 1931. DCE Papers, Box #85, Folder #2.

³⁰⁸ *Clarence J. Schoo to Sven B. Bugge*, 20 Nov. 1931. DCE Papers, Box #86, Folder #12.

³⁰⁹ *Monroe A. Wertheimer to Harry L. Wollenberg*, 27 May 1930; *Clark D. Everest to Harry L. Wollenberg*, 10 June 1931. DCE Papers, Box #74, Folder #14.

development of patented absorptive board. The consumer goods giant Procter & Gamble used it in packaging soap as it prevented the wrapping paper becoming too moist.³¹⁰

Monroe A. Wertheimer, manager of Kaukauna, Wisconsin, kraft firm Thilmany Pulp & Paper Company, explained the advantages of this production strategy plainly: “We are furnishing indirectly to several accounts a mixed grad of paper which pays us a profit through all of our ramifications, and with which Southern Kraft cannot compete, as this paper is made out of mixed old papers, and/or ground wood and/or Kraft or sulphite of the poorest quality, such as our own screenings and the very cheapest Sulphite we can purchase.”³¹¹

Wertheimer was probably the strongest proponent of contracting pulp, and in particular Swedish kraft pulp. He argued that it enabled him to off-set Southern competition with lower prices and higher quality. Wertheimer had traveled in Sweden, and knew personally the leading Swedish pulp and paper managers. At an extreme in 1930, he even proposed to Everest a complete withdrawal from vertically integrated kraft pulp and paper production.

While some disintegration did occur in the Lake States and New England, Wisconsin paper managers differed sharply on the issue. Everest, Clarence Schoo, and Harry Wollenberg were skeptical of depending on imported Swedish kraft pulp, and emphasized that the Swedish kraft industry was rather concentrated. They expected the price of imported kraft pulp to be susceptible to price hikes, and therefore dismissed

³¹⁰ *Monroe A. Wertheimer to Harry L. Wollenberg*, 19 June 1930. DCE Papers, Box #74, Folder #14; *Monroe A. Wertheimer to Harry L. Wollenberg*, 1 July 1930. DCE Papers, Box #74, Box #15.

³¹¹ *Monroe A. Wertheimer to Harry L. Wollenberg*, 10 Oct. 1931. DCE Papers. Box #86, Folder #12.

many of Wertheimer's claims.³¹² Clarence Schoo put it clearly: "I don't think the idea of shutting off Southern kraft production by the purchase of kraft pulp has any more logic."³¹³

The emerging emphasis on specialty kraft paper production deepened the differences between regional pulp and paper industries, and in particular the Pacific mills began to emulate the Wisconsin experiences. Dismissing horizontal cooperation and combinations as unreliable methods to achieve price stability, Harry Wollenberg presented new plans for the single product –kraft paperboard- Longview mill in Washington in 1930:

My ambition for our company is to diversify and integrate it. Diversification will come if and when we have a Fourdrinier machine and include the manufacture of Sulphite Pulp and bleaching of pulp. This is a program which I think might well come through increasing our own converting activities and through strengthening our jobber hook-up on the Pacific Coast.³¹⁴

For Wollenberg specialization was coupled with increased vertical integration. Persistent over-capacity and downward spiraling prices prompted managers to create

³¹² National Kraft Paper Manufacturers' Association, *Statistical Survey of the Kraft Paper Industry, 1926-1929*. DCE Papers, Box #77, Folder #7; *Clarence J. Schoo to Harry L. Wollenberg*, 23 March 1931; *Clark D. Everest to Harry L. Wollenberg*, 30 March 1931. DCE Papers, Box #86, Folder #10; *Clark D. Everest to Harry L. Wollenberg*, 28 July 1928; *Monroe A. Wertheimer to Harry L. Wollenberg*, 25 Aug. 1931; *Harry L. Wollenberg to Monroe A. Wertheimer*, 28 Aug. 1930. DCE Papers, Box #74, Folder #15. *Monroe A. Wertheimer to Harry L. Wollenberg*, 16 March 1931. DCE Papers, Box #86, Folder #10.

³¹³ *Clarence J. Schoo to M. A. Wertheimer*, 6 May 1930. DCE Papers, Box #73, Folder #1.

³¹⁴ *Harry L. Wollenberg to Clark D. Everest*, 22 April 1930. DCE Papers, Box #74, Folder #14.

specialty products that had less competition than mass volume standardized paper grades. Wollenberg planned to imitate the industrial organization typical for the leading Wisconsin paper centers, where geographically concentrated diverse production technology established advantages in specialty production. In contrast, Southern production technology was homogenous and released economies of scale only in the mass production of kraft pulp, wrapping paper, and paperboard.³¹⁵

The emergence of Southern mass production of kraft pulp and paper between 1925 and 1931 recast competitive forces in the North American pulp and paper industry. The dramatic effects in the sulphate pulp and paper industry alone were evident in the speed by which the highly concentrated Southern kraft industry captured a dominant share of national markets. The revolutionary transformation of the North American sulphate industry precipitated broader structural change in the entire pulp and paper industry. Technological learning in the kraft pulp and paper industries in the 1920's produced breathtaking economies of scale in the eyes of the contemporaries, and yet many engineers felt that the full potential of the sulphate process was yet to be released.

The persistence of the Great Depression, and the new political economy created in the early 1930's suspended the appeal and realization of such technological dreams, however. North American kraft pulp and paper managers agreed that the main problems of the industry was over-capacity, and technological learning in the industry was re-

³¹⁵ The Southern mills had limited capabilities to mix successfully kraft and sulphite pulp. Typically these were constrained to the production of the lowest grade and cheapest wrapping papers, thus substituting such products as the sulphite butchers wrapping paper –probably the cheapest sulphite wrapper. For a description of these dynamics, as well as the attempts of Pacific Coast St. Helens Pulp and Paper Company and Crown Zellerbach Company to imitate the diversification strategy of the Longview Fiber Company, see: *Harry L. Wollenberg to Monroe A. Wertheimer*, 1 July 1930. DCE Papers, Box #74, Folder #15 and *Monroe A. Wertheimer to Harry L. Wollenberg*, 10 Oct. 1931, DCE Papers, Box #86, Folder #12.

focused upon standardization, as it provided the fundamental mechanisms for regulation and price scheduling called for under the National Industrial Recovery Act.

Technology of Coordination: Standardization of Kraft Paper, 1929-1935

Standardization offered managers a flexible mechanism of cooperation that could be adapted to rapidly changing conditions of the kraft pulp and paper industry. At the early stages of the Southern kraft industry standardization was predominantly a vehicle to achieve uniform quality of the Southern kraft in order to have it accepted in national markets, and as such represented the single reason for the establishment of the Southern Kraft Pulp and Paper Association in the early 1920's. In the kraft paperboard industry standardization served a similar purpose beginning in the late 1920's, but the issue was more complex because of the government regulation of paper boxes.³¹⁶

Paperboard was predominantly converted into paper shipping containers, and fell therefore under the railroad regulation of the Interstate Commerce Commission (hereafter ICC). Official specifications for different types of paper containers were published as the Rule 41 of the Consolidated Freight Classification, and deviating paper containers were subject to penalty in the form of increased freight rates. The ICC prepared these standards in cooperation with the railroads and paper industry. Most regulatory standards for paper containers had been constructed in the 1910's, when all paper boxes were manufactured from jute, straw, sulphite or newsboard. Managers in the expanding kraft paperboard

³¹⁶ This single reason prompted the organization of the Southern Kraft Pulp and Paper Association. *J.P. Hummel* (Hummel-Ross Fibre Co.) to *Dr. Hugh P. Baker* (Secretary of American Paper and Pulp Association), 10 Jan. 1924. DCE Papers, Box #24, Folder #13

industry recognized that a reform of the regulatory standards for paperboard was essential to create demand for its products.³¹⁷

Table 5-5. Standard Qualities and Prices of Jute, Cylinder Kraft, and Fourdrinier Kraft Paperboard in 1929

	Jute board	Cylinder kraft board	Fourdrinier kraft board
Caliber (Thickness)	0.16	b0.16	0.16
Test (strength)	100	100	100
Weight	70	56	48
Price per ton	\$52.50	\$65.62	\$76.65
Price per Sq. Ft.	\$1.84	\$1.84	\$1.84

Source: *Table of Differentials. Jute and Kraft Liner Boards*. 11 Nov. 1929. The Paperboard Industries Association. DCE Papers, Box #67, Folder #14.

The problem for manufacturers of kraft paperboard was that the established standards coupled narrow classes of weight and strength. A comparison of the different paperboards in Table 5-5. demonstrates that Fourdrinier kraft paperboard weighed 45 per cent less than jute board with identical strength. The two paperboards cost the same for the converter manufacturing paper boxes, but the end user could be expected to prefer the lighter kraft paperboard box because it potentially lowered the freight costs. In 1929, the standards favored the jute boards over the Fourdrinier kraft, maintaining barriers of entry for mass production kraft paperboard firms, such as the IP, which were cutting the price of kraft paperboard.³¹⁸

³¹⁷ Comprehensive and detailed review of packaging and containers standards, although of slightly later date, is: C. M. Bonnell, *Bonnell's Manual on Packaging and Shipping*. New York: Bonnell Publications 1941.

³¹⁸ *Table of Differentials. Jute and Kraft Liner Boards*. 11 Nov. 1929. The Paperboard Industries Association. DCE Papers, Box #67, Folder #14.

Upon publicly disclosing the record size Panama City Fourdrinier kraft board mill, IP attempted to revise the paperboard standards. The company applied to the Classification Committee of the Paperboard Industries Association for a ruling that would permit the use of 0.14 caliber board with 174# Mullen strength test boxes instead of 0.16 caliber board, while maintaining the weight of the board. The proposal was an attempt to gain access to lucrative, but regulated markets. If approved by the Paperboard Industries Association, it would have to be negotiated with the railroads and the Interstate Commerce Commission, too.³¹⁹

The proposal manifested the complexities of regulated paper box markets. IP's competitors suspected that it employed the proposal as a ploy to introduce specific water finished board that would potentially capture markets from the incumbent board manufacturers. Nevertheless, many of the Association members acknowledged that unfolding structural change in the industry was manifest in the application, and expected inevitable change in the regulatory standards. Some advocated the wholesale abolition of paper container standards on the grounds that no such specifications existed for wooden boxes. Yet, for the time being, the committee members chose to resist IP's application, but this was likely only intended to slow down the inevitable. Schoo detailed this logic in a letter to Wollenberg:³²⁰

³¹⁹ *Clarence J. Schoo to Harry L. Wollenberg*, 11 June 1930. Box #73, Folder #1. The development of kraft board specifications is detailed in Grover J. Daly, *The Corrugated Container Industry – A History and Analysis*. Oak Park, Ill.: Harry J. Bettendorf 1971, 34-36. Also helpful is: A. W. Werner, *The Manufacture of Fibre Shipping Containers*. Chicago: Board Products Publishing Company 1941, 19-20.

³²⁰ *Schoo to Wollenberg*, 11 June 1930.

Naturally, the association is lending no support to this and is discouraging it [IP's application]... such boxes for a great many commodities will be equally as good or better than the present specifications, and I am further of the opinion that if some large shipper would put enough of such boxes in use, pay whatever penalty is assessed against them for the time being, and established over a period of time that claims for loss and damage have not been increased, they could then take the case before the Interstate Commerce Commission and compel the railroads to provide a classification for such containers... I have always felt that the classification restrictions have been a boom to the container industry. Whether or not they make for the greatest possible economy in the packing and transportation of merchandise is another question. I am inclined to think, however, that a deviation from arbitrary standards for economic purposes when sponsored by individual shippers will be the next trend in this industry, and when it is worked out by the individual shippers on a sound basis, it will be hard to combat. For instance, it will be difficult for anyone to hold out against a large shipper of cigarettes who can demonstrate that he can deliver his goods to destination safely in a package which costs him less than the specification standards, particularly when it is compensated by features of strength, which the standard container lacks.³²¹

The critical role of regulatory standards for creation of kraft paperboard markets forced IP to modify its aggressive dominant-firm strategy. The very nature of the process

³²¹ *Schoo to Wollenberg*, 11 June 1930.

whereby shipping container standards were constructed required the consent of the paper industry. Richard J. Cullen, the president of Southern Kraft division of IP, adopted a more conciliatory attitude towards his competitors upon the completion of the Panama City mill. Due to this change, the leading kraft firms were able to establish the Kraft Institute in 1931, which finally rewarded the Northern kraft mills' efforts to persuade IP to join national cooperation on prices and production.³²²

The Kraft Institute membership comprised about 70 per cent of the U.S. kraft pulp and paper industry. The new conciliatory tone of the industry was evident in its organization: Richard Cullen was appointed as the president, and Clark Everest the vice-president and chairman. At the time of the establishment of Kraft Institute, however, rapidly worsening economic conditions changed importantly the function of paper standards.³²³

In 1931, capacity utilization in the whole pulp and paper industry dived similarly to the kraft paper industry, and every manager in the business predicted worse conditions for the next year. This fostered a particular kind of innovation to prevent market breaking tactics by individual firms. Any experienced paper maker knew how the cost of pulp and quality of paper were related, and therefore firms attempted to gain market share by introducing imitations with lower quality and price. Rigid quality standards could prevent this. Ironically, IP had entered cooperation with other kraft firms in order to create

³²² "Outlook for Kraft Industry Clearing," *Paper Industry*, April 1931, 58.

³²³ "Outlook for Kraft Industry Clearing," *Paper Industry*, April 1931, 58.

markets for its innovative products, but the Kraft Institute and its officers struggled to suspend the effects of innovation.³²⁴

These principles guided the several cooperative conferences organized by the Kraft Institute. Speaking specifically on kraft bag and sack papers, institute's secretary Oliver M. Porter detailed the general principles of paper standards in 1932:

Study of existing trade conditions by the Kraft Institute clearly indicates that stable market conditions, which are of high importance in the present disturbed state of American industry, necessitate the strict maintenance of standard specifications... The best authorities agree that practices which involve deviation from standards...amount to nothing less than price-cutting – a practice so injurious to good business, that it should not be tolerated by any manufacturer.³²⁵

The Kraft Institute's standardization efforts were situated in the context of record low utilization of production capacity, and the desperate attempt of the industry to maintain prices. The Kraft Institute organized several conferences for the industry and its customers to work out "standard specifications" that prevented firms' ability to break markets with sub-standard quality products. For Porter, then, standards offered a potential mechanism to "freeze" innovation that created new markets by substituting existing products with poorer and cheaper imitations.

³²⁴ *The Kraft Situation and What to Do About it*. The Kraft Institute, 3 Nov. 1932. DCE Papers, Box #95, Folder #14.

³²⁵ *Oliver M. Porter to Sven B. Bugge*, 22 March 1932. DCE Papers, Box #95, Folder #14.

The Kraft Institute cooperation paved the way for voluntarily industry-wide cooperation on prices and capacity. The “management engineer” firm Stevenson, Jordan & Harrison began to implement a program to curtail over-production in the kraft paper industry on 23rd October, 1933.³²⁶ Such voluntary cooperation campaigns anticipated Franklin D. Roosevelt’s National Industrial Recovery Act of 1933, which was an experiment to turn around the deepening Great Depression through industrial self-regulation. The central approach of the established National Recovery Administration (hereafter NRA) was to derive industry specific codes that specified price floors and production quotas, and the plan relaxed antitrust laws for the participating firms and industries. The NRA regulation was administrated in practice by the industry specific Code Authorities, staffed with people from the industry to be regulated. The NRA required participating firms to file publicly prices for their products, as well as disclose production and delivery statistics. This made sense only if products were reasonably standardized, and information from different mills was compatible.³²⁷

In many ways the paper industry presented a tremendous challenge for such a coordination attempt. There existed hundreds, if not thousands, of different kinds of paper grades, not to mention converted paper products. The first task of the NRA Paper

³²⁶ *S. M. Hudson to John R. Miller* (Vice President of Westvaco), 27 Nov. 1933. Westvaco Collection #1781, Box #13, Packet #4.

³²⁷ Standardization and cooperation were central features of the political economy in the 1920’s, and in many ways importantly laid the foundation for the regulation during the early New Deal. See in particular: Ellis Hawley, “Three Facets of Hooverian Associationalism: Lumber, Aviation, and Movies, 1921-1930,” 103. In Thomas C. McCraw (ed.), *Regulation in Perspective*. Boston: Harvard University Press 1981, 95-123; Kendrick A. Clements, *Hoover, Conservation and Consumerism. Engineering the Good Life*. University Press of Kansas 2000; Charles McGovern, “Consumption and Citizenship in the United States, 1900-1940,” in Susan Strasser, Charles McGovern, and Matthias Judt (eds), *Getting and Spending. European and American Consumer Societies In the Twentieth Century*. Washington: Cambridge University Press 1998, 37-58. Definitive study for the political economy of the New Deal continues to be: Ellis W.

Industry Authority was to construct standards that covered the industry, and establish the fundamental mechanism for price and production controls. The Paper Industry Authority appointed the Committee on Production and Classification to produce a grade allocation to lay a foundation for the price scheduling and production controls.³²⁸

The inherent complexity and messiness of the paper business made the classification system appear arbitrary. The committee established four grades under the Kraft Paper Division of the Paper Industry Authority, namely “wrapping and converting Machine Finished” and “wrapping and converting Machine Glazed.” Sulphate board was divided into the sub-grades of “Corrugating”, “Test”, and “Sulphate Specialties not otherwise classified”, and placed under the Sulphate Pulp and Board Division. Many other kraft and sulphate paper grades were placed under the regulation of the additional 20 pulp and paper industry specific divisions.³²⁹

The quest for standardization followed from the pivotal importance of “uniform and accurate cost accounting” for the open price filing practice. This motivated the general chairman of the Operating Division of TAPPI, Frederic C. Clark, to suggest the wholesale replacement of trade names with scientific standards. He claimed the over 65 commercial brands of kraft paper could be rationalized into only few standard grades with his four-digit classification system that was compatible with automatic tabulating machines. Allowing the easy aggregation of sub-classes into firm or industry specific

Hawley, *The New Deal and the Problem of Monopoly. A Study in Economic Ambivalence*. New York: Fordham University Press 1995 (1966).

³²⁸ “Divisional Classifications of Papers Subject to the Jurisdiction of the General Code of Fair Competition for the Paper and Pulp Industry,” *Paper Industry Authority Bulletin*. No. 6, 28 May 1934. For the specific codes of fair competition, see: *The General Code and Subordinate Codes of Fair Competition for the Paper and Pulp and Industry. As Approved by the President of the United States*, 17 Nov. 1933. New York: American Paper and Pulp Association 1933.

production statistics, such standardization embodied a very potent mechanism of centralized coordination.³³⁰

These rationalistic dreams were frustrated by the dynamic forces of competition that emerged from long term structural change in the North American pulp and paper industry. In the case of the kraft paper industry, the NRA revived the deep rivalry between Northern and Southern firms. The Southern kraft firms attempted to create a two-tier classification system, in which the lower quality Southern kraft paper could maintain its pricing advantage. Northern and Pacific mills aggressively opposed this in the summer 1933, and insisted on a single category standardization. Marvin Preston, manager of the Wisconsin Thilmany Pulp and Paper Company, explained to Everest that if all kraft paper could be specified within one price and quality category, nobody would buy the lower quality Southern kraft for the price they could obtain good quality Northern.³³¹

Predictably, the Southern mills of IP, Brown Paper Company, and West Virginia Pulp and Paper Company continued to cut prices under these conditions in 1933. The NRA codes provided only voluntarily guidelines, but promised a relaxation of antitrust laws for the participating firms. Therefore the Northern and Pacific kraft mill managers could only observe and complain to each other of the market-breaking tactics of their

³²⁹ “Divisional Classifications of Papers.”

³³⁰ Frederic C. Clark, “Trade Names and Their Significance,” *PTJ* Vol. 98, No.8, February 22, 1934, 71-108. Paper presented at the joint meeting of APPA and TAPPI, New York, N.Y., Feb., 19-22, 1934. For a brief discussion of the relationship between paper standardization and uniform cost accounting during the construction of NRA codes, see Louis T. Stevenson, *The Background and Economics of American Paper Making*. New York: Harper & Brothers Publishers 1940, 178-179.

³³¹ *Marvin M. Preston to Clark D. Everest*, 29 June 1933, DCE Papers, Box #104, Folder #15.

Southern rivals. The Code authorities, on the other hand, regarded such moves as a serious violation.³³²

The kraft industry's failure to agree on standards released competitive forces that questioned the legitimacy of NRA. In September 1935, NRA officials charged the grocery bag division of the paper bag code with "wholesale violation" of the code by continuously cutting prices. In October, Executive Authority of Kraft Paper Division met to discuss problems with the code, such as the alleged violations by Westvaco and Brown Paper Company. As the code violations persisted, the code authorities and industry leaders organized an open meeting at which all kraft firms could discuss constructively the problems. Such attempts to induce cooperation and suspend competition proved fruitless, however, and the open price filing was suspended in the kraft paper industry in January 1935.³³³

The kraft paper industry resumed the earlier Stevenson, Jordan & Harrison managed curtailment program immediately.³³⁴ The continued collection and processing of cost and production information on standardized kraft paper grades laid the basis for the charges of violation of antitrust laws, and eventually the Department of Justice sued

³³² *Harry L. Wollenberg to Clark D. Everest*, 21 March 1933; *Monroe A. Wertheimer to Harry L. Wollenberg*, 6 Jan. 1933. DCE Papers, Box #104, Folder #15; *Clarence J. Schoo to Harry L. Wollenberg*, 20 Dec. 1933; *Harry L. Wollenberg to Clark D. Everest*. DCE Papers, Box #104, Folder #16.

³³³ *Address by Liet. D. H. Tulley to Members of Grocery Bag Division of Paper Bag Code*, 20 Sept. 1934; *Suggested Agenda of the Executive Authority of the Kraft Paper Division*, 3 Oct. 1934; *Charles W. Boyce (Secretary of APPA) to H. W. Ellerson (President of Kraft Paper Association)*, 21 Sept. 1934; *Resolution Adopted by Executive Authority of Kraft Paper Division*, 4 Jan. 1935; For detailed descriptions how individual mills violated the NRA codes and for the role of standard specifications, see: *Summary of Field Audits*. 3 Oct. 1934. Westvaco Collection #1781, Box #13, Packet #4.

³³⁴ *Paul Kellogg (of Stevenson, Jordan & Harrison) to John R. Miller*, 11 Jan. 1935. Westvaco Collection #1781, Box #13, Packet #4.

practically all U.S. kraft firms in 1939. The defendants produced over 90 per cent of all U.S. kraft paper, and agreed to a consent decree next year.³³⁵

The experience of standardization in the kraft paper industry between 1929 and 1935 demonstrated to leading firms the pitfalls of cooperative managerial coordination. Selfish interests enticed individual mills to break away from collaborative efforts, and, on the other hand, the rule of majority potentially threatened the economic viability of the minority.

The cooperative movement, epitomized in the NRA kraft paper codes, significantly shifted the focus of technological learning to standardization. Processing of information on costs and production occupied much of managerial efforts during the NRA. Moreover, the rigid regulation directed firms to focus on the improvement of existing kraft process technology, and pay less attention to potentially radical technological departures that would have retired old machinery and required investment into new mills.

Standardization and Diffusion of the Chemical Recovery Technology, 1934-1940

Between 1934 and 1940, the North American kraft pulp and paper industry experienced another rapid phase of expansion, mostly in the South. This structural change was critically facilitated by new stationary chemical recovery units that offered new scale economies and abolished quickly competing designs. Two large U.S. boiler manufacturers, Babcock & Wilcox Company (henceforth B&W) and Combustion

³³⁵ *United States of America v. Kraft Paper Association et al.* Cr. 105-336a (1939), Civil 10-329, *Complaint and Consent Decree* (1940); *United States of America v. Stevenson, Jordan & Harrison* Civil 10-213,

Engineering, Inc. (henceforth C-E), controlled central patents on the new recovery unit, and commercialized full-scale turn-key installations. The rapid diffusion of new superior chemical recovery technology throughout the kraft pulp and paper industry ended regional technological differences and effectively standardized the technology. This eroded the competitive strategy of the Lake States kraft industry, and gave significant advantage to the Southern industry.

The efficiency of chemical recovery in the kraft pulp process was significantly improved when B&W and C-E, the world's leading boiler technology firms, entered the business simultaneously around 1934. They had specialized capabilities for the improvement of the kraft recovery furnaces, particularly knowledge of behavior of heat, that the incumbent machinery suppliers and the pulp and paper industry lacked.³³⁶

B&W entered the chemical recovery unit business by collaborating with the leading builder of stationary recovery furnaces. In 1934, George H. Tomlinson began to install a new recovery unit at Windsor Mills, Quebec, of the Canada Paper Company, which had absorbed his employer Howard Smith Paper Company in 1929. Unable to solve technical problems inherent to the application of boilers to the operation of stationary chemical recovery furnace, which Tomlinson considered critical, he contracted the B&W for a solution.³³⁷

Complaint and Consent Decree (1940); Simon N. Whitney, *Antitrust Policies. American Experience in Twenty Industries*. New York: Twentieth Century Fund 1958, 343.

³³⁶ Thomas M. Grace, "Perspectives on Recovery Technology," 55. In Thomas M. Grace (ed), *Forum on Kraft Recovery Alternatives*. Appleton, WI: The Institute of Paper Industry 1957, 27-57.

³³⁷ The installation and project is recounted in detail in L. S. Wilcoxson, "Results from the B-W-Tomlinson Process for the Recovery of Chemicals and Heat From Black Liquor," *PTJ*, Vol. 100, (13 June 1935) 72-77.

B&W was not a newcomer in the pulp industry. An earlier collaboration with the Wisconsin Kimberly-Clark Corporation had resulted in a pioneering heat circulation system for pulp processes. In the early 1930's, the two firms collaborated to improve the heat economy of sulphite pulping process, and introduced the "Babcock & Wilcox-Kimberly-Clark Circulating and Indirect Heating System for the Sulphite Pulping Process." B&W introduced in pulp processes centralized control mechanisms that were commonplace in boiler technology, and also helped pulp engineers develop improved understanding of the behavior of heat. The cooperative effort produced undeniable and considerable savings for sulphite pulp mills, and established the boiler firm a name within the pulp and paper industry.³³⁸

Such widely publicized and allegedly successful cooperation did not escape the notice of people attempting to improve kraft pulping processes. In particular the kraft pulp engineers began to focus increasingly on heat economy. Like so many trade and engineering journals, the *Paper Industry* published specialized technical reviews on how to improve the utilization of waste heat in the kraft process. L. F. Bunde, a Wisconsin engineer, detailed in his two-part article the fruits of collaborating with an anonymous boiler manufacturer - probably B&W- on heat economy of pulp processes at his Wisconsin Rapids kraft mill in 1933. Such examples demonstrated the potential benefits pulp firms could derive from cooperating with boiler firms that had knowledge of

³³⁸ This cooperative project is discussed in detail in Lloyd Lang, "The B&C-K-C Circulating and Indirect Heating System for the Sulphite Pulping Process," *PTJ* 1 Dec. 1932, 26-36.

technologies of heat. For the B&W engineers the collaboration with pulp and paper firms provided an opportunity to learn the pulping and chemical recycle technology.³³⁹

Adopting a consistent and inclusive approach to the recovery cycle at the Canada Paper Company mill, B&W engineers worked to improve every phase of the projected 75 ton capacity unit. The unit embodied much of new equipment, such as “turbo-charger” and “super-heater,” resulting in 2100 degree Fahrenheit temperature in the furnace. Black liquor was sprayed into the furnace with an improved spray nozzle. The design improved economies of the recovery cycle by increasing the reuse of generated heat (over 90 per cent was employed usefully) and by reducing labor. A single person could operate the unit, while an additional person tended water and blew the tubes –a staffing enough to operate up to three units. A major advantage of the Babcock & Wilcox-Tomlinson Process, commercialized as the B&W unit, was that it could be scaled up significantly.³⁴⁰

Learning the sulphate recovery technology during the experimental work in 1934, the B&W decided to diversify into the stationary chemical recovery unit business. The entry of a leading boiler manufacturing company marked the beginning of new phase in the organization of technological learning in the kraft recovery cycle. B&W ignored the earlier personal disagreements between H. Tomlinson and Wagner that had continued since 1929, and integrated their respective discoveries on the chemical stationary recovery furnace technology. The boiler manufacturer purchased the key stationary recovery furnace from the C. L. W. Patents Corporation, which was Wagner's holding

³³⁹ L. F. Bunde, “Kraft Waste Heat Boilers... Their Value as Steam Generators,” *Paper Industry*, May 1933, 75-78; L. F. Bunde, “Kraft Waste Heat Boilers. Part II,” *Paper Industry*, June 1933, 137-139; Important review by the chairman of the TAAPI committee on Heat Utilization in Chemical Processes, and an engineer of the J. O. Ross Engineer Corporation.: W. T. Webster, “Heat Utilization in Pulp Cooking by the Alkaline Processes,” *PTJ* 5 April 1934, 184-186.

company for the patent applied in 1925 and eventually granted in 1930, as well as some other ones, too.³⁴¹ B&W obtained also Wagner's complementary patent from 1936 that had been applied in 1930.³⁴² In 1935, controlling owner of the B&W, Leslie Wilcoxson, applied with George Tomlinson for a patent for improvements in the original Tomlinson stationary recovery furnace patent that had been applied in 1932, and granted in 1937.³⁴³ Subsequently additional patents completed the efforts of B&W to establish broad intellectual property rights for its new line of products.³⁴⁴

Charles Wagner was a capable patent strategist and had constructed his original patent very meticulously to deserve a broad interpretation in courts. This intent was manifest in a patent review of alkali recovery technology he published in *Paper Trade Journal* in 1932.³⁴⁵ In the article Wagner listed only 19 U.S. patents on the subject –and of course enjoyed a moment of free publicity in the aftermath of the recent dispute with Tomlinson. Earlier patent reviews of sulphate process had confirmed that patents covered relatively weakly the technology. Both Wagner and Tomlinson had claimed broad intellectual property rights for the stationary chemical recovery furnace, but failed to diffuse it widely in the kraft industry. B&W had organizational capabilities to improve critically the technology, consolidate respective patent portfolios of Wagner and

³⁴⁰ Wilcoxson, "Results from the B-W-Tomlinson Process."

³⁴¹ Charles L. Wagner, U.S. Patent No. 1,771,829 (1930).

³⁴² Charles L. Wagner, U.S. Patent No. 2,050,400 (1936).

³⁴³ George H. Tomlinson, U.S. Patent No. 2,070,632 (1937); George H. Tomlinson and Leslie S. Wilcoxson, U.S. Patent No. 2,161,110 (1939).

³⁴⁴ Alfred G. Kerning, U.S. Patent, 2,138,278 (1938); Grace, "Perspectives on Recovery Technology."

³⁴⁵ Charles L. Wagner, "Alkali Recovery Patent Review," *Paper Trade Journal* Vol 94. No. 16 (7 April 1932) 40-41.

Tomlinson, as well as diffuse the new technology effectively within the kraft pulp and paper industry.³⁴⁶

The entry of an established boiler manufacturer enabled the realization of technological dream of self-sustaining chemical recovery cycle, already present in Carl Dahl's patent application in the 1880's. Wagner had further detailed the basic principles of a continuous and self-sustained chemical recovery process, and as such laid the basis for potential patent monopoly in 1925. His fundamental patent, U.S. Patent No. 1,771,829, was defined as an extension of the Le Blanc soda process and described in great mechanical and chemical detail. The core of the patent was a method of spraying atomized liquors into extremely hot vertical furnace, and a method of burning waste liquor that used auxiliary heat only little for preheating of the furnace. Yet Wagner and others in the industry had lacked the necessary knowledge of the boiler technology to realize this on a commercially viable basis.³⁴⁷

Specific technological capabilities in the heat economy of pulp processes opened an avenue for B&W to succeed where Dahl and Wagner had not, and the company guarded aggressively its knowledge assets. Intellectual property rights occupied a central role in the entry strategy of B&W, and although the company eventually litigated only one case of infringement, its aggressive style probably impeded imitation. In *Babcock & Wilcox Company v. North Carolina Pulp and Paper Company* the defendant was alleged of imitating the Wagner spray recovery unit. The New York contract engineering firm Day & Zimmerman, Inc., had designed and built a kraft chemical recovery unit at a kraft

³⁴⁶ Joseph Rossman, "Sulphate Process Patent Review," *Paper Trade Journal* Vol. 87 (9 Aug. 1928) 57-59.

³⁴⁷ Wagner, U.S. Patent No. 1,771,829.

mill in Plymouth, North Carolina for the North Carolina Pulp and Paper Company. The defendant argued that Wagner's two patents were invalid, and therefore no infringement could occur. When the North Carolina Pulp and Paper Company failed to demonstrate substantial prior art, the judge upheld the Wagner patents with rather broad interpretation. The decision secured B&W substantial business, no less because expert witnesses had argued that its equipment established a saving that equaled 20 per cent of the total cost of sulphate pulp.³⁴⁸

The success of B&W's chemical recovery unit aborted quickly prolonged efforts by others to improve the rotary chemical recovery furnaces. Between 1934 and 1936, the rotary recovery furnace technology peaked in a collaborative project between the Combustion Engineering, Inc., and the leading manufacturer of rotary recovery furnaces, Wisconsin's D. J. Murray Manufacturing Company. The latter firm was contracted by the Wisconsin Hummell-Ross Fibre Company to aid in its relocation in the South. Murray Company recognized that it did not know how to improve the arrangement of waste-heat boiler and design the extensive cooling of smelter, yet it identified them as critical for the success of kraft pulp operations. The company contracted C-E to carry out the required research and design, and jointly they installed a chemical recovery unit with a rotary smelter furnace, including almost complete water-cooling at a kraft mill in Hopewell, Virginia, in 1934. The design reduced drastically the labor intensive maintenance work, and similarly improved the heat economy of the process, and enabled increased size. Whereas traditional rotary recovery units typically had 25 ton capacity, the improved Murray-Waern, as it was called, was built with 50 and 75 ton capacities between 1934

³⁴⁸ *Babcock & Wilcox Company v. North Carolina Pulp and Paper Company*. 25 F. Supp. 596 (1938); 35

and 1936. Technological learning in the rotary recovery furnace peaked with the Murray-Waern design, as the success of the B&W recovery unit made it obsolete.³⁴⁹

The B&W installations of the stationary spray recovery unit exposed quickly the fundamental differences in economies of scale between it and the rotary recovery furnace. In 1936, the largest installations of the C-E improved Murray-Waern rotary recovery furnace and the Babcock & Wilcox-Tomlinson stationary furnace both equaled 75 ton capacity. The two designs shared much of basic technology, such as boiler and spray solutions, but differed fundamentally in their solution to the heart of the process, the furnace. The record size of the units showcased the limits of the respective technologies, as Thomas M. Grace has put it:

The deciding factor between rotary and spray units was the ability to scale up spray furnace designs to large units. The rotary reached maximum size at a capacity of 100/tons a day. It was not practical to increase the size of the rotary beyond this since the drying power of a rotary increases slowly with size. This limitation on size for the rotary coupled with the rapid expansion of the kraft pulp industry in the South proved the death knell of the rotary.³⁵⁰

Admitting the superiority of the stationary spray recovery unit, C-E abandoned its rotary furnace design and launched an extensive effort to imitate the B&W unit. Between 1936 and 1938, Fay H. Rosencrants managed for the firm the development of a spray

F. Supp. 215 (1940).

³⁴⁹ de Lorenzi, *Combustion Engineering*, Ch. 28, 12-13.

type recovery unit, the so called C-E Recovery Unit that did not infringe the B&W patents. Much of the required learning and experimentation occurred at the kraft mill of Chesapeake Paper Company, whose director Elis Olsson was a long time friend of the president of C-E, Joseph V. Santry. The cooperative research and development project erected a spray type unit with the record capacity of 250 daily tons in 1939.³⁵¹

The patent of C-E defined its merits explicitly against the original 1930 Wagner patent, as well as against “the so-called Tomlinson method.”³⁵² The patent claimed a novel arrangement of continuous water cooling system, but was specifically an attempt to circumvent the Babcock & Wilcox monopoly on furnace design that allowed tremendously improved economies of scale. In successfully doing so, the patent also marked the merging of long waves of technological learning in the rotary and stationary furnace schools.³⁵³

The decision by C-E to enter spray unit business effectively retired rotary chemical recovery furnaces. An C-E textbook from this period plainly stated that only four spray-type units were necessary for a projected 600-ton Southern mill, instead of six rotary ones. Rapid diffusion of new technology facilitated new investments, and boosted the daily Southern kraft production from 3,275 tons in 1935 to 9,128 in 1940, capturing over 80 per cent of total U.S. capacity.³⁵⁴

³⁵⁰ Grace, “Perspectives on Recovery Technology.”

³⁵¹ Roberts, “The Evolution of the Modern Recovery Unit.”; Dill, *Chesapeake*, 186-187.

³⁵² Fay H. Rosencrants and Alexander L. Hamm, U.S. Patent No. 2,213,052 (1940).

³⁵³ Grace, “Perspectives on Recovery Technology.”

³⁵⁴ de Lorenzi, *Combustion Engineering*, Ch. 28, 13; David C. Smith, *The History of Papermaking*, 408.

In 1936, Everest counted seven large new Southern mills under construction or just about to begin production, totaling new capacity of more than one million tons of kraft papers. Among the installations were two 100,000 ton per day capacity mills of incumbent IP and Westvaco. New entrants included forward integrating bag and box makers Union Bag & Paper Company and Container Corporation. Two projected mills of Mead Corporation marked that old papermaker's diversification into kraft, whereas the Crossett Paper Company entered pulp and paper from lumber. The new mills doubled the annual Southern kraft paper production to almost 2 million tons within a year.³⁵⁵

The construction of so many Southern mills badly worried the Wisconsin kraft firms.³⁵⁶ Analyzing detailed statistics on the regional relocation of the kraft industry, J. W. Kieckhefer, president of a Milwaukee paper box firm, emphasized the effects on Wisconsin: "Several members of the National paperboard Association have been giving much of their time and thought to developing a plan bringing in to the industry the large new Southern production in an intelligent manner... The problem is a serious one especially because of the large dislocation of Northern tonnage."³⁵⁷

Relocational dynamics developed renewed momentum during the 1940's and 1950's, and Lake State firms faced increasingly intensifying competition from the Southern firms. These dynamics were underpinned by technological innovation, and its

³⁵⁵ The mills are as listed in *Clark D. Everest to Harry L. Wollenberg*, 23 June 1936. DCE Papers, Box #121, Folder #12.

³⁵⁶ *Clark D. Everest to Harry L. Wollenberg*, 22 June 1936; *Monroe A. Wertheimer to Harry L. Wollenberg*, 18 June 1936; *Harry L. Wollenberg to Monroe A. Wertheimer*, 15 June 1936. DCE Papers, Box #121, Folder #12.

³⁵⁷ *J. W. Kieckhefer to Clarence J. Schoo*. 24 June 1934. DCE papers, Box #129, Folder #3.

rapid diffusion catapulted the sulphate industry to the largest branch of the pulp and paper industry.

Technology and Strategies of Growth in the Sulphate Pulp and Paper Industry, 1940-1960

Rapid diffusion of innovation prompted the leading North American pulp and paper firms to adopt aggressive strategies of growth in the kraft pulp and paper industry between 1940 and 1958. As a result, the sulphate industry became by far the largest and dominant branch of the pulp and paper industry. Investment in new sulphate pulp capacity was facilitated by the stabilization of the spray chemical recovery unit and two other important process innovations. Multi-stage bleaching enabled the production of white kraft and sulphate papers, and the continuous cooking kraft digesting process released new scale economies. This convergence of relatively distinct sustained waves of technological learning created an oxymoron that integrated mass production with product differentiation. In practice, improvements in sulphate bleaching technology widened radically the range of sulphate paper products that had a sustained price advantage over sulphite papers. These innovations prompted almost complete forward integration of the North American sulphate pulp industry. Between 1928 and 1939, 87 per cent of all sulphate pulp was manufactured by firms for their own use, but by 1947 the share had increased to 96 per cent - a level where it stabilized.³⁵⁸

This restructuring of the North American pulp and paper industry began with the rapid diffusion of spray chemical recovery unit. Upon learning of the innovation, the

³⁵⁸ *Census of Manufactures 1947. Vol. II.* Washington: Government Printing Office, 1949, 318.

incumbent firms with older rotary recovery furnaces re-evaluated their manufacturing technology. In the early 1940's, the engineering department of Westvaco reviewed monthly the equipment of its mills, and the engineers increasingly reported problems with the rotary recovery units. The engineering department's monthly report in January 1944 required immediate and extensive repair or substitution of rotaries at the Williamsburg mill. Rotary recovery units, at Tyrone, Piedmont, and Covington mills, usually supplied by the Dorr Company, were also in bad shape. At the last of these mills, C-E was already at work to replace the rotary units with spray type units. The efforts of Westvaco to modernize its chemical recovery units demonstrated how experienced kraft pulp mill engineers regarded the spray-type unit also as a remedy to the inherent maintenance problems of the rotary units.³⁵⁹

The C-E recovery unit underpinned the post-World War II expansion of the Chesapeake Paper Company, too. After the war the firm installed two C-E recovery units that totaled 250 ton daily capacity. Demonstrative of the potential scale economies of spray unit is that the third unit, installed in 1958, had the capacity to reclaim chemicals from 500 tons of pulp per day. Thus the radical technological departures in the chemical recovery technology had propelled the sulfate pulp and paper industry into the largest sector in the pulp and paper industry.³⁶⁰

Improvements in the bleaching of pulp constituted the second wave of technological learning that facilitated the tremendous expansion of the sulphate pulp industry. The basic principles of pulp bleaching and the chemical agent, elemental

³⁵⁹ *Engineering Dept. Activities. Last Report*, 6 Jan. 1944; G. R. Wadleigh, *Memorandum on Trip to Covington*. 27-29 March 1944. Westvaco Collection #1781, Box #49, Packet #4.

chlorine, had been described in 1912, but the process was not adapted on a commercially viable basis for kraft and other sulphate pulps until the mid-1930's. Exposure to chlorine improved the brightness of dark kraft pulp, but also radically decreased its strength, its most important characteristic. Early bleaching methods applied expensive chemical agents in one stage to pulp, and the process involved a trade between whiteness and strength of fibers. In the early 1920's, papermakers learned to reduce the cost of chemicals by using a two-stage hypochlorite bleaching method. Experimenting with the method, papermakers soon learned that it could be applied to kraft, but not sulphite pulp because of the character of its fibers. Repeated exposure to hypochlorite destroyed the sulphite pulp fibers so completely that it could not be fed smoothly into the papermachine. In contrast, kraft pulp consisted of much stronger fibers and emerged from the multi-stage bleaching with good quality for the papermachine. Thus, the "multi-stage bleaching" eliminated the trade between whiteness of sulphate pulp and its fiber strength.³⁶¹

³⁶⁰ Dill, *Chesapeake*, 233.

³⁶¹ Sven A. Rydholm, *Pulping Processes*. New York: Interscience Publishers 1965, 1072-1076; For early early 20th century developments in bleaching technology, see: Edwin Sutermeister, *The Story of Papermaking*. Boston: S. D. Warren Company 1954, 112-125; Good historical overview and clear presentation of technological milestones in pulp bleaching until the 1970's is: Rudra P. Singh. "History of Bleaching," in Rudra P. Singh (ed), *The Bleaching of Pulp*. (3rd Ed). Atlanta: Tappi Press 1979 (1953), 1-14; Good technical review of the bleaching technology in the late 1930's and 1940's is the industry textbook article: Ferdinand Kraft, "Bleaching of Chemical Pulp," in J. Newell Stephenson (ed), *Pulp and Paper Manufacture. Vol. I. Preparation & Treatment of Wood Pulp*. New York: McGraw-Hill Book Company 1950, 824-890. Comprehensive and accessible description of the bleaching technologies employed in the U.S. pulp mills is: OECD, *The Pulp and Paper Industry in the USA*. Paris: OECD 1951, 97, 181-184, 189-191, 200-202, 261; The effects of the introduction of kraft bleaching on the U.S. sulphate industry are analyzed in John G. Strange, *The Paper Industry. A Clinical Study*. Appleton: Graphic Communications Center 1977, 75-77.

Table 5-6. Production of Bleached Sulphate Pulp in the U.S., 1931-1958 (tons of 2,000 lbs.)

Year	Production	Per Cent Growth
1931	50,000	
1939	500,000	1,000
1947	1,100,000	220
1958	4,000,000	370

Sources: *Manufacturers* 1919, 559; *Census of Manufactures 1933*. Washington, D.C.: Government Printing Office 1936, 267; *Census of Manufactures 1947*, 318; *Census of Manufactures 1958. Part I.*, 26A-12.

The pioneering discovery and learning on the multi-stage process occurred simultaneously and independently in the North America and Europe. The leading Swedish pulp and paper firm, Stora Kopparbergs Bergslags AB, and the pioneer of stationary kraft recovery furnace, Brown Company, developed in the 1930's the processes of multistage bleaching of kraft pulps. Wisconsin's Nekoosa-Edwards Paper Company built a pioneering large scale pulp bleaching installation that used chlorine in 1930, and the firm's experiments with chlorine dioxide were soon adapted to other soda and kraft pulp mills in the North America.³⁶²

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 semibleached pulp, too, as demonstrated in the tables 12 and 13. The industry averaged 8 per cent annual growth of production over quarter of century. Such growth rates increased steadily the share of bleached pulp from the total sulphate production. In 1931, bleached pulp accounted only five per cent of the annual total sulphate pulp production of almost one million tons, in 1939 one sixth, in 1947 more than one fifth of the annual

³⁶² Rydholm *Pulping Processes*, 280.

production.³⁶³ By 1958, bleached pulp accounted for one third of all sulphate pulp production, and 40 per cent if one includes the semibleached pulps, too. In part this structural change was caused by World War II. The war destroyed much of European industrial capacity, and increased the price of European sulphate pulp, prompting North American firms to enter its production. On the other hand, technological innovation underpinned this change importantly. Bleached sulphate pulps enabled kraft paper firms to substitute a wide range of white sulphite pulp papers with cheaper imitations and product innovations. As a result, the share of sulphate pulp from the total U.S. pulp production increased from 42 per cent in 1939 to 45 in 1947, and to 59 by 1958 (Table 5-1).³⁶⁴

Organization of technological learning that enabled rapid diffusion of innovation explains this extraordinary growth to a great degree. During the 1930's, specialized supplier firms developed the multi-stage bleaching technique into continuous bleaching system. The leading firms, U.S.-based Hooker Electrochemical Company, Improved Paper Machinery Company, and Swedish Kamyr Company, controlled the technology through patents and specialized organizational capabilities. Their efforts improved the consistency of bleaching systems, and they sold aggressively turn-key solutions throughout the global kraft pulp and paper industry.³⁶⁵

³⁶³ The production statistics are from: *Manufacturers 1919*, 559; *Census of Manufactures 1933*, 267; *Census of Manufactures 1947*, 318.

³⁶⁴ *Census of Manufactures 1947*, 318; *Census of Manufactures 1958. Part I.*, 26A-12; Singh, "History of Bleaching," 4.

³⁶⁵ Sidney D. Wells, "Historical Review," 8-9. In *The Bleaching of Pulp. Tappi Monograph Series, No. 10*. New York: Tappi 1953, 1-10.

Table 5-7. U.S. Production of Sulphate Pulp by Grade in 1958 and Total Production of Wood Pulp (Tons of 2,000 Lbs.)

Grade tonnage	Production	Per Cent of Total Sulphate
Bleached	4,022,901	33 %
Semibleached	707,974	6 %
Unbleached for paper	2,972,783	24 %
Unbleached for board	4,613,719	37%
Total Sulphate Pulp	12,137,377	100 %
Total Wood Pulp	20,932,808	

Source: *Census of Manufactures 1958. Part I.*, 26A-12.

The Southern firms embraced opportunities for product diversification as opened by bleaching, and rapidly shifted capacity from standardized mass product grades into more specialized ones. Bleached Southern kraft had been introduced at an experimental scale in the early 1910's, and one mill commenced commercial production in the late 1920's. Multi-stage bleaching was introduced in the large Southern kraft mills first during the 1930's.³⁶⁶

The pioneering large-scale installation of multi-stage bleaching by IP at its Moss Point, Alabama, mill constituted a defining learning experience for the firm and the industry. In 1932, the Great Depression had forced the company to shut down the Moss Point mill without plans to resume operations. Two years later, IP opened the mill as a site to experiment with the bleaching of kraft pulp and production of white kraft papers on a commercial scale. Learning from this pioneering experiment, the company retooled

³⁶⁶ R. H. Stevens, "Bleaching Southern Kraft," *Paper Industry*, Oct. 1932, 501-503; The potential product innovations associated with the bleaching of Southern kraft are discussed in John D. Rue, "Bleaching Kraft," *PTJ* 18 Feb. 1937, 79-81.

around 1940 kraft processes at its two Louisiana and Camden mills, and the Mobile, Alabama, mill followed soon.³⁶⁷

The emergence of Southern bleached kraft production dealt another blow to Northern U.S. paper firms, which reconsidered again their competitive strategies. Everest and his managers worked intensely on the future corporate strategy of Marathon Corporation and its subsidiaries beginning 1944, when they perceived that World War II would soon be over. They considered a wide array of different technologies and products for the future corporate strategy of Marathon, but I will here focus exclusively on how they regarded sulphate pulp and papers. Citing the depletion of pulp wood resources in the Lake States region, Marathon managers pursued a partial, moderate, disintegration of production processes. Though its Wisconsin kraft pulp mill had been a central element of the corporation since the 1910's, now its managers decided to relocate sulphate production capacity to Canada.³⁶⁸

Marathon built a new-state-of-the-art bleached sulphate mill at Peninsula in the Province of Ontario. The roughly \$9 million investment created a mill with 250 ton daily capacity bleached sulphate pulp that was relatively easily shipped to Marathon paper mills in the U.S. Lake States.³⁶⁹

The managers of Marathon pursued simultaneously a careful program of forward integration into paper converting, and they assigned increasing importance on product innovation in bleached sulphate papers. The Marathon Post-War Planning Committee

³⁶⁷ *International Paper Company After Fifty Years*, 66-67.

³⁶⁸ Edgar Ricker & Company, *Marathon Corporation. History and Business*. 1 Aug. 1944. DCE Papers, Box #278, Folder #4.

³⁶⁹ *Marathon Corporation. History and Business*.

stated the aim of company's investment in "research on the utilization of our new kraft pulp in our products": "Considerable work is also going to be required to determine the best method of utilization in our products of the bleached Kraft pulp which is going to be available from Peninsula. There are many places where direct substitutions for sulphite pulp cannot be made and extensive studies on pulp blends will be required."³⁷⁰

Marathon's expansion of the kraft pulp production was prompted by new bleaching methods that allowed the replacement of sulphite pulp with cheaper bleached kraft pulp. This required systematic product innovation, though, and Everest argued that with research and development work bleached sulphate pulp could be used to make traditional sulphite paper products, such as napkins. The idea would have been dismissed as absurd perhaps only few years earlier, because every papermaker identified dark color, hard strength, and odor with kraft papers, and such characteristics formed stark contrast to the sanitized marketing ideal of napkins: white, soft, and odorless. Yet Everest proposed a research and development program that specifically imitated the Kimberly-Clark Corporation's pioneering and best selling Kleenex tissues.³⁷¹

In 1945, Marathon's monthly tissue production equaled 14,000 meters, and accounted for the third largest group of papers within the company.³⁷² This share was rapidly increasing, and Marathon managers focused on forward integration into tissue conversion. They allotted more resources into research and development of the napkins, in part in an effort to be able to continue to sell napkins at a premium after the expiration

³⁷⁰ *Post-War Planning Committee Meeting*. 14 Dec. 1944. DCE Papers, Box #279, Folder #5.

³⁷¹ *Post-War Planning Committee Meeting*. 14 Dec. 1944.

³⁷² *Post-War Planning Committee Meeting*, 6-7 Sept. 1945. DCE Papers, Box #279, Folder #5.

of patents on particularly successful type of dispenser napkins.³⁷³ The company also appointed a specific committee to study and plan the growth of its converting division.³⁷⁴

Specialized bleached kraft paper and board products accounted for a large share of the Marathon Corporation's post-war success. The company's sales increased from \$43 million in 1946 to \$112 million in 1951, while earnings tripled to \$18 million during the same period. This accomplishment reflected the favorable dynamics of the whole North American kraft industry.³⁷⁵

All the leading North American sulphate pulp and paper manufacturers adopted aggressive strategies of growth during the 1950's, as their managers responded to the same dynamic forces that had prompted the reorganization of the Marathon Corporation. The rush to grow required tremendous amounts of new capital, and the pulp and paper companies flooded Wall Street with bond and stock offerings. The securities firm Smith, Barney, & Company issued a special report on the industry, stating boldly that the pulp and paper industry was the third fastest growing major U.S. industry, trailing only aluminum and natural gas in the mid-1950's.³⁷⁶

Most of the growth occurred in sulphate pulp and paper, evident in the Table 5-1., which demonstrates how absolute growth of the sulphate production between 1947 and 1958 dwarfed the declining sulphite pulp production and modestly increasing groundwood pulp production. Smith, Barney & Company's analysis of the leading North

³⁷³ *Post-War Planning Committee Meeting*, 17 Jan. 1945. DCE Papers. Box 279, Folder #5.

³⁷⁴ *Post-War Planning Committee Meeting*, 19 June 1944. DCE Papers. Box 279, Folder #5.

³⁷⁵ Smith, Barney & Co., *The Paper Industry Today*. New York: Smith, Barney & Co 1956, 109; *Census of Manufactures 1954*. Vol II. Washington: Government Printing Office 1955, 26A-9.

³⁷⁶ Smith, Barney & Co., *The Paper Industry Today*. New York: Smith, Barney & Co 1956.

American firms detailed how individual companies navigated in the midst of this unfolding structural change.

The strategies of growth adopted by the leading pulp and paper firms converged radically, as if they had emerged from a single mind. In 1954, IP entered kraft production in Canada by acquiring the local operations of Brown Paper Company for \$40 million. Within two years, the company built an integrated kraft pulp and paper mill in Canada with annual capacity of 115,000 tons, as well as 100,000 ton machine in Mobile, Alabama. In 1957, the company opened 165,000 bleached kraft pulp and board mill in Pine Bluff, Arkansas.³⁷⁷

Other leading firms followed similar strategies of growth. Mead Corporation operated kraft board mills in Tennessee, Virginia and North Carolina that totaled 625 ton daily capacity, and had several joint ventures in the kraft business. Mead operated with Container Corporation two paperboard companies in Georgia, with combined daily capacity of 1,400 tons, and with Scott Paper Company, a leading tissue paper manufacturer, a 500 ton daily capacity bleached sulphate pulp mill in Brunswick, Georgia. Mead looked to grow, too, and undertook aggressive modernization and expansion programs during the post-war years. It doubled its sulphate linerboard capacity in 1954 with a mill in Rome, Georgia, and spent between 1951 and 1955 about \$40 million in plant equipment.³⁷⁸

The world's largest producer of paper bags and paper containers, Union Bag and Paper Company, had operated a single large sulphate pulp and paper mill in Savannah,

³⁷⁷ Smith, Barney & Co, *The Paper Industry Today*, 103.

³⁷⁸ Smith, Barney & Co, *The Paper Industry Today*, 111.

Georgia, since 1936. This mill was also modernized and expanded significantly. Between 1951 and 1955, investing over \$50 millions the company increased daily capacity of the mill to 1,800 tons of paper and board, and to 2,000 by 1956. Simultaneously the company acquired Camp Manufacturing Company, a fully integrated producer of bleached and unbleached sulphate pulp, paper, and board. The Union Bag-Camp Paper Company planned to increase the Camp mill's production capacity from 375 daily tons to 600 by 1959.³⁷⁹

Smaller firms followed the giants, such as the Riegel Paper Corporation. Bleached kraft pulp accounted only for 22 per cent of its total sales of \$50 million in 1955, and company management wanted to expand that business. Planning to increase its sales in board used for food packaging, the company announced the building of a 300 ton daily capacity bleached kraft pulp mill at its main site at North Carolina in 1955. The list of companies growing through investment in latest innovations in sulphate pulp process in the early 1950's is simply too long to be exhausted here, as it included practically all the big firms.³⁸⁰

Sulphate pulp technology represented the Holy Grail for the North American pulp and paper industry to a large degree because of the availability of innovations that enabled improved productivity and product diversification. The organization of technological learning in sulphate pulp and paper process had been radically transformed since 1940. Specialized machinery supplier firms formed a relatively stable and

³⁷⁹ Smith, Barney & Co, *The Paper Industry Today*, 125.

³⁸⁰ Smith, Barney & Co, *The Paper Industry Today*, 117.

consolidated industry that increasingly assumed control of technological knowledge of sulphate pulping, and thereby dominated the process of innovation.

The North American expansion of kraft pulp production in the 1950's was importantly facilitated by a Swedish innovation, the Kamyr continuous kraft cooking system. Complementing the continuous chemical recovery cycle, continuous chemical bleaching, and continuous Fourdrinier papermaking machine, continuous sulphate cooking presented the ultimate realization of totally continuous sulphate mill. Until its introduction, kraft pulp cooking was characterized by batch production. Large pulp mills employed typically a number of large digesters that required maintenance after each cook. The continuous cooking system, by nature, eliminated such labor and improved the throughput of the kraft process. Johan Richter had pioneered the experimentation with continuous cooking of kraft pulp with a 5 ton daily capacity pilot plant in Karlsborg, Sweden in 1938. His efforts were discontinued by the outbreak of the World War II, and resumed at a small kraft mill in Fengersfors, Sweden. Soon the Kamyr Company assumed responsibility for the research and development work at Fengersfors mill, and scaled up the digester to 50 ton per day capacity.³⁸¹

One basic element of the pioneering Kamyr continuous kraft cooking system, as it was called, was a downflow digester with high-pressure feeder. The system enabled potentially significant new scale economies, and between 1948 and 1951 Kamyr installed four other systems around the world. Learning from these projects, the Kamyr engineers

³⁸¹ The development of continuous kraft cooking system is detailed in an autobiographical account by Sven Rydholm, *Continuous Pulping Processes*. New York: TAPPI 1970, 1-10. Full technical review of the Kamyr system as perceived upon its publication is. J. N. Swartz, "Equipment and Operation," 453-458. In J. Newell Stephenson, *Preparation & Treatment of Wood Pulp. Vol I*. New York: McGraw-Hill Book Company 1950, 431-662.

installed the record size 100 metric ton* daily capacity system at Wifstavarfs, Sweden, in 1952. During the next years the Finnish Joutseno Pulp Company acquired two 120 ton units. Kamyr Company scaled up the capacity of the digester system, and reached the capacity of 350 daily tons by 1955.³⁸²

The Kamyr continuous kraft cooking system quickly attracted also the attention of North American pulp and paper firms. Canadian North Western Pulp & Power Company acquired the first North American Kamyr installations by ordering two 250 daily ton kraft systems in 1955. The same year IP installed a 150 ton kraft unit at Camden, Arkansas, Gulf States Paper Company built a 350 ton kraft unit at Demopolis, Alabama, and Weyerhaeuser Timber Company added a 150 ton kraft unit at Longview, Washington. The U.S. mills alone totaled annual capacity of half a million short tons (2,000 lbs.). World-wide Kamyr installed 50 continuous cooking systems between 1948 and 1959, and its remarkable scale economies had sizeable effect on the North American pulp and paper industry.³⁸³

Kamyr Company was a particularly appealing choice of for kraft pulp firms, because it was capable of supplying complete large-scale plants on turn-key principle. The company had introduced the so-called Kamyr high-density alkali bleaching towers for multi-stage bleaching of kraft pulp, and other process innovations that completed its offerings of kraft process technology. The company successfully captured a rapidly growing share of the pulp and paper equipment business, and reached monopoly position

* Henceforth I use metric tons unless stated otherwise.

³⁸² Rydholm *Continuous Pulping Processes*, 4.

³⁸³ Rydholm *Continuous Pulping Processes*, 4-5.

in some segments, such as the continuous cooking system. For managers of large-scale pulp and paper firms that looked to expand, such as the third largest U.S. corporation, St. Regis Paper Company, Kamyr was a predictable choice.³⁸⁴

St. Regis pursued an aggressive growth strategy in the early 1950's, achieving 65 per cent increase in its sales between 1953 and 1956, reaching annual sales of \$330 that year. The Kraft Pulp and Paper Division of St. Regis had been in particular hit by the war, as its four kraft paper mills in the Eastern U.S. mixed kraft pulp from its own mill in Tacoma, Washington, and Scandinavia. In 1946, the company initiated a Southern kraft strategy by acquiring the Florida Pulp and Paper Company, thereby assuming the employment of James H. Allen, who had been the closest associate of Richard J. Cullen at IP, and built and operated several kraft mills throughout the South. Allen assumed responsibility for the kraft operations of St. Regis, and became eventually the vice-president of the company. Allen looked to acquire Southern kraft pulp and paper capacity to supply St. Regis' already strong converting plants.³⁸⁵

In 1949, the slump in demand for multi-wall bags prompted St. Regis to embark on a product diversification program in its kraft division, and to reorganize its supply of pulp. In 1954, the company announced plans for bleached sulphate pulp mill at Alberta, Canada, with a daily capacity exceeding 400,000 tons. The provincial Government of

³⁸⁴ Rydholm, *Pulping Processes*, 878-881; For a complete list of the largest U.S. pulp and paper firms by annual sales in 1953, 1955, and 1956, see: Smith, *History of Papermaking*, 539. In 1953 International Paper Company had the largest annual sales with over \$673 millions, second Crown Zellerbach Company \$287 millions, St. Regis \$200 millions, and seventh largest, Westvaco \$117 millions. Marathon Corporation ranked eleventh with its sales of \$112 millions.

³⁸⁵ Amigo and Neuffer, *Beyond the Adirondacks*, 100-101.

Alberta guaranteed a steady supply of white spruce and lodgepole pine. St. Regis also contracted with the Kamyr Company for state of the art technology for the mill.³⁸⁶

St. Regis' new mill demonstrated also how Sweden had captured the lead in the sulphate process technology. The new mill utilized the Kamyr continuous process that consisted of six-stage bleaching with chlorine dioxide, producing allegedly the brightest kraft pulp without any weakening of strength. It also marked the stabilization of the three basic technologies of modern mass sulphate pulp and paper production: The spray chemical recovery unit, continuous sulphate cooking process, and multi-stage bleaching. These technologies were controlled by specialized equipment supplier firms, such as the Kamyr Company and C-E, that did not wish to enter pulp and paper production. With this development a long wave of technological learning in the sulphate pulping reached a culmination point.³⁸⁷

Stabilization meant increased systematization of technological learning, epitomized in the disciplined style of research and development, and control of knowledge by the leading equipment suppliers. Kamyr, B&W and C-E employed large staffs of specialized engineers and patent portfolios in order to maintain a sustained, and controlled wave of technological learning. This effort also reinforced the boundary between the communities of papermakers and equipment suppliers, signified by a sharpening contrast of their respective organizational capabilities.

³⁸⁶ Amigo and Neuffer, *Beyond the Adirondacks*, 101.

³⁸⁷ For an explicit statement of the impact of the stabilization of chemical recovery, multi-stage bleaching, and continuous cooking technologies on the world pulp and paper industry, see: United Nations Food and Agricultural Organization, *World Pulp and Paper Resources and Prospects*. New York: UN and FAO 1954, 72.

Conclusions

The evolution of the North American sulphate pulp and paper industry was characterized by dramatic growth and over-capacity, and punctuated by radical technological departures that offered new scale economies. Some striking observations are obvious. The early development of the North American kraft industry differed radically from that of all the other major pulp and paper segments, where entrepreneurs and managers coupled tight control of innovation with aggressive strategies of growth. A striking feature is the comparatively slow pace by which North American mills adopted the kraft pulp process, and this lag explains to a great degree why systematic research and development of the process was practically absent in the North America until the mid-1920's.

The organization of operational and technological clusters in the kraft industry co-evolved with the competitive structure of the North American pulp and paper industry. Small and medium-sized firms in the New England and Lake States were first to adopt widely the kraft process. These mills adapted the basic manufacturing technologies to their limited operations and failed to consider alternatives with larger economies of scale potential. The division of chemical recovery technology into two distinct schools, rotary and stationary recovery furnace, demonstrated the effects of organization of the Lake States kraft industry on innovation between 1915 and 1936. The rotary recovery furnace was the traditional technology with inherently limited economies of scale, whereas the stationary recovery furnace was radical technological departure invented in the early 1910's that enabled substantial new economies of scale.

Comprehensive regional systems of innovation advanced the rotary recovery furnace technology in the Lake States, where independent kraft firms were too small to carry out substantial research and development work. The public research and development network diffused rotary furnace innovations quickly, and thus provided for that technology's sustained competitiveness. The stationary chemical recovery furnace, in contrast, was advanced in relative secrecy by a few people without large-scale research capabilities, and fell under their broad patent monopolies. These factors impeded its diffusion, slowed down the rate of innovation, and the design did not become commercially viable until much later under very different circumstances.

The effect of this organizational structure on technological learning is more obvious, when one considers the massive investment into new Southern mass production capacity by the largest pulp and paper enterprises, such as the International Paper Company, during the late 1920's. Intuitively one would expect the emergence of mass production of kraft pulp and paper to have accelerated innovation in stationary recovery furnace. Although the large scale Southern mills of IP did involve the implementation of many pioneering mass production technologies by 1931, they depended on publicly available rotary recovery technology.

Critical improvements in the stationary recovery furnace resulted from efforts to improve productivity, in particular the heat economy, of basic pulping processes in Wisconsin during the Great Depression. Collaboration between pulp and paper firms and a leading boiler manufacturer, Babcock & Wilcox, enabled the latter an entry into chemical recovery unit industry. The entry strategy of B&W was characterized by acquisition of central intellectual property rights on the technology, as well as of

commercializing of full-scale kraft recovery units on turn-key principle. Only another leading boiler manufacturer, the Combustion Engineering, Inc., succeeded in entering the market with viable imitation.

B&W and C-E practically took over the research and development work on the chemical recovery units, and diffused the technology rapidly throughout the North American pulp and paper industry. This facilitated investment into new capacity, but the expansion of the sulphate pulp and paper industry was accelerated by two other inventions, too. Specialized machinery suppliers developed continuous multi-stage bleaching that enabled product diversification for the kraft pulp and paper mills, and they successfully captured markets from more expensive white sulphite papers. In addition, the Swedish Kamyr Company developed the continuous sulphate cooking system that enabled new economies of scale. The specialized machinery suppliers controlled these technologies through intellectual property rights, and diffused aggressively the innovations throughout the global pulp and paper industry.

The combination of rapid diffusion of innovation and strong intellectual property rights had deep impacts on the organization of technological learning in the kraft pulp and paper industry, where technological and operational clusters diverged. The community of papermakers became highly distinct from those that supplied the basic manufacturing technologies. Under these circumstances, technological innovation accelerated and increased the capital intensity of the kraft pulp mills, and as William Lazonick has demonstrated in the case of the British Cotton industry, this type of

technological change favored large-scale, vertically integrated firms.³⁸⁸ Changed circumstances that required large scale organizational capabilities sounded also the death knell even for the largest firms that specialized only into kraft pulp and paper. During the pulp and paper industry merger wave in 1950's and 1960's, the leading kraft firms were consolidated into divisions of giant multi-product forests firms.

³⁸⁸ William Lazonick, "Industrial Organization and Technological Change: The Decline of the British Cotton Industry," *Business History Review* Vol. LVII (Summer 1983), 195-236.

CHAPTER 6

VERTICAL LINKAGES OF LEARNING: THE DEVELOPMENT OF MACHINE COATED PAPER, 1930-1960

Printing firms engage in collaborative research and development with their suppliers and customers, even while they resist vertical integration. A sustained wave of such collaborative technological learning between 1930 and 1960 produced the radical technological departures that laid foundation for the modern mass printing industry. A fundamental element of this transformation of American printing industry was the development of new types of machine coated papers that released the full potential of modern electric mass printing equipment. A non-existent product in 1930, the market for machine coated papers totaled the annual value of over half a billion dollars by 1963. An evolving collaborative effort of printing, publishing, and paper firms to innovate underpinned this development.³⁸⁹

Such organization of innovation continues to be critical for the sustained global competitiveness of the U.S. printing industry, but involves the problem of opportunism. As demonstrated by Susan Helper et al, pragmatic technological collaboration by a

³⁸⁹ 1963 *Census of Manufacturers. Industry Statistics*, Pulp, Paper and Board Mills, Table 6A.

complex network of firms requires managers to resolve how the gains of new knowledge are distributed.³⁹⁰ Collaborative technological learning is vulnerable for opportunism, but such behavior may be controlled by mechanisms such as intellectual property rights, long term relationships, public policies, and culture. In 1989, the MIT industrial commission blamed lagging competitiveness of U.S. manufacturing industries exactly to inability to foster this type of collaborative vertical linkages of learning.³⁹¹

Indeed, ability to foster vertical linkages of technological learning underpins the influential theory of competitiveness proposed by Michael E. Porter. Porter emphasized the importance of technological learning between related firms as a key to industrial and national competitiveness. His study of the competitiveness of the German printing press industry details how firms in printing machinery, paper, and printing industry can potentially benefit from sustained cooperation.³⁹² While academics agree on the role of innovation for sustained competitiveness of firms, industries, and regions, there is considerable debate about the optimum form of organization to induce innovation.³⁹³

³⁹⁰ Susan Helper, John Paul MacDuffie, and Charles Sabel, Pragmatic Collaborations, "Advancing Knowledge While Controlling Opportunism," *Industrial and Corporate Change*. Vol. 9, No. 3 (2000), 443-487.

³⁹¹ Michael L. Dertouzos, Richard K. Lester, and Robert M. Solow, *Made In America. Regaining the Productive Edge*. New York: Harper Perennial 1989, 99-105.

³⁹² Michael E. Porter, *The Competitive Advantage of Nations*. New York: The Free Press 1990.

³⁹³ Key works in literature are: Richard R. Nelson and Sidney G. Winter, *An Evolutionary Theory of Economic Change*. Cambridge, Mass.: Harvard University Press 1982; David C. Mowery and Richard R. Nelson (eds), *Sources of Industrial Leadership: Studies of Seven Industries*. New York: Cambridge University Press. 1999. Much of this literature explores fundamental questions of industrial organization defined in Alfred D. Chandler, *Visible Hand. The Managerial Revolution in American Business*. Cambridge, Mass.: Belknap Press 1977 and Oliver Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications: A Study of the Economics of Internal Organization*. New York, 1975. A special contribution is: Nathan Rosenberg, *Inside the Black Box. Technology and Economics*. New York: Cambridge University Press 1982.

Following Porter, scholars have examined how and to what extent firms should cooperate while pursuing innovation. David Teece and others have suggested that firms capitalize on rapid technological change best by streamlining their internal organization and by avoiding inter-firm strategizing.³⁹⁴ William Lazonick has supported this view by arguing that large vertically integrated firms have stronger incentives and thus capabilities to facilitate technological change than small and disintegrated firms.³⁹⁵ In contrast, Charles Sabel and Jonathan Zeitlin have argued that networking offers the best corporate strategy against the uncertainties presented by technological change.³⁹⁶ Paul Robertson and Richard Langlois have suggested that the ability of firms to adopt vertically integrated or networked research and development organizations varies across environments, and depend critically on the scope of innovation and the relative maturity of the industries involved.³⁹⁷ David Mowery has argued that the organization of R&D capabilities in the 20th Century U.S. has occurred simultaneously with the shaping of the boundaries of firms.³⁹⁸ The debate on innovation, structure of the firm, and organization

³⁹⁴ David J. Teece et. al., "Dynamic Capabilities and Strategic Management," *Strategic Management Journal*, Vol. 18 (1997):7, 509-533.

³⁹⁵ William Lazonick, "Industrial Organization and Technological Change: The Decline of the British Cotton Industry," *Business History Review* Vol. LVII (Summer 1983), 195-236.

³⁹⁶ Charles. F. Sabel and Jonathan Zeitlin, "Introduction," in Charles. F. Sabel and Jonathan Zeitlin, *The World of Possibilities. Flexibility and Mass Production in Western Industrialization*. New York: Cambridge University Press 1997, 1-33. The advantages of disintegrated firms and flexible production is the subject of: Philip Scranton, *Endless Novelty. Specialty Production and American Industrialization 1865-1925*. Princeton: Princeton University Press 1997.

³⁹⁷ Paul L. Robertson and Richard N. Langlois, "Innovation, Networks, and Vertical Integration," *Research Policy* 24 (1995): 543-562.

³⁹⁸ David C. Mowery, "The Boundaries of U.S. Firm in R&D," in Naomi R. Lamoreaux and Daniel M. G. Raff, *Coordination and Information. Historical Perspectives on the Organization of Enterprise*. Chicago: Chicago University Press 1995, 147-176.

of industry is indeed capturing momentum currently and - despite a recent attempt for a new synthesis is far from a settled issue.³⁹⁹

Accurate understanding of the dynamics of technological learning in the printing and allied industries is of central importance for policy makers and industry leaders who wish to foster innovation based growth. This study analyses the dynamics of collaborative innovation during the formative decades of the modern mass printing industry between 1930 and 1960 by focusing on the development of machine coated papers. The study highlights technological, legal, and economic fundamentals of firms' strategic behavior during critical periods of industry transition.

Technological Relationships between the Printing, Publishing, and Allied Industries

The printing, publishing, and paper industries established a complex industrial organization whose technological core is the printing process. Modern printing is a delicate and complex technological system that integrates a number of distinct bodies of technological knowledge, and therefore innovation requires substantial cooperation of firms in different industries. The foundation stone of the printing process are the printing presses themselves, but their performance is directly dependent on the characteristics of ink and paper. Cooperation emerges from the need to synchronize the operation of these different technologies in the printing process. In addition, the rate and direction of inventive activity was shaped forcefully by the publishing industry. Publishing firms seek competitive advantage by introducing innovative publishing products that require

³⁹⁹ Naomi Lamoreaux, Daniel M. G. Raff, and Peter Temin, "Beyond Markets and Hierarchies. Toward a New Synthesis of American Business History," *The American Historical Review* Vol. 108, No. 2 (April 2003), 404-432.

modification and improvement of the manufacturing processes of publications. These technological relationships assumed their modern shape in the late nineteenth century, and preconditioned the dynamics of innovation in the machine-coated paper in the twentieth century.⁴⁰⁰

The central technological feature of the transformation of the printing and publishing industry in the 1920's and early 1930's was the introduction of capital intensive custom-built web rotary magazine presses that mass-produced color magazines and catalogues with unprecedented economies of scale. These giant machines of the printing industry represented the third major stage in the evolution of the printing technology. The early twentieth century printing industry comprised three basic technologies that can be divided by the time of their origin and scale of production. The platen print presses embodied the oldest technology. These machines were mechanically simple and affordable, consumed paper in sheets, and were typically employed in small "neighborhood" shops for custom jobs. The cylinder presses represented the next generation in terms of scale of production, and were more technologically challenging and expensive. Cylinder presses could consume paper in sheets or rolls, and were employed for jobs large enough to realize economies of scale. The final stage of technological change was embodied in the rotary printing presses. These were the heavy weights in the world printing equipment and were employed to mass print newspapers, magazines, and catalogues. Only their application in magazine and catalogue printing is

⁴⁰⁰ I rely here on the detailed historical overview of the printing technologies offered in James Moran, *Printing Presses. History and Development from the Fifteenth Century to Modern Times*. Berkeley: University of California Press 1973; For historical review and description of printing technology in the mid-twentieth century, see: Victor Strauss, *The Printing Industry. An Introduction to its Many Branches, Processes and Products*. New York: R. R. Bowker Company 1967.

examined here. Large web fed magazine rotary presses were always custom built at the large printing plants, and the use of large rolls of paper was an important element of their economy.

Relative cheap and visually challenging mechanical color printing had been pioneered in the early nineteenth century, but the business remained dominated by small specialty production printing shops limited to batch production. The real mass production of magazines and catalogues in color was precipitated by the introduction of magazine web rotary printing presses by the leading printing machinery firms, most notably the R. Hoe Company. Web rotary printing presses were first introduced into newspaper publishing in the mid-nineteenth century, but these machines never printed in color. Magazine and catalogue printing presented further technological challenges, because the visual perfection, color printing, and folding process were central elements of product innovation. The first designated magazine rotary printing press was introduced in 1890, and two years later the first four-color rotary printing press was introduced. These machines marked a radical technological departure in the magazine and catalogue printing technology, but enabled only relatively modest boosts in the scale of production. After decades of active learning in printing technology, the industry was at the threshold of true color mass printing in the early 1930's.⁴⁰¹

The printing industry contracted all its printing machinery from specialized suppliers, and had limited capabilities in the technology. This boundary resulted in part from the aggressive strategy of the leading printing machinery firms to control critical technologies with patent portfolios. Richard Hoe created perhaps the most successful and

technologically advanced printing press firm, but was never credited as original inventor. Instead Hoe took over patents from others whenever he could and often patented improvements upon others' imperfect inventions. The successful control of technology by R. Hoe Company and some others wiped out many of the smaller firms. By the late nineteenth century a handful of large equipment builders dominated the web-fed rotary printing press industry. Innovation in the rotary printing was driven by technological ideal of mass production. As in the newspaper printing press technology, managers utilizing expensive rotary magazine presses were driven to achieve as high output as possible.⁴⁰²

The effects of technological change on the organization of the early twentieth century printing industry were dramatic. Managers of the printing industry recognized economies of speed and scale as key elements for success, and developed mechanisms to monitor and employ different technologies important for the printing process. The rationale and urgency of such response followed from the potential of innovation for established firms and industries. One industry analyst echoed wide concerns in 1933 about the effects of the new magazine web rotary printing presses: "Two million magazine or mail-order catalogues are now printed with no more difficulty than were three or four thousand a quarter of a century ago."⁴⁰³ Yet the transition into mass production of color magazines and catalogues was at its infancy in terms of business and technological knowledge at the time.

⁴⁰¹ Michael Twyman, *Printing 1770-1970. An Illustrated History of its Development and Uses in England*. London: Eyre & Spottiswoode 1970, 32-47.

⁴⁰² Moran, *Printing Presses*, 178, 192.

Innovation in the large custom-built web rotary printing presses spearheaded structural change in the whole printing and publishing industry. The giant machines replaced craft and batch production of quality color printing with mass production, and caused everybody in the business to exclaim about over-capacity. The other side of mass production was increased automation that triggered worries about "technological unemployment." R. Hoe Company and its rivals competed to build bigger, faster, and more fully automatically controlled machines that could also do more demanding quality jobs. During the 1920's the press manufacturers perfected the changing of paper rolls while the press was running, and many other similar improvements that facilitated economies of scale and cut labor costs followed.⁴⁰⁴

Technological innovation in the manufacturing processes prompted organizational innovation by the leading publishing firms. Historian Theodore Pederson has showed how the new mass production technologies caused the largest American publishing houses to centralize printing operations. During the 1920's, publishing houses such as Hearst Publications and the McCall Company relocated their printing operations from the New York area to Chicago in an attempt to cut costs. The vibrant Chicago-area printing industry was dominated by the plants of four national industry leaders, the Cuneo Press, R. R. Donnelley and Sons, W. F. Hall Printing Company and the Kable Brothers. These firms pioneered the investments in the capital-intensive magazine rotary printing presses that narrowed the gap between deadline and publication. Speedy publication ensured fresh editorial content and was an important sales factor. This carried the separation of

⁴⁰³ Elizabeth Faulkner Baker, *Displacement of Men by Machines. Effects of Technological Change in Commercial Printing*. New York: Columbia University Press 1933, 15.

the magazine production from editorial staff, which often remained in New York. Specifically, the relocation was an attempt to gain economies of scale in the national distribution costs by shipping from the heartland, but offered other advantages too. Most importantly, the printing firms were a critical component in what was perhaps the world's largest community of printing technology experts. Skilled printing craftsmen, papermakers, manufacturers of ink and printing equipment, and marketing-savvy businessmen mingled with each other in Chicago, and created an environment in which ideas and knowledge circulated smoothly.⁴⁰⁵

For this community, new rotary printing technology held great potential. The high-speed color rotary printing presses delivered unprecedented visual appeal combined with low-cost, and thus catered to a large and expanding clientele in the magazine, advertising, and catalogue industries. Despite these lucrative prospects, the initial investments in the new technology by the leading printing houses fell short of providing quick returns. Efficient employment of the new process was repeatedly frustrated by technological problems. Magazine rotary presses were developed from newsprint presses that had released tremendous economies of scale in the newspaper industry since their introduction in the late nineteenth century, but the replication of this success with glossy color appeared almost impossible in the early 1930's.⁴⁰⁶

⁴⁰⁴ Moran, 216-8.

⁴⁰⁵ Theodore Pederson, *Magazines in the Twentieth Century*. Urbana: The University of Illinois Press 1956, 100.

⁴⁰⁶ For insightful analysis of the business and cultural potential of visual design in the early twentieth century U.S., see: Jackson Lears, *Fables of Abundance. A Cultural History of Advertising in America*. New York: Basic Books 1994, especially chapters 5 and 6.

Magazine and newsprint presses shared many technological features, but differed in two critical aspects. The most important difference was in the actual printing process. Newspapers were printed with single color ink that was dried by absorption in the paper. The leading printing houses aspired to print magazines and catalogues in color, and the process of printing was thus much more complex, involving the application of ink as well as its drying on the paper with specific machinery. The second major difference was in the folding of the final product. Newspaper folding was done without binding, and was fully mechanized in the late nineteenth century. The binding of magazine and catalogue printing jobs required labor intensive collating, folding, stitching, and pasting of covers on freshly printed and cut sheets. All this was done by hand in the early 1930's. The difficulties of running fast long runs of paper through the magazine printing presses further suspended economies of scale and speed. Printers complained that existing lines of paper did not fit the new printing presses and curled, clogged, or simply disintegrated in the machine.⁴⁰⁷

The introduction of web rotary printing presses involved complex scientific and technological challenges. Catalogue and magazine printers naturally looked toward the newspaper printers as a model. The smooth operation of the mass printing process was facilitated by technological routines shared by publishers, printers, and ink and paper suppliers. These inter-industry routines had been created upon the introduction of the newsprint rotary presses in the late nineteenth century. Newspaper publishers acquired the printing machines from specialized suppliers, and then prompted the ink and paper

⁴⁰⁷ Carleton Ellis, *Printing Inks. Their Chemistry and Technology*. New York: Reinhold Publishing Corporation 1940, 216; James Moran, *Printing Presses. History and Development from the Fifteenth*

suppliers to adapt their products to the new technology. Ink manufacturers developed new liquid inks that fit the fast printing, and the paper firms perfected a new kind of paper, the “roll newsprint.” American paper makers developed a specific sulphite-groundwood cellulose mix to produce strong paper that did not clog the fast mass printing process. Newsprint was uncoated paper and its fiber composition allowed fast drying of the ink through absorption in the paper. It was delivered in standard size rolls that allowed the continuous printing of long runs instead of the traditional sheets. The introduction of magazine web-rotary printing presses presented similar need of concerted innovation, but the adaptation of involved technologies was a much more complex project than its nineteenth century predecessor.⁴⁰⁸

The magazine web rotary printing press technology thus presented a compelling window of opportunity for the managers of the printing industry, and yet they must have been conscious of the challenges involved in the investment and transition into to the new technology. The color printing presented high quality demands on paper, and even depended on the development of totally new kind of coated magazine papers that were specifically adapted to the delicate high-speed color rotary printing. Similar need of improvement was required in the printing inks.

The introduction of new printing technology opened many frontiers of innovation unexpectedly. Printing managers were the first to realize this as their efforts to run the newly installed magazine rotary presses were frustrated by problems due to paper and ink. They turned to their suppliers for the necessary improvements, and came to trigger

Century to Modern Times. Berkeley: University of California Press 1973, 173-221; David C. Smith, “Wood Pulp and Newspapers, 1867-1900,” *Business History Review* 38 (1964), 328-45.

⁴⁰⁸Ellis, *Printing Inks*, 479-480; Smith, *Wood Pulp and Newspapers*.

the development of an extended organization of technological learning that evolved through the following decades.

Promise of Revolutionary Printing Technology: Need for New Paper

Printing firms' experiences of running the newly installed magazine rotary presses were characterized by frustration in the early 1930's. The management and workers of a leading American printing house, the W. F. Hall Printing Company, observed first hand how hopes of new economies of scale were ruined by paper that clogged the printing machine and distorted visual imprint. The company operated the world's largest printing plant in Chicago, and printed annually 180 editions of catalogues and almost 190 million magazines. The president of the company, Frank R. Warren, grew increasingly worried because of problems in running the recently acquired presses. He assigned in 1932 a production engineer to study the problems in detail. The engineer identified paper as the major source of trouble, and detailed specifications and requirements of paper for the four-color rotary press printing to the Chicago office of Westvaco (henceforth Westvaco). Consuming tremendous quantities of specialized papers, the printing firm had leverage over its paper supplier. At the time Westvaco managers attempted to expand their firms' traditional markets in the East Coast, and enter the competitive Chicago market traditionally supplied by the Mid-West paper firms. The success of this strategy rested with the director of the Chicago office of Westvaco, John R. Miller, whose experience in

this position accumulated much of the skills and knowledge that eventually leveled him to the chief strategist and vice-president of the company in the 1940's.⁴⁰⁹

The production engineer at Hall summarized the quality requirements under three major points in his letter to Miller. The first one effectively encapsulated the scientific and technological challenges presented by the rotary printing presses for the printing papers. The super-imposed colors and the speed of the press required Westvaco to pay more attention to the high level of ink absorption of paper and to take care that the both sides of the paper had identical properties, the engineer wrote. The correspondence expressed a typical belief for the printing industry that the technological and commercial success of the new printing techniques was measured in terms of visual perfection.⁴¹⁰

The problems of ink absorption were further complicated by the engineer's second point, under which he provided specifications for the density of paper. Ink absorption of paper was sacrificed as the density of the paper increased, which in turn improved the quality of surface and lay of the ink. Third, the engineer required paper to be wound in rolls with uniform tension, so as to reflect the delicacy of the high-speed color printing process that was too often disturbed by curling paper. Uniform squeeze of the paper during the printing process was fundamental for the accuracy of the printed impression. Because the flatness of the paper was determined mainly by the distribution

⁴⁰⁹ *Anonymous production engineer to John R. Miller*, May 18, 1932. Westvaco Collection #1781, Box #123, Packet #16.

⁴¹⁰ *Anonymous production engineer to John R. Miller*, May 18, 1932.

of moisture, it was coupled intimately with ink absorption capacity. The list of troubles demonstrated a belief that for solutions one needed to turn to chemistry.⁴¹¹

The last item of the engineer's letter informed Miller of the challenge of making an entry into the Chicago markets. The production engineer referred as quality standard to samples from the St. Regis Paper Company, Kimberly-Clark Company, and Consolidated Water Power and Paper Company. The printing industry possessed a competitive paper supplier industry, in which firms eagerly attempted to win over accounts from each other. In a technologically stable world, where printing paper would be standardized, the supplier relationships would fit economists' predictions of transaction costs, supplier switching costs, and bargaining power. However, faced with a radical technological change that presented complex challenges to develop new kind of inks and papers, the relationships between basic users and suppliers were subject to more strategic than cost considerations.⁴¹²

The problem of the Hall Printing Company was that it could not release the potential economies of scale of its new color mass printing machines without complementary innovation in printing papers. The printer was trapped between the complementary qualities of coated and uncoated papers. Coated papers enabled visually perfect printing, but offered no economies of scale because they could not be mass-produced at competitive prices. Uncoated papers were plenty and cheap in rolls, but they did not have sufficient printing qualities. The detailed analysis of troubles with Westvaco

⁴¹¹ R.F. Reed, "Paper Requirements for the Offset," in Victor Strauss (ed), *The Litographers Manual*. New York: Waltwin Publishing Company 1958, 13:40.

⁴¹² *Anonymous production engineer to John R. Miller*, May 18, 1932. Westvaco Collection #1781, Box #123, Packet #16.

uncoated papers by the production engineer reflected this need for technological innovation.

Frank Warren understood that the perfection of the offset high speed printing process required the development of a totally new kind of paper, and therefore the problem could not be done away with simply by switching the paper supplier. He believed the paper industry was reluctant to improve its products, and promptly assumed initiative in such a venture. Inevitably, such a strategy required the Hall Printing Company to develop new capabilities in paper chemistry. In the early 1930's, Warren hired one of the leading paper chemists of his time, the technical director of the Government Printing Office, Byron L. Wehmhoff. He was assigned to solve the problems caused by lagging scientific and technological understanding of properties of catalogue and magazine papers, and to help maneuver Westvaco to improve. Wehmhoff began his career at the Hall Printing Company by analyzing existing solutions presented by Westvaco to the paper related problems with the printing process.

Warren's actions were part of much broader effort of printing and publishing industries to gain understanding and control of the technical change in printing processes in the early 1930's. Traditionally the industry had relied on contracting all its machinery, and all chemical and paper supplies. As the sources of innovation resided outside the organization of the printing and publishing industry, the firms had acquired little capabilities in underlying technologies. The introduction of the rotary high-speed presses rapidly disturbed the balance of these historical technological relationships between users and suppliers, as the managers of the large volume printing firms identified the need to coordinate innovation in paper, ink, and machinery. Standardization offered a central

method to configure the different components of high-speed printing. Industry-wide cooperation on the chemistry of new printing processes was channeled via the Printing Industry Division of the American Society of Mechanical Engineers. In late 1934, the printing industry formalized research cooperation into a Graphics Art Research Bureau, whose primary interests lay in the latest developments of offset and color rotogravure, photo-mechanics of color photography, synthetic resins, rubber, and other chemical areas. All these technologies were undergoing rapid change that potentially had dramatic effects on the economics of the printing industry, and the rationale of research cooperation was to understand and control this impact.⁴¹³

Wehmhoff's function at the Hall Printing Company was to synchronize the different technologies involved in high-speed offset printing. He translated the problems of adapting the printing machinery, ink, and paper into the language of chemistry. In addition he systematized and improved the quality of research on paper at Hall Printing Company, but this work remained limited and confined by the existing organizational capabilities of the firm. It is very suggestive that almost all the work of Wehmhoff was directed at improving the uncoated paper in order to perfect the mass color printing, and that he and the firm management failed to begin research into the future potential of coated papers. This suggests that Warren hired Wehmhoff to solve immediate practical problems, rather than to engage the talented scientist in strategic long term research and development work.

⁴¹³ J. W. Rockefeller, "Production Standards. Can They Help the Industry?," *American Printer* Vol. 102, No. 4 (April 1936), 20-21; J. W. Rockefeller, "Precision Methods Pay Even in Smaller Plant," *American Printer* Vol. 102, No. 5 (May 1936), 13-15; "Research Bureau Organized at Technical Conference," *American Printer* Vol. 99, No. 5 (Nov. 1934), 16.

In his correspondence with the Westvaco people, Frank Warren quoted at length the long chemical analyses and opinions Wehmhoff submitted to him. Warren needed Wehmhoff's expertise and credibility, because Westvaco continuously explained away quality problems in terms of highly specialized scientific and technological practices of paper testing. Warren and his employees simply lacked the capability and resources to negotiate with such arguments. Nevertheless, enough opinions were exchanged to reach an agreement that uniform quality of paper was the critical problem. This conclusion placed the testing practices squarely in the middle of the correspondence. Warren opened an important letter to John Miller in April 1934 by quoting at length Wehmhoff, who argued that specific tests used by Westvaco to determine the printing quality of paper were "of but little value in maintaining uniform quality."⁴¹⁴ Wehmhoff scrutinized in a judgmental tone a letter by Paul B. Lacy that detailed all the different testing practices Westvaco employed to standardize quality. The critical question for Wehmhoff was whether testing guaranteed the necessary standard quality of paper if performed at the paper mill or the printing plant. Westvaco's Lacy was reluctant to accept testing at the customer plant as credible, and argued that there was no scientific basis for such arrangement. Wehmhoff lamented Lacy's accompanying and belittling analysis of the testing capabilities of the Hall Printing Company by stating that they reflected a condition of the past, and not the recently improved testing laboratory. Wehmhoff reiterated the critical point of the letter: "The true value of any tester for determining printing quality of

⁴¹⁴ *Frank R. Warren to John R. Miller*, 19 April, 1934. Westvaco Collection #1781, Box #123, Packet #16.

paper cannot be made in a paper mill. The test must be correlated with actual printing results. This is what we are now beginning to do.”⁴¹⁵

Quite obviously, the relationship between the Hall Printing Company and its paper supplier was becoming increasingly tense. Acute problems with Westvaco papers at the printing plant produced a stream of telephone calls, wire telegrams, and letters. In early 1935 the vice-president of the Hall Printing Company blamed the poor and varying quality of Westvaco coated paper for serious troubles with printing processes. Hall used coated paper to include visually important inserts in the trendy *Pictorial Review* that was otherwise printed on uncoated paper. This reflected an industry practice to experiment with new technologies by dividing large jobs into smaller, technologically different, sub-jobs. This allowed the printer to try out innovative techniques first on a, but required that the different sections were collated by hand and bound together. This time the tactic backfired because the Westvaco coated paper curled badly and the printer fell behind of the delivery of some two and half million copies of *Pictorial Review*. The paper did simply not rest flat during the high speed printing process. The only option was to slow down the machinery from the normal speed, although this meant inevitably falling behind the delivery date of March sixth.⁴¹⁶

Westvaco attempted to respond to the worsening situation by placing its technical expert J. C. Reynolds at the printing plant, but instead of promptly acting on the problem, he criticized how the plant was operated. Although he admitted Westvaco had to make an attempt to get paper to lay flat during the printing process, Reynolds emphasized

⁴¹⁵ *Frank R. Warren to John R. Miller*, 19 April, 1934. Westvaco Collection #1781, Box #123, Packet #16.

⁴¹⁶ *E.F. Sweeney, Jr. to John R. Miller*, 18 Feb., 1935. Westvaco Collection #1781, Box #123, Packet #16.

problems in the printing machinery and plant organization: “The real trouble at the Hall plant is, there are too many fingers in the pie. They badly need a real printer to run their plant, and do away with a whole lot of scientific monkey-business, which slows up their operations.”⁴¹⁷

In May 1935, Peter Massey of the Hall Printing Company concluded that the problems with the printing process had reached proportions that threatened the viability of the whole business. Frustrated by the regular channels of communication with Westvaco, he wrote directly to the paper firm’s vice president, David L. Luke, Jr. The Luke family controlled Westvaco, and David Luke was destined to assume the presidency and was already de facto acting as such. Massey complained that problems with the quality of Westvaco paper cost a lot of money and were eroding the reputation of the Hall Printing Company. The letter contained an exhaustive review of problems with four months of deliveries of paper that impressed with scientific, technological, and economic details. The chief problem was the varying quality of different paper deliveries, which disturbed the delicate printing process. Westvaco people were oblivious of these problems, Massey argued:

The actual paper cost on some of these items has been presented to your representative but no action has been taken and there is too much of tendency ‘poobah’ and ‘poopoo’ such matters which finally results in considerable sales resistance throughout the organization. To check up on all of the various items

⁴¹⁷ *J.C. Reynolds to John R. Miller*, 23 Feb. 1935. Westvaco Collection #1781, Box #123, Packet #16.

and determine just how they were allocated and disposed of, would, I am sure, be of mutual benefit.⁴¹⁸

Alarmed, David Luke, Jr. responded with promise of a swift change in attitude to the printer. At the time Luke was in the midst of crafting a new corporate strategy for Westvaco and all too aware of the problems threatening his company. Numerous memos had informed Luke and other top management of Westvaco that its traditional markets such as that for bag paper were shrinking. Increasingly, paper bags were converted from fancy kraft instead of kraft paper, thus allowing visually spectacular printing. This provided a new advantage to the integrated paper bag mills of the Advance Bag Company, Thilmany Paper Company, Northern Paper Mills, and others. These leading firms had hammered down the price on fancy kraft bags within a short time. Westvaco was steadily losing its former clientele in the disintegrated paper bag converting industry. Herman Orchard complained to Westvaco that his paper bag firm, the Orchard Paper Company, could not meet the competition by fully integrated bag mills. A Westvaco employee summarized the effects of the structural change for the company:⁴¹⁹

We believe West Virginia is facing a definitive problem, and sooner or later we must face the fact that we have got to put out papers of this kind or equip somebody to meet the self-contained mill competition. We have definitively lost business in this territory which was formerly on plain Kraft and which is now on

⁴¹⁸ *Peter J. Massey to David Luke, Jr.*, 20 May, 1935. Westvaco Collection #1781, Box #123, Packet #16.

⁴¹⁹ *David Luke, Jr. to Peter J. Massey*, May 27th, 1935. Westvaco Collection #1781, Box #123, Packet #16.

fancy Kraft. And without question, New York faces the same situation. The writer knows that a great many New York department stores are using these kind of papers exclusively. Mr. Orchard states that it has become increasingly difficult to take our paper, print it, and convert it and meet the self-contained mill competition.⁴²⁰

Herman Orchard hoped to erect a bag factory at the Westvaco paper mill in Covington and turn his company around, but David Luke and his associates had already decided to retreat from the depressed bag paper business in 1934. Instead of waiting for demand to pick up for their existing paper lines, the managers of Westvaco aspired to enter new markets with more promising prospects. They observed how their big clients, the leading printing and publishing houses underwent transformation that precipitated significant change in the structure of demand structure for printing papers. Their vision was very clear: the future trend was the coated magazine and catalogue papers. Their problem, too, was clear. Westvaco lacked organizational capabilities to develop such papers, and lagged far behind competitors, the Kimberly-Clark Corporation, Consolidated Water Power and Paper, and the Mead Corporation. Moreover, the company had wasted opportunities to learn and innovate with a large entrepreneurial customer, and actually frustrated the initiatives by Hall Printing Company. Now David Luke attempted to change this attitude and began an intense effort to imitate the practices of other

⁴²⁰ *K. L. Engholm to W. H. Smythe*, 13 March, 1935. Westvaco Collection #1781, Box #110, Packet #20.

companies. Indeed, vertical cooperation between publishers, printers, and papermakers increased and accelerated innovation in the printing papers and processes in the 1930's⁴²¹

Innovation in the Magazine Business: Demand for New Printing and Paper

Technology

The opportunities offered by innovation in the printing processes differed greatly for publishing, printing, paper, ink, and equipment supplier firms. In the 1930's the most significant determinant of innovation in the mass printing processes was the emergence and success of new visual print culture that was characterized by photorealism. In his impressive study of American advertising culture, Jackson Lears has demonstrated how the new technologies of visual reproduction in the early twentieth century were coupled with mass production and circulation. The same emphasis on mass circulation applies to the structural change of the American publishing industry in the 1920's and 1930's. However, historians of visual print culture often fail to recognize that the early twentieth century "visual revolution" was underpinned by a complex wave of innovation in the printing processes. As is readily evident, mass production of visual prints continued to pose significant technological challenges in the 1930's and required significant research and development work. The entrepreneurs who spearheaded the new American visual print culture in the early twentieth century recognized technological innovation in the printing machinery, ink, and paper as central for the realization of their strategy. Publisher's demand for improved mass production of visually pleasing magazines and

⁴²¹ *J. R. Reynolds to Stevenson, Jordan & Harrison*, June 21st, 1934. Westvaco Collection #1781, Box #122, Packet #20.

catalogues dictated to a great degree the dynamics of innovation in the machine coated paper in the 1930's⁴²²

The American magazine and catalogue business underwent a structural change between 1920 and 1960 that was characterized by increased mass production and consolidation. Historian John Tebbell has argued that during the 1920's a new format of mass circulation magazines began to replace the incumbent magazines established during the magazine revolution of late nineteenth century. In 1922, De Witt Wallace created the *Reader's Digest* that evolved into the world's most widely circulating magazine, and others followed the suit. Harold Ross established the *New Yorker* and in 1923 two recent Yale graduates, Henry R. Luce and Briton Haldé launched the *Time* magazine. The new magazine format emphasized advertising revenue and placed a distinct emphasis upon the visual outlook that was accompanied by a witty and daring editorial style. Strong emphasis on visualization changed the mail-order and other catalogue business too. Yet advertising catalogue publishers had to care less about the politics of reading and looking, and could pursue economies of scale and speed more blatantly. Most successful of the new type of magazines secured often first mover advantages in brand recognition and distribution, and continued to tower over the magazine publishing industry for decades.⁴²³

⁴²² The changing visual print culture is demonstrated in the conclusive study on the subject by Jackson Lears, *Fables of Abundance. A Cultural History of Advertising in America*. New York: Basic Books 1994; A pioneering analysis of the scope and effects of new visual advertising is: Susan Strasser, *Never Done. A History of American Housework*. New York: Henry Holt and Company 1982, Ch. 13.

⁴²³ John Tebbell, *The Media in America*. New York: Thomas Y. Crowell Company 1974, 348-9; There exist numerous detailed historical description of the outlay and editorial style of the leading American Magazines. Compact, rich and accurate for the *Reader's Digest* and *New Yorker* is James P. Wood, *Magazines in the United States*. 3rd Ed. New York: The Ronald Press 1971, Ch. 18 and 19. For the *Time* one of the best is: Frank Luther Mott, *A History of American Magazines. Vol. V: Sketches of 21 Magazines, 1905, 1930*. Cambridge, Mass.: Harvard University Press 1968.Ch. 20. Comprehensive historical interpretations of the magazine revolution are: Theodore Peterson, *Magazines in the Twentieth Century*. Urbana: The University of Illinois Press 1956; John Tebbell, *The American Magazine: A Compact History*.

The magazine industry was championed by entrepreneurial industry outsider Henry R. Luce, and his Time Inc. flourished by introducing new magazines and capturing business from incumbent publishing houses. Fuelled by the success of *Time*, Luce aggressively expanded his mass publishing business through innovative combination of editorship, visual design, and distribution. The Time Inc. started from nothing in the 1920's, and generated 1.3 million dollars in revenue in 1928. The success of the Time Inc. was based Henry Luce's pioneering understanding of how technological innovation changed the production of printing. By requiring his printers to adopt the latest technology, Luce looked to simultaneously reduce the unit cost of magazine issue drastically and accomplish unprecedented visual design. In 1930, *Time* passed important milestones by printing for the first time a 60-page issue, followed by a 68-page issue, the first portrait in color on the cover, and its first maps. These innovations were enabled by the adoption of new printing technologies that began to reach critical economic threshold by the early 1930's.⁴²⁴

One harbinger of the structural change in the printing industry was the new thirty-three story building of the McGraw-Hill Publishing Company in the New York City that integrated all production phases of publishing and printing into a single plant in 1931. On the sixth floor were 25 new heavy printing presses that spearheaded the technological change in the industry. A battery of Hoe rotary magazine presses, Miehle cylinder

New York: Hawthorn Books 1967; John Tebbell and Mary Ellen Zuckerman, *The Magazine in American, 1741-1990*. New York: Oxford University Press 1991. An overview of the historiography is offered in Bea Julian, "Mass Magazines, 1900-Present. Serious Journalism or Mass Entertainment," in Wm. David Sloan (ed), *Perspectives on Mass Communications History*. Hillsdale, NJ: Lawrence Erlbaum Associates 1991, 213-229.

⁴²⁴ Robert T. Elson, *Time Inc. The Intimate History of a Publishing Enterprise. Vol One, 19230-1941*. New York: Atheneum 1968, 75, 117-118; W. A. Swanberg, *Luce and His Empire*. New York: Charles Scribner's Sons 1972. 51-56.

presses, web presses and few other ones were an integral part of the new design of the printing process that embraced mass-production. The manufacturing process of the company's thirty-four periodicals and over 14 million annual other publications were divided into functional phases at different floors of the building. The urban print plant epitomized attempts of the leading printing and publishing firms to mechanize and streamline the manufacture of books and periodicals. The production of magazines and catalogues was a particular challenge because their different sections required distinct paper and printing techniques, and the final product had always to be assembled and folded with separate machines. Typically the cover sheets required fancy outlay and paper, whereas the inside pages were by comparison visually modest and thus more easy to print.⁴²⁵

Fortune was another brainchild of Henry Luce and became synonymous with his success. The magazine spearheaded also the innovative photographic visual design of the mass circulation magazines that became more numerous in the late 1930's. Luce and his staff began the planning of *Fortune* in 1928 to celebrate the decade long economic prosperity. They chose a visually unprecedented rich format to express this intention, as well as to generate a strong stream of advertising revenue. Instead of simply printing announcements by advertisers, the *Fortune* staff designed advertisements placed in it. The integration of advertising design and sale of promotional space reveals how the

⁴²⁵ "New McGraw-Hill Plant is Last Word in Scientific Planning," *American Printer* Vol. 92. No. 6 (June 1931), 36-43. For similar trend in other line of products, see: Robert F. Salade, "How Daily and Weekly Telephone Directories Are Produced," *American Printer* Vol. 94, No. 4, 30-33.

editorial staff took an uncompromising approach to the visual design of the new magazine.⁴²⁶

The grandiose design of the magazine involved costly printing, which was paid for with the unheard price of one dollar per issue when most magazines, such as the *Time*, sold for fifteen cents. Luce contracted Thomas M. Cleland, one of the America's most distinguished typographers, to perfect the design of the magazine, and he chose to pursue a classic, elegant, and costly style. Cleland specified 18th century Baskerville as the body type and contracted the English Monotype Company to manufacture it. The text was printed in letterpress and illustrations reproduced using a sheet-fed gravure printing press on "wild wove antique" that eliminated the glare of usual coated papers. The cover sheet was almost as thick as cardboard and had to be gathered and sewn by hand.⁴²⁷

Printing of the first issues of *Fortune* was a craft-based, labor intensive process. Only one printing plant in the United States, the Osborne Chromatic Gravure Company in East Orange, New Jersey, could print in the specified gravure style. The printing process involved a three-color, sheet-fed gravure press, then another press printed the monotone pictures, and each side of the sheet had to be run separately. The antique paper stock warped and shrank, forcing the printer to stop presses and make adjustments frequently. The production averaged eight thousand copies in one eight-hour shift. The ready pages were trucked to the Cuneo Eastern Press in Brooklyn, where letterpress, borders, text, and cover –that often required seven different runs- were printed.⁴²⁸

⁴²⁶ Walter A. Gaw, "The Making of 'Fortune'," *American Printer* Vol. 95, No. 6 (Dec. 1932), 27-30.

⁴²⁷ Elson, *Time Inc.*, 134-135.

⁴²⁸ Elson, *Time Inc.*, 135.

Such a printing process drained profits from *Fortune*, and the Time Inc. management rushed to examine ways to improve productivity. The publisher acquired specialized offset printing process –sadag gravure- with cutting edge German presses to manufacture *Fortune*, but the process was immediately “faced with seemingly unsolvable problems.” The printing firm now initiated cooperation between different suppliers. Time Inc. also contracted the Sorg Paper Company from Ohio to develop a more suitable paper for the offset printing process. Yet the quality of paper remained insufficient to satisfy toward conflicting demands of visual quality and mass production. As *Fortune* headed toward seemingly unavoidable failure, Luce and his associated initiated a new research and development project with one of the leading coated paper makers, the Champion Coated Paper Company. The crash program produced a new coated magazine paper that replaced the Sorg paper by 1932. The Champion paper was lighter, easier to fold, enabled high quality visual printing, and did not clog too easily the printing press. The new printing paper allowed the integration of the whole printing and binding process into the single plant of the Jersey City Printing Company in the same year.⁴²⁹

Adoption of the latest mass color printing technology and cooperation with paper and ink suppliers formed the foundational of success for *Fortune*. In a bold and risky fashion *Fortune* had based its marketing strategy on the successful pairing of mass production and cutting edge visual design before this was technologically possible and economically feasible. In the magazine industry others looked at awe as *Fortune* skyrocketed in the midst of the Great Depression, increasing its subscriptions from

⁴²⁹ Walter A Gaw, “The Making of ‘Fortune’,” *American Printer* Vol. 95, No. 6 (Dec. 1932), 27-30; M. Raoul Pellissier, “What’s New in Sheet-Fed Photogravure?,” *American Printer* Vol. 95, No. 6 (Dec. 1932), 20-23.

34,000 in 1930 to 139,000 in 1936, as well as increasing its advertising revenue from 427,000 dollars to almost two million in the same period. Henry Luce was able to coordinate a wave of technological innovation that restructured the publishing and printing industries, and the managers of Time Inc. continued to emulate the concept.⁴³⁰

Time Inc. management monitored carefully technological change that potentially changed the ways magazines were produced. The experience with *Time* and *Fortune* had convinced Henry Luce of photojournalism as the emerging trend of the magazine business, and he encouraged experiments with it in his magazines. Another result of these routines was the diversification into the news film industry with the brand name *March of Times*. On Luce's order the *Time* magazine published in 1933 its first major photographic feature, an eight-page layout on the London Economic Conference. Such experimentation was more easily carried out in *Fortune* since it was manufactured with more advanced printing technology. In an important way *Fortune* facilitated the development of American photojournalism, too. Its potential prompted the enterprising Henry Luce to formally propose in June 1936 his managers the introduction of a magazine that he planned to be:⁴³¹ "A bigger and better collection of current photographs than is available in all the current magazines plus all the Sunday gravure supplements combined. Altogether about 200 photographs with full explanatory captions."⁴³²

The plan would be realized in 1936 with *Life*, the first mass circulating magazine built solely on the idea of photojournalism. The new magazine was planned in effect

⁴³⁰ Elson, *Time Inc.*, 269-271; Peterson, *Magazines*, 226.

⁴³¹ Tebbell and Waller-Zuckerman, *Magazines in American*, Ch. 17; Peterson, *Magazines*, 315.

⁴³² Quoted in Elson, *Time Inc.*, 275.

around three revolutionary views of the magazine business. First, it employed the latest photograph and printing technology to achieve high quality photo printing at unprecedented unit price. Second, the pricing of the magazine was not based on the traditional model, according to which subscription and newsstand sales generated enough revenue to almost break-even and advertising revenue the profits. Instead, Luce reversed this pricing scheme. He argued that subscriptions should generate 1.3 million dollars of the planned 3 million dollars in revenues, and advertising the rest. The magazine was priced low at ten cents in attempt to maximize circulation. Third, the editorial design of the magazine reversed the functions of written text and visualization. In *Life* photographs conveyed the news, while written text was only an additional illustration, Luce and his associates argued.⁴³³

Luce and his closest associate, Charles L. Stillman, were personally in charge of the design of the magazine. *Life* was prepared simultaneously and independently of the other pioneer of photojournalism, *Look*, which grew out from the rotogravure section of the *Des Moines Register and Tribune* newspaper. The two magazines differed in important respects, however. The decisive technological difference between the *Life* and *Look* was the approach to visual design. *Look* was printed on relatively cheap uncoated paper as its publishers emphasized less visual perfection.⁴³⁴ Henry Luce, on the contrary, insisted on visual perfection and reserved 2.2 million dollars of the publication budget to paper and printing, whereas editorial expenses accounted only for 250 thousand dollars.

⁴³³ Elson, *Time Inc.*, 276.

⁴³⁴ Peterson, *Magazines*, 317.

Despite of such investment, the most difficult task in the making of *Life* was to meet his requirement of “quality reproduction of photographs on coated paper”.⁴³⁵

Luce was aware of the paradox that the printing technology enabled his innovative magazine format, but problems with the printing papers potentially ruined economies of mass production. Coated paper was practically impossible to purchase in rolls in 1936, because typical visually high demanding magazines were printed on sheet-fed presses in relatively small numbers. Champion Coated Paper Company could not supply *Life* with paper, and Time Inc. turned to the Mead Corporation that supplied *Time* with paper. Mead agreed to supply coated paper suitable for high quality printing in rolls, but at relatively high cost. Stillman examined the reasons for such a high price, and learned that the coating process used by Mead required each side of paper to be treated separately in one continuous operation. Worried about the paper supply, Stillman contracted with Mead for a research and development project focused on new coating method, which contributed to the introduction of the Mead Enameline coated paper.⁴³⁶

The printing of *Life* showcased the challenges of the revolutionary magazine business format. It required extended cooperation between the publisher and the company it contracted for printing, the Chicago based R. R. Donnelley & Sons Company. Technological problems with the high speed magazine rotary printing process forced the publishers, printer, and the paper and ink suppliers to improvise innovative solutions that maintained profitability. Stillman decided to print the experimental “dummy” version of the magazine on two presses formerly used to produce mail-order catalogues at the

⁴³⁵ Elson, *Time Inc.*, 283.

⁴³⁶ Elson, *Time Inc.*, 284.

Donnelley plant in Chicago, but these machines had to be adapted to the new quick-drying ink necessary for economic printing of photojournalism. Just two weeks before the deadline for the “dummy” issue, the printing plant staff informed Time Inc. management that continuing problems with the two presses would prevent a full delivery. New printing machinery was ordered immediately, but as a first-aid the company relied on additional costly rotogravure and sheet-fed presses.⁴³⁷

Despite the extended experimentation with the printing process, production of the first real number of *Life* was far from true mass production of a sort necessary to realize Luce’s business plan. When four rotary presses at the Donnelley Chicago printing plant began to roll the magazine, it took an extra six hours to reach the desired quality of printing. The collating of the twelve sections of the magazine proved unexpectedly the critical bottleneck of the production process. Four teams of girls first collated the sections, which were then fed into machines that bound the magazine together. The slow progress of their work built a sense of emergency. Eventually Donnelly management shuffled labor from other jobs to process *Life*. Utilizing all available labor at the huge printing plant, the production averaged seven thousand copies an hour. This was a rate that ran 50,000 copies behind the schedule and desperately too slow to produce the full print of 466,000 copies of the first issue in November 1936.⁴³⁸

Demand for *Life* exceeded all expectations. The first issue and many subsequent ones were sold out in record time. Printing technology simply lagged behind the mass magazine revolution pioneered by Henry Luce and his associates. Time Inc. management

⁴³⁷ Elson, *Time Inc.*, 285.

⁴³⁸ Elson, *Time Inc.*, 296-7.

was trapped between soaring circulation and printing problems. The company's historian Robert Elson has asserted that it was impossible to produce more copies. The pre-publication plans for *Life* called for the weekly production of 400,000 copies in 1936, and one million in 1939. With this pace of printing the machines ran constantly and were stopped only to change plates for the next issue. The printing process involved heat drying of the ink, and if the paper web in the high-speed press stopped –as it frequently did- it caught fire. The shortage of paper presented another problem for the mass production of magazines. Stillman had contracted Mead Corporation for 10 thousand tons of coated paper at the price of \$98 per ton, but within six months of the first issue he projected a demand of 40,000 tons in 1940. Mead and other paper companies did not have the capacity to meet such a demand. The supply was so precarious that the production staff of *Life* leaned out their office windows and count if the freight cars arriving at the Donnelley printing plant were sufficient to keep the presses going.⁴³⁹

Technological bottlenecks in the printing process presented the most serious problems for Luce's revolutionary business plan. Over sixty per cent of expenses of associated with *Life* came from paper and printing. Luce had emphasized advertising revenue instead of subscription or newsstand sales, and therefore the cost of paper and printing. This was bad news for Luce, because he had fixed the price of advertising the time of contracting and was not tied into unexpectedly rising circulation. Luce responded to this by announcing in December 1936 the doubling of advertising prices in the beginning of the following February. However, many pre-publication contracts included the privilege of ordering additional space at the original rates. Luce was locked in a

⁴³⁹ Elson, *Time Inc.*, 301.

situation where the soaring circulation and the increasing advertising deepened his losses.⁴⁴⁰

Time Inc. managers were desperate to turn around the economics of miraculously successful *Life*, and therefore reconsidered the organization of the magazine's manufacturing process. An attempt to improve the efficiency of the printing process was natural because it accounted for such a large share of the costs. Charles Stillman decided to persuade *Life*'s paper suppliers and printers into a new kind of relationship. He devised a plan that shared savings that resulted from improved productivity. Time Inc. had invested in total five millions in the introduction of *Life* within one year from the first issue. During the same period the plan induced three and a half million dollar in investment into new machines by the paper firms, and two million spent by printing firms on new equipment.⁴⁴¹

The search for improved efficiency prompted Stillman to learn more of the science and technology of paper making too, and he discovered that a number of firms were actively developing machine coated printing papers. Yet, such efforts were significantly impeded by the Great Depression, but this fact only gave an additional advantage to Stillman who searched for bargain priced innovation. Stillman discovered that the Consolidated Water Power & Paper Company owned critical patents by Peter J. Massey for the machine coating of paper. Massey was originally a printer with the A. F. Hall Printing Company in Chicago, where he had learned the offset printing technology. Massey devised a process to apply the offset printing method to the machine coating of

⁴⁴⁰ Elson, *Time Inc.*, 301-302.

⁴⁴¹ Elson, *Time Inc.*, 301-302.

paper. The machine coater was installed on the paper machine of the Bryant Paper Machine in Kalamazoo, Michigan, at a cost of \$150,000. This was probably the first machine coating paper machine in the U.S. Massey introduced his idea to the Consolidated, which installed it at its mill in Wisconsin Rapids. The cooperation of Massey and Consolidated produced improvements and more patents, and Consolidated's annual production of machine coated paper skyrocketed from nothing in 1933 to almost five tons in 1935, and twenty-eight tons in 1937.⁴⁴²

The technological features prompted Henry Luce to cherry pick Consolidated from a narrow pool of firms that could manufacture machine coated paper in the 1930's. Others included incumbent book and printing paper firms. The Kimberly-Clark Corporation had developed and patented, in some collaboration with the Mead Corporation, a novel roll-coater known as the KCM roll coater. Gerald Muggleton at the Combined Locks Paper Company had developed the first double- and triple coating machine, but it proved only marginally successful in the long run. The KCM and Combined Locks coaters allowed only slow production speed, and required the use of an expensive mix incorporating groundwood and sulphite pulp. These technological features of manufacturing process increased the price, and therefore Time Inc. managers dismissed them as too costly.⁴⁴³

The Consolidated process, on the contrary, was relatively fast and produced cheap machine coated magazine paper. It used only cheap ground wood pulp whereas other

⁴⁴² For the details see testimonies in *Consolidated Water Power & Paper Company et al v. Kimberly-Clark Corporation*, 107 F. Supp. 777 (1952).

⁴⁴³ George L. Booth, "Why Blade Coating – A Review of Coating Processes," in *Blade Coating Seminar*. Atlanta, Tappi Press 1990, 1-10.

machine coated paper firms applied solely or large quantities of costly sulphite pulp. Competing papermakers complained that the groundwood paper did not adapt to high quality printing jobs. Consolidated enjoyed a tremendous success with the Time Inc., and eventually some 95 per cent of its mill capacity was tied into the production of 80,000 tons of machine coated magazine paper in 1940. In fact, the success was based on the cooperative effort of the Time Inc. and Consolidated to improve the printing quality of the groundwood machine coated paper.⁴⁴⁴

Charles L. Stillman contracted the Consolidated for a research and development program that attempted to perfect the drying of ink on the paper. Due to this research program the printing quality of the groundwood machine coated paper improved enough to prompt Stillman in May 1937 to contract Consolidated for over 40,000 tons a year with a long term commitment of 17 million dollar value - the largest contract Time Inc. had ever done. The program reduced the price of Consolidated machine coated paper from 100 dollars per ton in 1937 to 88 dollars in 1940. Against the success of this cooperation, Stillman credited himself for the new kind of coated paper, and claimed that "*Life* was the midwife for long overdue children of other people's inventive genius." The bold statement reveals how a extraordinary phenomena Time Inc. was in the publishing industry in the 1930's. The pace of innovation in the printing paper industry was slow in part because the magazine business was so depressed.⁴⁴⁵

The urgency to perfect mass production of *Life* had created close relationships between the publisher and its paper suppliers. Yet, the publisher was careful not to trade

⁴⁴⁴ For detailed production statistics on machine paper production in the late 1930's, see: *Allied Paper Mills v. Federal Trade Commission*, 168 F.2d 600 (1948).

profitability for novelty, and began to foster a competitive pool of paper suppliers. In 1939 Stillman contracted the Champion Paper and Fiber Company for a long-term delivery of paper made from Southern pine. The Champion management planned to build a new paper mill close to its Houston bleached-pulp mill. To finance the mill the Champion management asked Time Inc. to invest 1.75 million dollars in its 6-per cent Preferred stock. Stillman persuaded his board to invest one million dollars that was enough in his view to guarantee the continuation of the Champion plan. The maturation of machine coated printing paper technology allowed Time Inc. now “supplier switching”-tactics that controlled the price of paper.⁴⁴⁶

The Champion plan signified a turning point in the relationship between Time Inc. and its paper suppliers. As the machine coated paper technology matured and stabilized, the publisher traded the feverish quest for innovation for efforts to standardize the magazine paper. This behavior reflected the awareness of Time Inc. management that the pool of potential suppliers was inherently limited, because machine coating of paper required very specific capabilities. Moreover, on the contrary of what Charles Stillman claimed, the leading paper firms developed actively machine coating technologies and had secured broad intellectual proprietary rights that potentially impeded competition.

Controlling Innovation in the Magazine and Catalogue Paper Industry

The developments in the magazine and catalogue industries during the 1920’s and 1930’s presaged a significant structural change in demand. The leading pulp and paper

⁴⁴⁵ Quoted in *Time Inc.*, 310.

⁴⁴⁶ Quoted in *Time Inc.*, 459.

firms did not respond to these prospects with intensive programs of research and development, but chose to innovate in a very cautious style. Selected firms with experience in the manufacture of the book paper did develop machine coated paper technologies throughout the 1930's, but even then they were always looking for partners to share costs. This approach characterized the cooperation between Time Inc. and the Mead Corporation, Champion Coated Paper Company, and Consolidated Water Power & Paper Company.

The managers of the Westvaco were caught off guard when its fiercest competitors locked in a high volume publishing firm as a customer through cooperation and innovation, while their own organization continued to ignore and downplay identical opportunities. Westvaco was a pioneer book paper firm in the U.S. and had ever since been the leading firm in tonnage. Yet, in the early 1930's innovation appeared to reduce the firm to obscurity. Alarmed, David Luke recognized the urgency of a sweeping organizational change at the company. By 1934 he contracted R. Hazen to analyze the ability of the firm to innovate and recommend improvements. Hazen maintained that a systematic research and development department was the most efficient method to arrive at the new products the company sought. The study urged managers of Westvaco to study seriously how other firms innovated, and establish a specific development department with competent staff.⁴⁴⁷

⁴⁴⁷ R. Hazen, *Suggested Procedure For Finding New Products Or Uses*. Sept. 15, 1934. Westvaco Collection #1781, Box #148, Packet #6.

Table 6-1. U.S. Patents on Coating of Paper, 1930-1959

Years	Patents
1930-1939	72
1940-1949	102
1950-1959	173

Source: Jack Weiner and Jerry Byrne, *Coating Equipment and Processes*. Appleton: The Institute of Paper Chemistry 1962, 176-178.

Falling behind in research and development in the 1930's made Westvaco vulnerable to the increasing patent portfolios of its competitors. Other leading book paper firms raced to file and acquire patents on coating of paper in order to diversify, evolve into new markets, and prevent competitors from following. Westvaco, on the other hand, was just beginning to recognize the strategic value of systematic research and development, and product diversification. Hazen's study was a first step in that direction.⁴⁴⁸

Westvaco was a late comer in the race, and trailed far behind the Kimberly-Clark Company, Mead Corporation, Champion Coated Paper Company, and the Consolidated Water Power & Paper Company. David Luke explored the patent agreements between these leading firms and innovators in November 1934, while secretly asking his aides secretly to investigate ways to invalidate patents held by the Mead Corporation.⁴⁴⁹

Luke's efforts to enter the machine coated paper industry faced mounting obstacles when the Kimberly-Clark Company and Mead Corporation established a jointly owned KCM Company to pool their patents on the machine coated magazine papers. The two leading firms now openly cooperated in the development of papers for the high-

⁴⁴⁸ Hazen, *Suggested Procedure*.

speed rotogravure and offset printing presses, and Luke was pushed further aside in the competition. The pooling of patents potentially amplified already strong dynamics of concentration in the machine coated paper industry. The Temporary National Economic Committee estimated in 1937 that the four largest machine coated firms, Champion, Consolidated, Kimberly-Clark, and Mead, controlled some fifty percent of the markets in machine coated free from groundwood, and almost all of the machine coated paper containing groundwood.⁴⁵⁰

Realizing the advance positions of his competitors, David Luke devised a dual strategy in order to succeed in the machine coated paper business. He led a sweeping organizational change within the West Virginia Pulp and Paper in order to foster its capability to innovate. Second, Luke began to maneuver with the patent situation. He entered prolonged license negotiations with the holders of the leading patents, while simultaneously trying to infringe and invalidate the very same patents. The pairing of patent contracting and development of new organizational capabilities were complementary tactics.

The most dramatic move of Luke was to hire Byron L. Wehmhoff away from the A. F. Hall Printing Company in 1936 to create and develop testing, research, and development routines at Westvaco. At the book paper firm the renowned paper chemist continued to improve its existing line of uncoated magazine and catalogue papers for mass printing presses, but more important was his responsibility to enable the

⁴⁴⁹ *David Luke, Jr. to John R. Miller*, 10 Nov., 1934. Westvaco Collection #1781, Box #110, Packet #20.

⁴⁵⁰ *John R. Miller to David Luke, Jr.*, 12 June, 1935. Westvaco Collection #1781, Box #110, Packet #20; The Special Committee to Study Problems of American Small Business. United States Senate. 79th Congress, 2nd Session. *Survival of Free Competitive Press*. Senate Committee Print No. 18. January 2, 1947. GOP: Washington 1947, 9-10.

diversification into machine coated papers. Wehmhoff began his career by examining monthly all the mills of the Westvaco, as well as by touring the customer printing plants. Based on these visits he compiled a detailed report that suggested scientific and technological improvements on the observed problems. Over time the tone of these reports became more strategic, as Wehmhoff recognized that the structural change in the printing industry was catching momentum.

Wehmhoff compiled his first monthly report in January 1936. It was, like all the subsequent ones, addressed to John R. Miller and passed on to David Luke. Wehmhoff brought to Westvaco a unique combination of systematic scientific thinking and an ability to adopt the perspective of customer printing plants. He was charged to collect information on paper quality at all the company mills and to produce coherent and comprehensive responses to any potential problems or challenges. When rotogravure printing firm complained of the paper quality of Westvaco's Tyrone mill production, Wehmhoff ordered chemical laboratory tests of the paper. Having read the test results, the paper chemist fixed the problems by increasing the absorbency of concerned paper.⁴⁵¹

At the Mechanicsville mill the problems were more numerous, but more important was his study of the comparative printing qualities of the Mead, Fraser, and Westvaco papers upon the request of a client. Westvaco paper lagged behind others, Wehmhoff concluded, and he outlined a program of improvements. A review of problems at the Piedmont, Williamsburg, and Covington mills followed, in which Wehmhoff analyzed in detail complaints by big customers, such as the Chicago Rotoprint, Cuneo Printing Company, Webb Publications Company, and Hall Printing Company. Again the

chemist responded with testing, and recommended changes in the production process.

Wehmhoff was now in charge of research and development at Westvaco, and the lack of previous routines required him to create and introduce them at the mills.⁴⁵²

These changes improved Luke's ability to contract cutting edge machine coated paper technologies. In summer 1938 George W. Mead offered Luke a license agreement on the Bair Color Pan patent -held by the KCM Company- with price of two dollars per ton of machine coated paper, and among other conditions proposed the division of markets and fixing of prices within the limits of antitrust laws. The patent of Thomas E. Bair for the "color pan" described a way to add the coating mixture, typically chalk and dyes, through the guiding wire of the Fourdrinier machine, and was considered by the industry as one of the most important ones. Yet, the high fee and unclear status of the KCM patents prompted Luke to explore the issue further. Luke suggested to his managers that the reason behind the licensing proposition was the attempt of Mead and the managers of Kimberly-Clark Company to end the patenting race:⁴⁵³ "Mr. Mead thought that it might be worthwhile to reconsider the value of the patents on the basis that it might be as well for several of us who are doing a fair amount of development work to cooperate a bit in this direction."⁴⁵⁴

Mead's proposition may very well be interpreted as an attempt to pool the critical technologies in order to gain control of the emerging markets. The KCM Corporation was

⁴⁵¹ *Byron L. Wehmhoff to John R. Miller*. 31 Jan., 1936. Westvaco Collection #1781, Box #124, Packet #19.

⁴⁵² *Byron L. Wehmhoff to John R. Miller*. 31 Jan., 1936.

⁴⁵³ *George W. Mead to David L. Luke, Jr.*, 10 June, 1938; *John R. Miller to David Luke, Jr.*, June 12, 1935. Westvaco Collection #1781, Box #110, Packet #20.

a nucleus of such pool, and entry of new firms would have strengthened it. Westvaco and similar firms had to consider carefully the bid for entry into the cartel, and this required a broad examination of the whole machine coating technology. Luke asked Mead for more time to consider the proposal, and studied whether Wehmhoff's research and development work on machine coated papers would have offered another option. Mead grew impatient with Westvaco and stated that if Westvaco refused to cooperate on the matter, he would demand licensing fees or sue the company for patent infringement. Luke was vulnerable to such demands because his company knowingly infringed the Bair patent. He began to draft a defense with other managers.⁴⁵⁵

Westvaco began immediately to replace the Bair Color Pan at its mills with an alternative solution defined in an expired patent granted to a George Wheelwright, a notable Wisconsin paper manufacturer.⁴⁵⁶ The Wheelwright machine coating method was first installed at the company's Southern mills at Tyrone and Piedmont, and Luke began to consider a tactic that would not alienate Mead and push Westvaco "too far from the party." A few years later, however, the Mead Corporation would take over the Wheelwright Paper Company. Meanwhile, Luke deepened exchange of information with the Consolidated Paper Company, which was pioneering experiments on light-weight coated papers, and in a final turn prepared to contract patents from Peter J. Massey.⁴⁵⁷

⁴⁵⁴ *David L. Luke to E. S. Hooker*, June 29th, 1938. Westvaco Collection #1781, Box #110, Packet #20.

⁴⁵⁵ *David L. Luke to E. S. Hooker*, June 29th, 1938; *David L. Luke to George W. Mead*, June 30, 1938. Westvaco Collection #1781, Box #110, Packet #20.

⁴⁵⁶ *David L. Luke to E. S. Hooker*, 30 June, 1938. Westvaco Collection #1781, Box #110, Packet #20.

⁴⁵⁷ *David L. Luke to Paul B. Lacy*, 30 June, 1938. Westvaco Collection #1781, Box #110, Packet #20.

The all groundwood pulp machine coated paper produced with the Massey method had a great record with the Consolidated, and some of the leading Chicago printing firms. The problem for Luke was that the Westvaco had followed since its incorporation the strategy of fully integrated production of book papers based on sulphite pulp. The retooling of Massey process into sulphite process was difficult, as was the switching of sulphite mills into the production of groundwood pulp paper.⁴⁵⁸

Luke took time to examine the Massey patents carefully. He concluded that they were a good bargain because the inventor was desperate to pay inheritance taxes. The inventor explained to Luke that his license negotiations had been fruitless with the Kimberly-Clark and Mead for various reasons and therefore offered an exclusive license for Westvaco at a fee of one dollar per coated paper ton. The Massey patents were an interesting option for Luke who tried to catch up with rivals, but we do not know if Westvaco actually took a license. In any case, we may be sure that Massey didn't mention the central reason for his urgent need to license the patents. Massey machine coated patents were commonly believed to be strong and fundamental. In fact they were weak and Kimberly-Clark opted to infringe them instead of paying licenses. It could do so because it believed that by litigating Massey risked courts to invalidate the patents, as eventually happened in 1952.⁴⁵⁹

The alternative to contracting innovations from outside sources was to develop new products independently. The responsibility for innovation at Westvaco rested with

⁴⁵⁸ *David L. Luke to John R. Miller*, 20 Aug., 1938; *Francis G. Rawling to David L. Luke, Jr.*, Aug. 31, 1938. Westvaco Collection #1781, Box #110, Packet #20; Peter J. Massey, U.S. Patent No. 1,921,368 and 1,921,369.

⁴⁵⁹ *Peter J. Massey to David Luke, Jr.*, 20 May, 1935. Westvaco Collection #1781, Box #123, Packet #16.

Byron L. Wehmhoff. Despite of all the improvements the company had made during the 1930's, Wehmhoff had an alarming message to convey from the customers to his managers in December 1938:

All our principal competitors have good machine coated papers now on the market, and the sales department has no doubt been asked the same question as put up to me at Donnelley's recently: 'When is West Virginia coming to life and going to produce a good machine coated sheet?' I see more and more of this paper in printing plants every month. Some of it replacing Marva sheets, and others on jobs we might have got if there had been no machine coated competition. I do not want to be a 'crepe-hanger' but we are falling behind the procession in respect to machine coated papers, and I have seen nothing at the mills that would indicate we are much ahead of where we were two years ago. In the meantime the use of this kind of paper is growing rapidly and our competitors have something to offer.⁴⁶⁰

The last item Wehmhoff mentioned referred to the new wave of technological innovation in the printing industry that was rapidly changing the demand structure for magazine, catalogue, and printing papers. The large printing firms, such as the Cuneo Press, Donnelley and Hall Printing Company, were changing the way they applied ink on the paper. This change was to a great degree triggered by the introduction of new kinds of inks, in particular the so called heat-set ink that was particularly developed for the web

presses. The installation of the new heat-set ink process and its operation was relatively costly, and beyond the reach of others than the largest firms.⁴⁶¹

The new technology was an integral part of Henry Luce's revolutionary business concept of photojournalism. The first printing of the *Life* in 1936 had employed new quick-drying ink that required the design and construction of new type of a printing press. Experts estimated that it took one year to engineer and build such a machine, but instead of waiting Luce pushed for another crash program. Management at the Donnelley printing plant installed improvised gas-fired heaters on the printing presses in order to accelerate the drying of ink. Two years later, however, specialized machinery suppliers provided routinely such heat-dryers, Wehmhoff reported.⁴⁶²

Heat-set inks improved the printing process by simplifying the delicate drying phase. Drying of the ink affected greatly the quality of print, and was influenced by the relative humidity of the printing room, amount of acid in the press fountain water, and by the qualities of paper. Ink dried faster on the uncoated than on coated paper. Also, the higher the pH of the coating on paper, the better the ink dried. Heat-set inks simplified this drying process because they didn't involve oxidation, and thus they were not at all affected by relative humidity, press moisture, the pH of the press fountain water or the

⁴⁶⁰ Byron L. Wehmhoff, *Report on work from December 1st to 25th 1938*. Westvaco Collection #1781 Box #124 Packet #19.

⁴⁶¹ Wehmhoff, *Report on work from December 1st to 25th 1938*.

⁴⁶² Elson, *Time Inc.*, 284; Wehmhoff, *Report on work from December 1st to 25th 1938*.

characteristics of paper. Only the largest printing firms could afford the high capital intensity of the heat-set ink process.⁴⁶³

According to Wehmhoff, the cold-set ink under development by the International Printing Ink Company had potentially similar effect on the printing industry. Cold-set ink could be applied to both sheet-fed and web-presses. The cold-set ink was distributed in solid form but kept liquid during the printing process by electrically heating the ink fountains, oil rollers and plate cylinders. The cold-set ink dried immediately at room temperature, and thus simplified the drying process significantly too. Its operation and installation was much lower than that of the heat-set ink. Because it was also adaptable to sheet-fed presses, the cold-set ink was probably going to spread rapidly within smaller printing firms too, Wehmhoff argued. He predicted a quick change in the demand structure of Westvaco papers:⁴⁶⁴

The widening use of heat-set inks and the probable wider use of the cold-set inks would indicate that the use of carbonate papers like Marva, has reached, if not passed the zenith. These absorbent papers were the answer to high speed quality publication work on web presses as long as inks were all of the oil base type formerly used. Since these new inks can be dried between the first and second impressions, the absorbent qualities of carbonate filled papers are no longer of supreme importance when such inks are used.⁴⁶⁵

⁴⁶³ R. F. Reed, "Lithographic Ink Fundamentals," in Victor Strauss (ed), *The Lithographers Manual*. New York: Waltwin Publishing Company 1958, 13:1.

⁴⁶⁴ Wehmhoff, *Report on work from December 1st to 25th 1938*.

⁴⁶⁵ Wehmhoff, *Report on work from December 1st to 25th 1938*.

Employing the new ink-setting methods, the W. F. Hall Printing Company had been able to print four colors on machine coated paper with presses originally designed for use with halftone newsprint paper, which was an uncoated high-absorbent paper grade. Wehmhoff argued that the new inks caused printing firms to replace high absorbent papers with machine coated ones. Westvaco had to quickly respond to this change and begin systematic research and development of new machine coated papers, the chemist urged. Wehmhoff had, in fact, already begun such work by visiting the leading printing press firm Miehle Press Company in Chicago. The company owned numerous important patents on machine coating, and Wehmhoff had inspected the patents so David L. Luke could proceed in patent negotiations.⁴⁶⁶

These efforts culminated with the introduction of new machine coated magazine paper. In January 1939, John Miller and David Luke, Jr. demonstrated the new Westvaco paper to Charles L. Stillman of the Time Inc., who was considering it potentially for *Life* magazine. Apart from differences in its wire and felt side, the Westvaco paper was good quality and light, Stillman concluded. Many of the mass circulation magazines, including *Time* magazine, had decided to shift into such machine coated papers, he told the paper managers. He also stated that the Champion Coated Paper Company, Consolidated Paper Company, Mead Corporation, and the International Paper Company all were actively developing these new machine coated papers, and that he already possessed sufficient

⁴⁶⁶ Wehmhoff, *Report on work from December 1st to 25th 1938*.

sources of innovation and supply. Nevertheless he agreed to arrange trial prints on Westvaco, whose prices were below competitor's.⁴⁶⁷

Westvaco magazine papers continued to lag behind others, but its people had renewed belief in their capacity to produce the critical breakthrough. In such a faith a manager informed Luke that temporary improvements in coated papers had been done to satisfy the *American Home* magazine and the Hearst Publications, "until we can produce a real Machine Coated cheaply."⁴⁶⁸ As Luke decided to embark on intensified program of innovation, the issue was rather to perfect mass printing than to introduce new product. Perfection of the new printing technique required the orchestration of innovation between the printer and the ink and paper suppliers. Analyzing the problems with the drying of printing inks on different Westvaco papers in the Chicago area, Wehmhoff argued that the solution did not lie with improvements in the paper but in ink. The ink suppliers must alter their ink to fit the paper, he wrote.⁴⁶⁹

These relationships proved critical when Westvaco management decided to intensify its development of improved machine coated papers. In an effort to emerge as leader in quality, Wehmhoff shuttled between printing companies and the Westvaco paper mills, and compared his products with those of Kimberly-Clark. The superintendent of the Kable Brothers printing plant detailed him in September 1940 the difference, as did the catalogue printers at the Sears Roebuck & Company. "We try to

⁴⁶⁷ David L. Luke Jr., *Messrs. Jas. Miller and David L. Luke, Jr. to see Mr. C. L. Stillman of LIFE*. 3 Jan., 1939. Westvaco Collection #1781, Box #110, Packet #20.

⁴⁶⁸ *Anonymous "Jim" to David L. Luke, Jr.* 12 Sept., 1939.

⁴⁶⁹ *Byron L. Wehmhoff to W. H. Smythe*, 26 Sept., 1941. Westvaco Collection #1781, Box #124, Packet #19.

make a ground wood roto sheet as good as Kimberly Clark Rotoplate,” Wehmhoff defined the meaning of these visits.⁴⁷⁰

Kimberly-Clark had set the benchmark with the introduction of its light machine coated paper “Fallscoat”. The company innovated very much in identical way as Westvaco. That is, Kimberly-Clark fostered vertical linkages of learning across the different industries and firms engaged in the publishing and printing process. In such a vein, the company introduced its new light machine coated roto paper for catalogue printing for experimental purposes in the early 1940’s.⁴⁷¹

Wehmhoff’s complained that available chemical and mechanical test practices did not yield realistic enough practical results. When trying to analyze how one’s products fared against a competitor’s, the manufacturer of machine coated paper was forced to rely on information obtained at the printing plants. Only a knowledgeable and experienced printer could point out the difference of printing on the papers of Westvaco, Mead, Consolidated, and Kimberly-Clark. Wehmhoff tapped such information at the Chicago printing plants of Cuneo, where the plant managers explained how different papers fit the printing of *Life* magazine. Underlining the importance of this relationship, the Westvaco supplied the Cuneo plant with experimental rolls of paper in order to learn whether the research and development work was going anywhere.⁴⁷²

Such practices reveal that the Time Inc. indeed enjoyed a competitive pool of innovative suppliers of paper for its mass circulating magazines. Tactics employed by

⁴⁷⁰ Byron L. Wehmhoff to John. R. Miller, 16 Sept., 1940. Westvaco Collection #1781, Box #124, Packet #19.

⁴⁷¹ Byron L. Wehmhoff, *Report for Feb. 1942*. Westvaco Collection #1781, Box #124, Packet #19.

Charles Stillman and Henry Luce had certainly fostered the emergence of competitive machine coated paper market, but their efforts were backed by the political economy too. In theory horizontal cartels would have allowed the book paper firms a strong grip of the customers and a mechanism to control the emerging markets, but this proved impossible for two political and legal reasons. The book paper firms had established a national industry association in the 1933. During the National Recovery Administration the association maintained price floors and production quotas for traditional paper grades. Such practices were continued in the industry even after the National Recovery Administration was dissolved in 1935. The Federal Trade Commission attempted to root such schemes from the book paper industry by examining the industry in late 1930's, and ordered the industry to adhere to antitrust laws. However, in the machine coated industry the innovative firms could get around the regulatory authorities by pooling patents. A cartel organized around rapidly moving technology was difficult to build, as the problems of cooperation between Massey, Mead, and Westvaco demonstrated, and was potentially illegal too. Byron Wehmhoff himself warned that the Sherman antitrust act prevented Westvaco from pooling research and development resources with the other leading machine coated paper makers.⁴⁷³

⁴⁷² Byron L. Wehmhoff to John R. Miller, 25 Nov., 1942. Westvaco Collection #1781, Box #124, Packet #19.

⁴⁷³ Federal Trade Commission, *The Book Paper Manufacturers Association*, Docket No. 3760 (1939); Byron L. Wehmhoff to John R. Miller, 9 April, 1942. Westvaco Collection #1781, Box #124, Packet #19.

Reluctant Vertical Integration: User-Supplier Relationships during the Great Depression

Attempts by the pulp and paper firms to create new markets for new products overlapped with the challenge to maintain old markets in the 1930's and 1940's. The publishing business was turbulent and the death of a big magazine hurt badly its printer and paper supplier. The Time Inc. was an exception in generally depressed industry. The attempt to maximize the consumption of magazine paper and utilization of printing plants induced paper makers and printers to extend financial ties to publishing firms. The practice was so commonplace in the 1930's and 1940's that it was almost the rule.

In extreme cases paper makers financed the establishment of a new magazine. In 1932 Westvaco gave financial aid to William H. Eaton so he could lease and revitalize *American Home* magazine. It was more typical that the printer and the paper firm extended credit to a failing magazine in the hope of eventual turnaround. Usually this path led the creditors to assume increasing operational responsibility of the publishing house, and in extreme cases its ownership. This was the case in 1932, when the Cuneo Press and International Paper Company took over Screenland Magazine Incorporated and installed a new management. Suppliers integrated reluctantly forward into publishing business, and did so only with a ready plan of divestment. Typically management installed by the printing and paper creditors received preferred stock as compensation, and if successful could assume the ownership over time. In 1934, William R. Hearst, perhaps the leading publisher of his time, purchased *Pictorial Review* from its printer and

paper suppliers under an arrangement that allowed him to write off its back debts unless it showed a profit.⁴⁷⁴

Despite of new opportunities during the 1930's the leading firms continued to be plagued by sluggish demand and heavy investments in new printing technologies. As a result many accrued burgeoning debt to their suppliers, and most notably to the paper firms. Thus paper managers faced a serious strategic dilemma. Should they continue to supply struggling printing and publishing firms and hope they would pay off the debts with better times? How should specialized machine-coated paper firms respond to the demand of innovation by their indebted customers? In the minds of the managers of the pulp and paper firms these two questions were intertwined, because the indebtedness of the large publishing houses set off a domino effect throughout the industrial organization that was engaged in the production of magazines.

In the competitive magazine industry success and failure could occur rapidly and unexpectedly. The publishing empire of the William Randolph Hearst exemplified the industry trend. After a period of great growth, Hearst Publications faced deepening financial problems in during the 1930's. The problems began with the newspapers and the company accrued burgeoning debt to the Canadian newsprint firms. By 1937 the firm was in a crisis, and the reputation of Hearst as publisher and businessman began to suffer. These problems allowed Richard Berlin, the closest associate of Hearst, to gain increasing power in the company, and he assumed the responsibility to deal with

⁴⁷⁴ Pederson, *Magazines*, 70-71, 156-157.

creditors. Berlin pleaded with John Cuneo, the printer, for breathing space to bring business around.⁴⁷⁵

The troubles of Hearst worsened, and by 1939 the publisher struggled at the brink of dissolution because of its failing finances as David Nasaw had demonstrated.⁴⁷⁶ The company owed millions to its creditors and negotiated intensely to solve the problems. The Hearst Corporation owed almost \$16 million alone to Westvaco and the Oxford Paper Company. The managers of these two firms assumed major responsibility for correcting the situation. By March 1939 the Hearst Corporation agreed to divest its magazine business for the value of \$23 million. However, from this only \$15 million could be allotted to the paper companies. As the negotiations about the future of the Hearst magazines between the creditors and Richard Berlin ensued in the early 1939, the question of future relations between the Hearst Publications and its major paper suppliers became pivotal.⁴⁷⁷

The problem was that the magazines were profitable, but not when charged with the indebtedness of the parent company. The paper companies depended on the continued operation of the magazines, because they constituted key customers. Charlie Gordon of the Oxford Paper Company entertained the idea of taking over the Hearst magazines, but failed to convince David L. Luke, Jr., to join the plan. Most paper managers shared the

⁴⁷⁵ Tebbell and Zuckerman, *The Magazine in America*, 154-155.

⁴⁷⁶ David Nasaw, *The Chief. The Life of William Randolph Hearst*. Boston: Houghton Mifflin Company 2000, 508, 529-42.

⁴⁷⁷ David L. Luke, Jr, *Hearst-memorandum. March 16th, 1939*. Westvaco Collection #1781, Box #132, Packet #27;

attitude of Luke, who did not want venture into businesses he did not know.⁴⁷⁸ The entire publishing industry suffered from the problems exemplified by the Hearst Publications, and the printing and paper industries suffered with it. The president of Kimberly-Clark Company, F. J. Sensenbrenner, cooperated with the Cuneo Press and Westvaco in order to bring around the large Chicago McFadden Publications Company.⁴⁷⁹

The financial troubles of the publishing firms forced paper and printing firms to gain increasing operational control of the magazines they were supplying and serving. The management of Westvaco cooperated closely with Cuneo Press while trying to bring around the troubled MacFadden Publications. Almost no operational decision was done in the magazines or the publishing house without the consent of creditors. The president of MacFadden publications, Orr J. Elder, detailed routinely the accounts and operational issues at his magazines to the Vice President of Cuneo Press, who in turn circulated the information to Westvaco. The problem was that the creditors mistrusted business and editorial capabilities of Bernarr MacFadden, the founder of the MacFadden publications.⁴⁸⁰

A powerful personality that worshipped physical culture and a writer of over 100 books on the subject, MacFadden had begun his career in publishing with magazines on physical culture. The acquisition and founding of new magazines that blended physical culture, erotic, popular culture and politics into a mix of early form of tabloid magazines

⁴⁷⁸ David L. Luke, Jr, *Memorandum of Conversation with Richard Berlin of the Hearst Publications Under Date of March 21, 1938*; Adam. K. Luke, *Memorandum. Hearst Corporations*. 9 Jan., 1939. Westvaco Collection #1781, Box #132, Packet #27.

⁴⁷⁹ *F. J. Sensenbrenner to Thomas K. Luke*. 25 Nov., 1941. Westvaco Collection #1781, Box #125, Packet #18.

⁴⁸⁰ *Orr J. Elder to Raymond P. Fischer*, 2 July, 1942. Westvaco Collection #1781, Box#125, Packet #18.

boosted his business. With the onset of the Great Depression, the financial troubles began to plague the successful entrepreneur who increasingly had to surrender operational and editorial control to his creditors.⁴⁸¹

The flagship of the MacFadden publications was the *Liberty* magazine with a circulation beyond one and half millions, and the creditors engaged into its time-consuming micro-management.⁴⁸² The MacFadden Publications owned in total one and half million dollars to Kimberly-Clark, Westvaco, Cuneo Press, Art Color Printing, and few others. According to the historian Theodore Pederson, the desperate creditor-suppliers injected millions to keep the *Liberty* alive for several years in the 1940's.⁴⁸³ Thomas, David, and Adam Luke were drawn into such micro-management of number of smaller publishing firms, including the negotiations to merge the *Financial Reporter* and *Commercial & Financial Chronicle* of the WM. B. Dana & Company in 1941, and many others.⁴⁸⁴

The troubles of the magazine industry worried the producers of magazine papers. However, the managers of the Kimberly-Clark, Mead, Westvaco and others kept an eye in the future and hope the best for their high volume clients. Paper firms engaged reluctantly into the management of the magazines, even while they abhorred vertical

⁴⁸¹ Robert Ernst, *Weakness is a Crime: The Life of Bernarr Macfadden*. Syracuse: Syracuse University Press 1991; William R. Hunt, *Body Love: The Amazing Career of the Bernarr Macfadden*. Bowling Green, OH: Bowling Green State University Popular Press 1989; Pederson, *Magazines*, 242-248.

⁴⁸² Creditors choose the editor of the manager, decided on potential increased circulation, page numbers per issue, and price of an issue. See: *Orr J. Elder to Thomas K. Luke*, 2 Feb., 1942; *Raymond P. Fischer to Cola G. Parker* 16 June, 1942; Adam K. Luke, *Memorandum. Macfadden publications*. 12 May, 1942; *Orr J. Elder to Raymond P. Fischer*, 2 July, 1942. Westvaco Collection #1781, Box #125, Packet #18.

⁴⁸³ Pederson, *Magazines*, 71,

⁴⁸⁴ E. S. Johnson, *Memorandum. WM. B. Dana & Co. Minutes of Meeting*, 28 Aug., 1941. Westvaco Collection #1781, Box #151, Packet #1.

integration. Although firms occasionally received stock or interest as a collateral or payment for credit, the firms always promptly divested such properties.

Paradoxically, when the good times for mass magazines and mail-order catalogues arrived, firms in these industries had successfully turned the tables with the paper firms. Innovation in the machine coated paper had enabled a small group of paper firms to control emerging markets throughout the 1930's, because the number of manufacturers was successfully kept at bay. The large publishing firms looked to increase the number of suppliers, and moved to stabilize magazine and catalogue machine coated papers instead of pushing for more innovation. They simply pulled out from the cooperative efforts to innovate further, and instead emphasized the need to create narrow standards for machine coated paper. Once established, such standards naturally unleashed competition and pulled the price of machine coated paper further down. The unexpected outbreak of the Second World War and the ensuing war time regulation of business suspended such attempts in the early 1940's, however.

Innovation in the War Economy, 1942-1947

Government regulation during the Second World War changed the incentives for innovation operating upon firms in the pulp and paper, printing, and publishing industries. Regulation of the labor, raw materials, energy, power, and prices established almost overnight a new political economy in which firms could not be sure how a return on investment in innovation would occur. Nevertheless, the war time shortages encouraged innovation in the machine coated papers, especially the development of new light weight magazine papers. This was primarily due to interrupted pulp supply from

Scandinavia, which created an increasing shortage of pulp in the paper industry. The leading paper makers recognized the transition into lighter paper grades as a way to produce paper from a given amount of pulp. As firms intensified the search for new magazine papers, they also facilitated broader phenomena of technological learning that came to pave the way for many innovations introduced after the deregulation. The wartime regulation disturbed the traditional relationships in the industrial network involved in mass printing too, because both material flows and prices were not determined by market forces. The unexpected suspension of competitive forces had a lasting impact on how firms in different industries regarded innovation. Paper, printing, and ink firms continued to emphasize cooperative innovation as a way to create new markets, but during the 1940's the publishing industry withdrew almost completely from such collaboration. In part this was because innovation in magazine papers occurred without the entrepreneurial involvement of large customers, and in part because the publishing industry emphasized the competitive price of paper.⁴⁸⁵

The United States entered the Second World War in December 1941, and the first measures to regulate pulp and paper production were introduced on January 1, 1942. The first regulatory orders were simple stop-gap measures to buy critical time to plan a more comprehensive regulatory program of the sixth largest manufacturing industry of the country. The regulatory philosophy of the War Production Board was to ensure the supply and smooth production of products deemed essential for the war effort, and in such a vein it issued limitation orders, so called "L-orders". The initial L-120 was aimed at reducing waste and improving efficiency in the pulp and paper industry, as were the

⁴⁸⁵ James Playsted Wood, *The Curtis Magazines*. New York: Ronald Press Company 1971, 172-173; *Byron*

subsequent fourteen other orders directed at specific pulp and paper grades. The American Paper and Pulp Association estimated that the L-177 order for magazines and L-245 for books saved 1,250,000 tons of paper per annum. Subsequent War Production Board Limitation Order L-244 limited the magazine industry to 75 per cent of its previous consumption. In June 1942 Government published in the *Priorities Regulation* what became the Allocation Classification System for the pulp and paper industries, a law effective June 30, 1942. The system required pulp and paper firms to specify the end users of its products so that the War Production Board administration could approve the allocation of energy, labor, and resources.⁴⁸⁶

Table 6-2. Estimated Consumption of Book Paper by Magazines in the United States, 1925-1944. (Tons of 2,000 lbs.)

Year	Consumption
1925	354,000
1930	524,300
1935	418,400
1940	656,700
1941	704,400
1942	730,800
1943	635,500
1944	545,500

Source: *Report of the Econometric Institute*. Prepared for the Book Paper Manufacturers Association. No. 4 –February 1, 1946, Appendix Table D.

These regulations shifted unexpectedly the balance of bargaining power between the paper makers and their customers. While the priority regulations eased the cut-throat competition in the paper business, most of the time it was the publishers who benefited

L. Wehmhoff to William. F. Huck, 2 Jan., 1944. Westvaco Collection #1781, Box #112, Packet #23.

from the new war-time political economy. Under the War Production Board and Office of Price Administration regulation the production of paper was matched with the estimated circulation of magazines, and any potential price increases were regulated or prevented. Moreover the publishers, as a powerful wartime propaganda arm of the government, had renewed lobbying leverage over the regulators. Managers in the magazine paper industry could only watch in awe when the Time-Life group lobbied the War Production Board in 1943 to lower tariffs for paper from Canada, an act directly undermining the competitive position of U.S. firms.⁴⁸⁷

The regulation reduced drastically the demand for the machine coated paper just as the pioneering paper firms were preparing for its full scale mass production, and hoping to profit after investing a decade into research and development. The first reliable statistics for production of machine coated paper begin from the year 1942, when its production totaled 322,000 tons. A year later production had fallen to 308,000 tons. Production of machine coated paper continued to decrease and remain low as long as the war regulation limited demand for it. The war-time regulation evidently disturbed the paper business, but in rule the paper managers believed in rapid growth of demand after future deregulation. This prediction was shared in rule by all the leading paper companies, and their managers crafted careful post-war corporate strategies of growth and diversification. Rapid technological innovation underpinned these efforts.⁴⁸⁸

⁴⁸⁶ *The War Years of the United States Pulp and Paper Industry*. New York: American Paper and Pulp Association 1946, 7-8; *Priorities Regulation*, No. 10, June 1940.

⁴⁸⁷ *John R. Miller to David L. Luke*, 30 July, 1943. Westvaco Collection #1781, Box #110, Packet #20.

⁴⁸⁸ Lawrence K. Gessner, *The Paper Industry Today*. New York: Smith, Barney and Company 1956, *Appendix*, Table B.

Managers of Westvaco watched closely how the War Production Board curtailed demand for magazine and catalogue papers, and how these customers shifted in large numbers to lighter papers. At the request of the Book Paper Association, the Econometric Institute estimated this shift be so wide-spread that the 1944 consumption of 545,000 tons of paper by magazines would have totaled over 900,000 tons in the heavier pre-war paper grades.⁴⁸⁹ This transition into lighter magazine papers presented difficult scientific and technological challenges for the paper and printing firms. Lighter papers required stiffer coating, and this in turn had an impact on printing imprint. The continuous improvement of paper by the printing and ink firms was the prerequisite for the increased consumption of paper. Thus, in the midst of the war economy, innovation assumed central role for the future strategic plans of Westvaco.⁴⁹⁰ In a rare involvement into the management of his company, the patriarch of the Luke family, William G. Luke, expressed the view his view on the plans in the spring 1943:

We must bear in mind the money we are spending and are to spend on research, as this will have an influence on all the paper outlined in your report, especially in the Pulp Mill end of our business, and the outcome of all this research may mean not only betterment of the papers we are making to-day, but also new uses for pulp and paper and new kinds of papers that we do not think of to-day... We are in a changing world, and those who don't change with it are out of picture, and

⁴⁸⁹ *Report of the Econometric Institute*. Prepared for the Book Paper Manufacturers Association. No. 4 – Feb. 1, 1946, 13.

⁴⁹⁰ *J. R. Reynolds to John R. Miller*, 9 April, 1943. Westvaco Collection #1781, Box #113, Packet #20.

especially does this apply to people in any manufacturing business, such as we are in.⁴⁹¹

John R. Miller assumed the leading role of strategic planning at Westvaco, and in May he circulated a template of his post-war plans for Westvaco. Miller was convinced that war-time regulation had heavily suppressed the competitive forces in the pulp and paper industry. He forecast that an intense competition for markets would follow the eventual de-regulation. Westvaco had to regroup its production lines to match the new structure of demand that would emerge and prepare its production facilities to respond quickly to the new competitive environment. Miller was convinced that machine coated papers were the single most important production line for the future expansion of the company. He commented broadly on the situation of Westvaco:

It is felt that we have more work to do in development; or, to put it another way, expanding our production of Machine Coated than anything else which is in evidence at the present time. We have No. 5 and No. 2 machines at Piedmont equipped to make Machine Coated, and our policy has been to push slowly our Machine Coated on these machines until we get straightened in our quality... it is felt strongly that our production on this grade should be increased at the earliest possible moment after the war.⁴⁹²

⁴⁹¹ William G. Luke to John R. Miller, 21 April, 1943. Westvaco Collection #1781, Box #113, Packet #20.

⁴⁹² John R. Miller, *General Survey of Post-War Papers Which The West Virginia Pulp and Paper Company Will Be Called On To Manufacture And To Meet Competition*. 19 May, 1943. Westvaco Collection #1781, Box #152, Packet #11.

Investment in research and development was essential pre-requisite for such a corporate strategy. Although Miller learned from the printers of magazines and catalogues that his products set the benchmark in quality for the industry, he emphasized further quality improvements as a base for the future expansion of the firm. Machine coating technology allowed Westvaco potentially to diversify into other paper markets, too, but in 1943 Miller had only vague ideas what these could be. He entertained paper cups as a potentially viable application of machine coating capabilities. Yet, this choice did not converge with his other major strategic choice, the Southern kraft. Westvaco managers thus shared a belief that the machine coating technology could be potentially applied to a number of paper grades, but failed to specify them in detail. Yet, the management believed that the strong research and development capabilities of Westvaco would produce commercial applications. Driven by this conviction management agreed to purchase a new paper machine for the production of machine coated paper in August. It took almost five years before Westvaco eventually was able to apply its machine coating capabilities to new major paper grades.⁴⁹³

Managers at Westvaco crafted their expansion plans of the machine coated paper production with a keen eye on markets. The company's main problem was inability to respond to rapidly growing demand for new paper grades. The head of the Chicago sales office, J. C. Reynolds, informed Miller that *Life* magazine people were courting several machine coated paper suppliers for the cheapest price for a very large tonnage. The demand by smaller firms was picking up too, but Westvaco was not able to respond to the

⁴⁹³ *David J. Luke to Paul B. Lacy*, 26 Aug., 1943. Westvaco Collection #1781, Box #152, Packet #10.

demand for new printing papers.⁴⁹⁴ Reynolds wrote in September 1943: “Practically all of our customers will want Machine Coated from us at the earliest possible moment, and we must point all our efforts to this end... We are pressed daily to take Machine Coated orders at good prices, but do not have the production to do so. We have lost a lot of business because we could not furnish Machine Coated.”⁴⁹⁵

Inability to supply large quantities of machine coated caused Westvaco to lose business with Kable Brothers to the Consolidated Paper Company, Reynolds complained. Westvaco could not even meet the orders from existing customers. This fact was further insinuated by information that Westvaco’s customers, such as *American Home* and some Hearst magazines, wanted to shift from uncoated to machine coated, too. *American Home* was forced to follow the printing and publishing trend if they wanted to meet competition by *Better Homes and Gardens*, Reynolds argued. The demand for machine coated paper was surging even under the war-time regulations, and Westvaco managers became more and more convinced of its future potential.⁴⁹⁶

In response to these concerns, a small research and development program was launched in 1942. Within a year, this research and development program on new offset paper had become the vehicle of corporate strategy for John R. Miller and David Luke. Bromwell Ault, the president of International Printing Ink that was the leader among ink suppliers, had suggested to Luke that their two firms collaborate in development of new

⁴⁹⁴ J. C. Reynolds to John R. Miller 7 Sept., 1943. Westvaco Collection #1781, Box #113, Packet #16.

⁴⁹⁵ J. C. Reynolds to John R. Miller 7 Sept., 1943.

⁴⁹⁶ J. C. Reynolds to John R. Miller 7 Sept., 1943.

high-speed offset and lithography printing process. Management at Westvaco was rather enthusiastic of the proposal.⁴⁹⁷

Though Westvaco managers would later admit that this program had failed in its goal to produce a new line of offset paper products, they credited for saving the company. The “three cornered” research and development project fostered organizational capabilities that sustained company’s leadership in the machine coated papers and allowed successful diversification into new lines of machine coated paper products. The program was originally defined as the development of press-ink-blanket-combination for high speed four color offset work, a technology that would cater to medium size catalogue printing jobs that required higher quality than, say, the mass printing of *Life* allowed. The pulp shortage and the increasing over-seas editions of mass magazines redefined the program towards the development of light-weight printing paper in 1943. William Huck, the chief development and research engineer of R. R. Hoe & Company, told Wehmhoff in late 1943 that the South-American edition of *Time* magazine presaged the future of publication printing. Time Inc. printed the edition in the U.S. with four-color web offset presses on light magazine paper, and saved tremendously in the postage costs compared with the older heavier paper grads. Based on his correspondence with Huck, Wehmhoff argued to top management of Westvaco that the whole offset development program needed to be redefined.⁴⁹⁸

⁴⁹⁷ David L. Luke, Jr. to Thomas Luke, 11 Dec., 1942. Westvaco Collection #1781, Box #125, Packet #21.

⁴⁹⁸ Byron L. Wehmhoff, *Memo*. Undated, probably late last days of December 1943 or first days of 1944; see also attached letter *William F. Huck to Byron L. Wehmhoff*, 30 Dec., 1943. Westvaco Collection #1781, Box #112, Packet #23.

The overseas editions of *Time* signaled to paper managers where the printing and publishing industries were heading. Yet the potential business was easily lost because of competing innovations and the sheer difficulty of producing economically and technologically viable light weight magazine paper. Publishers could as well produce printing plates in the U.S., and simply ship them by air mail overseas and print there. Wehmhoff, Luke and Miller realized that unless they produced real savings in the air mail of magazines quickly, other industries and firms would seize the opportunities. Luke and Miller authorized new resources for Wehmhoff to pursue innovation in cooperation with the International Printing Ink and the R. R. Hoe, but the partners faced particular technological challenges.⁴⁹⁹

Web offset printing with light papers was a costly and unreliable process in January 1944, and presented three threshold problems. First, light weight paper wrinkled easily in the machine and distorted the printing imprint. Second, light paper was so thin it was practically transparent, so that the color imprint on one side of the paper distorted the other side. Third, light paper was a premium paper and more expensive than traditional runs of magazine and catalogue paper. The cooperative research and development program in 1944 had to overcome these three specific problems before a new line of business with the publishing industry would open. The task of reducing cost of the paper proved the most difficult of the three challenges.⁵⁰⁰

⁴⁹⁹ Byron L. Wehmhoff to William F. Huck, 2 Jan., 1944. Westvaco Collection #1781, Box #112, Packet #23.

⁵⁰⁰ Byron L. Wehmhoff to William F. Huck, 2 Jan., 1944. Westvaco Collection #1781, Box #112, Packet #23.

The perfection of the light offset paper printing process required extensive cooperation between the printing machinery, ink, and paper suppliers. Wehmhoff assumed again a central role and coordinated the learning at different sites. Mechanical improvements at the Westvaco paper mills resulted eventually more uniform winding of the paper rolls. The transparency of the light offset papers required the development of more water-proof coating for the paper, and its synchronization with the color inks and the heat-set dryer.

Working systematically and persistently, Wehmhoff was able to produce visible improvements in the color web offset printing with light papers within a short time. Although Wehmhoff produced a technological breakthrough, he was unable to assess the economic viability of the new product, because the wartime regulation prevented Westvaco from moving into full-scale production.⁵⁰¹

The coordination of technological learning between the leading firms in three industries exposed the venture to struggles typical to large organizations. Such quibbles were fuelled further by the fact that costs were much more difficult to control than the scientific and technological problems. Early in 1944, the program ran into problems caused by the internal power struggle at the International Printing Ink, and the War Production Board priority regulations. Nevertheless, Byron Wehmhoff insisted on the project together with people from the R. R. Hoe & Company. In July 1944 Wehmhoff argued that the program had instead of succeeding in its original mission to develop new offset paper only proved that it was a critical vehicle of technological learning for Westvaco. Reviewing the research and development program he wrote to David L. Luke:

This press will print standard quality offset papers, but unfortunately such papers are more expensive than letterpress papers used for similar printing jobs. It was obvious that we would have to develop lower cost offset papers both uncoated and machine coated, if the whole combination was to be offered to the printing industry as a competitor for letterpress. It is also obvious that such paper development could come only after the press was mechanically correct, and inks had been developed to some extent.⁵⁰²

The lack of technological improvement in the offset printing machinery did not allow the development of economically viable offset paper, then. Instead of developing a specific product for specific markets as originally intended, Wehmhoff had come to realize that he should manage the development a pool of generic knowledge on coated papers that would allow West Virginia Pulp and Paper Company to produce a diversified family of innovative coated paper products. The program assumed now a strategic character, and Westvaco management placed the predicted new organizational capabilities in the heart of their post-war corporate strategy.

John Miller coordinated the strategy planning at Westvaco, and in April 1944 he stratified the machine coated markets from the vantage point of the unique capabilities of his company. The competitive mass magazine field should be catered to with low cost

⁵⁰¹ Byron L. Wehmhoff to William F. Huck, 2 Jan., 1944. Westvaco Collection #1781, Box #112, Packet #23.

⁵⁰² Byron L. Wehmhoff, *Present Status of these Offset Development Programme*. 18 July , 1944. Westvaco Collection #1781, Box #112, Packet #23.

machine coated paper, whereas higher quality machine coated papers should be offered to the trade catalogue market composed of smaller printing runs. Here was also the plot: the right employment of Westvaco's capabilities would tie competitors into the magazine field, where long term prospects for profits were low, and allow it to capture a disproportionately large share of the quality machine coated markets. Westvaco should urgently expand and improve efficient production of magazine papers in order to meet the margin destroying competition, which Miller believed would follow armistice. This would engage most of Westvaco's competitors with fewer machines suitable for production of machine coated paper, and allow the company to capture markets in the higher quality machine coated papers that had much better margin of profit too. Miller and Luke authorized increased resources for Wehmhoff, who predicted better quality products and more cost efficient production processes.⁵⁰³

Typical of the whole industry, the strategy of Westvaco emphasized research and development cooperation between the ink, printing and paper industries and largely excluded publishers. In an active economy where prices were frozen to pre-war levels, every manager understood that the eventual armistice would create booming price pressures and acted on that assumption. Concerned with their strategic interests, the high volume publishing houses were weary of the leading magazine paper firms' strategies of market segmentation, didn't cooperate in extended research and development projects with firms in supplier industries, and eventually initiated a large counter move when the war appeared to be over.

⁵⁰³ John R. Miller, *Memorandum*, 21 April, 1944. Westvaco Collection #1781, Box #152, Packet#1; Byron L. Wehmhoff, *Present Status of the Offset Development Programme*. 18 July, 1944. Westvaco Collection #1781, Box #112, Packet #23.

Managers in the publishing industry recognized very well that the price of the magazine and catalogue paper depended on the organization of that industry. Large publishing houses integrated backward into paper production in an effort to control prices and supply. Already during the war Time Inc. acquired the Hennepin Paper Company in Minnesota. In March 1945, it purchased the paper mills of the Bryant Paper Company in Kalamazoo, Michigan, and in October 1945, it took over the Maine Seaboard Paper Company. Time Inc. contracted with the St. Regis Paper Company to manage these mills, which also eventually purchased the mills in 1946. As a condition of the sales, Time Inc. negotiated an advantageous long-term contract with St. Regis. Time Inc. also acquired increasing interest in the Champion Paper and Fiber Company, which supplied much of the paper for *Life*. Other publishers followed suit. McGraw-Hill and Chilton Publishing Company jointly acquired the Newton Falls Paper Mill. In an extreme case of backward integration, the Curtis Publishing Company acquired extensive lumber tracts in addition to paper mills. Publishers entering the machine coated paper industry were typically frustrated, however, by the heavy capital requirements and difficulties of successfully running such mills.⁵⁰⁴

Attempts by the publishing industry to gain improved bargaining power with the paper and printing industries was facilitated by a post-war shift in the political economy. In 1945, the Federal Trade Commission resumed its 1939 antitrust scrutiny of the book paper industry. Based on its six-year-old hearings and evidence the commission issued a Cease and Desist Order. Legal experts of the book paper industry reviewed the 1939 case

⁵⁰⁴ Eleanor Amigo and Mark Neuffer, *Beyond the Adirondacks*, 96; The Special Committee to Study Problems of American Small Business. United States Senate. 79th Congress, 2nd Session. *Survival of Free*

and argued that the order was not warranted by evidence, and encouraged a petition to the Federal Circuit Court of Appeals.⁵⁰⁵

The court's ruling in *Allied Paper Mills v. Federal Trade Commission* sustained the Cease and Desist Order, but vacated it in the case of Consolidated Water Power and Paper Company that pursued a price-cutting strategy with its patented groundwood machine coated papers. This interpretation emphasized that significant and real innovation intensified competition, and defined importantly how firms could avoid antitrust by innovating, then.⁵⁰⁶

The 1945 Cease and Desist Order was only a part of much larger post-war government scrutiny of the pulp and paper industry. The several investigations and decrees intensified the competitive environment in the paper industry. Antitrust shaped importantly the post-war organization of the pulp and paper industry, but technological innovation was the central dynamic force for the evolution of the printing paper industry. The leading printing paper firms had secured a control over the alternative machine coating technologies, and effectively erected barriers of entry for others. Byron Wehmhoff, reviewing Westvaco capabilities in 1947, argued that the company was in good position to benefit from the definitive shift into machine coated paper in letterpress printing, where only pulps and comics continued to be printed on uncoated paper. Machine coated will increasingly replace uncoated in rotogravure printing of magazine

Competitive Press. Senate Committee Print No. 18. 2 Jan., 1947. GOP: Washington 1947, 10; Wood, *Curtis Magazines*, 172-3.

⁵⁰⁵ *Clarence A. Clough to Sheppard Dillingham, Re: Cease and Desist Order*, 17 July, 1945. Westvaco Collection #1781, Box #19, Packet #2.

⁵⁰⁶ *Allied Paper Mills v. Federal Trade Commission*, 168 F. 2d. 600 (1948); Simon N. Whitney, *Antitrust Policies. American Experience in Twenty Industries*. New York: The Twentieth Century Fund 1958, 346-

and mail order catalogues too, he continued. Westvaco should proceed to develop distinct products in these categories, but not too many as it would sacrifice economies of scale from production. He also argued that the offset-paper market was unattractive for the company so long as the offset printing machinery was not improved, and it was currently impossible to produce a satisfactory paper at reasonable price. Other leading print paper firms shared Wehmhoff's vision and built their corporate strategies on the machine coating technologies they controlled.⁵⁰⁷

Demise of Patent Control: Expansion and Segmentation of the Machine Coated Paper Industry, 1945-1960

The leading book paper firms faced a new strategic challenge between 1945 and 1960, when the markets for the machine coated paper expanded and new specialized lines of business emerged to complement the standardized high-volume, low quality printing papers. Technological change in machine coating and printing technologies triggered demand for coated kraft paper and paperboard in food and drink packaging, and the improvement of offset and office copy printing technologies increased demand for the high quality offset and copy paper. The ability of pulp and paper firms to diversify into new machine coated paper product lines, or to maintain leadership in old ones, depended on their pre-existing organizational capabilities because the production processes of the respective coated papers had significant technological differences.

350; *Survival of the Free Competitive Press*. 79th Congress, 2nd Session. Senate Committee Print No. 18. Washington: Government Printing Office 1947.

⁵⁰⁷ Byron L. Wehmhoff to L. W. Strattnner, 4 Feb., 1947. Westvaco Collection #1781, Box #146, Packet #22.

Competitive magazine and printing papers and coated kraft and board were predominantly manufactured with the so-called on-machine coaters. With this method the coating operation was fully integrated in the back part of the Fourdrinier paper machine. High quality offset and office copy papers, on the other hand, were typically manufactured with the off-machine coater method, in which a finished roll of uncoated paper was fed through a coating machine set apart from the Fourdrinier machine. The tightly integrated on-machine coating process maximized throughput and economies of scale of a single type of coated paper because of the complexity of grade shifting. On the contrary, the disintegrated nature of the off-machine paper production allowed the paper mill a relatively flexible mode of production of an array of different kind of coated papers. The pulp and paper firms faced the choice between unforgiving but cheap mass production and a more flexible and expensive mode of production.

Such a choice became available gradually for managers during a battle for the control of machine coating technology that unfolded between 1945 and 1955. The pioneering book paper firms, Kimberly-Clark, Mead, Consolidated, Champion, and Westvaco firmly controlled through patents the machine coating technologies during and immediately after the war, and this control allowed them to coordinate industrial change effectively. The booming demand for magazine and printing paper cried for more capacity, and all the leading firms had followed the wartime expansion strategy of Westvaco. Mead had acquired three other paper concerns and a power company between 1941 and 1943, and Kimberly-Clark purchased vast new timber holdings. Consolidated Water Power & Paper Company acquired the last newsprint mill of Wisconsin in 1945

and retooled it into machine coated paper. Control of machine coating technology was critical for the viability of these expansion plans of these firms.⁵⁰⁸

The on-machine patents allowed leading firms to reap the profits of booming demand fueled by mass magazine and mail-order catalogue industries. In 1950, W. F. Hall Printing Company alone printed 480 million magazines, 225 million catalogues, and 132 pocket books. When the demand simply outgrew supply, the patents allowed Champion, Consolidated, Mead, and other firms to grant pricey machine coating licenses to competitors without sacrificing markets or depressing the price of paper. Typically the licensor had an iron grip on licensee, and the contracts included high cancellation penalties that equaled licensing fee through expiration of the patent. On-machine coating involved for a licensee costly installation, high license fees, and the strategic decision of tying the paper machine into single paper grade. A licensee had also no way to predict how many licensees would be eventually granted. All these considerations frustrated the attempts of the Mid-West Blandin Paper Company to enter the magazine and catalogue paper industry. The firm had long explored possibilities to diversify from its traditional newsprint production, and regarded on-machine coated paper as a viable option. As its managers learned the licensing conditions for the technology, they pulled back. Decisive for the Blandin managers was the fact that license agreements were not insured against potential, and indeed numerous patent infringement litigation. In case a court awarded

⁵⁰⁸ *Survival of Free Competitive Press*, 9-11; For illustrative and typical case, see: Donald L. Boese, *Papermakers. The Blanding Paper Company and Grand Rapids, Minnesota*. Grand Rapids, Minnesota: Charles K. Blanding Foundation 1984, 268-276.

damages for patent infringements, a licensee had to bear the costs on top of the license fee.⁵⁰⁹

The likelihood of patent infringement litigation increased together with innovation, which accelerated during the 1940's and 1950's as demonstrated in the Table 6-1. Leading firms, as well as outside inventors, scrambled for more patents in order to secure control of technology, markets, and of course profits in the increasingly competitive magazine paper business. Intensified innovation had a paradoxical effect on the organization of the industry. As the technological frontier expanded, accelerated, and involved a growing number of other technologies, it became too large and complex to be dominated by any narrow group of firms. This was exacerbated by the fact that the original and so-called "fundamental" machine coated patents granted expired. The Massey roll printer patents held by the Consolidated, the roll coater patents of the KCM Corporation, the Doctor blade coating patents of the Champion, as well as Westvaco roll printer coating patents expired by the early 1950's. In response, these firms intensified research and development, and patented new machine coating innovations. Yet, these patents were usually interpreted by the courts as improvements of the original art of machine coating, and thus granted them narrow protection from competing inventions.⁵¹⁰

Eventually a patent infringement case disintegrated this carefully built managerial system of control. In 1947, Consolidated Water Power and Paper Company sued Kimberly-Clark Corporation for infringement of its 1933 Massey machine coating

⁵⁰⁹ Boase, *Papermakers*. 318-320.

⁵¹⁰ George L. Booth, "Why Blade Coating – A Review of Coating Processes," in *Blade Coating Seminar*. Atlanta, Tappi Press 1990, 1-10; OECD, *Pulp and Paper Industry in the USA. A Report by a Mission of European Experts*. Paris: OECD 1951, 229-234.

patents. Traditionally the industry and engineering community had regarded Massey's patents as fundamental breakthroughs, and shared the praise for the patent by the plaintiff.⁵¹¹

Coating process invention was one of the greatest advances in the paper-making industry in that it taught an economical and efficient method of applying a mineral surface on a web of paper as it moved through a paper-making machine and thereby so reduced the cost of making paper for use in fine half-tone printing that it revolutionized both the paper-making and the printing industries.⁵¹²

Consolidated attempted to demonstrate the novelty of famous Massey patent by emphasizing the prizes and recognition awarded to the inventor, as well as detailing its large licensing fees and networks in the court. The defendant argued that no infringement had occurred, and no such case had been demonstrated after the inspections of its mills. Kimberly-Clark employed its own proprietary machine coating technologies that were independent from the Massey patent. The court agreed with the defendant, but a much more severe blow to Consolidated, and indeed the whole machine coated paper industry was still to come. Evidence put forth by the Kimberly-Clark Corporation during the trial

⁵¹¹ *Consolidated Water Power & Paper Company et al v. Kimberly-Clark Corporation*, 73 F. Supp. 936 (1947); Peter J. Massey, U.S. Patent No. 1,932,368 (1933)

⁵¹² *Consolidated Water Power & Paper Company et al v. Kimberly-Clark Corporation*, 107 F. Supp. 777 (1952).

prompted the court to examine the novelty and validity of the Massey patent, and whether it should be entitled to a narrow or broad interpretation.⁵¹³

The defendant showcased evidence on how weak the original patent application of Massey had been. He had filed the original application on May 19, 1930, and in January 1931 the Patent Office Examiner rejected the claims as being devoid of invention over prior art. Massey amended an application in June 1931, and began to negotiate about the claims that could be accepted by the Examiner. In January 1932, the Examiner rejected other twelve claims of the application as “lacking invention,” and wrote: “The applicant has merely combined elements all which are old in the art and which have been used in similar combinations, without producing more than the aggregate of old results.”⁵¹⁴

Following the rejection of his application, a personal interview between the Examiner, Massey, the vice president of Seamen Paper Company of Chicago, and a lawyer was arranged to discuss the patent and its claims. Based on this meeting Massey submitted a third amendment to his patent application, adding 10 new claims and increasing the total of claims into 21. In February 1933, the Examiner rejected again all claims, and Massey submitted a fourth amendment that made a claim specific to the elimination of water during the coating process. Based on this claim the patent was finally granted to Massey, who carefully hid the difficulties to secure the patent. As Kimberly-Clark detailed how vague case the Massey patent had originally been, the Wisconsin District Court ruled in 1952 that the Massey patent, which was already

⁵¹³ *Consolidated v. Kimberly-Clark*. (1952)

⁵¹⁴ *Consolidated v. Kimberly-Clark*. (1952)

expired, was neither original nor novel, and deserved the narrowest possible interpretation for protection from competing technologies.⁵¹⁵

In effect, the court established that there was no fundamental patent for the machine coating of paper. Instead all the valid claims of patents granted to Kimberly-Clark, Mead, Westvaco, and others presented rather narrow improvements in the art of machine coating of paper. The whole community of pulp and paper trade had perceived that these patents covered the heavy machinery of the on-machine coating machines, but realized now overnight their mistake. A wave of roll on-machine coaters imitations, developed without publicity in the late 1940's, were now patented and put to markets. St. Regis Paper Company patented in 1953 an on-machine roll coater developed in the late 1940's by Harry Faeber, as another one developed by William Zonner. These patents completed the entry of the third largest U.S. pulp and paper firm into the high volume magazine paper industry.⁵¹⁶

Leading book paper firms had invested two decades on the on-machine coaters, and based their competitive strategy on aggressive control of technology. In 1952, they fell collectively to the prey of their own success, and they were forced to revisit these tactics. Incumbent large scale machine coated firms responded to the court decree by placing renewed emphasis on their existing organizational capabilities. If they could not erect barriers of entry with patents, they could do so by raising the bar on capital requirements. The court had duly noted this fact in 1952:

⁵¹⁵ *Consolidated v. Kimberly-Clark*. (1952)

⁵¹⁶ Booth, *Why Blade Coating*.

It is difficult for the court to conceive of an industry where opportunity for experimentation would be so costly and difficult. Huge plants may contain only three or four machines, each which extend almost the length of the building and operate as continuous integrated units wherein watery solution is introduced at one end and the finished product is rolled up at the other end. One machine will cost a million or more, and voluntary or involuntary shutdown of a machine is a costly matter.⁵¹⁷

Pioneers of the machine coated paper invested heavily in the on-machine coaters and production of competitive magazine and printing paper. The large capital requirements discouraged and prevented smaller paper mills from entering this line of paper business. By applying the coating directly on the paper in the Fourdrinier machine the incumbent large scale paper enterprises achieved tremendous economies of scale, and pulled down the price of the on-machine coated paper. However, this mode of manufacturing also tied the giant on-machine paper coater mills into single, low quality and competitive paper market, because the change of paper grade would have required slow and expensive retooling of the Fourdrinier machine. This was also the prime reason why Westvaco could not realize John Miller's two-headed strategic plan of producing low quality and cheap coated paper simultaneously with high quality and more expensive one.⁵¹⁸

⁵¹⁷ *Consolidated Water Power & Paper Company et al v. Kimberly-Clark Corporation*, 107 F. Supp. 777 (1952).

⁵¹⁸ Robert H. Mosher, "Introduction," in Robert M. Mosher and Dale S. Davis (eds), *Industrial and Specialty Papers. Vol. I. Technology*. New York: Chemical Publishing Company 1968,1-12.

In the case of Westvaco, the existing organizational capabilities reshaped the strategic visions of the management. The company had charged in 1942 the offset paper development program with the future product diversification, but realized some six years later that the program enjoyed a paradoxical success. The program failed to produce high quality offset paper on Westvaco's on-machine coater Fourdrinier machines. On the other hand, Byron L. Wehmhoff had fostered the very capabilities necessary to maintain a leading position in the low quality magazine and catalogue printing papers. Moreover, the program fostered knowledge of chemistry, and allowed Westvaco to enter the extrusion coating of paper and board that was introduced in 1948.

Extrusion coating applied polyethylene plastic on paper or board, and enabled the introduction of wide range of new products in general food and drink packaging and containers, such as new kind of milk bottles. Kenneth Arnold at St. Regis developed the extrusion of polyethylene of paper in the late 1940's, when the company struggled to get around the on-machine coating patents of the leading magazine paper companies. Arnold had collaborated extensively with the Du Pont Company and potential customers, such as the Oscar Mayer Company, to perfect the production processes of paper, printing, and food packaging. Successful entrance into extrusion coating technology required strong capabilities in chemistry and mass production, and therefore firms such as St. Regis, Westvaco, and Crown Zellerbach pioneered the industry.⁵¹⁹

Firms with smaller mills and less technological capabilities had to explore the potential of smaller market segments, and contract stabilized technology. The

⁵¹⁹ Robert H. Coffing, "Extrusion Coating of Paper and Board," in Robert H. Mosher and Dale S. Davis, *Industrial and Specialty Papers*. Vol. IV. Product Development. New York: Chemical Publishing Company 1970, 152-186,

Consolidated v. Kimberly-Clark decision had unleashed competitive forces in the machine-coating technology by making it relatively freely available. A number of inventors and firms looked to create markets for the off-machine coaters that were relatively inexpensive and allowed flexible production of high quality papers. In 1951, British Ronald Trist applied for U.S. patent for trailing blade coater that produced high quality coated papers. The patent was granted in 1955, and Trist assigned it to one of the leading paper machinery supplier in the U.S., the Rice-Barton Corporation, which began to improve and commercialize it. Another popular version of the off-machine blade coater was commercialized by the other leading U.S. paper machinery supplier, the Black Clawson Company, under the brand name Flexi-Blade. Off-machine coaters were now supplied by competitors not engaged in the manufacture of paper, and who looked to maximize sales without concern for possible over-capacity.⁵²⁰

Blade coaters were exactly that kind of off-machine coaters that allowed relatively small or medium-sized paper mills to successfully enter the high quality coated paper market. The Blandin Paper Company acknowledged the off-machine coating as viable diversification tactic in 1954. The company contracted Rice-Barton to install the first off-machine coater in the U.S. at its mill in 1956, where it was employed to produce coated offset paper. Early difficulties with the quality of coating and printing prompted the paper maker, machinery supplier, printer, and publishers to work together towards the perfection of the process, and thus repeated a familiar pattern of vertical linkages of learning.⁵²¹

⁵²⁰ Booth, "Why Blade Coating."

⁵²¹ Boese, *Papermakers*, 322-328.

Printing and paper firms also scouted recent significant improvements in the offset and office copy technology that anticipated the emergence of new line of printing and paper business. Since the 1930's, a number of individuals and companies were pursuing research and development in electrophotography and thermography that resulted in the introduction of office copy machines. Chester F. Carlson and Otto Kornei had invented Eletrophotography in 1938. Continuing the development work, Carlson patented with the Battelle Memorial Institute what was the other nucleus of the emerging office copy technology, and commercialized the first working applications. In 1948, the Haloid Company acquired a license on the Carlson process, and continued research and development name under new name, the Xerox Corporation. In 1950, Xerography, which involved offset technology, too, was commercialized first time with the Xerox Model D Copier. The RCA entered the office copy market in 1954 with its Electrofax-technology, and it granted quickly over 100 manufacturing licenses. The 3M Company introduced in the early 1950's the Thermo-Fax copying system, based on the research of Dr. Carl S. Miller during the 1940's. The system was the first reprographic system that required the use of only one sheet of coated paper. Introduction of new office copy machines created potentially large new markets of coated papers, but the chemical complexity and heat of reproduction required extensive improvements in the quality of coated papers. Innovation in copy paper, then, was the last step to guarantee the visual quality of printing picture and the technology's commercial viability.⁵²²

⁵²² David S. Most, "Reprographic Papers," in Robert H. Mosher and Dale S. Davis (eds), *Industrial and Specialty Papers. Vol. III. Applications*. New York: Chemical Publishing Company 1969, 138-178; Thomas W. Busch, "Water-Base Coatings," 79-80. In Robert M. Mosher and Dale S. Davis (eds), *Industrial and Specialty Papers. Vol. I. Technology*. New York: Chemical Publishing Company 1968, 75-177.

Pulp and paper and off-machine coating machinery supplier firms followed carefully developments in the office copy markets, and became quickly convinced of its future expansion. Potential markets for off-coating machinery in the U.S. was predominantly composed of newsprint mills that were increasingly squeezed by the Canadian competition in the 1950's, and whose managers explored options to shift production capacity into more profitable paper grades. The second largest U.S. pulp and paper firm and predominant West-Coast newsprint producer, Crown Zellerbach Company (hereafter C-Z), built a very large coating mill in St. Francisville. Another important vehicle of production diversification for C-Z was the building of Newton Falls paper mill, a joint venture of Time, Inc., and C-Z.⁵²³

Newton Falls paper mill showcased how the maturity of technology and narrow paper standards enabled large publishing houses a new grip on suppliers. Consequently the Newton Falls mill was the trailblazer of new mode of efficiency in coated paper production. In 1961, Ronald Trist installed the 118-inch wide and 2,500 feet per minute Black-Clawson Flexiblade off-machine coater that was supposed to give the company price advantage in high quality coated enamels, book, envelope, and book papers. The throughout automated mill housed two Flexiblade and one air-knife coaters, whose "flexible operation" allowed the production of different paper products. The new coaters allowed blade coating on one or two sides of the paper sheet, or the air-knife coated coating alone of one side of the sheet, which catered distinct market segments.⁵²⁴

⁵²³ J. H. Heuer to John E. McLeod, June 16, 1964. The Great Northern Paper Company Papers. University of Maine, Fogler Library. Special Collections, Box #840, Folder #12, Special Files. Manufacturing Investment Company.

⁵²⁴ A. W. Dyck, "New Flexible Coater at Newton Falls," *Paper Industry*, Vol. 1. No.9 (December 1961), 584-585, 595.

Maturity of coating technology and its availability from specialized machinery suppliers prompted the managers of the last U.S. firm producing only newsprint, the Great Northern Paper Company, to revisit their expansion and diversification plans in the 1960's. Since the early 1950's, the Great Northern management had been desperate to meet increasing competition by Canadian newsprint mills. It had first responded by massive modernization and expansion plan of its newsprint mills in 1953. The investments proved ill advised almost immediately, and the management began to search for better strategy of productivity improvement.⁵²⁵

Availability of the off-machine coating technology allowed the Great Northern to shift course of its suffering expansion plans. Great Northern decided to shift production capacity away from depressed newsprint and enter the specialty grade markets for quality coated papers in 1961. The company's new vice president, J. H. Heuer, had collaborated with Ronald Trist during the installation flexible coater at the Newton Falls paper mill, and brought with him considerable experience about the new technology. The construction of \$6 million dollar coating plant at the huge Millinocket mill site was completed in 1963, and a massive off-machine coater was supplied by Black Clawson Company. The plant produced light weight quality coated paper at the astonishing speed of 3,500 feet per minute and total of 100,000 tons a year.⁵²⁶

Industry experts questioned the move, because the market already suffered from over-capacity. The Blandin Paper, Champion Paper, Consolidated Papers, International Paper, Kimberly-Clark, Mead, Newton Falls Paper Mill, New York & Pennsylvania,

⁵²⁵ *Annual Report of the Great Northern Paper Company 1954*, 7, 12-19.

⁵²⁶ *Annual Report of the Great Northern Paper Company 1961*.

Oxford Paper, St. Francisville Paper, St. Regis, S. D. Warren, Westvaco, and C-Z already produced all kinds of coated papers in excess of demand. Yet the industry continued to build more capacity. During the 1960's, the U.S. subsidiary of Canadian newsprint giant Bowater constructed a blade coating mill in South Carolina. The entry of incumbent newsprint giants, such as Bowater and Great Northern, in machine coated paper was characterized by the belief of management that their firms had special skills to run high capacity mills exceptionally efficiently.⁵²⁷

Table 6-3. Annual Value and Production of Machine Coated Paper Production in the U.S., 1947-1963 (thousands of dollars and tons of 2,000 lbs.)

Year	Value	Quantity
1963	498,637	2,171,778
1958	362,505	1,547,408
1957	329,001	
1956	318,273	
1955	263,686	
1954	252,617	1,222,873
1947	100,609	623,724

Sources: *Census of Manufactures 1954. Vol. II.* Washington, D.C.: Government Printing Office 1955, 26A-10; *Census of Manufactures 1958. Vol. II.* Washington, D.C.: Government Printing Office 1960, 26A-15.

The production of machine coated paper soared as a result of massive wave of investment in new manufacturing capacity during the 1950's, as is evident from the Table 6-3. The industry did not repeat the price decline of so many other paper industry segments, however, because the market for machine coated papers was fragmented in specialty products. While the annual production of machine coated paper increased two and half-fold between 1947, the annual value increased four-fold during the same period.

⁵²⁷ Maurice R. Castagne, "Big New Coating Challenger," *Pulp and Paper*, February 18, 1963.

Yet, some segments experienced very difficult times, in particular the firms that produced standardized mass-circulation magazine papers.

Conclusions

Growth of the leading U.S. printing, publishing, and paper firms between 1930 and 1960 depended critically on vertical linkages of technological learning. A basic reason for the extended duration of such collaborative efforts was the technologically modular nature of printing process, whose performance depended on the synchronization of printing machinery, ink, and paper technologies. Vertical linkages of learning between printing firms, their suppliers and customers, persisted under a great variety of economic and political conditions. This suggests that such organization of technological learning is essential element of the industry and its sustained competitiveness.

Innovation in printing machinery and machine coated papers was rapidly accelerated by the publisher Henry Luce and his Time Inc. in the 1930's. Luce realized his revolutionary mass circulation magazine business format by fostering vertical linkages of technological learning backwards to printing and paper firms. These collaborative crash programs of technological learning perfected the mass printing technology and new machine coated paper types. However, upon stabilizing these production technologies, Time Inc. decreased its participation in collaborative innovation, and emphasized competitive prices of standardized printing and paper. When the publishing giant recognized the need for lighter magazine paper, it devised again vertical linkages of learning with printers and paper makers. Such responsive and flexible strategy of collaboration of the publishing giant was enabled by the fact that it was not

vertically integrated into printing. Thus, the entrepreneurial opportunism of Henry Luce importantly triggered fundamental improvements in the printing processes and paper technologies.

Collaboration between the printing industry and its ink, paper, and machinery suppliers was determined by shared technological processes of printing that required synchronization. This organization of technological learning discouraged risk-taking and radical technological departures, and induced rather incremental innovation. Moreover, technological knowledge was highly vulnerable for opportunism by firms that controlled or could gain control of the key intellectual property rights. On the other hand, the technological relationships inherent to the printing processes limited importantly such opportunism.

This study suggests that public policies play an important role for the dynamics and structure of vertical linkages of learning, and especially antitrust policies. Efforts to control opportunities in vertical collaboration between paper and magazine firms induced horizontal collusion among the paper firms, and in this particular aspect antitrust policies may enhance the operation of vertical linkages of learning.

The history of the development of machine coated paper demonstrates that the dynamics of collaborative innovation was paradoxically boosted and impeded by opportunism. Literature on industrial organizations and this study demonstrate that managers of collaborating firms need to resolve through formal and informal methods how the gains of new knowledge are distributed.

CHAPTER 7

CONCLUSIONS

The evolution of the North American pulp and paper industry between 1860 and 1960 was driven by successive waves of technological learning that spawned structural change. Such waves transformed and expanded the sulphite and sulphate pulp, envelope, paper container, paper bag, magazine and printing paper, coated paper, board, and many other pulp and paper industries between 1860 and 1960. These waves repeated a pattern of co-evolution of technology and industrial organization that enveloped dynamic forces of change, such as innovation, corporate strategies, industrial relocation, and policy. As distinct branches of the pulp and paper industry passed from the early nascent phase to full maturity, the sources of innovation, nature of technological change, strategy and structure of leading firms, and industrial organization underwent transformation.

A narrow group of firms typically originated these waves of co-evolution of technological learning and industrial organization. Innovative firms created new markets through radical technological departures, and attempted to prevent imitation by employing strategically intellectual property rights. Standardization of products, maturation of technology, diffusion of innovation, expiration of intellectual property

rights, and policy undermined such barriers of entry over time, and prompted the leading incumbent firms to consider alternative competitive corporate strategies. Typically, the leading firms became resolved to consolidation of the industry and economies of scale, but in some cases they also made a renewed effort to diversify into new product lines by innovating. At the last stage of these waves, the attempts of the original innovators to maintain barriers of entry and prevent imitation lost their effectiveness, and firms lost their ability to differentiate themselves in terms of technological capabilities.

The dynamic, overlapping evolution of the individual pulp and paper industries underpinned the structural change of the whole North American industry. As the significance of technological differentiation declined in the corporate strategy of leading firms, the managers emphasized strategies of scale and scope. This facilitated the creation of unprecedented large multi-product pulp and paper enterprises. This change is evident if one compares the organization of the industry around 1900 and 1960.

Around 1900, the organization of the North American pulp and paper industry was characterized by relatively high degree of technological specialization, and the leading firms were different in terms of their product focus and organizational capabilities. The largest firm, International Paper Company, was predominantly a sulphite newsprint firm. Other leading companies were specialized, too. Westvaco was a bookpaper firm, Robert Gair Company a paper container firm, and Union Bag and Paper Company a paper bag firm.

By the 1960's, the leading pulp and paper firms had similar diversified, multi-divisional organizational structure and capabilities. The IP owned substantial timberlands and manufactured groundwood, sulphate, and sulphite pulp. The company produced

practically every kind of paper, such as newsprint, book paper, machine coated papers, kraft board. It had also integrated forward into paper converting, and produced corrugated specialties, paper bags, and milk bottles among other specialty products. Industry's second largest firm, Crown-Zellerbach, had identical organization and product scope, and so did the third largest one, St. Regis. Westvaco, Mead, Champion, and Consolidated had identical structure, too. Georgia Pacific, Weyerhaeuser, Boise-Cascade, and many others adopted similar structure within a decade.

Cycles of American political economy punctuated this evolutionary path, and the period between 1890 and 1960 can be divided in successive sequels in regard how the government regulation influenced industry concentration. The pulp and paper industry experienced three intensive merger waves, between 1895 and 1904, in the 1920's, and 1950's. During these waves the political economy was relatively favorable for industry consolidation, if compared to the late teens, Great Depression, and 1940's, when regulation of production and prices froze the competitive structure of the industry.

Early Evolution of the Sulphite Pulp and Paper Industry

The adoption of virgin timber as the main source of cellulose was the most significant change in the North American pulp and paper industry during the nineteenth century. Problems with the traditional sources of cellulose, such as cotton rags, and opportunities with alternative sources fueled a broad industry-wide wave of technological learning in the Europe and North America.

Groundwood pulp was the radical technological departure that enabled papermakers for the first time to produce paper from only timber, but the technology

failed to produce the quick economic returns its inventors had dreamed to capture with their patent monopoly. German Heinrich Völter patented in the 1840's path-breaking groundwood pulp machines, but the first attempts to employ the technology in North America were frustrated experiences. Groundwood pulp potentially enabled the production of paper at unprecedented low unit cost, but technological problems prevented economies of scale at the first North American groundwood pulp mills during the 1860's. Moreover, the paper was relatively poor quality, yellow colored, and there was relatively little demand for it. The technology was mechanically simple, and in the absence of significant improvements, it became freely available after the expiration of central patents in the 1880's.

Groundwood pulp triggered dramatic change in the pulp and paper industry, however, because papermakers recognized that by mixing it with chemically treated pulp one could produce cheaply good quality white papers, which were the most consumed line of paper. American Benjamin Tilghman discovered the sulphite pulp process in the early 1860's. Tilghman controlled a patent monopoly on his revolutionary pulp process, and entered the commercial production of sulphite pulp. However, he went bankrupt. Technological problems with the process frustrated the attempts of Tilghman and others to produce sulphite pulp on large scale. Industry leaders and engineers insisted on the economic potential of the sulphite process, and an intensive transatlantic patent race ensued.

Discovered in the 1860's, the sulphite process was developed slowly and painstakingly into a commercially viable mass production technology during the 1890's. The sulphite process was a strategic innovation, however, because it critically

complemented other wood pulps. Application of sulphite pulp with ground wood pulp allowed firms to improve significantly the quality of paper, introduce a wide array of new products, such as sulphite newsprint and bookpaper, and simultaneously dramatically reduce the unit cost. This fueled industry-wide learning in the technology.

In 1889, this long wave of technological learning in sulphite pulp technology culminated in a path-breaking patent filed by George F. Russell, whose discovery enabled for the first time the mass production of sulphite pulp. The research and development work was managed and coordinated by his brother, William A. Russell, who controlled a technologically leading North American wood pulp company. William Russell understood fully the economic potential of the revolutionary sulphite pulp method, and aspired to monopolize the technology. During the 1890's, Russell acquired intellectual property rights on alternative sulphite technologies, and increased the value of his patents through active litigation policy. In 1897, an Appeals Court decision awarded him a monopoly on sulphite technology in the North America.

This patent monopoly prompted Russell to promote the consolidation of leading New England mills into the International Paper Company that had almost monopoly control of the U.S. newsprint markets. The sulphite patent monopoly dominated the early corporate strategy of IP, and the company undertook extensive investment program in order to build vertically integrated sulphite pulp and newsprint mills.

IP had secured its sulphite monopoly through innovation, imitation, extensive litigation, pooling of technology, and horizontal combination. Yet, following a broad-based effort to discover a superior wood pulp process, the subsequent patent monopoly remained vulnerable to challenges, and the managers of the company recognized

extensive and inclusive licensing as a way to strengthen its patents. This afforded the managers of IP a mechanism to coordinate unfolding expansion and structural change in the pulp and paper industry, and prevent over-investment into new production capacity. IP created an extensive licensing network, and awarded over 200 licensees by 1903. The company favored vertically integrated, specialized firms that did not compete with IP's newsprint operations.

The combination of rapid diffusion of innovation and patent monopoly undermined the incentives for all U.S. pulp and paper firms to innovate in sulphite technologies. Such effects were amplified by antitrust policies, which had prevented the formation of newsprint giant that could have potentially competed with the IP. Antitrust also prompted IP to diversify production capacity from newsprint to other paper products in order to avoid legal challenges. Policy makers also abolished protective tariffs at a time when the U.S. newsprint industry was particularly vulnerable for such a change, and prompted the relocation of manufacturing capacity to Canada. The changed incentives quickly discouraged coordinated efforts to improve the basic sulphite pulping processes with radical technological departures.

IP management responded to these challenges by crafting a new corporate strategy that was based on its dominant size. Most significantly, the role of innovation for corporate strategy was changed. The company did not produce again radical technological departures that had characterized its origins, but emphasized the constant incremental improvement of the efficiency of its existing operations, and constant expansion that was based on ability to produce paper at lower unit cost than other firms.

In short, the company stopped being a producer of its own manufacturing technology, and its managers valued the ability to adopt innovations developed by others.

Technology and Cartels

The development of the sulphite pulp industry exemplified challenges that faced all the pulp and paper industries, and culminated during a critical period of industry transition around 1900. The maturation of mass production technology during the late nineteenth century required the pioneering American pulp and paper firms to revise their corporate strategies and structures. The origins of large scale pulp and paper firms cannot simply be explained in terms of managerial coordination of production, transaction costs, or market control, but one has to consider the control of key intellectual property rights as a key determinant of successful combinations in the industry.

Mergers between 1895 and 1904 that did not involve managerial control of key technologies typically fell prey to competitive pressures embodied in price decline, overcapacity, easy of entry, as well as to legal challenges from the antitrust authorities. These problems explained the failure of the “writing paper trust”, “wall paper trust”, “board trust”, and some others. Cartels built on strong patent monopolies were difficult to sustain, too, as was evident in the case of the “newsboard trust.” Misguided licensing policy, failure to adopt tightly integrated corporate structure, and inability to prevent imitation undermined what had been a viable monopoly of annual value beyond one million dollars in 1900.

Most horizontal pulp and paper combinations avoided these mistakes, however, as is evident from the example of the International Paper. In addition, monopoly companies

in the folding box, corrugated paperboard, envelope, drinking cup, and most notably in the bag paper industries did so. Leading firms in these segments of the pulp and paper industry responded by consolidating into tightly integrated large-scale enterprises that towered over their competitors. Most importantly, their managers deployed large patent portfolios to erect barriers of entry.

Specialty paper firms were particularly equipped to adopt such a strategy.

Specialty production dominated the paper converting industry that purchased ready sheets and rolls of standard paper, and converted them into specialized paper products, such as bags, envelopes, and boxes. The formation of the Union Bag and Paper Company in 1899 is the best example of such cartel. The combination involved over 90 per cent of U.S. bag paper industry, and its major strategic asset was the one million dollar valued patent portfolio. The combination was an attempt to frustrate the entry of IP into the bag paper industry through the Continental Paper Company, and this tactic culminated in the extensive patent litigation case in the early 1900's. Strong patent portfolios laid the foundation for the corporate strategy of both Union and Continental, which together dwarfed the rest of the bag industry.

The technological core of successful cartels is best explained by the fact that intellectual property rights enabled them to circumvent antitrust. Yet, institutional change in the early twentieth century America reduced this function of patents. In response to allegations of patent misuse by cartels, landmark court rulings and the Clayton Act established limits for firms' ability to create monopolies through patents.

Evolution of the Paper Container Industry

The co-evolution of industrial organization and technological learning is striking in the North American paper container industry between 1870 and 1960. The modern paper container industry evolved from the invention of corrugated paper in the mid-nineteenth century. Cooperation between two firms that controlled central patents impeded process and product innovation until the 1890's, when the patents expired. This was followed by immediate entry of new firms, and intensified product and process innovation. The establishment of the paper box as standard railroad shipping container created vast new markets by 1915, and as a consequence, paperboard passed newsprint as the most consumed line of paper in the U.S.

The leading firms, such as Hinde and Dauch Paper Company, attempted to erect barriers of entry by pooling product and machinery patents, but federal policies and technological innovation frustrated such efforts. Antitrust policies prompted the voluntary disintegration of some patent pools, but more important was the emergence of a competitive corrugated paper box machinery industry that supplied new entrants. The leading firms responded to these conditions by adopting aggressive strategies of growth, and the corrugated paper container industry experienced a merger wave during the 1920's.

Mergers and acquisitions enabled managers another central response to the difficulty of sustaining control over specialty product markets. Large-scale vertically integrated national enterprises had several advantages over smaller rivals in markets for standardized paper containers, because of their ability to coordinate mass production. In addition, consolidation arrested the effects of imitation by smaller rivals. The large-scale

corrugated paper box firms could not control machinery technology, but made a successful effort to monopolize selected markets with patented product innovations. Industry-wide these tactics successfully created barriers of entry, and prevented the entry of competing firms until the late 1930's.

The paper container industry confronted specific and serious challenges in the late 1930's. Patents covering many specific product lines expired, and the leading firms were unable to obtain new intellectual property rights on basic paper boxes. Secondly, a landmark antitrust case abolished collusive practices from the industry. These two factors reinforced firms' reliance on economies of scale, when the World War II propelled the demand for paper boxes. During the wartime mobilization, 80 per cent of military shipments were in standard paper containers. The new demand facilitated mass production technology in the basic standard products.

Under these conditions, managers paid increasing attention to economies of scale and scope, but wartime regulation prevented industry consolidation. Subsequently, the industry experienced massive merger wave during the 1950's, when the number of leading specialized corrugated paper container firms was reduced from fifty to fifteen firms. These large-scale vertically integrated enterprises had similar organizational capabilities and overlapping geographical operations. Thus, their managers' ability to deploy strategies of differentiation was inherently constrained. This was evident when most of these firms were acquired by even larger multi-product forests products giants, and organized into one of many corporate divisions.

The North American paper container industry had a long history of innovation, but since the 1950's its organization did not foster radical technological departures. As

the organizational capabilities of firms converged, and they engaged primarily in competition in same markets, they became more likely to compete by improving production efficiency rather than through product differentiation. In contrast, radical technological departures propelled two export oriented European firms, Swedish Tetra-Pak and English Smurfit-Stone, into global paper packaging giants by the late twentieth century.

Evolution of the Sulphate Pulp and Paper Industry

The most significant twentieth century development in the pulp and paper industry was the replacement of sulphite technology as the major pulping method by sulphate technology. The annual production of sulphate pulp increased over 232-fold from 53 tons to over 12,000 between 1914 and 1958. 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 within the same period. The growth of the industry was based on technological characteristics of the sulphate process. It enabled the production of paper from cheap and abundant tree species, such as the Southern pine, that did not adapt to other wood pulp processes. In addition, the sulphate process was much cheaper than the sulphite pulp process, though it was long plagued by technological problems. Invented in 1850's, the modern mass production technology of sulphate pulp was perfected first between 1930 and 1950.

Technological breakthroughs punctuated the long-term growth of the sulphate industry, and distinct periods of industry transition exhibited different mechanisms and speeds of diffusion of innovation. In comparison to Europe, the industry had a relatively

slow start in the North America. There hardly existed any sustained effort to innovate in the basic technology by the leading U.S. pulp and paper firms. Instead firms such as IP, Westvaco, and St. Regis, chose to rely on specialized machinery suppliers. As a consequence, the industry became mired in enduring over-investment into new capacity and price depression.

Strong regional differences and inter-regional competition patterned the North American sulphate industry during the first half of twentieth century. The first significant regional concentration of the sulphate industry in the North America was developed by relatively small Lake States firms during the 1920's. The growth of the U.S. industry took off with the emergence of Southern mass production in the late 1920's, which was pioneered by IP. The Lake States and Southern sulphate industries had very different organizational structure, technological capabilities, and factor endowments. Because the two regional industries competed in the same markets, the regional industrial organization influenced greatly how managers chose to cope with simultaneous expansion and over-capacity.

The organization of operational and technological clusters in the kraft industry co-evolved with the competitive structure of the North American pulp and paper industry. In the Lake States, small and medium-sized pulp and paper firms adapted the manufacturing technology to the size of their operations, and neglected potential economies of scale. This regional pattern of technological learning influenced deeply the development of chemical recovery technology in the sulphate pulp production.

Since the nineteenth century, papermakers acknowledged that the recovery of chemicals and heat discharged from the sulphate digester could have potentially

revolutionary effects on economics of the process. Yet, despite this universal dream, the development of chemical recovery technology was heavily patterned by regional industrial organizations. Between 1915 and 1936, the technology was divided into two distinct schools in the U.S., the so-called rotary and stationary recovery furnace-schools. Rotary recovery furnace was the traditional, widely diffused technology, but its fundamental design inherently limited potential economies of scale. On the contrary, the stationary recovery furnace was a radical technological departure invented in the early 1910's, and only few experimental commercial size installations were installed. However, its fundamental design enabled potentially tremendous economies of scale, pulp and paper engineers acknowledged.

In the Lake States, where individual companies were too small to afford substantial research and development work, comprehensive regional systems of innovation advanced the rotary recovery furnace technology. In contrast, the stationary chemical recovery furnace was developed in relative secrecy by geographically scattered small or medium sized firms that held key patents. The limited size of these companies denied the engineers necessary resources for expensive research and development work, and also impeded the diffusion of technology. Consequently, the technology did not become commercially viable until large-scale firms took over the research and development work in the late 1930's.

The sulphate industry took off in the North America when the International Paper Company opened several large-scale Southern kraft pulp and paper mills. IP acquired the latest technology from its machinery suppliers in an effort to lower production costs, and fueled innovation in many technologies, but not stationary recovery furnaces. The

company did install the first continuous kraft chemical recovery cycle, and pioneered the mass production of kraft Fourdrinier board and multi-stage bleaching of sulphate pulp. The success of the Southern strategy of IP put the company on sound financial footing, and established it firmly as the world's largest pulp and paper enterprise.

The sulphate industry experienced a rapid wave of expansion when the organization of technological learning in the chemical recovery furnace was transformed. Collaboration between pulp and paper firms and a leading boiler manufacturer, Babcock & Wilcox, produced stationary chemical recovery unit with unprecedented economies of scale. Moreover, the collaboration enabled B&W entry into chemical recovery unit industry, and this changed quickly the way innovations diffused in the sulphate pulp industry. B&W strategy included the acquisition of central intellectual property rights on the technology from pulp and paper firms, and an effort to frustrate imitation through patent infringement litigation. Controlling a monopoly, B&W commercialized full-scale sulphate recovery units on the turnkey principle. Only one other specialized equipment supplier company, Combustion Engineering, Inc., managed to offer competing solutions to the pulp and paper industry during the 1940's.

B&W and C-E had large and experienced engineering staffs, and they quickly routinized research and development in the chemical recovery units. They commercialized large-scale installations, but two other innovations by specialized machinery suppliers also fueled investment in new sulphate pulp and paper capacity. Continuous multi-stage bleaching enabled product diversification for the kraft pulp and paper mills, as they could successfully capture markets from more expensive white sulphite papers. In addition, the Swedish Kamyr Company developed the continuous

sulphate cooking system that enabled new economies of scale. Specialized equipment suppliers developed and commercialized multi-stage bleaching and continuous sulphate cooking systems. These firms controlled their respective markets through large patent portfolios, and their large research and development staffs produced innovations systematically.

The combination of rapid diffusion of innovation and strong intellectual property rights had deep impacts on the organization of technological learning in the sulphate pulp and paper industry, where technological and operational clusters diverged. Under these circumstances, technological innovation accelerated and increased the capital intensity of the pulp and paper mills. This sounded the death knell for the smaller sulphate firms, but also the largest specialized sulphate pulp and paper firms disappeared. During the 1950's and 1960's, the leading sulphate pulp and paper firms were consolidated into divisions of giant multi-product forests firms.

Evolution of the Magazine and Machine Coated Paper Industries

A sustained wave of collaborative technological learning between 1930 and 1960 created the modern machine coated paper industry that supplies such diverse markets as food containers, office copy machines, and mass-circulation magazines. A non-existent product in 1930, the market for machine coated papers totaled half a billion dollars annually by 1963. An evolving collaborative effort of printing, publishing, and paper firms to innovate underpinned this development.

In order to realize his revolutionary mass-circulation business strategy, publisher Henry Luce and his Time Inc. requested paper firms to produce new types of machine

coated papers in the early 1930's. Luce fostered vertical linkages of technological learning backward to printing and paper firms, which perfected publisher's vision of the new photojournalism. These collaborative crash programs of innovation perfected the mass printing technology and new machine coated paper types.

The leading paper firms attempted to control these collaborative programs through patents, patent pools, and other collusive practices. This strategy stemmed from the belief that the Peter J. Massey and the Consolidated Water Power and Paper Company had obtained a key patent for the machine coated paper in 1933. A patent race ensued, during which Kimberly-Clark, Mead, Westvaco, and some smaller firms obtained several competing patents to manufacture machine coated paper consumed by mass-circulation magazines.

Patents enabled paper firms to frustrate the attempts of big publishing houses to expand the pool of paper suppliers. Entry into magazine paper production was discouraged because of the large and strong patent portfolios held by the leading magazine paper firms, and the active patent infringement litigation between them. Managers of firms that hoped to enter the production of machine coated paper, such as the Blandin Paper Company, knew that they had to obtain a patent license. However, expensive license agreements were not insured against potential infringement litigation. In addition, a potential licensee had no control of how many licenses would be eventually be granted. Upon learning these conditions, Blandin managers cancelled their diversification plans.

Ironically, the strong intellectual property rights encouraged behaviour that eventually led the industry to shoot itself in the foot. In 1947, the Consolidated sued

Kimberly-Clark for infringing its Massey patents. Five years later, an appeals court agreed with Kimberly-Clark that no infringement had occurred, and ruled that the already expired patent by Massey was originally invalid. In fact, the court declared that there did not exist a so-called fundamental patent for the machine coating technology.

Although most of the original patents obtained on machine coating of paper had expired during the 1940's, the leading firms had obtained several new ones that were based on the assumption that the original ones were valid. The 1952 court ruling undermined this, and quickly a wave of alternative methods to manufacture machine coating papers flooded the markets. The third largest U.S. pulp and paper firm, St. Regis Paper Company, filed patents on several different type of machine coating technologies it had developed secretly during the 1940's. Two leading American papermaking equipment suppliers, Rice-Barton Company and Black Clawson, became within short time the major source of innovation in machine coating technology. They acquired patents and hired specialized research and development staffs. Again, the rapid diffusion of manufacturing technology induced industry-wide over-investment into machine coated paper capacity.

Yet an important difference in corporate strategy and manufacturing technology emerged between incumbent machine paper companies and new entrants. The incumbent machine coated paper companies, such as Westvaco and Mead, emphasized mass production of standardized magazine and printing papers. These companies chose to install capital intensive on-machine coating machines that could produce a single standard grade of paper, but did so at unprecedented low unit cost. New entrants installed typically so-called off-machine coating technology that allowed the flexible production of

different qualities of specialty paper, and was sold to the emerging office copy market and small quality printing jobbers. Most of new entrants were incumbent large-scale pulp and paper firms, such as Crown-Zellerbach and the Great Northern Paper Company, that attempted to diversify into another line of paper markets.

The Dynamic Evolution of the North American Pulp and Paper Industry

The dynamic co-evolution of organizational structures and technological learning in the North American pulp and paper industry between 1860 and 1960 is a story with mixed lessons. The multi-division forests products giants of the 1960's ran large, capital and technology intensive operations, and acquired the most important technological innovations from specialized equipment suppliers. The leading pulp and paper firms had identical corporate strategies and structures, and competed in the same markets. The specialized equipment suppliers diffused latest technological innovations symmetrically throughout the industry. Under these circumstances, industry managers were locked into a strategy emphasizing economies of scale and scope.

A few decades earlier, specialized pulp and paper firms controlled the underlying manufacturing technology in their respective industry segments, and were the leading source of most important innovations. This technological capability enabled firms to create new markets, and gain spectacular growth rates.

Industry leaders and analysts insist today that the consumption of paper per capita is determined by the per capita gross national production. Affluent Americans consume most paper in the world, while Chinese consume little. Although the maxim is true, it also

betrays the idea that the industry could prosper through the creation of new markets with innovative processes and products, as it used to do.

BIBLIOGRAPHY

MANUSCRIPTS AND ARCHIVAL COLLECTIONS

Carl A Kroch Library, Rare Manuscript Collection, Cornell University. West Virginia
Pulp and Paper Collection #3118, and ##2830.

Fogler Library, University of Maine, University of Maine. Great Northern Paper
Company Papers, 1896-1960.

State Historical Society of Wisconsin. David Clark Everest Papers, Mss 279.

LEGAL CASES

Allied Paper Mills v. Federal Trade Commission, 168 F.2d 600 (1948)

American Sulphite Pulp Company v. De Grasse Paper, 190 F. 39 (1911)

American Sulphite Pulp Company v. De Grasse Paper, 193 F. 653 (1912)

American Sulphite Pulp Company v. Howland Falls Pulp Company, 70 F. 986 (1895)

American Sulphite Pulp Company v. Howland Falls Pulp Company, 80 F. 395 (1897)

Babcock & Wilcox Company v. North Carolina Pulp and Paper Company, 25 F. Supp.
596 (1938)

Babcock & Wilcox Company v. North Carolina Pulp and Paper Company, 35 F. Supp.
215 (1940)

Consolidated Water Power & Paper Company et al v. Kimberly-Clark Corporation, 73
F. Supp. 936 (1947)

Consolidated Water Power & Paper Company et al v. Kimberly-Clark Corporation, 107 F. Supp. 777 (1952)

Continental Wall Paper Company v. Louis Voight and Sons Company, 21 U.S. 227 (1909)

Corrugated Paper Patents Company v. Paper Working Machine Company, 237 F. 380 (1913)

Corrugated Fiber Company v. Paper Working Machines Company et al., 259 F. 283 (1919)

Eastern Paper Bag Company v. Continental Paper Bag Company, 150 F. 741 (1906)

Eastern Paper Bag Company v. Continental Paper Bag Company, 210 U.S. 405 (1908)

Eastern Paper-Bag Company v. Nixon et al, 35 F. 752 (1888)

Eastern Paper-Bag and others v. Standard Paper-Bag and others, 30 F.63 (1887).

Henry v. A.B. Dick Company, 224 U.S. 1 (1912)

Henschel v. Carthage Sulphite Pulp Company et al., 194 F. 114 (1909)

Henschel v. Carthage Sulphite Pulp Company et al., 169 F. 114 (1909)

Individual Drinking Cup Co. v. Errett And Individual Drinking Cup Co. v Hudson River Day Line, 300 F. 955 (1916)

Individual Drinking Cup Co. et al. v. Public Service Cup Co., 226. F. 465 (1915)

Individual Drinking Cup Co. v. Public Service Cup Co., 261 F. 555 (1919)

Individual Drinking Cup Co. v. United States Drinking Cup Co., 220 F.331 (1914)

Individual Drinking Cup Co. v. Sanitary Products Corporation, 267 F. 196 (1920)

McEwans Brothers Company v. White, 63 F. 570 (1894)

McEwans Brothers Company v. William W. McEwan, George W. Downs, Matthias Plum and Matthias Plum Jr., 91 F. 787 (1899)

Morgan Envelope Company v. Albany Perforated Wrapping Paper Company, 152 US. 423, 433 (1894)

National Folding Box & Paper Company v. Dayton Paper Novelty Company et al, 97 F. 331 (1899)

National Folding Box & Paper Company v. Elsas et al, 86 F. 917 (1898)

- National Folding Box & Paper Company v. Gair*, 97 F. 819 (1899)
- National Folding Box & Paper Company v. Gair*, 105 F. 191 (1899)
- National Folding Box & Paper Company v. Munson & Company*, 99 F. 86 (1900)
- National Folding Box & Paper Company v. Robertson* , 112 F. 1013 (1902)
- National Folding Box & Paper Company v. Stecher Lithographic Company et al*, 81 F. 395 (1897)
- New York Paper-Bag Machine Company v. Union Paper Bag-Machine Company*, 32 F. 783 (1887)
- Peter Heibel & Sons & Manufacturing Company v. Corrugated Paper Patents*, 247 F. 332 (1917)
- Union Paper-Bag Machine Company et al v. Waterbury et al*, 39 F. 389 (1881)
- Union Paper-Bag Machine Company et al v. Waterbury et al*, 39 F. 389 (1889)

LITERATURE

- Eleanor Amigo and Mark Neuffer, *Beyond the Adirondacks. The Story of the St. Regis Paper Company*. Westport, Conn.: Greenwood Press 1980.
- Elizabeth Faulkner Baker, *Displacement of Men by Machines. Effects of Technological Change in Commercial Printing*. New York: Columbia University Press 1933.
- Ross Knox Bassett, *To The Digital Age. Research Labs, Start-Up Companies, and The Rise of MOS Technology*. Baltimore: Johns Hopkins University Press 2002.
- Harry J. Bettendorf, *Paperboard and Paperboard Containers. A History*. Chicago: Board Products Publishing Company 1946.
- Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (eds), *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology*. Cambridge, Mass.: MIT Press 1987

- Donald L. Boese, *Papermakers. The Blanding Paper Company and Grand Rapids, Minnesota*. Grand Rapids, Minnesota: Charles K. Blanding Foundation 1984.
- C. M. Bonnell, *Bonnell's Manual on Packaging and Shipping*. New York: Bonnell Publications 1941.
- George L. Booth, "Why Blade Coating – A Review of Coating Processes," in *Blade Coating Seminar*. Atlanta, Tappi Press 1990, 1-10.
- Barry E. C. Boothman, "High Finance/Low Strategy: Corporate Collapse in the Canadian Pulp and Paper Industry, 1919 – 1932," *Business History Review* 74 (2000):4, 611-656.
- Ward S. Bowman, *Patent and Antitrust Law. A Legal and Economic Appraisal*. Chicago: The University of Chicago Press 1973.
- William Boyd, "The Forest is the Future? Industrial Forestry and the Southern Pulp and Paper Complex," in Philip Scranton (ed), *The Second Wave: Southern Industrialization From the 1940s to the 1970s*. Athens : University of Georgia Press 2001, 168-218.
- Thomas W. Busch, "Water-Base Coatings," in Robert M. Mosher and Dale S. Davis (eds), *Industrial and Specialty Papers. Vol. I. Technology*. New York: Chemical Publishing Company 1968, 75-177.
- Louis L. Bucciarelli, *Designing Engineers*. Cambridge, Mass.: MIT Press 1994.
- George Carruthers, *Paper-Making*. Toronto: The Garden City Press Cooperative 1947.
- Alfred D. Chandler, Jr., *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. Cambridge, Mass.: The MIT Press 1962.

- Alfred D. Chandler, Jr., *Visible Hand. The Managerial Revolution in American Business*.
Cambridge, Mass.: Belknap Press 1977.
- Alfred D. Chandler, Jr., *Scale and Scope: The Dynamics of Industrial Capitalism*.
Cambridge, Mass.: Belknap Press, 1994.
- Grosvenor B. Clarkson, *Industrial America in the World War. The Strategy Behind the
Line, 1917-1918*. Boston: Houghton Miffling Company 1924 (revised ed.).
- Kendrick A. Clements, *Hoover, Conservation and Consumerism. Engineering the Good
Life*. University Press of Kansas 2000.
- Howard Coady, *Sheet Harbour History: From the Notes of and Old Woodsman*.
Hantsport, N.S.: Lancelot Press 1988.
- Robert H. Coffing, "Extrusion Coating of Paper and Board," in Robert H. Mosher and
Dale S. Davis, *Industrial and Specialty Papers. Vol. IV. Product Development*.
New York: Chemical Publishing Company 1970.
- Avi J. Cohen, "Technological Change as Historical Process: The Case of the U.S. Pulp
and Paper Industry, 1915-1940," *Journal of Economic History*, Vol. XLLIV
(Sept. 1984): 775-799.
- Grover J. Daly, *The Corrugated Container Industry – A History and Analysis*. Chicago:
Board Products Publishing Company 1971.
- Robert W. D'Ambry, *Langston. Leadership by Design, 1901-1951*. Camden, NJ: Samuel
M. Langston Company 1951.
- Paul A. David, "Clio and the Economics of QWERTY," *American Economic Review* 75
(1985): 332-336.

- Michael. E. Dertouzos, Richard K. Lester, Robert M. Solow, *Made in America. Regaining the Productive Edge*. New York: HarperPerennial 1989.
- Trevor O. Dick: "Canadian Newsprint, 1913-1930," *Journal of Economic History*, XLII (Sept. 1982), 659-87.
- Alonzo Thomas Dill, *Chesapeake. Pioneer Paper Makers. A History of Company and Its Community*. Charlottesville: The University Press of Virginia 1968, 36-38.
- Giovanni Dosi, "Technological Paradigms and Technological Trajectories," *Research Policy* 11 (1982): 147-162.
- Carleton Ellis, *Printing Inks. Their Chemistry and Technology*. New York: Reinhold Publishing Corporation 1940.
- L Ethan Ellis, *Print Paper Pendulum. Group Pressures and the Price of Newsprint* (1948). Reprinted in his: *Newsprint: Producers, Publishers, Political Pressures*. Rutgers University Press 1960.
- Robert T. Elson, *Time Inc. The Intimate History of a Publishing Enterprise. Vol One, 1923-1941*. New York: Atheneum 1968.
- Elwood R. Maunder and Elwood L. Demmon, "Traiblazing in the Southern Paper Industry," *Forest History* 5:1 (Spring 1961): 6-12.
- Robert Ernst, *Weakness is a Crime: The Life of Bernarr Macfadden*. Syracuse: Syracuse University Press 1991
- J. L. Fearing, *American Newsprint*. New York: International Paper Company 1933.
- Neil Fligstein, *The Transformation of Corporate Control*. Cambridge, Mass.: Harvard University Press 1990, 63.

- Tony Freyer, *Regulating Big Business. Antitrust in Great Britain and America, 1880-1990*. New York: Cambridge University Press 1992.
- Louis Galambos and Joseph Pratt, *The Rise of the Corporate Commonwealth. United States Business and Public Policy in the 20th Century*. New York: Basic Books 1988.
- Thomas M. Grace (ed), *Forum on Kraft Recovery Alternatives*. Appleton, WI: The Institute of Paper Industry 1957.
- John A. Guthrie, *The Newsprint Industry. An Economic Analysis*. Cambridge, Mass.: Harvard University Press 1941.
- David M. Hart, *Forged Consensus. Science, Technology, and Economic Policy in the United States, 1921-1953*. Princeton: Princeton University Press 1998.
- David M. Hart, "Antitrust and Technological Innovation in the US: Ideas, Institutions, Decisions, and Impacts, 1890-2000," *Research Policy* 30 (2001): 932-936.
- Ellis W. Hawley, *The New Deal and the Problem of Monopoly. A Study in Economic Ambivalence*. New York: Fordham University Press 1995 (1966).
- Ellis Hawley, "Three Facets of Hooverian Associationalism: Lumber, Aviation, and Movies, 1921-1930," in Thomas C. McCraw (ed.), *Regulation in Perspective*. Boston: Harvard University Press 1981, 95-123.
- Charlotte Heath, *Dennison Beginnings, 1840-1878*. Framingham, Mass.: Dennison Manufacturing Company 1927.
- Thomas Heinrich, "Product Diversification in the U.S. Pulp and Paper Industry: The Case of International Paper, 1898-1941," *Business History Review* 75 (Autumn 2001): 467-505.

- Susan Helper, John Paul MacDuffie, and Charles Sabel, "Pragmatic Collaborations: Advancing Knowledge While Controlling Opportunism," *Industrial and Corporate Change*. Vol. 9, No. 3 (2000), 443-487.
- Eric von Hippel, *The Sources of Innovation*. New York: Oxford University Press 1988.
- David A. Hounshell, *From the American System to Mass Production, 1800-1932*. Baltimore: Johns Hopkins University Press 1984.
- David Hounshell and John Kenly Smith, Jr, *Science and Corporate Strategy: DuPont R&D, 1902-1980*. New York: Cambridge University Press 1988.
- David A. Hounshell, "The Evolution of Industrial Research in the United States," in Richard S. Rosenbloom and William J. Spencer (eds), *Engines of innovation: U.S. Industrial Research at the End of an Era*. Boston: Harvard Business School Press 1996, 13-85.
- Wilbur F. Howell, *A History of the Corrugated Shipping Container Industry in the United States*. Camden, N.J.: Samuel M. Langston Company 1940.
- Thomas P. Hughes, *Networks of Power. Electrification in Western Society, 1880-1940*. Baltimore: Johns Hopkins University Press 1983.
- Thomas P. Hughes, *American Genesis. A History of the American Genius for Invention*. New York: Penguin Books 1989.
- William R. Hunt, *Body Love: The Amazing Career of the Bernarr Macfadden*. Bowling Green, OH: Bowling Green State University Popular Press 1989.
- Dard Hunter, *Papermaking. The History and Technique of an Ancient Craft*. 2nd Ed. New York: Dover Publications 1981 (1947).

- International Paper Company After Fifty Years, 1898-1948*. New York: International Paper Company 1948.
- Adam B. Jaffe, Manuel Trajtenberg, and Rebecca Henderson, “Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations,” *Quarterly Journal of Economics* 108: 577-598.
- Bea Julian, “Mass Magazines, 1900-Present. Serious Journalism or Mass Entertainment,” in Wm. David Sloan (ed), *Perspectives on Mass Communications History*. Hillsdale, NJ: Lawrence Erlbaum Associates 1991.
- Steven Burton Karges, *David Clark Everest and Marathon Paper Mills Company: A Study of A Wisconsin Entrepreneur, 1909-1931*. Unpublished Ph.D. Dissertation. University of Wisconsin 1968.
- Royal S. Kellogg, *Pulpwood and Wood Pulp in North America*. New York: McGraw-Hill 1923.
- Ronald R. Klein, *Steinmetz: Engineer and Socialist*. Baltimore: Johns Hopkins University Press 1992.
- Gabriel Kolko, *The Triumph of Conservatism; A Re-Interpretation of American History, 1900-1916*. New York:Free Press 1963.
- Ferdinand Kraft, “Bleaching of Chemical Pulp,” in J. Newell Stephenson (ed), *Pulp and Paper Manufacture. Vol. I. Preparation & Treatment of Wood Pulp*. New York: McGraw-Hill Book Company 1950, 824-890.
- Thomas S. Kuhn, *The Structure of Scientific Revolutions*. 2nd Ed. Chicago: The University of Chicago Press 1970 (1962).

- L. M. Lamm, *Tariff History of the Paper Industry of United States, 1789-1922*. New York: The American Paper and Pulp Association 1927.
- Naomi R. Lamoreaux, *The Great Merger Movement In American Business 1895-1904*. Cambridge: Cambridge University Press 1985.
- Naomi R. Lamoreaux and Daniel M. G. Raff (eds), *Coordination and Information. Historical Perspectives on the Organization of Enterprise*. Chicago: The Chicago University Press 1995.
- Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Temin (eds), *Learning by Doing in Markets, Firms, and Countries*. Chicago: The University of Chicago Press 1999
- Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Temin, Beyond Markets and Hierarchies: Toward a New Synthesis of American Business History. *The American Historical Review* 108 (April 2003): 404-432.
- David S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe From 1750 to the Present*. London: Cambridge University Press 1969.
- William M. Landes and Richard A. Posner, *The Economic Structure of Intellectual Property Law*, Cambridge, Mass.: Belknap Press 2003.
- William Lazonick, "Industrial Organization and Technological Change: The Decline of the British Cotton Industry," *Business History Review* Vol. LVII (Summer 1983), 195-236.
- Jackson T Lears, *Fables of Abundance. A Cultural History of Advertising in America*. New York: Basic Books 1994

- Otto de Lorenzi (ed), *Combustion Engineering. A Reference Book Fuel Burning and Steam Generation*. New York: Combustion Engineering, Inc. 1953..
- Bengt-Åke Lundvall (ed), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London : Pinter Publishers 1992.
- Gary B. Magee, *Productivity and Performance in the Paper Industry: Labour, Capital, and Technology in Britain and America, 1860-1914*. Cambridge, Mass.: Cambridge University Press 1997.
- Charles McGovern, “Consumption and Citizenship in the United States, 1900-1940,” in Susan Strasser, Charles McGovern, and Matthias Judt (eds), *Getting and Spending. European and American Consumer Societies In the Twentieth Century*. Washington: Cambridge University Press 1998, 37-58.
- Michael J. McQuillen and William P. Garvey, *The Best Known Name in Paper: Hammermill. A History of the Company*, Erie, Penn.: Hammermill Paper Company 1985.
- Judith A. McGaw, *Most Wonderful Machine. Mechanization and Social Change in Berkshire Paper Making, 1801-1885*. Princeton: Princeton University Press 1987.
- Thomas K McCraw, *Prophets of Regulation*. Cambridge, Mass.: Belknap Press 1984.
- David G. McKendrick, Richard F. Doner, and Stephan Haggard, *From Silicon Valley to Singapore. Location and Competitive Advantage in the Hard Disk Drive Industry*. Stanford: Stanford University Press 2000.
- Thomas J. Misa, A Nation of Steel. *The Making of Modern America, 1865-1920*. Baltimore: Johns Hopkins University Press 1995.

- Hugh K. Moore, "Chemical Engineering Aspect of Renovating a Sulphide Mill,"
Metallurgical and Chemical Engineering Vol.17, No. 3 (1 Aug. 1917), 117-125.
- James Moran, *Printing Presses. History and Development from the Fifteenth Century to Modern Times*. Berkeley: University of California Press 1973.
- Robert H. Mosher, "Introduction," in Robert M. Mosher and Dale S. Davis (eds),
Industrial and Specialty Papers. Vol. I. Technology. New York: Chemical
Publishing Company 1968,1-12.
- David S. Most, "Reprographic Papers," in Robert H. Mosher and Dale S. Davis (eds),
Industrial and Specialty Papers. Vol. III. Applications. New York: Chemical
Publishing Company 1969, 138-178.
- Frank Luther Mott, *A History of American Magazines. Vol. V: Sketches of 21 Magazines, 1905, 1930*. Cambridge, Mass.: Harvard University Press 1968.
- David C. Mowery, "The Boundaries of U.S. Firm in R&D," in Naomi R. Lamoreaux and
Daniel M. G. Raff, *Coordination and Information. Historical Perspectives on the
Organization of Enterprise*. Chicago: Chicago University Press 1995, 147-176.
- David C. Mowery and Nathan Rosenberg, *Paths of Innovation: Technological Change in
20th Century America*. New York: Cambridge University Press 1998.
- David C. Mowery and Richard R. Nelson (ed), *Sources of Industrial Leadership. Studies
of Seven Industries*. New York: Cambridge University Press 1999.
- David Nasaw, *The Chief. The Life of William Randolph Hearst*. Boston: Houghton
Mifflin Company 2000.
- Richard R. Nelson and Sidney G. Winter, *An Evolutionary Theory of Economic Change*.
Cambridge, Mass.: Belknap Press 1982.

Richard R. Nelson and Gavin Wright, "The Rise and Fall of American Technological Leadership: The Postwar Era In Historical Perspective," *Journal of Economic Literature*, Vol 30 (Dec. 1992): 1931-1964.

Richard R. Nelson (ed), *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press 1993.

Ralph L. Nelson, *Merger Movement in American Industry, 1895-1959*. Princeton: Princeton University Press 1959.

David F. Noble, *America By Design. Science, Technology, and the Rise of Industrial Capitalism*. New York: Knopf 1977.

Douglass C. North, *Institutions, Institutional Change and Economic Performance*. New York: Cambridge University Press 1990.

OEEC, *The Pulp and Paper Industry in the USA. A Report by A Mission of European Experts*. Paris: OEEC 1951.

Alan L. Olmstead and Paul Rhode, "Induced Innovation in American Agriculture: A Reconsideration," *Journal of Political Economy*. Vol 101: (February 1993): 100-118.

Paper Industry

Paper Trade Journal

Theodore Pederson, *Magazines in the Twentieth Century*. Urbana: The University of Illinois Press 1956.

Michael J. Piore and Charles F. Sabel, *The Second Industrial Divide: Possibilities of Prosperity*. New York: Basic Books 1984.

- Michael E. Porter, *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: Free Press 1985.
- Michael E. Porter, *The Competitive Advantage of Nations*. New York: The Free Press 1990.
- R.F. Reed, "Paper Requirements for the Offset," in Victor Strauss (ed), *The Litographers Manual*. New York: Waltwin Publishing Company 1958, 13-40.
- Leonard S. Reich, "Research, Patents, and the Struggle to Control Radio: A Study of Big Business and the Uses of Industrial Research," *Business History Review* Vol. 51 (Summer 1977): 208-235.
- Leonard R. Reich: *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1926*. New York: Cambridge University Press, 1985.
- Thomas R. Roach, *Newsprint. Canadian Supply and American Demand*. Durham: Forest History Society 1994.
- William G. Robbins, *American Forestry. A History of National, State, & Private Cooperation*. Lincoln: University of Nebraska Press 1958.
- Frank W. Roberts, "The Evolution of the Modern Recovery Unit for Soda and Sulfate Pulp Mills," *Paper Trade Journal*, Vol 131 No. 22 (30 Nov. 1950) 191-202.
- Paul. L. Robertson and Richard N. Langlois, "Innovation, Networks, and Vertical Integration," *Research Policy* 24 (1995), 543-562.
- Nathan Rosenberg, "Technological Change in the Machine Tool Industry," *Journal of Economic History*, 23 (1963): 414-443.
- Nathan Rosenberg, *Inside the Black Box. Technology and Economics*. New York: Cambridge University Press 1982.

- Sven A. Rydholm, *Pulping Processes*. New York: Interscience Publishers 1965;
- Sven A. Rydholm, *Continuous Pulping Processes*. New York: TAPPI 1970.
- Charles. F. Sabel and Jonathan Zeitlin, *The World of Possibilities. Flexibility and Mass Production in Western Industrialization*. New York: Cambridge University Press 1997.
- AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard University Press 1994.
- Joseph Schumpeter, *The Theory of Economic Development*. Cambridge, Mass.: Harvard University Press 1934
- Joseph Schumpeter, *Capitalism, Socialism, and Democracy*. 3rd ed. New York: 1950: Harper.
- Philip Scranton, *Figured Tapestry: Production, Markets, and Power in Philadelphia Textiles, 1885-1941*. New York: Cambridge University Press 1989.
- Philip Scranton, *Endless Novelty. Specialty Production and American Industrialization, 1865-1925*. Princeton: Princeton University Press 1997.
- Martin J. Sklar, *The Corporate Reconstruction of American Capitalism 1890-1916. The Market, The Law, and Politics*. New York: Cambridge University Press 1988.
- Rudra P. Singh, "History of Bleaching," in Rudra P. Singh (ed), *The Bleaching of Pulp*. (3rd Ed). Atlanta: Tappi Press 1979 (1953).
- David C. Smith, "Wood Pulp and Newspapers, 1867-1900,". *Business History Review* 38 (Autumn 1964): 328-45.
- David C. Smith, *History of Papermaking in the United States (1691-1969)*. New York: Lockwood Publishing Company 1970.

- Smith, Barney & Co., *The Paper Industry Today*. New York: Smith, Barney & Co 1956.
- John G. Strange, *The Paper Industry. A Clinical Study*. Appleton: Graphic Communications Center 1977.
- H.H. Squire, *A Brief History of the Hinde & Dauch Paper Company with a Sketch of the Development of the Corrugated Fibre Industry*. The Hinde & Dauch Paper Co, Sandusky, Ohio, 1926.
- Louis T. Stevenson, *The Background and Economics of American Paper Making*. New York: Harper “& Brothers Publishers 1940.
- Susan Strasser, *Satisfaction Guaranteed. The Making of American Mass Market*. Washington: Smithsonian Institution Press 1989.
- Susan Strasser, *Never Done. A History of American Housework*. New York: Henry Holt and Company 1982.
- Victor Strauss, *The Printing Industry. An Introduction to its Many Branches, Processes and Products*. New York: R. R. Bowker Company 1967.
- Edwin Sutermeister, *Chemistry of Pulp and Paper Making*. New York: John Wiley & Sons, Inc. 1920.
- Edwin Sutermeister, *The Story of Papermaking*. Boston: S. D. Warren Company 1954.
- W. A. Swanberg, *Luce and His Empire*. New York: Charles Scribner’s Sons 1972.
- J. N. Swartz, “Equipment and Operation,” in J. Newell Stephenson, *Preparation & Treatment of Wood Pulp. Vol I*. New York: McGraw-Hill Book Company 1950, 431-662.
- John Tebbell, *The American Magazine: A Compact History*. New York: Hawthorn Books 1967.

John Tebbell, *The Media in America*. New York: Thomas Y. Crowell Company 1974.

John Tebbell and Mary Ellen Zuckerman, *The Magazine in American, 1741-1990*. New York: Oxford University Press 1991.

David J. Teece et. al., “Dynamic Capabilities and Strategic Management,” *Strategic Management Journal*, Vol. 18 (1997):7, 509-533.

Karl M. Thorsen, “Manufacture of Sulphate Pulp,” In J. N. Stephenson (ed), *The Manufacture of Pulp and Paper. Vol III*. New York: McGraw-Hill Book Company 1927, Section 6.

George H. Tomlinson, II, “Black Liquor Recovery – An Historical Note,” in Thomas M. Grace (ed), *Forum on Kraft Recovery Alternatives*. Appleton, WI: The Institute of Paper Industry 1957, 15-26.

George Brown Tindall, *The Emergence of the New South, 1914-1945*. Louisiana State University Press 1967.

Michael Twyman, *Printing 1770-1970. An Illustrated History of its Development and Uses in England*. London: Eyre & Spottiswoode 1970.

United Nations Food and Agricultural Organization, *World Pulp and Paper Resources and Prospects*. New York: UN and FAO 1954.

United States Census Office, *Manufactures 1900. Part III*. Washington, D.C.: Government Printing Office 1902.

United States Census Office, *Manufactures, 1905*. Washington, D.C.: Government Printing Office 1908.

United States Census Office, *Manufactures 1909*. Washington, D.C.: Government Printing Office 1913.

United States Census Office, *Census of Manufactures 1914. Vol II.* Washington, D.C.:
Government Printing Office 1919.

United States Census Office, *Census of Manufactures: 1919.* Washington, D.C.:
Government Printing Office 1923.

United States Census Office, *Biennial Census of Manufactures 1927.* Washington, D.C.:
Government Printing Office 1930.

United States Census Office, *Biennial Census of Manufacturers 1931.* Washington,
D.C.: Government Printing Office 1935.

United States Census Office, *Census of Manufactures 1933.* Washington, D.C.:
Government Printing Office 1936.

United States Census Office, *Biennial Census of Manufactures 1931.* Washington:
Government Printing Office 1931.

United States Bureau of the Census Office, *Census of Manufactures 1947.* Washington,
D.C.: Government Printing Office 1949.

United States Bureau of the Census Office, *Census of Manufactures 1954.* Vol II.
Washington, D.C.: Government Printing Office 1955.

United States Bureau of the Census Office, *Census of Manufactures 1958.* Washington,
D.C.: Government Printing Office 1960.

United States Bureau of the Census Office, *Census of Manufacturers 1963.* Washington,
D.C.: Government Printing Office 1960.

Steven W. Usselman, "Patents, Engineering Professionals, and the Pipelines of
Innovation: Internalization of Technical Discovery by Nineteenth-Century
American Railroads," in Lamoreaux, Raff, and Temin, *Learning by Doing*,

- Steven W. Usselman, *Regulating Railroad Innovation. Business, Technology and Politics in America, 1840-1920*. New York: Cambridge University Press 2002.
- Walter G. Vincenti, *What Engineers Know and How They Know It: Analytical Studies From Aeronautical History*. Baltimore: Johns Hopkins University Press 1990.
- The War Years of the United States Pulp and Paper Industry*. New York: American Paper and Pulp Association 1946.
- C. L. Wagner, "Alkali Recovery from Pulp Liquors by a Chemical Engineering Process," *Industrial and Engineering Chemistry* Vol 22. (Feb. 1930): 122-127.
- Lyman Horace Weeks, *A History of Paper-manufacturing in the United States, 1690-1916*. New York: B. Franklin 1969 (1916).
- Sidney D. Wells, "Historical Review," in *The Bleaching of Pulp. Tappi Monograph Series, No. 10*. New York: Tappi 1953, 1-10.
- A. W. Werner, *The Manufacture of Fibre Shipping Containers*. Chicago: Board Products Publishing Company 1941.
- Roy P. Whitney (ed), *Chemical Recovery in Alkaline Pulping Processes*. TAPPI Monograph Series No. 32. New York: TAPPI 1968.
- Simon N. Whitney, *Antitrust Policies. American Experience in Twenty Industries*. New York: Twentieth Century Fund 1958, 334-335.
- Oliver Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications: A Study of the Economics of Internal Organization*. New York, 1975.
- James P. Wood, *Magazines in the United States*. 3rd Ed. New York: The Ronald Press 1971.
- James Playsted Wood, *The Curtis Magazines*. New York: Ronald Press Company 1971.

Gavin Wright, "Can A Nation Learn? American Technology As A Network Phenomenon," in Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Temin, *Learning by Doing in Markets, Firms, and Countries*. Chicago: The University of Chicago Press 1999, 295-320.