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Chapter 11

The Quest for Raw Materials in the British Paper Trade: The Development of Bamboo Pulp and Paper Industry in British India up to 1939

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Abstract

The British paper trade history has been defined since the mid-1850s by a quest for a new raw material to replace rags. The requirements of the paper trade were first met by a discovery that esparto grass from Spain, and later from North Africa, could be utilised in British mills. Beginning in the late 1870s, the success of using esparto encouraged mill developments in British India. The increased dependence on imported wood pulp, the likelihood of a pulp famine, and the consequent increase in price for imported wood pulp drew attention to the possibility of making commercial volumes of good quality pulp from indigenous Indian grasses. Bamboo began being treated after the First World War, when the Government of India offered financial incentives to induce the creation of a bamboo pulp and paper industry. The bamboo pulping process entered the period of commercial production in 1922 but developed in an economically viable manner only after tariff protection had become effective in 1925. The technology was developed under British auspices, but was later adopted by Indian paper producers in response to the rising costs of imported wood pulp.

Keywords

Papermaking; Bamboo; Esparto; Sabai; India

11.1 Introduction

Paper is manufactured from plants containing cellulose fibres, which can be planted or grow naturally under favourable conditions of climate and soil. Today, the typical plants used for paper manufacture are coniferous trees, such as pine, spruce, fir and hemlock, and deciduous trees, such as eucalyptus, with the rest of coming from various fibrous, non-wood feedstocks. Natural growing reeds and grasses form an important source of fibre in developing countries, where about 60% of cellulose fibres originate from fibrous plants such as esparto, sabai and bamboo, (Bajpai 2012, p. 7) which are discussed in this chapter.

The properties of paper depend on the colour, length, diameter, flexibility and strength of the fibres used, which is why paper manufacturers tend to devote serious attention to the selection of the best available raw material for the finished paper. While the selection of a papermaking material is based on research done in the field of cellulose chemistry, this chapter highlights that it also involves a function of changes in product market demand, investments, knowledge, technology, the surrounding institutional environment and organisational solutions.

The chapter deals with the relationships between technology transfer, technology leadership, and product variety in the context of the British paper trade. By the paper trade we refer to the manufacture of printing, writing and wrapping paper for both the export trade and

domestic consumption. The research focuses on the roles played by the availability of technology, knowledge, capital, and raw materials on the one hand and demand characteristics on the other, within British domestic, colonial and organisational frameworks, and considers specifically the development of bamboo pulp and paper industry in British India.

The investigation takes its inspiration from the changes in the British paper industry's structure since the beginning of the twentieth century and looks back at its performance while it was a leader in world markets in contrast to times when its leading role was challenged by various competitors. Since the birth of the mechanised paper industry in early nineteenth century Britain, the outlook of the global paper industry has changed radically. While Britain was the industry leader during the earlier part of the nineteenth century, toward the end of the century its dominance was contested by producers in Canada, Finland and Sweden. These countries were endowed with abundant supplies of hydro-electric energy, wood as a raw material and efficient transport systems of lakes, rivers and ports, and they thus became the major papermaking players. In the Nordic countries (i.e., Sweden, Finland and Norway), pulp and paper manufacture adopted the character of an export industry, which was built to supply the growing British and global demand for wood pulp and finished paper products.

The lack of indigenous raw materials was an enormous impediment to the British paper industry, whose existence was threatened by increased overseas paper imports, low investments in new plants and machinery as well as low profit margins. (Särkkä 2012) By the mid-nineteenth century, increased domestic demand for paper combined with the scarcity in the supply of rags compelled British papermakers to look for new raw materials in the form of tropical and semi-tropical grasses. The requirements of the trade were first met in the

shape of semi-tropical esparto grass from Spain, and later also from North Africa. The success of esparto encouraged enterprises in India beginning in the late 1870s, a location that offered great natural advantages for manufacturing paper because of abundant supplies of indigenous tropical grasses such as sabai and bamboo. Although theoretically known since the mid-1870s, only during the 1920s did pulping bamboo started on a commercial scale in India, the first country to use bamboo as the primary raw material anywhere in the world. As it transpired, bamboo raw material provided the basis for the long-term development of the pulp and paper industry in India.

This country is the setting for this investigation, which will follow the business historical tradition of in-depth and rich historical descriptions based on primary sources and secondary literature. In his seminal study *Industry and Empire* (1968), Eric Hobsbawm claimed famously that Britain's relative decline as a leading technological innovator (he was witnessing this process in the 1960s) was due to its early and sustained involvement as a leading international industrial power. To understand why the industrial revolution and many of the technological innovations attendant upon it took place in Britain and not another country, Hobsbawm claimed that we must focus on the 'world' economy of which Britain was a part. In other words, he was referring to the 'advanced' areas of (mainly) Western Europe and their relations with the colonial or semi-colonial dependent economies. (Hobsbawm 1999) More recently, an increasingly global perspective in business history has emerged. It advocates the study of the behaviour of firms over extended periods of time and an understanding of the global framework, composed of markets, institutions and organisations, in which this behaviour occurs (e.g. McNeill 1990; O'Brien 2006; Pomeranz 2000). With this case method, it is hoped to provide information that will add to our understanding of the

British paper trade's history and possibly extend or clarify the history of papermaking as a whole.

11.2 Quest for a New Raw Material

Britain was the first country in the world to possess the capital, the enterprise and the skill necessary to develop its industrial capacity in the field of mechanical papermaking. This process began when experiments were undertaken with papermaking technology at Frogmore Mill, on the River Gade, near Hemel Hempstead in Hertfordshire, and the adjoining Two Waters Mill, where the first Fourdrinier papermaking machines were installed in 1803 and 1804. The stimulus given by this early mechanisation revolutionised the whole process of paper manufacture, and by the 1860s mechanisation had become widespread in the paper industry. (Coleman 1958, pp. 179–183)

The production of handmade papers had been established to satisfy the local demand for paper, but improvements in papermaking technology and building of a network of canals and railroads made possible the production of greater quantities for wider markets. An increasing population contributed directly to the rising domestic demand for paper. The census of 1801, shows that the population of the British Isles was 15 million, whereas sixty years later it was nearly 29 million (Census records for England and Wales; Scotland; Ireland 1861). New patterns of social interactions, increased literacy and heightened social consciousness also contributed to the increasing demand for paper. The extension of education and literature, the need for cheap newspapers and serial publications, the increased demand for writing paper for writing and manufacturing and commercial purposes generally, greatly stimulated domestic consumption. In addition, the growth of the industries of the Second Industrial

Revolution increased the demand for papers of all kinds. The mechanisation of industry indirectly gave people and institutions more reason to need paper. The early growth of mass communication through new forms of cheap publications was made possible by mechanical printing and papermaking. The single factor that most contributed to the increased demand for paper was the demand generated by the London publishing industry. Penny and halfpenny newspapers, journals, magazines, reviews and cheap editions of books came within the reach of the very poorest members of society. Without paper manufacture, it would not have been possible to bring many of these cheap publications into existence. (Coleman 1958, pp. 210–211)

To meet the increased demand, within less than fifteen years from the abolition of the Customs and Excise duties in 1861, the annual production of paper had more than doubled. The improved productivity, wider markets and the increased demand for papers meant that a sufficient supply of raw materials became essential to the industry. Before the middle of the nineteenth century, the refuse material from cotton, hemp, flax and jute mills formed the principal and almost sole source of fibre. Besides the waste from textile mills, other refuse materials such as thread, string, ropes, burlap, gunny bags, cotton linters and waste paper were pulped. Raw fibres were but little used in paper manufacture, and only small quantities of cereal straws and cotton stalks were used in some grades of paper. Recycled fibres were preferred over raw fibres because the former had undergone the process of semi-manufacture, and thus this material could very easily be reduced by simple mechanical means to a mass of fine fibres, which interlaced and formed a continuous, even-textured web. Old garments were especially valued in paper manufacture because, having been exposed to sun and weather and repeatedly washed, all but the most highly resistant material had already been removed from them. Being essentially pure cellulose, it was possible to treat old garments in a very weak

alkaline solution by digesting them for a relatively short period of time with little or no pressure, which greatly reduced the need for chemicals and fuel and therefore kept the costs of treatment low. (Herring 1855, pp. 49–55; Podder 1979, p. 92; Routledge 1875)

One of the most pressing problems faced by the British paper manufacturers was failure to supply enough rags to keep up with the increasing demand for paper, and this problem recurred at various times prior to 1861. There were two developments that helped to alleviate the pulp famine. The first was the continued expansion of the cotton textile industry in nineteenth century Britain and the second was an early nineteenth century invention, the introduction of chlorine bleaching, which made coloured rags suitable for papermaking. Nevertheless, Britain continued to need to import 20% of its total rag needs (15 thousand tons p.a.) to meet the requirements of its paper industry. By the middle of the nineteenth century, rags were imported to Britain from various ports all over the world, especially from Hamburg. This was not a cost-efficient way to obtain papermaking materials, not only because of the high transportation costs it entailed but also because many nations increased their existing export duties on rags. Owing to increased demand for paper and papermaking materials, the price of rags doubled between 1848 and 1855. In the British paper trade, over half of all running costs were accounted for by raw materials. It was thus regarded essential for the successful introduction of a substitute for rags that the substance should be available in abundance to guarantee the continuity of supply at a constant price. (Coleman 1958, pp. 214, 338, appendix IV; Hills 1988, pp. 128, 131; Spicer 1907, diagram III, p. 32; Magee 1997; Shorter 1971, pp. 113–115, 139)

In an elementary way, several British papermakers tried out modern processes for the isolation of cellulose from raw fibres. The first and one of the most important attempts was

made by Matthias Koops, who started to experiment with wood, straw and vegetable fibres as early as 1800, but only cereal straws proved to have any commercial value in Britain. Being an easily pulped material, the main advantage of straw was that pulping required little energy and thus the need for fuel was low. In addition, since the cereals are rich in carbohydrates with a low lignin content, they provided a good yield with little chemical consumption. In terms of paper quality, the main disadvantage of straw as a papermaking material was that its fibres are short, giving the paper it produced a low tear strength. (Herring 1855, pp. 55–56; Podder 1979, p. 60)

In Britain, a sustained supply of straw proved difficult to assure, however, and therefore the use of straw as a papermaking material remained marginal and temporary. Being agricultural residues (i.e. by-products of agricultural operations), the availability of cereal straws was conditioned by seasonal variations. In addition, cereal straws had a great liability in terms of their tendency to deteriorate while in storage. Owing to the consumption of straws for agricultural and feeding purposes, the continuity of supply at a constant price was difficult to assure. To economise the use of straw, it was often pulped with rags. Cereal straws and straw pulp were imported from Holland and Belgium into Britain up to about 1860, when the commercial manufacture of paper from straw ceased.

The outbreak of the American Civil War, immediately following the repeal of the Customs and Excise duties, threatened to cause a cotton famine in the British paper mills. It seemed evident that, unless a new raw material suitable for papermaking was speedily introduced, the British paper trade would have been seriously crippled. To address this problem, in 1861 the House of Commons ordered a Select Committee to inquire into the situation. In its report, the committee directed its special attention to the possibility of identifying a new raw material,

which could be utilised directly, without having to pass through the process of semi-manufacture. (Routledge 1875)

As it transpired, it was esparto grass that first offered a solution to the raw material shortage in Britain. Esparto constitutes two perennial grasses, *Stipa tenacissima* (Spanish grass) and *Lygeum spartum* (African grass), that are both endemic to the Western Mediterranean (growing in Portugal, Spain, Morocco, Algeria, Tunisia and Libya). It grows in clumps grouped in relatively dense formations in dry or semiarid Mediterranean areas (rainfall between 200–400 mm/year), often in poorly developed soils on limestone, and at elevations from 0 to 1,000 m. above sea level. (Fajardo et al. 2015) The first papermaker in England, who devoted his attention to the use of esparto in the manufacture of paper, was Thomas Routledge (1819-1887), who begun to experiment with various vegetable fibrous plants obtained from Kew Gardens at Eynsham Mill, on the River Evenlode, near Eynsham, Oxfordshire in the 1850s. Having visited Spain, Routledge entered into contracts with grass harvesters for their produce. After being dried like hay, sorted into different qualities and baled, the grass was ready to be transported to the British markets. (Esparto Paper 1956; Hills 1988)

There were two developments in the British paper and chemical industries that alleviated Routledge's experiments with esparto. The first was the introduction of the so called "soda process" by Charles Burgess and Hugh Watt in 1851 at Frogmore Mill. Burgess and Watt used "caustic soda" (sodium hydroxide) for pulping the wood fibres, but in the absence of a readily available wood raw material, there was little financial support in Britain for the development of a pulping process based on wood. In 1854, Burgess took out a patent in the United States, where the first mill, which utilised the soda process, began its operations near

Philadelphia in 1855. (The Paper Trail at Frogmore Mill 2013). What Routledge found at the Eynsham Mill was that the soda process was ideal for esparto, which gave easy bleaching pulp in good yield when cooked with caustic soda. Another significant development took place in the 1860s, when the Weldon process of bleaching powder was introduced. It greatly increased the power of production and diminished the cost of manufacturing bleaching powder (CNJIS, 24 December 1875, p. 299). After the introduction of these two processes, the comparative expense of chemically reducing raw fibres was no longer an obstacle to progress. Except for the use of more chemicals, there was little cost difference in processing paper from esparto or from rags.

Up to 1860 Routledge himself was the only paper manufacturer who used esparto, but it did not take long before other British papermakers availed themselves of the new raw material. By 1865, the esparto imports into Britain rose to 50,800 tons and by 1871 to 146,300 tons. The import of esparto reached its peak in 1888, with 249,000 tons compared to 41,000 tons of rags. (Routledge 1875; Spicer 1907, Diagram V, Export of Esparto, pp. 13–17, 35, 89–90; Magee 1997, pp. 118–127; Shorter 1971, pp. 141–142) Under these circumstances, the demand for esparto was not being met, and this led to a rapid extinction of the Spanish grass. Being a wild grass, or, botanically speaking, a sedge, reproduction from a seed was a laborious, slow and costly process. In the 1870s, African esparto (known to the paper trade as alfa) was substituted for the Spanish imports. Most alfa imports came from Algeria, where the French Government had offered monetary incentives and concessions to induce railway communication with the interior district, where the plant abounded on mountainous plateaus. 61,000 tons of alfa were imported into Britain from Algeria in 1874, but the difficulty of procuring labour and the cost of railway carriage added considerable transportation costs to British mills. Furthermore, being a French colony, British producers had little hope of

obtaining a reduction in prices. Owing to the increased demand and transport costs the price of esparto almost doubled between the early 1860s and 1875. The real cost of the finished paper was even higher because the value of alfa paper was proportionately lower in the market compared to paper made from Spanish esparto. (Routledge 1875)

11.3 Introduction of Wood Pulp for the British Paper Trade

Before the mid-1870s British paper makers had been using a wide variety of raw materials, consisting mainly of refuse from the cotton, flax, linen and jute industries together with amounts of raw fibres, which were mainly obtained from cereal straws and esparto. Wood emerged as the predominant source of fibre in the late 1870s, when international breakthroughs in the production of chemical wood pulp had made the product available for the British manufacturers. Wood pulp began its steady rise to prominence in Britain initially at the expense of esparto but then later at the expense of both esparto and rags. (Coleman 1958, pp. 342–343; Hills 1988, pp. 150–153; Shorter 1971, p. 114)

In the absence of readily available domestic wood resources, British manufacturers quickly availed themselves of Scandinavian wood, and there were several reasons for this development. These included its close proximity, the suitability of the product for newsprint and finally the low cost of the product compared to other available materials. Much of Scandinavia was covered in coniferous forests, and primarily two species – Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris* L.) – were being harvested. The uniformity of this raw material permitted pulp and paper makers to obtain a regular product, and because cutting was occurring on a large scale, standard products were available in international markets at very low rates. The process of wood pulping at the time was fairly straightforward.

The logs were first debarked and cut in small pieces, and then pounded into fibre by a grinding machine. Next water was added to the fibre and the resulting pulp was cleaned by pressing it through sieves. Then the pulp was graded into equal lengths of fibre, thickened and fed into a machine which spread it into an even layer. The excessive water was removed by means of a high pressure press. Finally, the layer of pulp was cut into sheets, which were pressed into bales with a hydraulic baling press and dried in a machine. (The Finnish Sawmilling, Pulp and Paper Industries 1936)

In terms of quality, the product – dry, mechanical pulp – was unsuited to the manufacture of better qualities of paper, as sunlight caused it to fade and change its colour. The product was, however, perfect for the manufacture of newsprint by being mixed with about 20–25% chemical pulp. It was also used in manufacturing board of various kinds as well as cheaper types of wrapping, writing and printing papers. Since these papers have a short life, the paper on which they are printed need not possess either purity or permanence. They must, however, be as cheap as possible.

By the early twentieth century, the British paper industry had grown increasingly dependent on wood pulp imports to maintain its rate of growth. In 1913 the share of mechanical and chemical wood pulp was 79.6% (993,000 tons) of the total imports of raw materials into the UK (1,249,000 tons), while the import of esparto and other fibrous vegetable materials constituted 18% (225,400 tons) and rags a mere 2.4% (30,000 tons). The First World War caused a violent disruption to the British paper trade, but it recovered rapidly during the interwar period. In 1919, the total imports of raw materials were about one million tons but doubled by 1929. The share of wood pulp imports of total imports of raw materials was constantly over 80%. (Table 11.1) The Nordic countries were collectively the dominant

suppliers of wood pulp to Britain; for instance, they delivered 1,300,000 tons in 1929. In the same year British pulp producers, which sourced their raw material from Norway, stood at 209,000 tons, which represented 13.9% of the total wood pulp use. (LN, 1938–1939)

By 1959, the British papermaking industries imported over two million tons of raw materials. The share of wood pulp had risen to nearly 100% of the total imports of raw materials (2,289,800 tons). (Table 11.1) For instance, within the Bowater organisation, the sources of supply were in Scandinavia for mechanical pulp and in Newfoundland for pulpwood and sulphite pulp. (Reader 1981, pp. 209, 245) The early esparto and wood pulp preparation plants established in Britain during the interwar period did not survive the post-war period but were closed down by the end of the 1950s as they could not operate economically. (Hills 1988, p. 142) Thereafter, wood pulp was delivered to British mills exclusively from the countries in which the wood was grown,¹ and the paper mills in Britain depended for survival entirely on imports of wood pulp.

¹ The first integrated paper and pulp mill in the UK that tried to utilise domestic wood resources in any significant scale was Fort William of Wiggins, Teape & Co., Ltd. in the Scottish Highlands that went into production in 1966. The venture was economically unviable, and the pulp mill remained operational only for the first fifteen years (until 1980). (Owen 2000)

Table 11.1 Raw material imports into the UK, 1913–1959 (thousand tons and %²)

Year	Rags	Wood Pulp	Esparto	Other fibrous vegetable material	Total
1913	30.0	993.6	208.2	17.2	1,249.0
1919	6.6	952.9	71.8	1.3	1,032.6
1929	20.0	1,664.5	317.7	9.7	2,011.9
1939	15.5	1,147.0	225.0	15.7	1,404.1
1949	20.7	1,326.0	366.4	20.6	1,733.7
1959	na	2,263.6	na	26.2	2,289.8
Total 1913-1959	92.8	8,347.6	1,189.1	90.7	9,720.2
% of total	1.0	85.9	12.2	0.9	100.0

Source: Accounts Relating to Trade and Navigation of the United Kingdom

11.4 Bamboo Considered as a Papermaking Material

Bamboo is an old papermaking material that was subject to a new processing treatment at the beginning of the twentieth century. In East Asia, where the plant is indigenous, bamboo had long been used to produce good quality pulp in the production of handmade papers. (Herring 1855, pp. x, 22–23, 31–33) In Britain, the increased dependence on wood pulp, the likelihood of a pulp famine, and the consequent increase in the price of imported wood pulp were the factors that raised the possibility of making large volumes of good quality pulp from bamboo. The most significant factor that contributed to undertaking experiments to use bamboo for pulp was the simple fact that the plant flourished in many parts of British India. For the early twentieth century British paper trade, which was nearly crippled by the lack of a readily available indigenous papermaking material, bamboo groves in India provided a seemingly inexhaustible supply of raw material. From the very beginning, it was obvious that it would

² The figures are calculated from imperial tons. One imperial ton equals 2,240 lb avoirdupois or 20 cwt (about 1,016 kg).

not be economical to import bamboo in large quantities into Britain owing to the bulkiness of the material and its relatively low value. Furthermore, the plant's tendency to be damaged from fermentation made importing raw bamboo difficult. Even if it were dried, its high cost of carriage made bamboo imports commercially unviable. It was evident, therefore, that to ensure a continuous supply of bamboo, it would have to be reduced into fibrous stock where grown. This development induced export capital into India, where industrial interests had been shunned as inferior to plantation and mining undertakings. (Bagchi 1972; see also Cain and Hopkins 1994)

Bamboo is a grass, which can be propagated by seed and transplanting. The life cycle for bamboo varies with different varieties and different climates and soil. In India, *Bambusa arundinacea* has a 12-year reproduction period and a 34-year life cycle. The plant is gregarious and frequently exterminates other vegetation: a clump throws out 15 to 20% new shoots every year. Thus old plants were cut every fifth year. (Podder 1979, p. 53) The main benefit of bamboo as a papermaking material is that, under favourable conditions of climate and soil, the plant produces a heavy crop with minimal care and cost. In addition, the plant grows thick in clusters or clumps and not in patches, which makes its collection easy. (Watt 1885; Sindall 1909; Raitt 1928, pp. 155–165)

Bamboo's suitability for paper manufacture had been under consideration since 1875, when Thomas Routledge initiated the first serious attempt to utilise it as a regular source of supply for pulp at the Ford Paper Mills at South Hylton, on the River Wear, near Sunderland. Routledge published the results of his experimental investigations in two pamphlets, *Bamboo considered as a Paper Making Material* (1875) and *Bamboo and its Treatment* (1879). They outlined how he had confirmed that bamboo as a papermaking material had definite benefits

over other fibrous plants. The modest experiments preceding Routledge's had failed both industrially and commercially by virtue of bamboo having been collected and treated without regard to its age. Owing to the presence of a large quantity of silica, and the extreme hardness of the stem, the only possible means of converting bamboo into pulp was to subject it to a prolonged digesting process in very strong solutions of caustic alkali at an elevated temperature. By this means pulp had been produced but at a great cost and under perilous conditions (caused by digesting the material under high pressure). The chief breakthrough Routledge made was to reveal that cutting bamboo stems at an early stage of their growth (before the cellulose and lignin have become indurated and silica deposited) would allow it to be processed using only a mild chemical treatment. (Routledge 1875; Routledge 1879)

Nevertheless, it took twenty-five years before Routledge's experimental work led to the first serious attempts to utilise bamboo for mechanical papermaking in India. In 1900, the Government of India decided to experiment on a commercial basis with using bamboo for papermaking, and requested Robert Walter Sindall, a consulting chemist to the wood pulp and paper trades, to conduct experiments with it in Burma. Sindall's experiments, carried out under the auspices of the government between 1900 and 1904, demonstrated the technical possibility to produce soda pulp bamboo. The results of Sindall's work were published in a pamphlet titled *Bamboo for Papermaking* (1909), and the general impression it presented was that bamboo was difficult to treat. The main challenge in digesting bamboo lay in the removal of its starchy carbohydrates, which required a large amount of alkali. Sindall also noted that digestion turned the pulp dark brown, which made it difficult and expensive to bleach. A further challenge was related to making the nodes reducible (i.e., the bamboo stem is a hollow culm with solid joints called nodes). Cutting the nodes out by means of a circular saw was experimented with but it proved to be very time-consuming and costly. Despite these

difficulties, in 1908 some eight to nine tons of selected *Bambusa polymorpha* were shipped to Britain and this was converted into paper by Messrs. Thomas & Green Ltd. at Soho Mills on the River Wye, in Wooburn Green, Buckinghamshire. The experiment was most satisfactory. The yield was over 50%, and the use of 8 to 10% bleach gave the paper a considerable brightness. The manufacturer reported that the raw material worked exceedingly well on the paper machine and produced a very good sheet of paper, capable of withstanding considerable wear and tear, and therefore it was specially suitable for book printing. Some of the paper manufactured at Soho Mills was later sent to the North of Ireland Paper Mill Company for lithographic printing. (Sindall 1909)

Encouraged by these positive results, further steps for developing a pulping process suitable for bamboo were taken at the cellulose and paper branch of the Forest Research Institute and College in Dehra Dun (some 150 miles north of Delhi). The history of pulp and paper development work at the Forest Research Institute can be traced back to 1909, when Sir Ralph Pearson, a forest economist, commenced an investigation of several bamboo areas in India and Burma with a view to ascertaining whether bamboo existed in commercially exploitable quantities. Pearson's report established the definite commercial possibilities of manufacturing pulp from bamboo. (Pearson 1913) In the following year, W. Raitt, the mill manager of the Bengal Paper Mills Co. at Raniganj, employed the first research worker in Dehra Dun to conduct laboratory experiments into developing a pulping process suitable for bamboo. (The Work of the Forest Department in India 1920)

It began with transporting the raw material to the factory. The stems were then passed through heavy crushing rolls in order to split and flatten them, and at the same time crush the nodes. Then the material was tightly packed in the digester where it was cooked for a period

of six to seven hours with caustic soda of suitable strength. After the boiling process, the material was put through the washing and breaking engine, which reduced it to pulp. Finally, the thoroughly washed fibre was dried and baled up in hessian for storage or export (in a similar manner to cotton or jute in textile industry). Using this method, Pearson and Raitt succeeded in manufacturing bamboo pulp by the soda process on a limited scale but the process did not work satisfactorily enough for commercial production. (London Metropolitan Archives [hereafter LMA], CLC/B/022, BPC, MS28965:1, pp. 241, 281; Sindall 1909; Clapperton 1947)

The technology of paper manufacture from bamboo and grasses was perfected over the next few years, and this resulted in an improvement in crushing technology and the economic use of chemicals in treating the pulp. A decisive step in the commercial utilisation of bamboo as a papermaking material was taken on 27 July 1911, when Samuel Milne patented a new type of crushing machine that was able to break the nodes without destroying the fibre (Espacenet. British Patent 20560). This meant that bamboo stems could be treated as a whole. The obvious advantage was that it saved the expense of cutting the nodes out, and there was also a saving in raw material. Furthermore, crushing the nodes before digestion allowed for easier chemical treatment, and the period of digestion was shortened owing to the greater speed with which the cooking liquors penetrated the pulp. It also permitted the use of a weaker solution of cooking chemicals.³

³ According to Podder (1979) it was James C. Lowe, who designed the apparatus for node crushing (59).

The next step in the development work was taken on 16 March 1916, when two British papermaking and cellulose experts, James Lockhart Jardine and Thomas Nelson, patented a process for the production of an acid magnesium sulphite solution for the extraction of cellulose from bamboo. The patentees found that the acid sulphite process was cheaper than the alkali sulphate or the caustic soda processes. They also found that the sulphite process produced paper with more enduring whiteness. The acid process was similar to that employed on coniferous wood but instead of calcium bisulphite it used magnesia bisulphite after calcium was found to be too acidic for bamboo. (Espacenet. British patent 2509)

Although Routledge, Sindall, Pearson and Raitt had all demonstrated that using a properly adapted treatment made it possible to obtain good quality pulp from bamboo, they received no encouragement from financiers for commercial production. Competing in markets against wood pulp or finished wood pulp paper imports was impossible unless financiers were assured that bulk supplies could be delivered to a mill at rates that would permit the finished paper to be sold at a profit. Raitt's experiments were, however, said to have impressed Lord Minto, the Viceroy and Governor-General of India, 1905–1911. As a result, in 1914 the Forest Department started negotiations with Thomas Nelson, one of the original patentees, to build a mill in Beypore but it appears that no agreement was made. Further investigations into the cost of cutting and transporting bamboo were made in 1917, but these, too, proved to be in vain. (Marsden 1922, p. 39) In 1919 the Government of India followed up the initial success of the Forest Research Institute in the production of bamboo pulp. Raitt's laboratory experiments justified setting up a pilot plant, which went into operation using the soda process in 1924. (Bagchi 1972, p. 395; Podder 1979, p. 36)

11.5 Experiments with Bamboo on a Commercial and Organised Basis in India

Mechanical papermaking in British India was introduced in the late 1870s when Britain's increasing demand for paper combined with the scarce supply of rags compelled papermakers to look for new raw materials, specifically tropical and semi-tropical grasses. The success of using esparto in Britain encouraged business interests to try it in India, where indigenous sabai grass (*Eulaliopsis binata*) was the primary raw material of the trade. It is a perennial plant belonging to the family *Poaceae*, and is grown in wide areas in India, East Asia and South-East Asia. The main advantage of sabai as a papermaking material was that its pulping required little chemical treatment to give good quality pulp. Like esparto, sabai yielded easy bleaching pulp in good volumes when cooked with caustic soda. Furthermore, the plant's thin and long leaves possess high-quality fibre, which were ideal for papermaking purposes.

(Khandual 2016) The extraction of sabai was difficult and cumbersome, however. The grass grew in widely scattered patches, which made it hard to keep collection costs low. (Podder 1979, pp. 51–52) By the early 1900s, the known sources of sabai in the sub-Himalayan tracts were already tapped by the existing Indian paper mills. The biggest Indian paper producers, the Titaghur Paper Mills Co., Ltd. (established 1882) and the Bengal Paper Mills Co., Ltd. (established 1887), were forced to transport sabai over long distances inland (from Nepal, the Punjab, United Provinces, Bihar, Orissa, and Central Provinces) to their mills in Bengal, which greatly increased their transportation costs. (Bagchi 1972, pp. 395-396, 398)

The gradual expansion of the wood pulp industry in Europe and North America put a stop to further progress of the paper industry based on natural growing reeds and grasses and shifted the focus of interest from tropical regions to Scandinavia and North America. Favoured by seemingly inexhaustible supplies of cheap timber in these regions, not only was the demand for wood pulp met but it was exceeded, thereby leading to the sale of the excess at “dump

prices” in the world markets. In 1912-1913, wood pulp imports into British India totalled 13,250 tons (The Work of the Forest Department in India 1920) and comprised mechanical pulp from Canada and sulphite pulp from Sweden. During the period 1899 to 1910, paper and board imports into British India peaked at 38,380.2 tons. (Table 11.2.) British imports represented between 35 and 67.4% of the annual total paper and board imports into British India, with the rest arriving from European paper mills on the Continent, particularly from Germany, Austria, Sweden and Norway. (TN, 1899–1910)

Table 11.2 Paper and board imports into British India, 1899–1910 (tons and %⁴)

Year	Printing paper	Other kinds of paper	Board (all kinds)	Total
1899-1900	4,854.1	4,353.3	763.9	9,971.3
1900-1901	5,472.0	3,325.0	1,005.8	9,802.8
1901-1902	5,981.5	4,747.1	1,012.0	11,740.6
1902-1903	6,464.8	4,737.2	1,321.7	12,523.7
1903-1904	5,576.0	4,821.5	1,491.3	11,888.8
1904-1905	7,883.3	11,226.3	1,567.8	20,677.4
1905-1906	7,715.1	15,879.6	1,916.7	25,511.4
1906-1907	11,032.0	16,055.1	1,866.3	28,953.4
1907-1908	14,392.3	18,136.5	2,223.4	34,752.2
1908-1909	12,014.3	19,930.8	2,406.0	34,351.1
1909-1910	12,924.5	22,354.2	3,101.5	38,380.2
Total 1899-1910	94,309.9	125,566.6	18,676.4	238,552.9
% from total	39.5	52.7	7.8	100.0

Source: Annual Statement of the Sea-borne Trade and Navigation of British India with the British Empire and Foreign Countries

As paper manufacturing is a highly capital intensive industry and it is characterised by rather inflexible combinations of inputs of investments, knowledge and technology, Indian paper mills could not respond to the threat of imports either by producing wood pulp or newsprint

⁴ The figures are calculated from imperial hundredweights (cwt). One imperial cwt equals 112 lb avoirdupois (about 50.8 kg).

cheaply in India or by the extensive substitution of labour for capital (or chemicals) in the manufacture of paper. Besides, Indian timber resources were poor from the point of view of developing a low cost wood pulp industry. The growth of coniferous woods was limited to the Himalayas, and their comparative inaccessibility and difficult terrain rendered their exploitation unviable. (Podder 1979, p. 46) A factor which favoured the use of imported wood pulp over indigenous materials was that it took a much larger quantity of sabai to produce the same quantity of paper (it took between two and a half and three tons of sabai to make a ton of sabai pulp). Furthermore, the cost of imported wood pulp went down in relation to that of indigenous raw materials. (Bagchi 1972, pp. 395–396, 398; ITB 1931, p. 68)

The increased price for sabai pulp as well as increased imports were the factors that drew attention to the possibility of making good quality and large volumes of pulp from bamboo. But the factor that most increased interest towards the use of bamboo as a papermaking material was the outbreak of the First World War. During the conflict a shortage of shipping caused trade between India and the rest of the world to collapse. The difficulty of obtaining wood pulp and paper during the war forced manufacturers in India to switch to indigenous raw materials instead. (Marsden 1922, p. v) It also revealed India's vulnerability in terms of supply of overseas imports. The decreased imports and the consequent increase in prices meant that Indian mills were not in a position to meet the demand for paper. The effects of the war, then, gave the necessary economic incentive for the papermakers in India to utilise bamboo for large-scale paper manufacture.

11.5.1 Capital and Entrepreneurship

Before 1914, most of the capital employed in the Indian paper industry was controlled by two British managing agency houses, F. W. Heilgers & Co. and Balmer Lawrie & Co. The former controlled the largest Indian producer, The Titaghur Paper Mills Co., and the latter the second largest, the Bengal Paper Mill Co. Such a large degree of concentration of capital facilitated the smooth working of Indian paper markets through various price and market-sharing arrangements. (Bagchi 1972, pp. 134, 158–159, 175–176, 178, 391–392) At the beginning of the twentieth century, there was no sharp distinction between the commercial and industrial interests of the managing agents. Typically, managing agents acquired a diverse group of subsidiary companies and built up a portfolio of investments primarily in British companies. Whether a subsidiary company was registered in the UK or India depended primarily on the convenience of the managing agents. (Bagchi 1972, pp. 162, 200; see also Jones 1992)

The Bamboo Paper Company was the first London-based company that was established to carry on the business of manufacturing and dealing in pulp from bamboo in India. On 27 January 1919 the incorporated company was ‘freestanding’ in the sense that it had limited managerial resources, and it operated with the support of the financial and marketing services provided by commercial and financial City firms. (Wilkins 1988, p. 264) The Bamboo Paper Co. was a private company under the meaning of the Companies Acts of 1908 to 1917. Its investments were made through channels other than the Stock Exchange, and no invitation was made to the public to subscribe for any shares, debentures or debenture stock of the company. The private capital invested in the company constituted reinvested profits and capital raised from their partners of the managing agency firm in India, Andrew Yule & Co., which had its registered offices in Calcutta. (LMA, CLC/B/022, BPC, Memorandum and Letters of Association. MS28961)

After its establishment, the Bamboo Paper Co. left technical and production matters for the India Paper Pulp Co., which was incorporated on 4 April 1918 by Andrew Yule & Co. According to an indenture, which was made on 4 November 1919 between the Bamboo Paper Co. and the India Paper Pulp Co., the latter company got exclusive rights in the use of inventions relating to improvements in making bamboo pulp and authority to manufacture and sell it. In return, the India Paper Pulp Co. allotted and issued 3,800 fully paid up shares of its capital to Bamboo Paper Co. (i.e., 20% of the equities). (LMA, CLC/B/022, BPC, Indenture, MS28963)

The Bamboo Paper Co. did not invent the process for extracting cellulose from bamboo using acid sulphite but had acquired the patent rights by assignment from the original patentees, Thomas Nelson, his brother Ian Nelson and J. L. Jardine, who acted as the company's paper and cellulose experts. The patents covered two principal areas: the actual pulping process by which it was possible to manufacture high-grade pulp on a commercial basis and the machinery for crushing bamboo. (LMA, CLC/B/022, BPC, Letter Book, MS28964:1, pp. 126, 241) Thomas Nelson & Sons, Ltd., which had its registered premises at Parkside Works, Dalkeith Road, Edinburgh, acted as the patent agents for the Bamboo Paper Co. The former tried to eliminate potential competitors in the field by securing foreign and colonial patents for the sulphite pulping process and the crusher.

According to the requirements of the Patent Office, working on a commercial scale should have been carried out within four years of the issue of the patent (Espacenet. British Patent 14421, 16 June 1914) but this provision was suspended during the war and the period for complying with it was extended until 1922. A certain amount of crushing, pulping and paper manufacturing was initially done at the works of James Brown & Co., Ltd., the Esk Mills,

Penicuik, Midlothian. (LMA, CLC/B/022, BPC, Letter Book, MS28964:1, p. 335; MS28964:2, p. 178) For the commercial development of the process, the India Paper Pulp Co. required a large plant, which it started to construct in 1919 on the bank of the River Hooghly, at Hazinagar, near Naihati, Eastern Bengal Railway, 30 miles from Calcutta. The experimental and development work was carried out over the next four years at the Naihati mill, and this resulted in improvements in the mechanical treatment as well as the economic use of chemicals in treating bamboo. The mill started to pulp bamboo by using the acid sulphite process in 1922. (ITB 1924, p. 312; Podder 1979, pp. 8–9, 55–56)

11.5.2 The Essential Conditions for Successful Bamboo Pulp and Paper Industry

Taking for granted the commercial value of the bamboo in its application to papermaking, the following points needed to be considered in the erection of the Naihati mill. First, to reduce transportation costs, it was imperative that the mill be located close to the source of raw materials. The amount of raw material needed was calculated by estimating the quantity of bamboo required for the manufacture of a stated annual amount of finished, air-dry pulp, and the area of land that was estimated to be necessary for the production of that quantity. Air-dried bamboo typically yielded 42 to 50% pulp depending on which species was used. On the basis of a 45% yield, the manufacture of one ton of pulp required the treatment of two and a quarter tons of bamboo. (Sindall 1909)

Initially, the India Paper Pulp Co. adopted a business model by which the supply of raw material was ensured from the point of view of the system of cropping and cultivating the Kasalong Bamboo Reserve, which the company leased and was located in Chittagong Hill Tracts. By gradually harvesting the older growth for the manufacture of certain qualities of

pulp and introducing a system of cropping, it was possible to control the growth of bamboo and thus ensure a permanent supply of raw material. The bamboo was procured by first cutting it and then floating it in rafts down to the company's crushing and baling plant in Chittagong. The capacity of this crushing plant was approximately 24 tons of raw bamboo per day. The crushed material was then transported by steamer to the Chittagong Jetties, and finally delivered by rail to the Naihati mill (the total distance from the bamboo reserve to the mill was 470 miles). Working the concession directly proved to be too costly, however, and before long the company started to obtain its raw material directly from contractors in Assam as well as Chittagong. (ITB 1924, pp. 312, 362; ITB 1931, pp. 40, 45) Although this approach was cost-effective, its obvious disadvantage was that it was difficult to ensure the uniformity of the raw material.

Second, the location of the mill needed to be considered. Up to the late 1930s, Indian paper mills were almost entirely dependent on imports from abroad for their requirements of machinery, machine tools, various chemicals and other materials. (Bagchi 1972, p. 434). To ensure the delivery of the supplies of raw material, coal for energy and various chemicals and loading materials and the transfer of the finished paper, a railway siding and a port contiguous to the mill had to be built. In wood pulping, hydro-electric energy resources were essential in choosing a location for the mill, but this consideration did not apply to the Naihati mill, which obtained electric power from a steam driven power station situated in the mill. Coal was brought by rail from the Bengal coalfields (a distance of 150 miles). (LMA, CLC/B/022, BPC, Letter Book, MS28964:2, p. 197)

The technology in connection with the crushing process was perfected in Edinburgh at Messrs. James Bertram & Son, Ltd., which supplied the crushing plant. The same company

delivered a 98-inch wide paper machine to the mill together with various fittings. Besides the actual machinery needed for the production of pulp and paper from bamboo fibre, the equipment for the Naihati mill varied widely and included, among other items, corrugated roofing materials from British Everite & Asbestilite Works, Ltd. of Manchester, a Turbo-Generator from Messrs. Bruce, Peebles & Co. of Edinburgh, an engine from Belliss & Morcom, Ltd. of Ladywood, Birmingham, and a steam turbine from Ljungström Steam Turbine Co. (Aktiebolaget Ljungströms Ångturbin) of Sweden. (LMA, CLC/B/022, BPC, Letter Book, MS28964:2, p. 197) The supplies of heavy chemicals and minerals included, for instance, 50 tons of refined rock sulphur per month from Sicily, together with volumes of bleaching powder, China clay, dyes and magnesite. In terms of the latter, which was imperative for the extraction of cellulose from bamboo, the company relied on supplies from the Salem Mines, located in Kancheepuram, near Chennai. (LMA, CLC/B/022, BPC, Letter Book, MS28965:1, pp. 246, 273, 325) It also considered acquiring its own magnesite deposits in India. (ITB 1924, p. 315)

Finally, the total operating costs, which would determine whether the finished paper could be sold at a profit, needed to be considered. The enormous demands for all kinds of machinery, equipment and chemicals on the one hand and the existing industrial problems both in England and India, and the serious shortage of building materials and the shortage of shipping and communication in general (in 1921 cables from London to India frequently took from seven to eight days) on the other meant that reliable cost estimates were difficult to make. (LMA, CLC/B/022, BPC, Letter Book, MS28965:1, p. 317)

In particular, fluctuations in the exchange value of the rupee created difficulties for the India Paper Pulp Co. Between 1898-1899 and 1919-1920 the value of the rupee was maintained at

the fixed rate of 1s. 4d. in sterling. The breakdown of the pre-war monetary mechanisms and the inability of the Government of India to introduce a paper currency to replace the old silver rupee meant that the fixed value of the rupee became linked to the soaring price of silver. (Bagchi 1972, pp. 64–65) Fluctuations in the rupee's exchange value combined with intense competition from abroad made the potential development of the bamboo pulp and paper industry look extremely gloomy. In 1919, it was estimated that a total expenditure on the Naihati mill was Rs. 750,000 (£50,000 when the exchange value of rupee was 1s. 4d in sterling). (LMA, CLC/B/022, BPC, Letter Book, MS28965:1, pp. 275–277) This was significantly higher than Sindall's estimate some ten years earlier. In 1909, the cost of a dry-pulp plant, which had a weekly output of 200 tons pulp, was in total about £36,000 (Sindall 1909).

The estimated production cost at the Naihati mill was Rs. 80 per ton of wet pulp and Rs. 140 per ton of paper. (LMA, CLC/B/022, BPC, Letter Book, MS28965:1, p. 273) These estimates were exclusive of labour costs, which amounted to 38% of the total production costs in the UK, but were significantly lower in Bengal, where cheap and abundant Indian labour was one of the main assets of the pulp and paper industry. (ITB 1924, p. 311; Bagchi 1972, pp. 152–153) In general, from the mid-1920s onwards there was abundant labour in most of India's major industrial centres. Since working conditions in mills were much better than in mines and plantations, and wages were higher, particularly for skilled workers, it was unnecessary for the managing agents to make any special effort to recruit labour. (Bagchi 1972, pp. 135, 138) In 1924, it was estimated that the Naihati mill employed some 800 to 1,000 labourers (inclusive of those workers who were extracting and collecting raw material). (ITB 1924, p. 315) The wages of Indian workers varied from Rs. 190 per month at the high end of the scale (i.e., the Head Mechanic) to Rs. 14 per month at the low end (i.e., a 'Boy'). (ITB 1924, p.

318). These wages were significantly higher than average monthly wages of Indian workers in the Calcutta jute mill, where workers earned between Rs. 12 and Rs. 20 a month. (Bagchi 1972, pp. 126–127) The management at the Naihati mill was European, earning approximately 50% more than the average wage rate that would have been drawn in England. (ITB 1924, p. 318)

11.5.3 The Paper and Pulp Trades and Indian Tariff Policy

Up to 1914, the Government of India pursued the policy of free trade and non-intervention in industry, and there was virtually free trade as far as imports into India from other countries were concerned. This pattern of trade primarily served the British imperial system; Britain had a large market, in which Lancaster and Manchester piece goods (i.e., fabrics woven in standard lengths for sale) and other industrial products in demand in India such as machinery and hardware, entered duty-free at the time when other markets in the world were closing against them. On the other hand, Britain was the largest purchaser of raw materials and manufactured jute from India. The system's smooth functioning was facilitated by the fact that the Indian money market was directly linked to the City, the world's chief money market before 1914, and also the fact that there was little industry in comparison with trade. (Bagchi 1972, pp. 5, 48–50, 58–59)

An early attempt at import substitution in the Indian paper industry was choked off before the First World War by the rapid progress of the wood pulping process in Europe and North America. The war caused a violent disruption to the trade owing to the lack of shipping capacity. By 1918-1919, the amount of wood pulp imported into India had recovered to merely 2,090 tons, causing soaring prices. At this time, the Raneeunge Mill of the Bengal

Paper Mill Co. was buying imported sulphite pulp at the very high price of £20 a ton. Its average cost of manufacture from all materials was £14 a ton. (LMA, CLC/B/022, BPC, Letter Book, MS28965:1, pp. 198–199) By the end of 1922, competition from European paper makers had started in earnest, and thus prices fell rapidly. In this regard, competition was most intense from the UK, Norway, Sweden, Finland, Germany and Holland. In terms of wood pulp, Sweden, Finland and Norway were the main suppliers to the Indian markets. (ITB 1924, p. 321) The average price of imported Scandinavian pulp was in the neighbourhood of £10-15 a ton. By way of comparison, the price of Scandinavian wood pulp at an English mill was reported to be approximately £9 a ton. (ITB 1931, pp. 19, 90)

The first step in erecting a tariff on imported pulp and paper occurred in June 1923 when the Indian Paper Makers' Association submitted its claim for protection to the Government of India. The question was referred to the Indian Tariff Board (hereafter ITB) one year later. The ITB considered it inadvisable for the government to commit itself firmly to the protection of the bamboo pulp and paper industry until the bamboo pulping process had really proved itself commercially. Instead, the ITB suggested that the government support the India Paper Pulp Co. by providing capital either in the form of loans or by guaranteeing a public issue of debentures for an extension its capacity. Secondly, it recommended that, in place of the existing 15% ad valorem duties on printing and writing paper, a specific duty of one anna per pound should be imposed on all writing paper and on all writing paper other than newsprint containing 65% or more of mechanical pulp. Newsprint was exempted from the protective duty on the grounds that mechanical pulp had never been made from either sabai grass or bamboo and that the existence of cheap newsprint on the Indian markets depended

on imports.⁵ The government rejected the ITB's recommendation to provide financial assistance to the India Paper Pulp Co. for the three reasons. First, the India Paper Pulp Co. was a private company. Second, the acid sulphite process was covered by patent rights held by Jardine and the Nelsons, who were members of the company. And finally and most importantly, financial assistance to the Indian paper industry should assist equally all competitors within the industry and should not benefit the India Paper Pulp Co. alone and thereby give it an undue advantage over its rivals. (ITB 1931, p. 3; Bagchi 1972, p. 397)

Ultimately, the ITB ended up endorsing protection instead of financial assistance to the India Paper Pulp Co. because it considered that bamboo could serve as the raw material for the long-term development of the Indian paper industry. The two major producers of paper in India, the Titaghur and the Bengal Paper Mills, did not have promising prospects, on the one hand, because the supplies of sabai grass from known sources were rather limited, and on the other, because the both companies' mills situated far from the known sources of sabai. The Bamboo Paper Industry Protection Act of 1925 marked the end of the free trade era. It imposed an import duty of one anna per pound on printing and writing paper, and on all writing paper other than newsprint containing 65% or more mechanical pulp. Papers made from bamboo were protected for seven years (up to 31 March 1932). (ITB 1931, pp. 3–5; Bagchi 1972, pp. 5, 396–397; Podder 1979, p. 56)

⁵ In general, the underdeveloped countries like India imported most of their newsprint from the outside world. The first Indian newsprint mill, National Newsprint and Paper Mills, Ltd. started production in 1955-1956. (Podder 1979, pp. 177, 196)

The protective duty for the bamboo pulp and paper industry in India had numerous effects. The bamboo pulping process, although theoretically known since the mid-1870s, only entered the period of commercial production in 1922 and developed in an economically viable manner only after tariff protection had become effective. The technology was first developed at the Naihati mill, but was later adopted by the other Indian mills in response to the increased cost of sabai pulp. (Bagchi 1972, p. 419) In 1923, the Titaghur Paper Mills Co. and the Bengal Paper Mill Co. had twelve paper machines altogether (an aggregate capacity of 31,000 tons). The India Paper Pulp Co. had initially only one paper machine (its capacity was 6,000 tons and it installed a second machine in 1927), with which it had managed to produce (by using entirely their own bamboo pulp) 4,228 tons of paper by the end of 1924. (ITB 1924, p. 311; ITB 1931, p. 10) Although it had started production only in 1922, it already showed lower production costs than its competitors in Bengal. Including labour, its costs were Rs. 485.27 a ton of paper for 1923-1924. (ITB 1924, p. 335). In 1930-1931 the costs were approximately one third lower (Rs. 330.65 a ton). (ITB 1931, p. 54) The fall in costs is attributable to the growing familiarity with bamboo as a papermaking material, the employment of contractors as opposed to using men who were on the company's payroll to work the concession and improved efficiency in production, which reflected positively on the demand for coal. (ITB 1931, pp. 63, 65–66)

The tariff protection was not much of a success in terms of increasing production of bamboo paper in relation to India's total output of paper. The rate of growth of the bamboo paper industry under tariff protection was initially very modest. Production of 2,500 and 5,000 tons were recorded in 1925 and 1931 respectively, while the total output (from all materials) of the Indian mills increased from 25,000 to 40,000 tons. In 1925, the protected bamboo paper industry represented 14.7% of the total Indian paper production and dropped to a mere 8% in

1931. (ITB 1931, pp. 18, 25) Protection was primarily effective in restricting the consumption of certain grades of paper, but a substitution of unprotected for protected varieties took place. The total Indian consumption of all grades of paper increased from 112,000 tons in 1924-1925 to 154,300 in 1930-1931, and the consumption of tariff protected paper increased from 43,300 tons in 1924-1925 to 49,000 in 1930-1931. (ITB 1931, p. 105)

One of the unintended effects of protecting the bamboo pulp and paper industry was a rise in the proportion of imported wood pulp used in the manufacture of paper. This was a natural outcome because the bamboo pulping process developed very slowly. At the time of the 1931 enquiry by the ITB, besides the India Paper Pulp Co., only the Titaghur Paper Mills Co. seemed to have succeeded in developing a truly effective bamboo pulping process. Titaghur relied first on the soda process but later applied the alkali process together with other Indian mills. Only the India Paper Pulp Co. continued to rely on the acid sulphite process it had developed. (ITB 1931, pp. 47, 106) Between 1924-1925 and 1930-1931 the use of both indigenous and imported materials increased, but there was a drastic decline in the ratio of indigenous compared to imported materials used. All the major companies were using a higher percentage of wood pulp in 1930-1931 than they had done in 1924-1925. In the case of the India Paper Pulp Co., for example, imported wood pulp accounted for 21.02% by weight of the finished paper it produced in 1924-1925. In 1930-1931 wood pulp accounted already for 63.04% by weight of the finished paper produced and bamboo some 30%, with the rest coming from recycled fibres. The total quantity of wood pulp imported into India in 1930-1931 was 22,715 tons, which was equivalent to nearly 20,000 tons of finished paper or about half the total Indian paper production. (ITB 1931, pp. 55, 87, 93; Bagchi 1972, p. 402)

The Bamboo Paper Industry (Protection) Act of 1932 extended protection by another seven years since the withdrawal of the protective duty would have meant the disappearance of bamboo as a raw material for the manufacture of paper. The ITB estimated that without tariff protection it would be far too expensive for the mills to use bamboo pulp. This would have wasted all the development work, left indigenous raw material resources undeveloped and kept the Indian paper industry dependent on imported wood pulp. During the First World War, the scarcity of wood pulp had nearly crippled the paper industry and highlighted the importance of having a domestic pulp industry. (ITB 1931, pp. 82–84; Bagchi 1972, p. 45)

During the period from 1932 to 1937 India's total production increased every year. This was due to the better utilisation of existing production capacity under the stimulus of higher duties. The protective duty on paper was raised in 1932 from 18.75% to 30% ad valorem, with a preferential duty for grades manufactured in Britain. (Bagchi 1972, p. 402) This was a result of the imperial preference system, created at an Imperial Economic Conference in Ottawa in July-August 1932, which aimed at expanding trade among the members of the British Commonwealth in a world of shrinking commerce and rising trade barriers. (Pollard 1963)

A period of seven years (1932 to 1939) afforded the Indian paper industry an opportunity to consolidate its position and encouraged it to undertake further expansion. It also made considerable progress in substituting bamboo pulp for wood pulp. This was primarily the result of the imposition in 1932 of a specific duty of Rs. 45 per ton on imported pulp by the Bamboo Paper Industry Act of 1932. Since all protective duties were subject to the revenue surcharge imposed in November 1931, the effective rate of specific duty on imported pulp came to Rs. 56.25 per ton. The replacement of imported pulp by domestically produced pulp

was also facilitated by resolving the problems involved in the mechanical treatment of bamboos. (ITB 1931, pp. 95–96; Bagchi 1972, p. 399)

The monetary incentive given by the Bamboo Paper Industry Protection Act of 1932 was sufficient to introduce bamboo into the paper industry. As it transpired, bamboo raw material provided the basis for the long-term development of the Indian paper industry. Between 1936 and 1939, a number of new mills appeared, including Star Paper Mills in 1936, Mysore Paper Mills in 1937, Orient Paper Mills in 1938, Sirpur Paper Mills in 1938 and Rohtas Industries in 1939. In the late 1970s, bamboo formed 67% of the country's pulp raw material (Podder 1979, pp. 66, 177). In the more recent decades, the scarcity of bamboo, softwoods, and recycled fibres has led to the development of eucalyptus for plantation purposes and pulping hardwoods.

11.6 Conclusions

The British paper trade history has been defined since the mid-1850s by a quest for a new raw material to replace rags. Increasing demand for paper combined with the scarcity in the supply of rags induced British papermakers to look for new raw materials in the shape of tropical and semi-tropical grasses. The requirements of the paper trade were first met by Routledge's discovery that esparto grass from Spain, and later from North Africa, could be utilised. Since the late 1870s, the success of esparto encouraged mill developments in British India, where the primary raw material was sabai grass. The gradual expansion of the wood pulp industry in Europe and North America put a stop to further development work based on naturally growing grasses and shifted the focus of British papermakers from tropical regions to those of Scandinavia and North America. Favoured by seemingly inexhaustible supplies of

cheap timber in these countries, and assisted by their cheap hydro-electric power and efficient transport systems, imported wood pulp assumed a pre-eminent position as a papermaking material in Britain, whose large paper industry offered a convenient market for wood pulp and finished papers produced in Scandinavia and North America. Not only was the demand for wood pulp met but it was exceeded, which inevitably led to “dumping” of the excess in world markets.

A decade before the outbreak of the First World War, competition from European paper and wood pulp had started in earnest in India. Although theoretically known since the mid-1870s, bamboo began being treated only after the First World War, when the Government of India offered financial incentives and concessions for the exploitation of forest areas to induce the creation of pulp and paper industry based on utilising bamboo as the raw material. The increased dependence on wood pulp, the likelihood of a pulp famine, and the consequent increase in price for imported wood pulp were the means for drawing attention to the possibility of making commercial volumes of good quality bamboo pulp. The bamboo pulping process entered the period of commercial production in 1922 but developed in an economically viable manner only after tariff protection had become effective in 1925. The technology was developed under British auspices, but was later adopted by Indian paper producers in response to the rising costs of imported wood pulp.

In India, coniferous species were limited to the Himalayas, making exploitation of softwood resources economically unviable. In their absence, papermakers in India adopted technologies and organisational solutions that distinguish them from the other British Empire and Commonwealth countries. These developments took place within British national, colonial

and organisational frameworks, and reflected the availability of technology, knowledge, investments, and raw materials on the one hand and demand characteristics on the other.

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