Draft 1: Comments welcome

Industrial Policy, Structural Change and Technology Gap: A study of Indian Pulp and Paper industry

Vinish Kathuria (vinish.kathuria@gmail.com)*

Professor
SJM School of Management
Indian Institute of Technology Bombay
Powai, Mumbai – 400076
India.
Ph. 022-25767863(O)

Paper submitted for Knowledge Forum Conference on "Technology: Corporate and Social Dimensions" to be held in NIAS Bangalore – Oct 27 to 29, 2014

Acknowledgements –

* The funding for this paper is received from IIT Bombay as part of seed-grant. My thanks to IIT Bombay for giving the grant. I am thankful to Rekha for collecting the organized sector data. My special thanks to Anurag for clearing some of the technical doubts. The usual disclaimers apply.

Industrial Policy, Structural Change and Technology Gap: A study of Indian Pulp and Paper industry

1. Introduction

The year 1991 is a turning point in the economic history of India. An economy, which was highly regulated until 1991, started dismantling various controls and slowly inched towards a full-fledged market economy. Among various reforms, external liberalization in the form of allowing Foreign Direct Investment (FDI) and gradual reduction in import duties are seen as vital. This is because FDI and freer import often brings in new and better technology, newer products, improved managerial practices, efficient processes, all these in turn facilitate improvement in the competitiveness of the industries (Kathuria, 2002). Reduction in the technology-gap is generally seen as an outcome of this increased openness (Kathuria, 2010). However, the impact on technology-gap may be marginal, if the source country firms are not on a higher technological trajectory or if the trajectory is changing fast. The nineties have also witnessed changing patterns of FDI in India mostly originating from the OECD countries with US forming nearly 25% of the total inflow. This would have affected the kind of technology transferred, thereby spurring the innovation activities leading to fall in technology-gap. An important question that arises now is whether the opening up of the economy and change in FDI origin has been beneficial to the Indian manufacturing industries in bridging the technology-gap or not.

This proposed study aims to analyze the impact of external liberalization on the technology-gap in one key Indian manufacturing industry – pulp and paper. The paper industry is one of the oldest industries with a history of over 200 years and is also one among the 35 high priority industrial sectors[1] in India.

The study attempts to address the following two questions: a) does policy has any role to play in structural change in the industry? and b) what role does technology-gap pay in influencing technical efficiency of the Indian pulp and paper industry?

The organization of remaining paper is as follows. Section 2 gives the present structure of Indian pulp and paper (IPP) industry. The section also gives the development of IPP industry since independence. Section 3 talks about technology development in the IPP. Section 4 discusses the models estimated a) to see structural change in the industry, and b) to see impact of technology gap in productivity of IPP. Section 5 gives a brief description of data and variables. Section 6 reports the results for structural change and break in the sector. Section 7 gives stochastic frontier results and also role of technology gap in explaining efficiency of paper segment. The paper concludes with section 8 giving policy implications of the study.

[1] Eleventh Five Year Plan Report

2. Indian Pulp and Paper Industry

2.1 Structure of the Paper Industry

There are three different ways to characterize the industry: a) based on size; b) based on raw material used; and c) based on product.

a) Structure – based on Size

Based on size, papers mills can be characterized in three different categories: large, medium and small mills. Large mills are those mills having capacity more than 100 tons to 800 tons a day, producing on an average of 300 tons a day; Medium mills are the mills with a capacity in the range of more than 50 tons to 100 tons a day with an average of 60 tons a day; and lastly small mills are the mills with a capacity in the rage of 5-50 tons a day with an average of 15 tons a day.[2]

The number of mills in each of the three categories - small, medium and large - has multiplied manifold in last several years (Table 1). Between 1985 and 2005, i.e., 20 year period, there was an addition of 20 large integrated mills, 160 medium-scale mills and 471 small mills (Table 1). Proliferation of small mills though has resulted in significant addition to the installed capacity, but has also caused under-utilization of the installed capacity, as many of these smaller units eventually become sick units.

b) Structure – based on Input Use

Apart from the installed capacity, IPP can be categorized based on input/raw-material use. Three broad segments based on input use are – i) segment using wood (forest based) raw material; ii) segment using non-wood (agro-residues) raw material; and iii) segment using waste paper (recycled fibers) raw material (CPPRI, 2002). Incidentally, mills using waste paper as input are the small mills. Mills using wood (forest based) are large mills and those using agro-residues are medium sized mills. At present hardwood like eucalyptus, cereal straw and waste paper are the main sources of raw material. Last 40 years has seen drastic change in the resource use. With increased paper demand, ban on cutting down of tress and due to shortage of raw material, the paper industry has moved from wood to agriculture residue. From wood (forest based) (≈ 84%) intensive paper production in 1970, only 31% of the total paper production was from wood in 2011 (Figure 1). On the other hand, with barely 9% agro-residue as input in 1970, their share has gone upto 47% in 2011. Despite 31% of industry using hardwood (i.e., approx.. 9.0 million tons), this forms only 2-3% of the total wood consumption of the country.[3]

[2] This classification based on per day production capacity came only in late 1980s.

[3] Source: CPPRI (2007) Final Draft, Updating of Statistical Data for the Indian Paper Industry, Central Pulp and Paper Research Institute, Saharanpur, UP (www.dcpulppaper.org/gifs/report16.pdf accessed in Sep. 2014).

c) Structure - Paper Products

Based on end-product, IPP can be divided into four broad categories – i) Writing and printing paper; ii) Industrial paper or paperboard; iii) Newsprint; and iv) Speciality paper (Figure 2). Writing and printing is further divided into Copier, Creamwove (a wood free paper used for computer stationery, textbook and notebook), Maplitho (a surface sized paper used for premium notebooks) and Coated paper (a superior quality printing paper used for brochures, calendars, greeting cards etc.) with end use from education sector, office printing, printing for advertisement and publicity purpose. Industrial paper / paperboard is generally used for consumer packaging and tertiary packaging (kraft paper). Newsprint is used by newspaper and magazine industry. Speciality paper is used for manufacturing cigarettes, tissue paper etc. (CRISIL, 2011).

For accounting of various economic activities in the country, the GoI categorizes industries based on National Industrial Classification (NIC). As per the latest NIC (2008) classification, output of Paper industry is categorized in three broad categories – i) manufacture of pulp, paper and paperboard – consisting of newsprint, paper and paper rolls not further processed, packing paper, straw board, hard board etc.; ii) manufacture of corrugated paper and paperboard and containers of paper and paperboard; and iii) manufacture of other articles of paper and paperboard including computer paper, paper cups, saucers, plates, file cover, wall paper, carbon paper & stationary items etc.

II Demand for paper

Per capita consumption of paper in India at the end of the Eleventh plan period was 7.2 Kgs per annum against world average of 54 Kgs.[4] This is miniscule compared to the consumption by the developed countries and also by the United States (320 kgs/annum), the highest paper consuming country, and Japan (220 kgs/annum), the highest paper consuming Asian country. However, we can see an increasing trend in paper consumption in India over the past 4 decades though growth is much below that of China and Vietnam (Table 2).

2.2 Growth and Development of the Paper Industry

The first paper mill in India was set up by William Carey in 1812 at Serampore (W. Bengal) with the help of local kagzis.[5] With the mechanization of paper making, development in this industry pivoted around the paper making technology. In the beginning paper machines were imported. These machines used primarily soft wood as raw material. The focus on indigenization of the paper machinery affected the growth of the paper industry in subsequent period. This is because

[4] http://www.forestindustries.se/documentation/ppt-files/international_1/per_capita_paper_consumption accessed in July 2013.

[5] "Kagzi" clan is the principal owner of the handmade paper industry. The history of the clan dates back to the 14th century during the rule of Feroze Shah Tughlaq. The handmade paper made by them was very famous in those times and was mostly used by royalties for official documents, miniature paintings, calligraphy, copying of the Quran, and account books of traders (Source: http://islamicvoice.com/december.2001/initiative.htm accessed in June 2013).

indigenous machines were to be made that could use plenty available hardwood as the raw material. With advent of use of bamboo as a raw material in 1914, an indigenous source, the trajectory of paper production changed. At present, variety of raw material is used in production of paper. Also paper machines are manufactured indigenously.

Growth of Paper Industry[6]

Table 1 gives the growth of paper industry since 1950. It can be clearly seen that the industry has grown both in size and volume, especially over the last few decades. While there are 25-30 large integrated players, the industry mainly comprises of almost 1,000 small unorganised players Over the years, several small scale players have entered the industry primarily due to the incentives provided by the government.

During 1950s and 1960s, the government exempted all new units from excise duty to the extent of 50 per cent for a period of 5 years, and linked the excise duty structure to the installed capacity of the manufacturing unit. This was done with a view to augment supply in the industry. The exemption was made available up to a certain production limit. This move facilitated the entry of many smaller players into the industry.

Further, in 1970s, in order to ease capacity constraints in the industry, the Government of India granted excise concessions to small agro-based mills. This led to the emergence of several small scale units that augmented the industry's capacity and helped meet the growing demand for paper and the corresponding pulp shortage. The continuation of this regulatory move resulted in an oversupply situation during 1980s, with capacity utilisation levels falling to as low as 60 per cent. Hence, in early 1990s, the government reversed the policy granting excise concessions.

Regarding newsprint, there was no indigenous capacity for it until 1955. The entire requirement of newsprint was imported under open general license (OGL). The manufacture of indigenous newsprint commenced with the setting up of National Newsprint and Paper Mills (NEPA), which could produce 88,000 tpa in 1956. The number of mills increased in the 1980s to five from one; capacity increased to 330,000 tpa.

In 1989-90, the government permitted the private sector to manufacture newsprint, which resulted in an increase in the supply of indigenous newsprint. Newsprint units based on non-conventional raw materials such as straw and bagasse were exempt from holding an industrial license (however, producers had to file for an industrial entrepreneur memorandum). In 1990-91, companies expanding their capacity to over 20,000 tpa were allowed to manufacture newsprint from their additional capacities. This change in government policy encouraged the private sector to manufacture newsprint. Hence, many paper units such as Rama Newsprint, NR Agarwal Industries, Jayant Paper and Sun Paper entered this business.

[6] This subsection builds on CRISIL (2011).

In the 1950's large integrated mills where set up as public sector undertakings (PSUs). A large integrated mills was defined as those mills which have the capacity to produce more than 20,000 tones per annum until 1980s. Eventually private investment in the industry was welcomed and at present both large and small paper mills are being operated by both private and public sector. Paper production in 2012 was approximately 5.8 million tones[7] and installed capacity of 8.5 million tones recording 1.75 times growth in total capacity and 2.5 times growth in total paper production (Figure 3). Paper production was predominantly to meet domestic consumption requirements. In the period from 1996 to 2002 paper was imported to fulfill domestic demand (Figure 4). The number of paper mills multiplied from 17 mills in 1950 to 568 mills in 2012. Of the total industry output, PSUs produce approximately 60% and the private sector constitute the other 40%. Figure 5 gives share of different products in paper production for two time periods – 2000 and 2010.

The development of the paper industry in India thus can be broadly classified into four phases.

Pre-protection period (before 1923): During the pre-protection period, the annual production was 30,000 tonnes against the total installed capacity of 35,000 tonnes. This output was distributed among 6 paper mills.

Pre-independence period (1924-36): With the interest to encourage the growth of the paper industry, in 1924 the government initially granted protection to the paper industry for five years. Higher duties were imposed on imports of paper and paper products. A duty of Rs. 45 was imposed on imported paper. This was later extended to another seven years. The World War gave impetus to the paper industry and paper production doubled. There were 17 paper mills with a capacity utilization of about 84%. All types of paper and paper board were made during this period. The government however, kept the prices regulated.

Post-independence plan period and post-liberalization period: The period from 1950-1990 constitutes the pre-liberalization period and from 1991onwards is classified as post liberalization period. In considering performance of the industry in terms of capacity utilization, pre-liberalization period fared better than the post liberalization period with an average of full capacity utilization in comparison to an average of 60% capacity utilization in the post liberalization period (Tables 3 and 4).

At the end of the eleventh five year plan, the installed capacity increased about forty times since the first five year plan. But this increase in installed capacity is not commensurate with increase in industry output. The industry output grew only about thirty times during the same period. The bottlenecks to higher growth in the paper industry, or growth in paper production in commensurate with the installed capacity in paper production may be attributed to the

[7] Eleventh Five Year Plan Report

fragmented industry structure and lack of required raw material leading to poor financial performance by the mills and eventually closing down, especially of the small scale paper mills.

Table 5 gives the chronological account of major policy revisions pertaining to paper industry since independence.

3. Paper Machine – Technology Development

A paper machine (PM) is defined as the **paper making machine itself** and various auxiliary equipments located in the intermediate area (Figure 6a). Figure 6b is more detailed process of paper making, giving details about the pulping. In paper making industry, the basic principle (technology) through which paper is made has evolved without discarding much of the previously build technology. This facilitates upgrading the existing technology when required without completely discarding the previous technology.

Technology in Paper Machine

A PM is mainly classified as Cylinder machines and Fourdrinier machines. These machines differ on account of the method used in supporting the forming mesh and the methods used to control drainage through the forming medium. In a Fourdriner machine the wet pulp is drained using Fourdrinier wires while in Cylinder machines the forming wire mesh is supported by a porous cylindrical structure. With respect to the quality of paper they make, the Cylinder Machines produce heavier sheets with course finish while Fourdriner produces lighter sheets with superior finish. A third category of paper machine is the Yankee Machines. This particular machine is a special type of paper machine developed for making light weight paper such as sanitary paper and facial tissues. These machines differ from Fourdrinier and Cylinder machines as they have relatively short Fourdriner wires. The low weight of these papers is due to free draining property of the stock used in paper making.

Fourdrinier Machine

This machine uses a wire mesh belt supported by a series of rolls and drainage control devices in a horizontal position during the draining process. The essential parts of the system are

a) A flowspreader system for spreading the flow of stock from its delivery pipe
b) A head box or flow control system to improve the uniformity of stock flow
c) The Fourdriner table consisting of hardware necessary to support and run the Fourdriner wire and provide drainage through it by the means of table rolls, foils, deflectors, suction boxes, suction rolls and other associated equipments
d) A press section to receive the wet web of paper
e) Dryer section
f) Calendar stack consisting series of rolls applying high ironing pressures to dry sheet of paper
g) Reel a winder for winding up the dry sheets

Cylinder Machines

In a Cylinder machine the forming mesh is supported by a porous cylindrical structure. The drainage of the stock through the cylinder is controlled by the pressures applied to the outside and various means utilized within the forming roll. Cylinder machines are made with multiplicity of forming cylinder. The stock/ pulp is applied to the outside of each rolls by the means of a vat. The rolls are carried at a reduced pressure to promote the rate of drainage and sheet formation. The sheets are picked up by a common picked up felt which combines individual webs into a single composite mat. This is followed by pressing and drying process which is similar to that of the Fourdriner machines.

Yankee Machines

Yankee machines are specialized type of paper machine for making light-weight paper for example sanitary papers. These machines use short Fourdrinier wires to obtain low basis weight of the product and free draining properties of the stock. Theses sheets are pressed as in the case of Fourdriner machines but he drying process differs. The conventional dryers are replaced with Yankee or creping dryer. The Yankee dryer is a large cylinder to which sheets is applied by special pressure roll. The intimate contact achieved by the sheet against the Yankee dryer also increases the rate of drying. Yankee dryers due to high velocity air hoods are able to obtain drying rates 10 to 15 times as high per square foot of area in contrast to conventional dryers.

4. Methodology

4.1 Role of Policy - Finding structural break

Our first objective is to find out whether policy has any role to play in influencing performance (as measured by output) of the Indian paper industry. We hypothesize that if policy has played any role, this would result in structural break in the output of the industry. Since the data is time-series data, we first need to test for stationarity. The presence of non stationarity is indicative of a trend break in the data analyzed. We perform Augmented Dickey Fuller (ADF) test and Phillips Perron (PP) test to check for stationarity. These trend breaks could be plausibly due to policy changes pertaining to the paper industry. The Chow test is employed to identify breaks. However, the Chow test requires a priori knowledge of the trend break date. Since the impact of any policy may not be immediate, break date information won't be correctly available. Under the situation, Quandt likelihood ratio test is performed. This test calculates Chow test statistics for each date except from some trimmed portions from both ends of the data. Then a supremum test is calculated which finds dates that maximizes Chow test statistics which are also the most probable break points.

The auto regressive function for output (denoted by Pdtn) of IPP considered is:

$$Pdtn_t = \alpha + \rho Pdtn_{t-1} + e_t$$

The general form of Chow test is

$$y_1 = \alpha_{11} + \beta_{12} x_{12} + e_1$$

$$y_2 = \alpha_{21} + \beta_{22} x_{22} + e_2$$

$$y_3 = \alpha_{31} + \beta_{32} x_{32} + e_3$$

Chow test in case of an auto regressive function

$$y_{1t} = a_{11} + B_{12} x_{t-1_{12}} + e_1 \text{..... Eq .1 – group 1}$$

$$y_{2t} = a_{21} + B_{22} x_{t-1_{22}} + e_2 \text{..... Eq .2 – group 2}$$

$$Y_t = a_1 + B_2 Y_{t-1} + e_3 \text{..... Eq .3}$$

$$F_{(k, N1+N2-2k)} = \frac{\left[\sum_{i=1}^{n} e_3 - (\sum_{i=1}^{n} e_1 + \sum_{i=1}^{n} e_2)\right] / k}{(\sum_{i=1}^{n} e_1 + \sum_{i=1}^{n} e_2) / (N_1 + N_2 - 2k)}$$

Where, N_1 and N_2 are number of observations in group 1 and group 2; K is the number of parameters to be estimated including the constant term.

4.2 Role of TG in influencing Technical Efficiency

For our second objective, we hypothesize that lower is the technology gap (TG) for the firm producing paper, more would be its efficiency. In order to test this we use a stochastic frontier analysis (SFA) method first to measure the efficiency of Indian paper industry. Stochastic frontiers are advantageous over deterministic frontiers as they allow for random deviations from the production frontier due to factors beyond the control of firms. In other words, SFA allows for a separation of the error term into a random noise component and an inefficiency component (Seo and Shin, 2011). The first part of this error term captures the randomness in the production process (as caused by machine breakdown, strikes, luck etc.) and can thus take either positive or negative values. The second part specifies plant inefficiency and hence takes only negative values (Kumbhakar and Lovell, 2000; Knittel, 2002).

The general specification of a stochastic frontier function for cross-section data following Battese and Coelli (1995) is:

$$Y_i = \exp(X_i\beta + V_i - U_i) \qquad (1)$$

where, Y_i is output of the i^{th} plant; X_i is the vector of values of known functions of production inputs of the i^{th} plant; β is the vector of unknown parameters; V_i is the vector of random errors assumed to be independently distributed of U_i - the technical inefficiency effect i.e. the vector of non-negative random variables associated with technical inefficiency and assumed to be independently distributed.

The technical inefficiency effect U_i can be further specified as

$$U_i = z_i\delta + W_i \quad (2)$$

where, z_i is the set of explanatory variables influencing technical inefficiency; δ is the unknown vector of coefficients and W_i is a truncated random variable of normal distribution with zero mean and variance σ^2.

In order to estimate the parameters of the stochastic frontier, a maximum likelihood method is applied and the resulting technical efficiency takes the form,

$$TE_i = \exp(-U_i) = \exp(-z_i\delta - W_i) \quad (3)$$

Given our aim is to find out the effect of TG on the variation of the inefficiency error term we estimate the model in two steps. In step 1, we estimate a Cobb-Douglas stochastic frontier production for the IPP. The specification of the general form of an SFA is given as:

$$\ln \text{Output}_i = \beta_0 + \beta_1 \ln(\text{Capital}_i) + \beta_2 \ln(\text{Labour}_i) + v_i - u_i \quad (4)$$

where, v_i is the random error term and, u_i is the technical inefficiency (TE) effects.

Among the factors affecting technical efficiency (TE), the key variable though is TG, there are other factors that can also have an influence on TE. These include: age of the firm, ownership of the firm (publicly-owned or private firm), type of firm (group company or single firm) and lastly, how many machines a firm has (No. of machines). The study expects that younger firms, firms being part of a group and a public-limited firm and having more number of machines would tend to be more efficient. Thus, in the second stage, we estimate the following:

$$u_i = \pi_0 + \pi_1 \text{TG} + \pi_2 \text{Plant Age} + \pi_3 \text{Ownership} + \pi_4 \text{Type} + \pi_5 \text{No. of Machines} \quad (5)$$

The next section explains the data and variables.

5. Data and Variables

Structural Break

To find out impact on policy on output of paper industry, we require data on output. We use annual paper production in tons from 1954 to 2006. The data is collected from different sources.

Step 1 - SFA

For estimating SFA or production function, past studies have often used PROWESS data (i.e., the Annual Report data of the firms listed in stock exchange). These studies have used data in monetary terms as reported in the annual report and also included only those firms which are listed (i.e., public limited firms). We however have used data in real terms for both inputs and output variable and also included both public limited and private limited firms. For output, we have used output of paper mill in Tons. For the two inputs, labour and capital, we use labour in number (as the manpower employed by the paper manufacturing unit) and capital as the total plant capacity in tons. The data for the plant level input and output variables were collected from

the annually published directory of Indian Pulp and Paper Technical Association (IPPTA) for the year 2013. For several of the firms, there was missing data especially, the year of incorporation and the plant capacity. For several of these firms, we used their websites to get the data. The data used in SFA is for the year 2011. It is to be noted that output can vary over time period, we have taken average for 2011 and 2012.

Step 2 – Effect of Technology gap (TG) on Efficiency

One of the methodological problems encountered in literature has been how to measure TG. Since, most studies have used productivity gap as a proxy for TG (see for example, Kokko et al. 2002, Kathuria, 2010 etc. and the literature cited therein), the present study uses technical parameters of paper making proposes to construct an index of TG. The computation of TG requires information about the kind of machines used by firms in an industry. In paper industry, the three parameters which evaluate capability of a machine are paper grammage (gm/cm^2), machine deckle (m) and operating speed (m/min) (Noah *et al*., 2014). These are called fundamental operating variables. Of the three, first one is not a fixed number – often comes up with a range, whereas other two can attain maximum values. A machine with higher deckle and operating speed tends to have higher capability, whereas optimum output (and hence profitability) is obtained with production of mid-range grammage of the paper (*ibid*.).[8] Since deckle and speed have monotonic relationship with performance, we take these two variables to measure TG. We first compute how much is the gap for the machine speed as used by the representative firm vis-à-vis fastest machine in our list of paper manufacturing firms. If Si is the speed of the i^{th} machine, then speed gap (SGap) would be SGap = Si/max.(Si). Correspondingly, we find Deckle gap (DGap = Di/max.(Di)). We compute an index of TG by aggregating the two gap parameters in two different ways. In TG1 we aggregate the two gap parameters by giving equal weight (i.e., 0.5). Alternatively, we compute TG2 as an interaction between the two parameters. Both these indexes imply that a firm having paper making machine with max. speed and deckle will be at the frontier in Indian paper industry.

$$TG1 = 0.5 * SGap + 0.5 * DGap$$

$$TG2 = SGap \times DGap$$

As expected, both TGs are highly correlated (0.96 significant at 1% level). Regarding other variables that can influence the efficiency of paper making – we use age of the firm, ownership of the firm, type of firm and lastly, how many machines firm has. Age (Age) is measured as years since firm was incorporated till 2011. Ownership is measured as a dummy, which takes the value as 1 if the firm is publicly owned and zero otherwise. The study expects that a publicly owned firm to be more efficient. Similarly, a firm which is part of a group tends to have greater leaverage and risk taking ability and also possibility of cross-sharing of ideas, thus would be more efficient. The variable is measured as a dummy that takes the value 1 if firm belongs to a

[8] Figure 10 indicates the positive relation between deckle length and speed on the average production for the sample firms.

group and 0 otherwise. Another variable that can influence on the efficiency of the firm is number of machines owned by the firm. If firm owns more machines, there is less likelihood of stopping the production even if one machine breaks down. Alternatively, large number of machines may facilitate a firm to have greater flexibility in operations, thus having positive influence on efficiency.

6. Structure break in Pulp and Paper Industry

Before looking into the structural break and the role of policy in the indian paper industry, we first look at the trend in sales, profitability and concentration of industry for the organized sector. The data pertaining to organized paper mills is collected from CMIE database. The time period considered is from 1988-2011. The data on mills were grouped on the basis of the products they produced. The National Industry Classification (NIC) is taken as the reference category. Following the NIC classification, the main product from the industry are (1) manufacture of paper and paper rolls not further processed (NIC code 17013); (2) manufacture of other primary paper materials including composite paper and paperboard (NIC code 17019); and (3) manufacture of other containers of paper and paperboard not elsewhere classified (NIC code 17029). Figures 7 and 8 report trend in annual sales and profits for each of the categories respectively. The annual industry sales depict an increasing trend in general, but more so with respect to 17019 and 17029 categories.

The profitability in the industry shows a mixed trend of increases and decreases in contrast to steady increasing pattern of industry sales. This mixed trend could be due to poor capacity utilization. At present average capacity utilization in the industry is about 60% only.

Concentration in Organized sector - Herfindahl Hirschman Index (HHI)

HHI index is a measure of industry concentration. The index scores are indicative of the level of the market structure. The index ranges from 0-1, with perfect competition getting a score of 0 and for monopoly, the score tends to 1. HHI index was calculated from the annual industry sales data since 2000 and is computed as follows:

$$HHI = \sum_{i=1}^{n} S_i^2$$

Where S^2 is the square of firm share in industry sales

Table 6 suggests the high level of concentration is observed in case of 17019 and 17029 segments with increasing trend. For paper segment which does not need further processing (i.e., Product segment 17013) scores are indicative of highly competitive market structure as the values are mostly below 0.1 and are declining (except for 2011) (Table 6).

Testing for Structural Break

The primary interest in this section is to understand the effect policy changes on paper industry. For this, total production data from 1954-2006 was collected. The data was then tested for stationarity. Augmented Dickey Fuller test (ADF) and Phillips Perron (PP) test confirmed the presence of unit root and hence the inference that the data set is non-stationary (Table 7).

Non stationarity of data suggests trend breaks in dataset. These trend breaks could be plausibly due to policy changes pertaining to the paper industry. The Chow test is employed to identify breaks. As Chow test requires some prior knowledge of the trend break date, this information being unavailable, Quandt likelihood ratio test is performed. This test calculates Chow test statistics for each date except from some trimmed portions from both ends of the data. Then a supremum test is calculated which finds dates that maximizes Chow test statistics indicating the most probable break points (Table 8).

The test identifies two such breaks in the production trend with the first break occurring in 1961 and the second in 1990. The two key policies that could have caused this break: Essential Commodities Act, 1955 and Export Restriction of 1990. A lagged reaction to The Essential commodities Act, 1955 could have caused the first structural break and the Export Restriction passed in 1990 could have caused the second structural break (Figure 9).

7. SFA estimation

Before giving the results for SFA, there are few caveats which we would like to mention. Ideally, we should use a panel data to see change in efficiency and then corresponding change in technology gap (TG) to see the effect in the post-1991 liberalisation scenario. Unfortunately, we could not get hold of information of paper manufacturing plants in both categories – public limited and private limited - for a year closer to 1991. Consequently, we have carried out only a cross-section analysis for 2011. Another caveat is pertaining to the capital measurement. We have not looked into capacity utilization part – we used the capacity as reported by the firm. Third caveat pertains to the paper manufacturing process. The process consists of two major steps – making pulp and then making paper. We have looked efficiency of only paper making process (coloured portion of Figure 6b) – not the pulp making. Lastly, while computing TG, we have compared speed and machine deckle of a given firm with the fastest and highest deckle within Indian segment and not compared with the world frontier. While interpreting results, these caveats need to be kept in mind.

Table 9 gives the mean values of different variables as used in SFA estimation and in the second stage. As can be seen from the table, average annual production varies from 188 tons to 541,801 tons. There are units employing 10 workers to firm employing over 4000 workers. The average speed of the machines employed by sample firms is 242 m/min with max. of 850 and minimum of 25 m/min. Similarly, maximum deckle length is 6.8 meter against average of 2.53 meter.

Though not reported, 61 % of the firms in the sample are public-limited firms and 22% firms are group firms.

Does Technology Gap influences SFA?

Table 10 reports the results for SFA. We estimated a Cobb-Douglas production function with age as explanatory variable in variance function for idiosyncratic error. For inefficiency term, we assume the distribution to be truncated-normal. Results indicate that both labour and capital are significant at 1% level. The estimated SFA also indicates that the industry has constant returns to scale (CRS) with the value being 1.057. Next we compute technical efficiency and then compare technical efficiency with the most efficient firm in the industry (i.e., s_i = ui/max(ui)). The average TE of the firms in the sector is 74% with the minimum being 27%. Infact, half of the firms have TE higher than 76%. Table 11 and Figure 11 give the distribution of TE of the firms.

Table 12 reports the estimation to see how technology gap (TG) influences technical efficiency. As indicated by correlation matrix (results not reported), some of the variables are highly correlated (e.g., age with the type of firm), we could not use all of them together. The results indicate that a younger firm is more closer to the frontier (row 2). Being a listed firm or part of the group does not facilitate increased TE. Our main variable of interest i.e., TG however is not statistically significant. This implies that being technical closer to the industry frontier does not have any bearing on its technical efficiency.

In Model 2, we use number of machines instead of Group and Type of firm. The results does not change, though number of machines comes out to be statistically significant. This suggests that a younger firm with more number of machines tends to be more efficient. We repeat the exercise with our alternate measure of TG (i.e., TG2). Results are reported in columns 3 and 4 of the table. The results do not change. This indicates that technological gap or nearness in terms of speed of the machine or deckle length does not have any bearing on the technical efficiency of the firm.

8. Conclusions

This paper uses both industry level data and firm level data covering both organized sector firms (i.e., the public limited) and also the private limited firms for Indian paper industry to address the following two questions: a) does policy has any role to play in structural change in the industry? and b) what role does technology-gap pay in influencing technical efficiency of the Indian pulp and paper industry?

For the first question, paper uses output data of paper industry from 1954 to 2006 and does tests for structrual break. For second question, paper uses cross section plant level data of 160 paper manufacturing units to first estimate the stochastic production frontier (SFA) and then uses output of SFA to find association between TG and technical efficiency. A methodological problem encountered in earlier literature has been to measure TG. Past studies have used

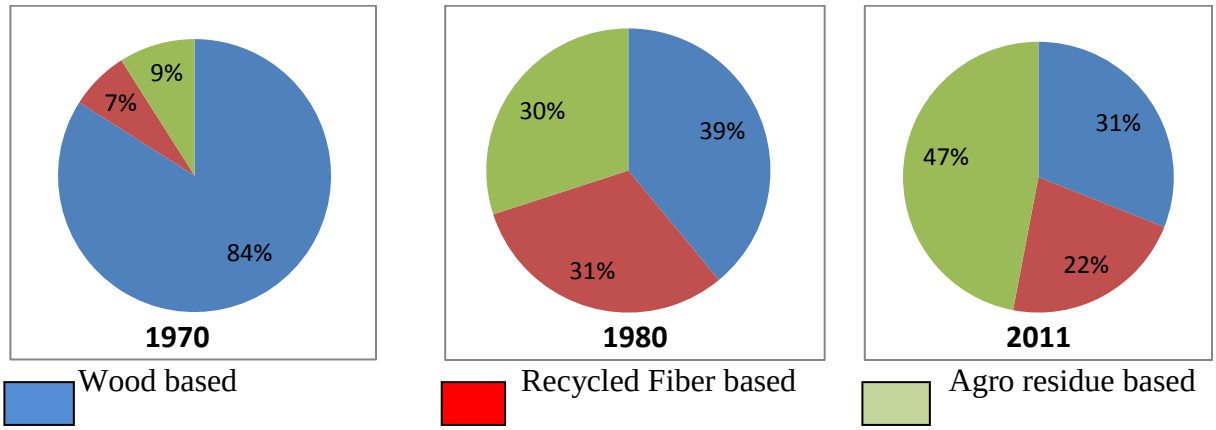
productivity gap as a proxy for TG, the present study uses technical parameters of paper making - machine deckle (m) and operating speed (m/min) - to construct an index of TG.

Regarding results, the test identifies two breaks in the production trend with the first break occurring in 1961 and the second in 1990. The two key policies that could have caused this break: Essential Commodities Act, 1955 and Export Restriction of 1990.

The estimated SFA indicates that both labour and capital contribute to the output with the industry having constant returns to scale (CRS) (value being 1.057). Based on SFA results, the average TE of the firms in the sector is 74% with the minimum being 27%. Infact, half of the firms have TE higher than 76%. Lastly, for the results pertaining to the impact of TG on technical efficiency, the study does not find any impact. Based on the results, the study concludes that technological gap or nearness in terms of speed of the machine or deckle length does not have any bearing on the technical efficiency of the firm. One probable reason TG not influencing TE could be use of data for one period only. It is likely that change in TG over a period of time might influence TE.

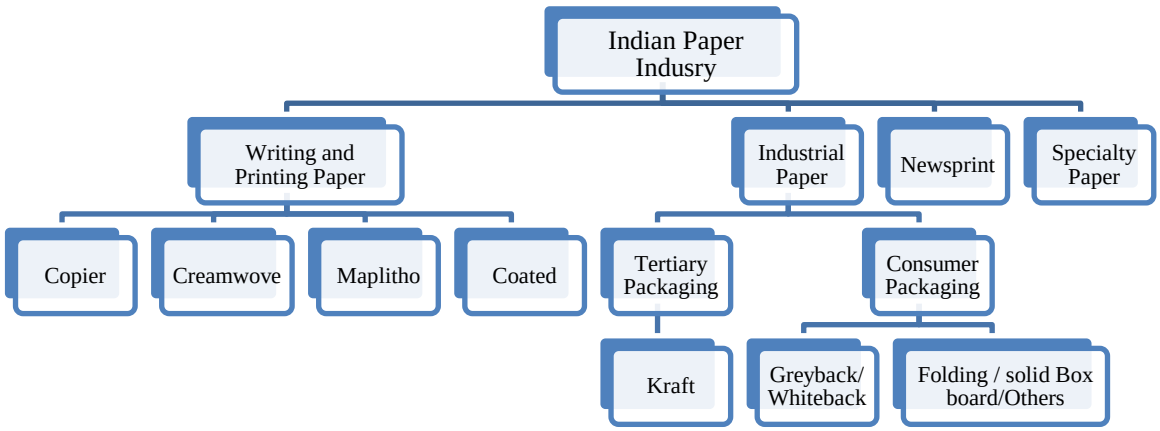
The study though contributes to the literature by including technical parameters for technology gap has some limitations as indicated in section 7 and has avenues for research. The study did not look the pulping process and raw material used. It is likely that TG may have more influence for firms using recycled paper as raw material then agriculture residue or vice versa. The study can be extended to see the role of raw material. Similary, the study did not distinguish the type of paper produced – industrial, kraft or printing etc. Lastly, the use of panel data can shed more light on change in technical efficiency and hence role of TG on TE.

Figures



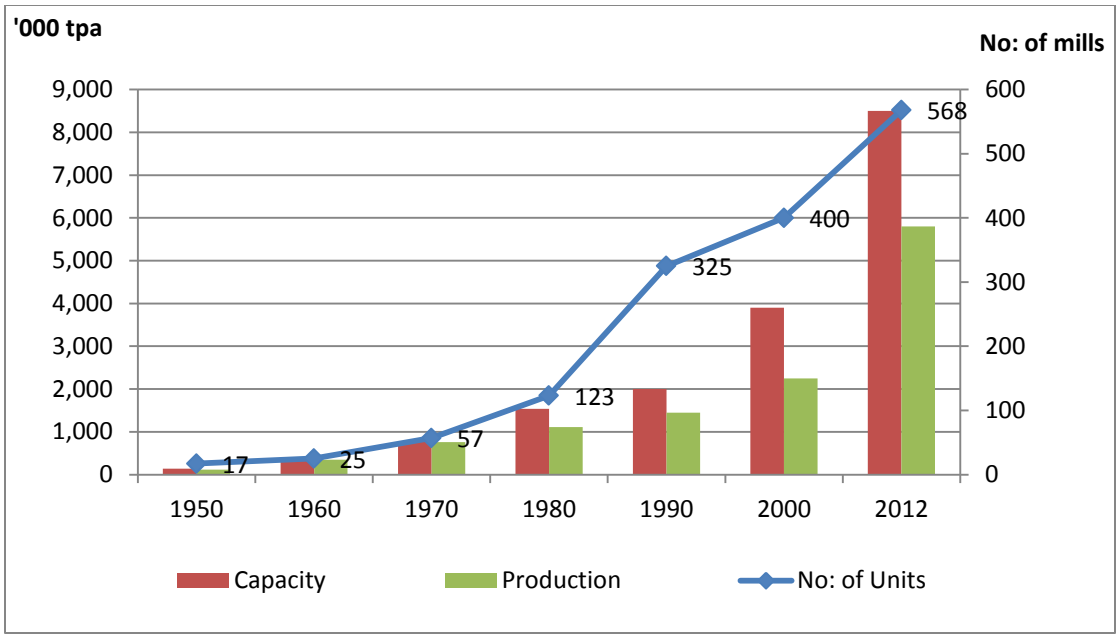
Source: Central Pulp and Paper Industry

Figure 1: Raw Material Break-up for the Paper Industry as on 2011



Source: CRISIL (2011)

Figure 2: Types of papers produced by Indian Pulp and Paper Industry



Source: Rao (1989) and Eleventh Five Year Plan Report.

Figure 3: Growth in the Indian Paper Industry

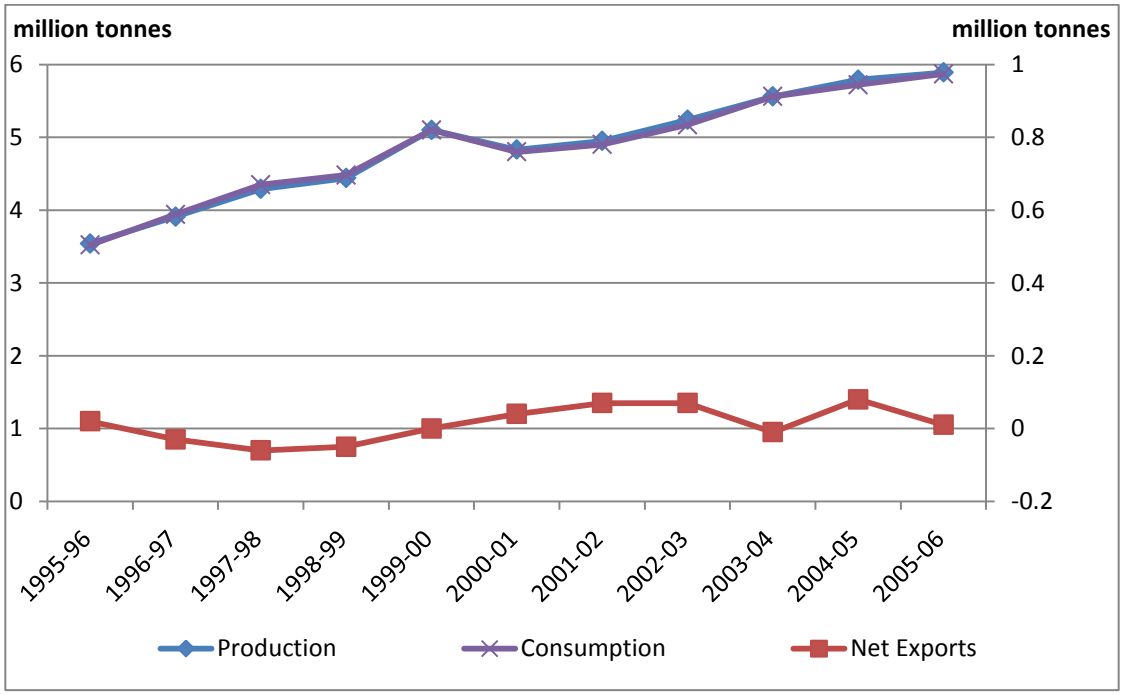


Figure 4: Production, Consumption and Net Exports of Paper and Paper Products

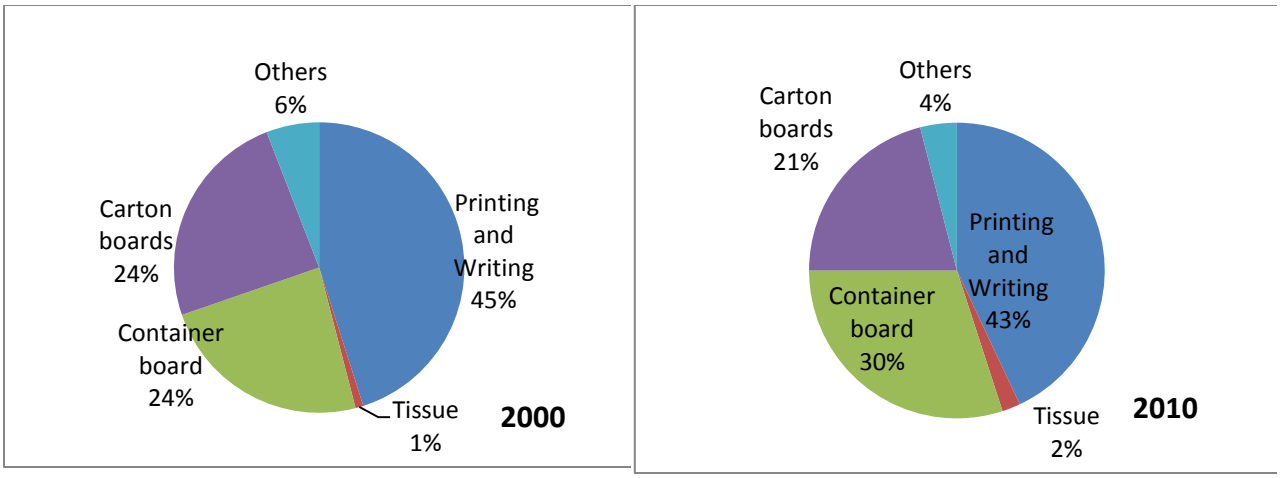


Figure 5: Break-up of Select Few Paper Products in Total Production

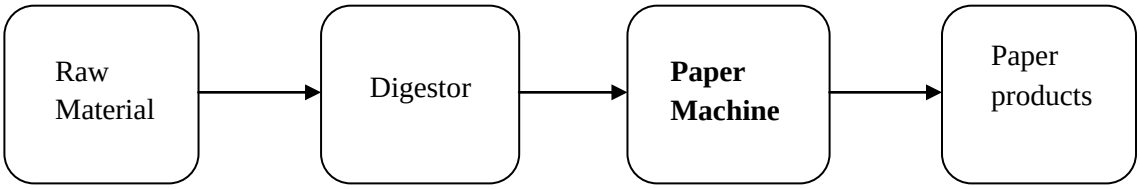


Figure 6a: Paper Making Process

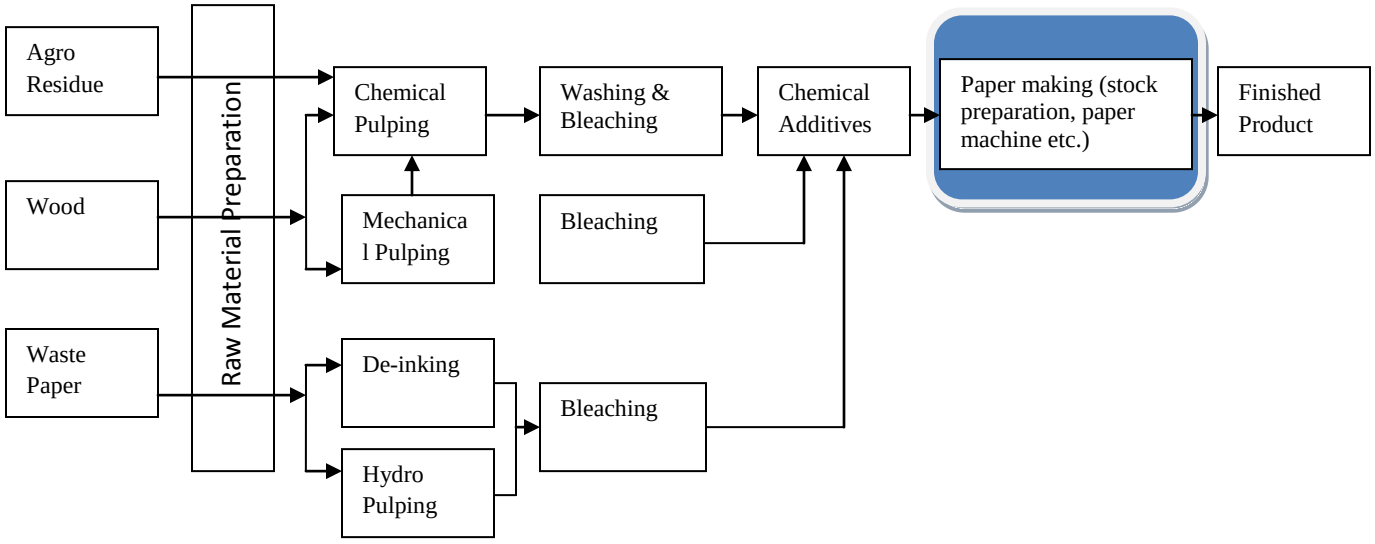


Figure 6b: Paper Making Process – detailed description

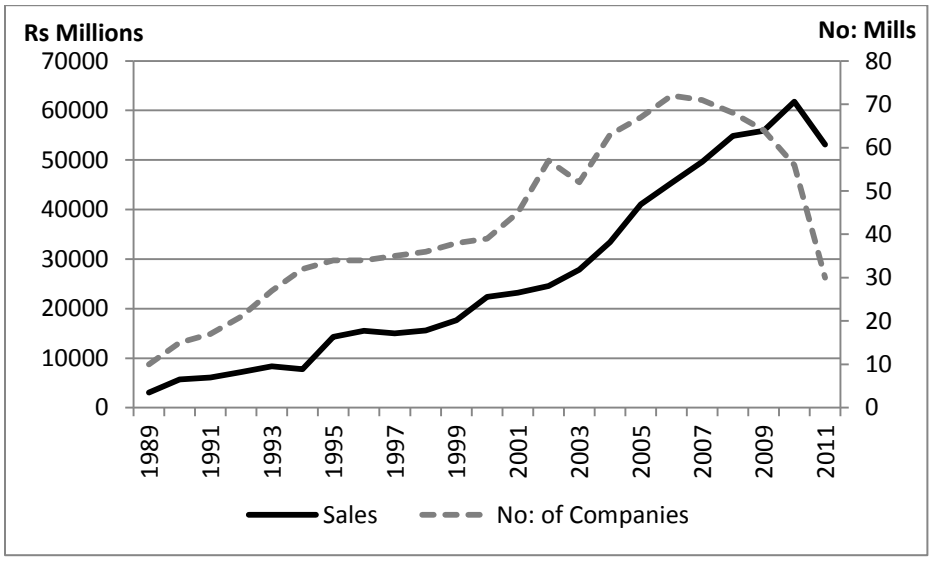


Figure 7a: Annual Sales in Paper and Paperboard not further Processed

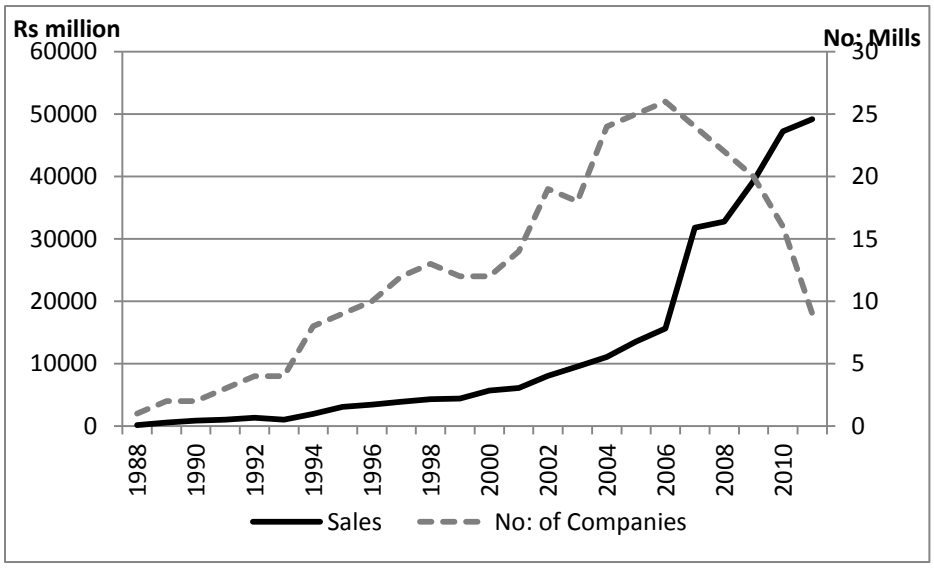


Figure 7b: Annual Sales in Primary Paper Materials including Composite Paper and Paperboard n.e.c

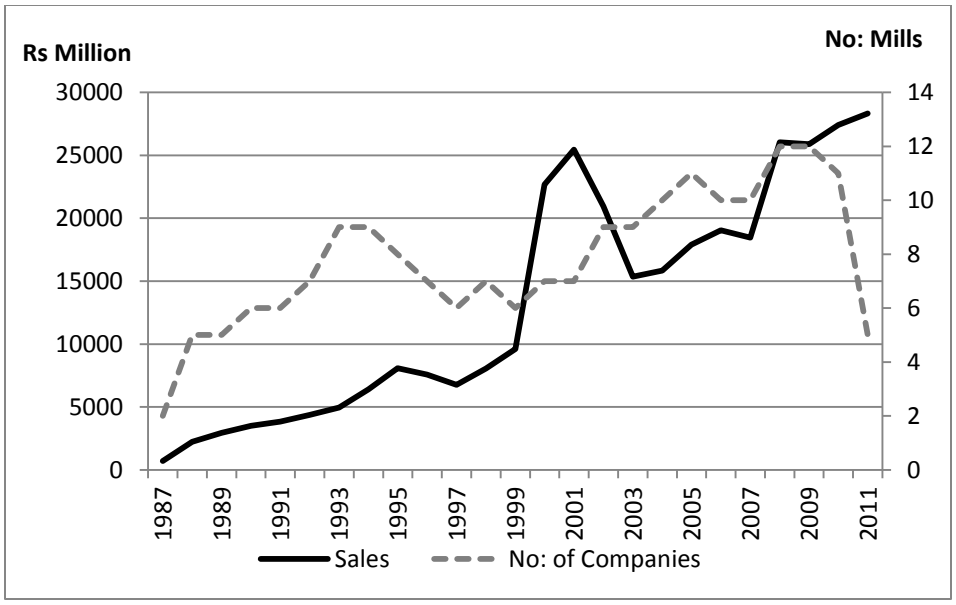


Figure 7c: Annual Sales in Other containers of Paper and Paperboard n.e.c

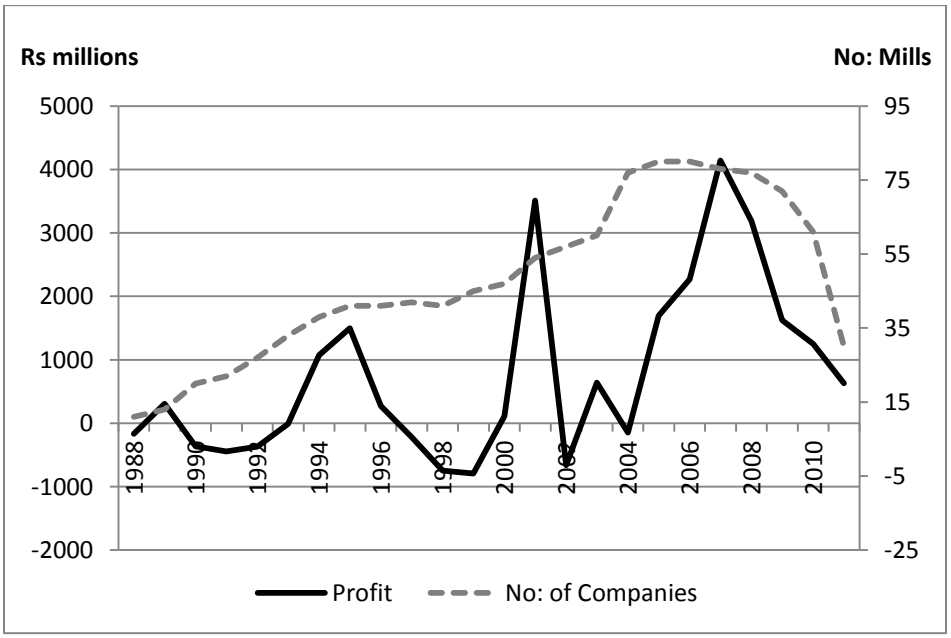


Figure 8a: Annual Profits in Paper and Paperboard not further processed

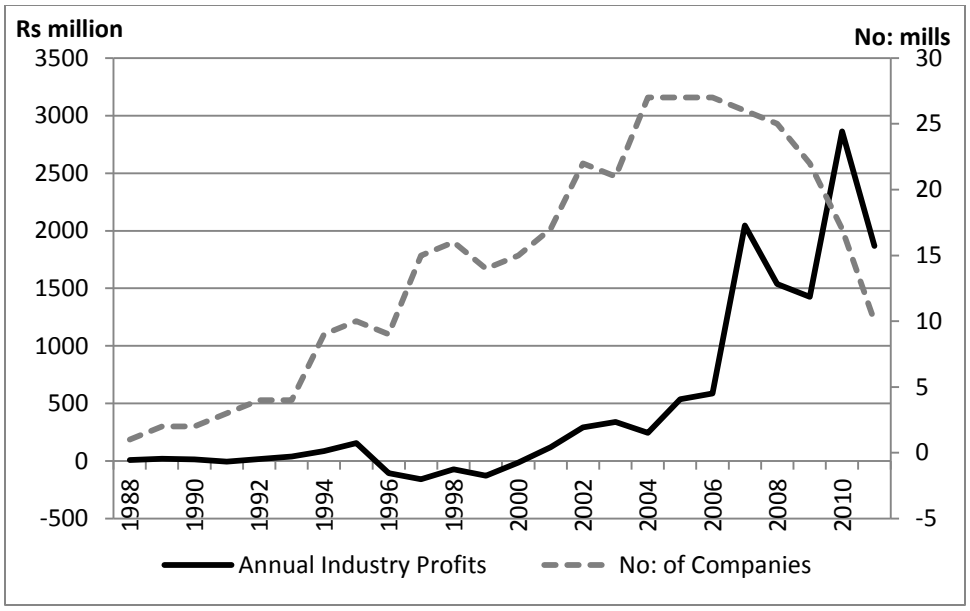


Figure 8b: Annual Profits in Primary Paper Materials including Composite Paper and Paperboard n.e.c

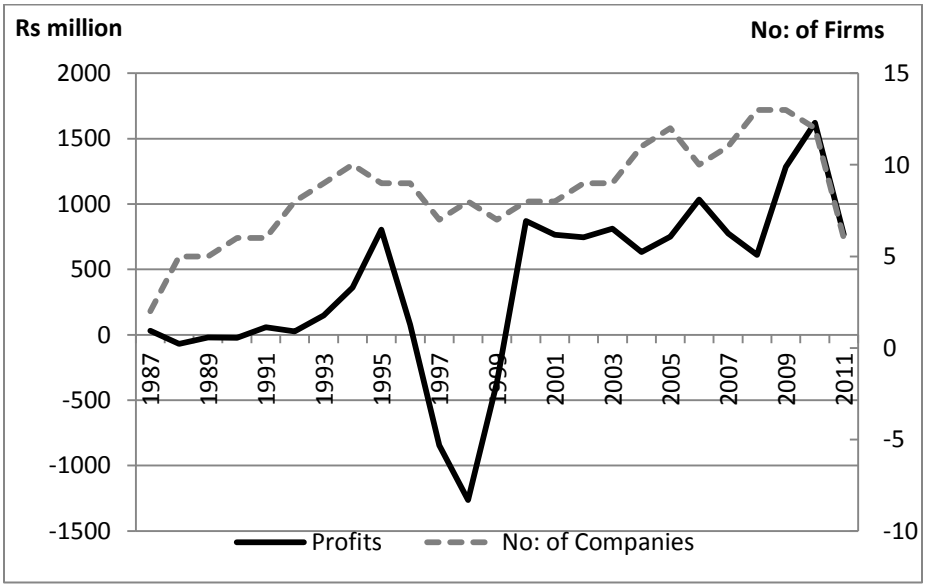


Figure 8c: Annual Profits in Other Containers of Paper and Paperboard n.e.c

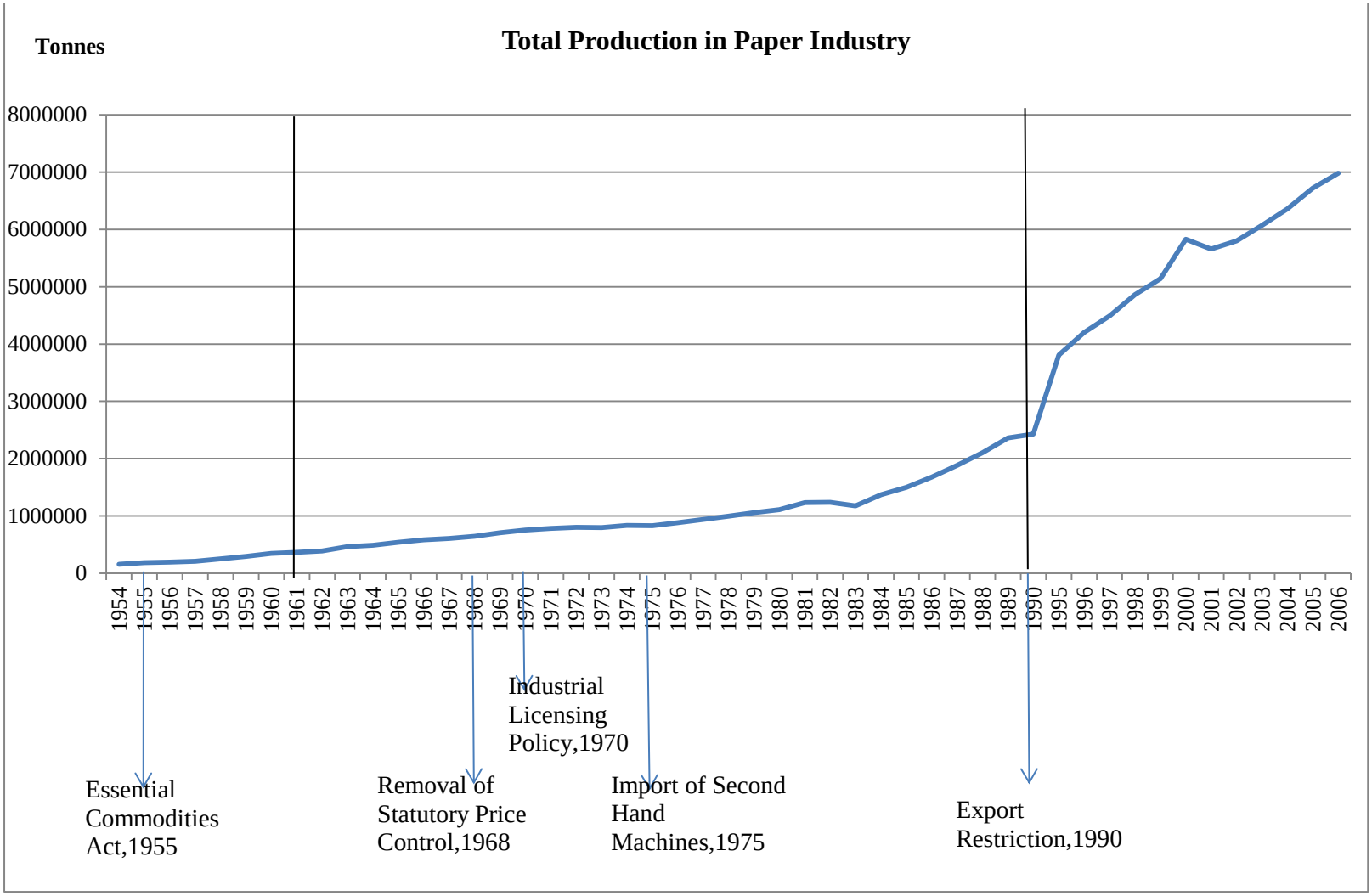
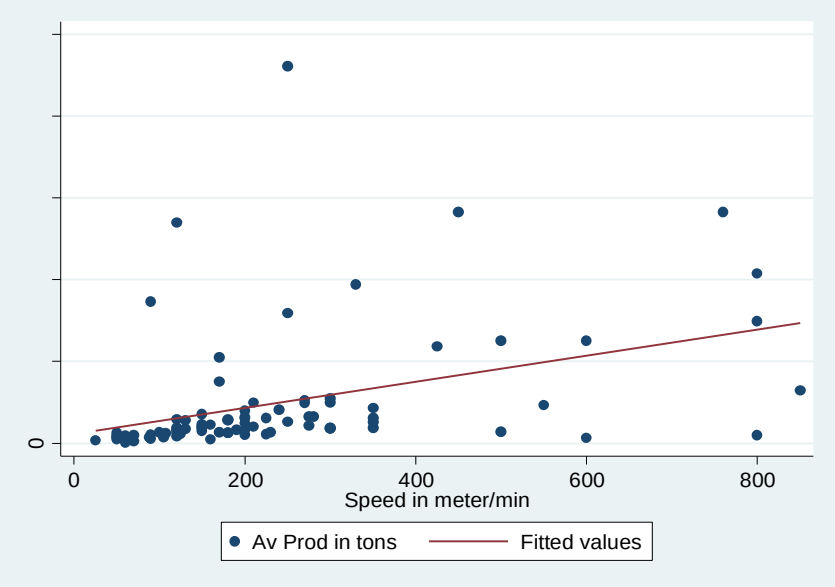


Figure 9: Linkage between policy changes and growth in Paper Industry (2 structural breaks)



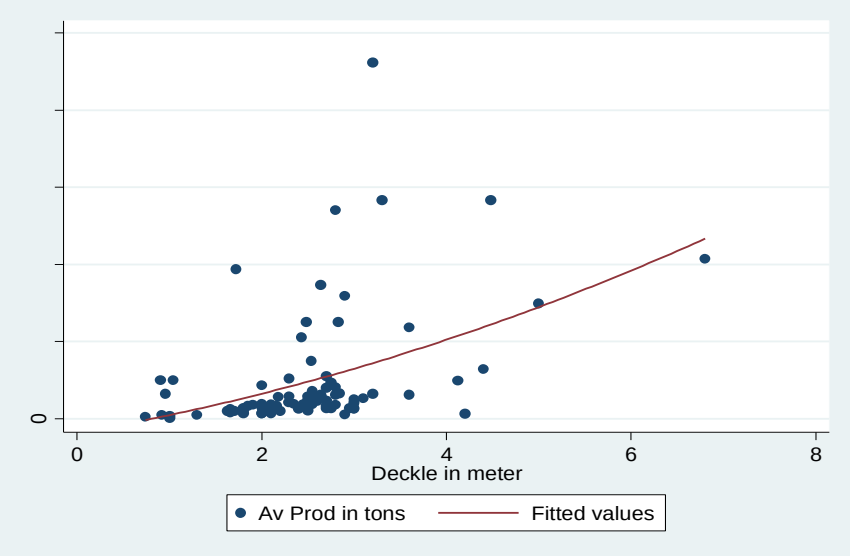


Figure 10: Relation of Av. Prod (in tons) with Machine Speed (in m/min) and Deckle (in m)

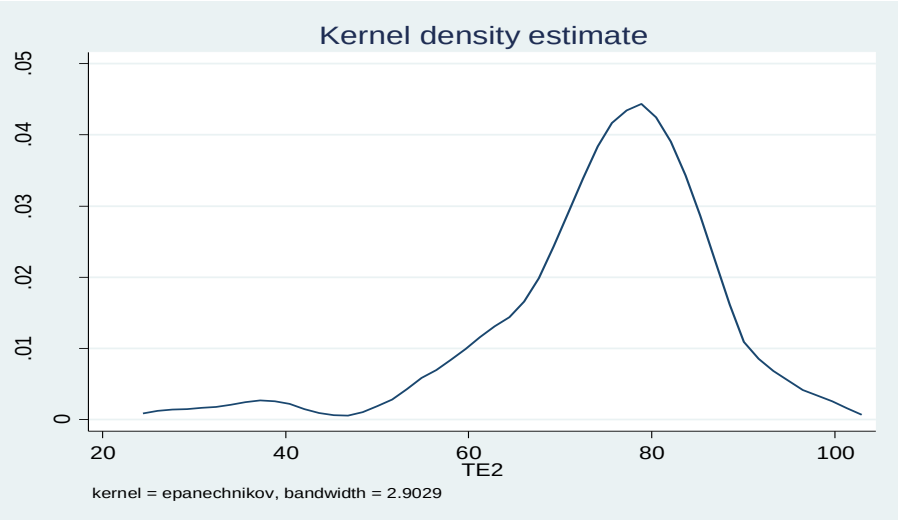


Figure 11: Kdensity of Technical Efficiency vis-à-vis frontier firm in the Paper industry

Table 1: Structure of Paper Industry as on 2005

Category of Mill	1970[a]	1975 [a]	1980 [a]	1985 [a]	Nature of Raw-material	Scale of operation (Tonnes per day)	2005 [b]
	No of Mills	No of Mills	No of Mills	No of Mills			No of Mills
Large Integrated Mills (Capacity >20,000 tpa)	13	16	21	23	Wood based	101-800	33
Medium Paper Mills (Capacity 10,000 - 20,000 tpa)	5	7	10	17	Agro based	50-100	165
Small Paper Mills (Capacity upto 10,000 tpa)	39	51	92	211	Waste Paper based	5-50	510
Total	**57**	**74**	**123**	**251**	**..**	**..**	**708**

Note: tpa – Tonnes per annum

Source: (a) Rao (1989); (b) CPPRI (2007)

Table 2: Per capita Paper Consumption in Select Few Countries

Year	India	USA	Japan	China	Indonesia
1970-71	1.45	257	118	5	..
1980-81	1.78	289	153	6	3
1990-91	2.53	308.7	220.4	15	10
2000-01	4.2	331.7	..	29.1	20.8
2011-12	7.2	320	220.5	70.7	33.6

Source: Collated from different sources

Table 3: Targets and Achievements during Plan Period (Pre Liberalization)

Plan Period	Capacity		Output		Realization*		Capacity Utilization
	Target	Achieved	Target	Achieved	Capacity	Achieved	
First Plan (1950-55)	214	214	203	190	1.00	0.94	88.8
Second Plan (1956-61)	457	430	356	350	0.94	0.98	81.4
Third Plan (1961-66)	833	669	711	558	0.80	0.78	83.4
Annual Plans (1967-69)	750	730	635	658	0.97	1.04	90.1
Fourth Plan (1969-74)	1,000	992	850	825	0.99	0.97	83.2
Fifth Plan (1975-80)	1,300	1,538	1,050	1,112	1.18	1.06	72.3
Sixth Plan (1980-85)	2,050	2,360	1,500	1,371	1.15	0.91	58.1
Seventh Plan (1985-90)	2,700	3,020	1,800	2,200	1.12	1.22	72.8

* Realization =(Achievement/ Target)

Table 4: Targets and Achievements during Plan Period (Post Liberalization)

Plan Period	Capacity	Output	Capacity Utilization (%)
Eight Plan (1992-1997)	..	..	..
Ninth Plan (1997-2002)	4,350	2,800	64
Tenth Plan (2002-2007)	5,100	3,200	63
Eleventh Plan (2007-2012)	8,500	5,800	68

Source: Various Five Year Plan Reports

Table 5: Policies to influence Pulp and Paper industry

Year	Policy	Purpose	Likely Impact
1944-46	Paper Price Control Orders 1944-46	Regulation of prices which short up due to paper scarcity	+
1948	Industrial Policy Resolution,1948	Recognized the paper and newsprint industry as basic industry among 18 others	+
1950	Paper Price Controls withdrawn	Paper price control order of 1944-46 was withdrawn	+
1951	Industries (Development and Regulation) Act,1951	The Act provides a system of licensing in the First Schedule to the Act(Item 24)	-
1955	Essential commodities Act,1955	Empowers Central Government to control and regulate production, supply and distribution	-
1962	Newsprint Control Order,1962		
1968	Removal of Statutory Controls on Price		+
1970	Industrial Licensing Policy, February 1970	Large industrial House to participate in development of core and heavy industry sectors	+
1973	Appendix I of Press Note Feb, 1973	Large industrial Houses to participate in development of core and heavy industry sectors	+
1974	Paper (Control of production) Order on August 1,1974	Manufactures to produce a minimum stipulated production of total production in six variety of cultural paper	-
1974	Prevention and Control of Pollution Act,1974		+/-
1975	Paper (Control of production) Order on August & September 1,1975	Order modified to retain control over white paper	
1975	Press Note dated 28-3-74 by Deptt of Heavy Industry, Ministry of Industry and Civil Supplies	Import of second hand paper machine	+
1978	The Paper (Regulation of Production) Order, 1978	Paper (Control of Production) Order, 1974 replaced by Paper (Regulation of Production), Order, 1978 - White paper to be mfrd to the extent of 30% of total production	
1979	The Paper (Control) Order,1979	Statutory Control on White Printing Paper and Cream Woven Paper	-
Until 1980's	Excise and custom duty	Excise and custom duty leviable on paper and paperboard of all sort	
	Exemption from excise duty	Exemption from excise duty for units using 75% and more of non-conventional raw materials, exemptions for specific	

		other units also	
till June, 1980	Fixed sale price on newsprint		-
1981	Ad valorem customs duty on newsprint	15% ad valorem customs duty on imported newsprint	-
1982-83	Ban on Export	Ban on Export	-
1985	Press Note, February 8,1985	Manufactures given flexibility to take up manufacture of any variety of paper	+
1985	Press Note, March 16,1985	No industrial license required if (a) industry does not fall under MRTP, (b) article not reserved for the small scale sector industrial location not situated at specified urban location	+
1985	Revision of Newspaper Sale Price,1985	Revision of ex-mill price of newsprint	+
1987	Repeal of Paper (Control) Order, 1979		+
1987	Repeal of Paper (Regulation and Production) Order,1978		+
1988	Revision of Newspaper Sale Price,1988	Revision of ex-mill price of newsprint	+
1989	Environmental Protection	Discharge standards even for small paper mills.	+/_
Early 1990's	Export Restriction	Export of paper & paper boards limited to only 1000 tons/ year, only to neighboring countries (Nepal and Bhutan)	
1995	Open General License	Free import and export	+
2001-02	Excise & Custom duty at 16 & 35%		-
2002-03	Excise at 16% and Custom at 15%		-
2004	Newsprint Control Order,2004	Regulation of selling of stock- newsprint	-
2006	Excise duty reduced from 16 to 12%		+
2008	Ban on Import of waste paper	Terming it as hazardous waste	_
2008	Excise duty reduced from 12 to 8%		+

Source: Same as Table 1 and Schumacher et al (1999)

Table 6: HHI Scores for the IPP

Year	Paper and Paperboard not further processed	Primary Paper Materials including Composite Paper and Paperboard n.e.c	Other Containers of Paper and Paperboard n.e.c
2000	0.14	0.31	0.23
2001	0.13	0.28	0.22
2002	0.13	0.22	0.25
2003	0.11	0.22	0.32
2004	0.09	0.18	0.31
2005	0.09	0.16	0.32
2006	0.08	0.17	0.32
2007	0.08	0.28	0.26
2008	0.07	0.26	0.29
2009	0.06	0.38	0.30
2010	0.07	0.43	0.32
2011	0.13	0.48	0.35

Data Source: CMIE
Source: Author's Compilation

Table 7: Unit root test results

Test	Test Statistics	1% Critical	5% Critical	P value
ADF	3.211	-3.594	-2.936	1
PP	2.864	-3.594	-2.936	1

Table 8: Quandt likelihood ratio test results

Lags	Year	Quandt Likelihood Ratio
7	1960	6.908884
8	**1961**	**77.99318**
9	1962	64.73335
11	1964	4.14065
36	1989	6.327787
37	**1990**	**61.25126**

Note: Bold means significant Quandt likelihood ratio tests – thus structural break

Table 9: Mean of different variables

Variable	Mean	Std. Dev.	Min	Max
Av. Production (tons)	45077	78068.3	188	541801
L (No.)	490	776.58	10	4016
K (tons/day)	132.19	174.74	4	1100
Age	22.24	16.69	1	75
Speed (m/min)	242	165.09	25	850
Deckle (m)	2.53	1.04	0.4	6.8
No of machines	1.98	1.53	1	10

Table 10: Estimation of Stochastic Production Frontier for IPP

VARIABLES	(1) lnAvprod	(2) lnsig2v	(3) lnsig2u
lnK	0.628*** (0.0769)		
lnL	0.429*** (0.0619)		
Age		-0.0104 (0.0190)	
Constant	5.339*** (0.303)	-0.911*** (0.278)	-1.028 (0.779)
N	160	160	160
Wald $\chi 2$	463.92		

Note: *** p<0.01, ** p<0.05, * p<0.1 give robust standard errors in parentheses

Table 11: Distribution of TE (N = 160)

Range	Number	Share
20-30	2	1.26
30-40	4	2.52
40-50	1	0.63
50-60	9	5.67
60-70	23	14.49
70-80	65	40.95
80-90	46	28.98
90-100	10	6.3

Table 12: Does technology gap influences technical efficiency?

	VARIABLES	(1) TE2	(2) TE2	(3) TE2	(4) TE2
1	TG1	0.0132 (0.0742)	0.0416 (0.0744)		
2	Age (Yrs)	-0.202** (0.0854)	-0.204** (0.0854)	-0.208** (0.0848)	-0.205** (0.0856)
3	Public Ltd (1 - Yes, 0- No)	3.168 (2.245)		3.502 (2.201)	
4	Group Co. (1 – Yes, 0 – No)	2.459 (2.881)		2.646 (2.904)	
5	No of machines		1.316* (0.789)		1.351* (0.792)
6	TG2			-0.0256 (0.0702)	0.00944 (0.0705)
7	Constant	76.29*** (2.594)	75.30*** (2.668)	76.93*** (1.614)	76.51*** (1.612)
	N	160	160	160	160
	R-squared	0.061	0.061	0.062	0.058

Note: *** p<0.01, ** p<0.05, * p<0.1 give robust standard errors in parentheses

References

Battese, G.E. and Coelli, T.J. (1995) A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics,* 20.2**,** 325-332.

CPPRI (1996) Background and Technological Trends in Indian Paper Industry, Development Council for Paper, Pulp and Allied Industries .1996,

CPPRI, Vol-II, Saharanpur, Uttar Pradesh Report on Updating of Statistical Data for the Indian Paper Industry, (Undated), CPPRI, Vol-I, Saharanpur, UP

Johnson et al. (2011) India – An emerging giant in the pulp and paper industry) http://www.becaamec.com/media/~/media/beca_amec/media/technical_papers/india_emerging_giant_pulp_paper_industry.ashx

Kathuria, V. (2002) "Liberalization, FDI and Productivity Spillovers – An Analysis of Indian Manufacturing Firms", *Oxford Economic Papers*, 54: 688-718.

Kathuria, V. (2010) "Does the technology gap influence spillovers? – A post-liberalisation analysis of Indian manufacturing industries", *Oxford Development Studies*, 38(2): 145-70.

Knittel, C. R. 2002. Alternative Regulatory Methods and Firm Efficiency: Stochastic Frontier Evidence from the US Electricity Industry. *Review of Economics and Statistics,* 84.3**,** 530-540.

Kumbhakar, S.C. and Lovell, C. A. K. (2000) *Stochastic Frontier Analysis*, Cambridge University Press.

Noah, A S, J O Alao and J K Abiola (2014) Theoretical Review of the Economics of Paper Machine Operation, International Journal of Scientific Research and Management (IJRSM), 2(4): 787-94.

Podder, V. (1979) *Paper Industry in India- A Study*, Oxford & IBH Publishing Co. Pvt. Ltd,

Rao, Y.A. (1979) *The Paper Industry in India Status and Prospects*, Oxford & IBH Publishing Co. Pvt. Ltd, Delhi.

Schumacher, Katja and Sathaye, Jayanth (1999), India's Pulp and Paper Industry: Productivity and Energy Efficiency, Environmental Energy Technologies

Seo, D. and Shin, J. 2011. The Impact of Incentive Regulation on Productivity in the US Telecommunications Industry: A Stochastic Frontier Approach. *Information Economics and Policy,* 23.1**,** 3-11.

http://www.dcpulppaper.org/gifs/report20.pdf (Studies On Benchmarking /Input Norms for Pulp and Paper Industry, CPPRI, Saharanpur, UP (2004))

http://planningcommission.nic.in/aboutus/committee/wrkgrp12/wg_paper.pdf (Working Group on Pulp & Paper Sector for 12th Five Year Plan accessed in June 2013)

http://www.canopusindia.com/casestudy.pdf (The pulp and paper Industry as a sample case study)

http://www.observerindia.com/cms/export/orfonline/documents/Energy1/eventpdf/Malte%20Schneider.pdf (Corporate Responses to the Clean Development Mechanism – The Indian Pulp and Paper Industry)

http://dipp.nic.in/English/Publications/Reports/Final_9092002.pdf (Global Competitiveness of the Indian Paper Industry – report prepared by CPPRI, 2002).

Pulp and Paper Industry Regulatory Overview Naidu (undated) http://www.igep.in/live/hrdpmp/hrdpmaster/igep/content/e48745/e49028/e51797/e52844/02_PulpPaperSector-RegulatoryOverview_BRNaidu_CPCB.pdf

Technical EIA Guidance Manual for Pulp and Paper industries (2010) (http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_Pulp_and_Paper_010910_NK.pdf)

http://www.khosla.in/pdf/Development_of_the_Indian_handmade_paper_industry.pdf (Development of the Indian handmade paper industry – a case study)

Planning Commissions (various years) Five year plans - http://planningcommission.nic.in/plans/planrel/fiveyr/welcome.html as accessed on 4-06-2013