Vertical Integration in the American Pulp and Paper Industry, 1970-2000

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ABSTRACT

The paper and pulp industry saw an increase in the number of mergers in 1980's and 1990's. There had been consolidation of a number of smaller companies into larger corporations, which have greater management, financial, and marketing power. This merging trend has resulted in a fewer number of firms and an increasing concentration in the industry. Although the number of firms has decreased, the total industry capacity has been increasing. The combination of these interesting factors has motivated the topic of this master's thesis. The primary purpose of this research is to explore the factors that positively influence a firm's decision to vertically integrate into producing its own pulp.

CHAPTER ONE

INTRODUCTION

1.1 Economic Background

The United States of America has the highest consumption of paper and paperboard in the world – 98,974 thousand short tons as of 2002[1]. With annual consumption of pulp, paper and paperboard larger than all other continents, the U.S pulp and paper industry is the largest manufacturing sector in the world. This is a mature industry that continues to grow, but the rate has slowed considerably. On an average, the production has increased at an annual growth rate of less than 1% over the past few years, which is less than the U.S gross domestic product (GDP) growth of 3.5%.

USA is a major exporter of paper and paperboard due to the relatively low dollar and high quality products at low cost; with 11,597 thousand short tons of paper and paperboard being exported. However, the gap between export and imports has narrowed because US papermakers are facing increasing competition from foreign producers. This has also resulted in consolidation to eliminate excess production capacity.

The North American pulp and paper industry features a highly concentrated asset base, large capital requirements, and very cyclical business cycles. These factors have had a major impact on the industry's performance over time. The U.S paper industry has faced very challenging business conditions over the past few business cycles. However, in 1999, paper producers rallied to push sales and earnings to the highest level since 1995.The American Forest and Paper Association (AF&PA) showed an increase in total

[1] The facts and figures under this section are from North American Fact Book (NAFB), 2000 and American Forest and Paper association (AF&PA), 2003.

net sales from $165,149 million to $184,490 million in 2000.The overall net profit margin improved to 2.2% from 4.0%.

The pulp and paper industry is a capital-intensive industry, with very large investments required to build new pulp and paper mills. The various components of the capital expenditures and their percentage shares can be studied from figure 1.1[2]. The total capital expenditures from 1998 to 2000 for the industry as a whole are $8.7 billion. The highest percentage of capital expenditures is on the pulp mills followed by paper machine rebuilds and new paper machines. A substantial amount of expenditure incurred is the environment cost, which is discussed in detail below.

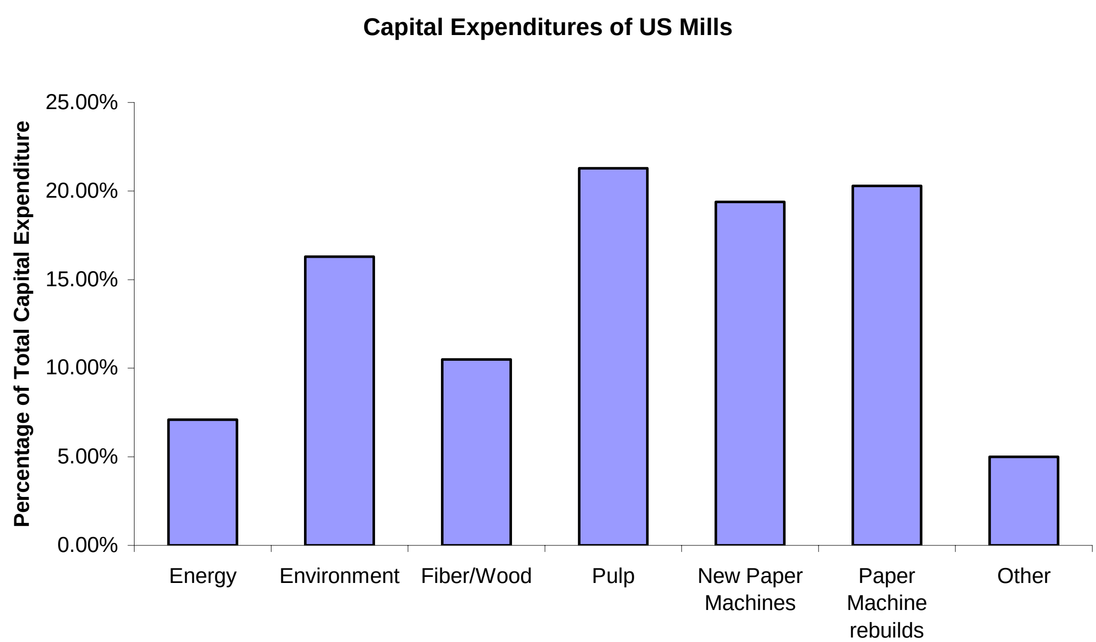

Figure 1.1- Capital Expenditure of US mills

The pulp and paper industry is one of the most environmentally regulated industries. The first environmental acts have been introduced during late 1960's early 1970's.

[2] The source of this data is *Pulp & Paper Project Report Mill-by-Mill Listings*, July 1999.

Wastes and emissions from the industry include solid and liquid wastes, air emissions and wastewater. Chemical recovery, bleaching, papermaking, deinking, sludge drying are some of the processes that contribute to air emissions. Aqueous wastes result from pulp washing, bleaching, pulping, coating operations and wood preparation. The total paper and pulp industry capital expenditures for environmental purposes have been highly unstable with steep increases in the years of an active legislature as well as a few years after the legislative changes. The periods of environmental compliance are: 1970-1975, 1986-1991, and in 1995 there is a reversal towards further capital increases. From 1993 to 1997 the Environmental Protection Agency has worked to enact the new Cluster Rule that is considered to have the most serious impact on the pulp and paper industry in general

The year 1999 was the second consecutive year in which the capacity grew at an average annual rate of less than 1%. Total U.S capacity to produce paper and paperboard increased by a mere 0.6% in 1998, the lowest annual growth rate since the 0.3% rate recorded in 1970. The capacity trends for all the products are discussed in detail in the following section.

1.2 Overview of the Paper Industry

The growth patterns of paper and pulp are taken from the FPL-UW database that is maintained at the USDA Forest Service, Forest Products Laboratory (FPL)[3] in Madison, Wisconsin, in collaboration with the University of Wisconsin- Madison. This

[3] The FPL aggregated data at the national level is comparable to the industry data published by leading trade association, the American Forest & Paper Association (AF&PA). The total U.S. paper and paperboard capacity from the FPL is close to the AF&PA numbers from 1970 to 2000. There are some differences between the aggregate data but for most of the years, the difference is less than 1%.

report consists of data of annual production capacity for all mill locations in the United States where paper, paperboard or market pulp were produced for each year from 1970-2000.Besides the capacity, company name, city, region, local ZIP code and capacity estimates of principal categories of paper, paperboard and market pulp are included. This report divides U.S. in three large regions, the North[4], the South[5], and the West[6].

The paper commodity group includes eight conventional categories: newsprint, four categories of printing and writing paper (uncoated free sheet, coated free sheet, uncoated groundwood and coated groundwood), tissue and sanitary paper products, unbleached kraft packaging paper and other specialty packaging and industrial papers. The paperboard commodity group includes four conventional commodity categories: linerboard and corrugating medium, solid bleached board and other recycled paperboard. The market pulp includes hardwood and softwood kraft market pulp, deinked market pulp, cotton linter pulp and bleached chemithermomechanical (CTMP). Paper and market pulp capacity grew at 2.1% annually from 1970 to 2000 while paperboard grew at 2.0% per year.

Market pulp is pulp produced at one location and sold to industrial users at another location or exported. This represents a very small share of the U.S. pulp capacity and roughly half of it is exported. The principal categories of market pulp produced in the United States include bleached paper-grade chemical pulp (chiefly kraft pulp), deinked, dissolving pulp and cotton linter pulp. Expansion in the U.S. market pulp capacity in

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[4] North includes the following States: Connecticut, Delaware, District of Columbia, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, West Virginia, Wisconsin and Vermont.

[5] South includes the following States: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee and Texas.

[6] West includes the following States: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, New Mexico, North Dakota, Nevada, South Dakota, Utah, Washington and Wyoming.

recent decades was concentrated in kraft pulp and deinked pulp. Regionally, the South witnessed most of the capacity growth, mainly due to the expansion in kraft pulping capacity. The capacity in the North has fluctuated but increased moderately during the past decade. In the West, however, the capacity receded significantly since the late 1980s.

Figure 1.2 graphically depicts the capacity trends of paper, paperboard and market pulp. All three witness an increase in capacity over the years. Paper capacity for the majority of the years has been less than or equal to the paperboard capacity. Also, the increase in market pulp capacity over the years has not been significant.

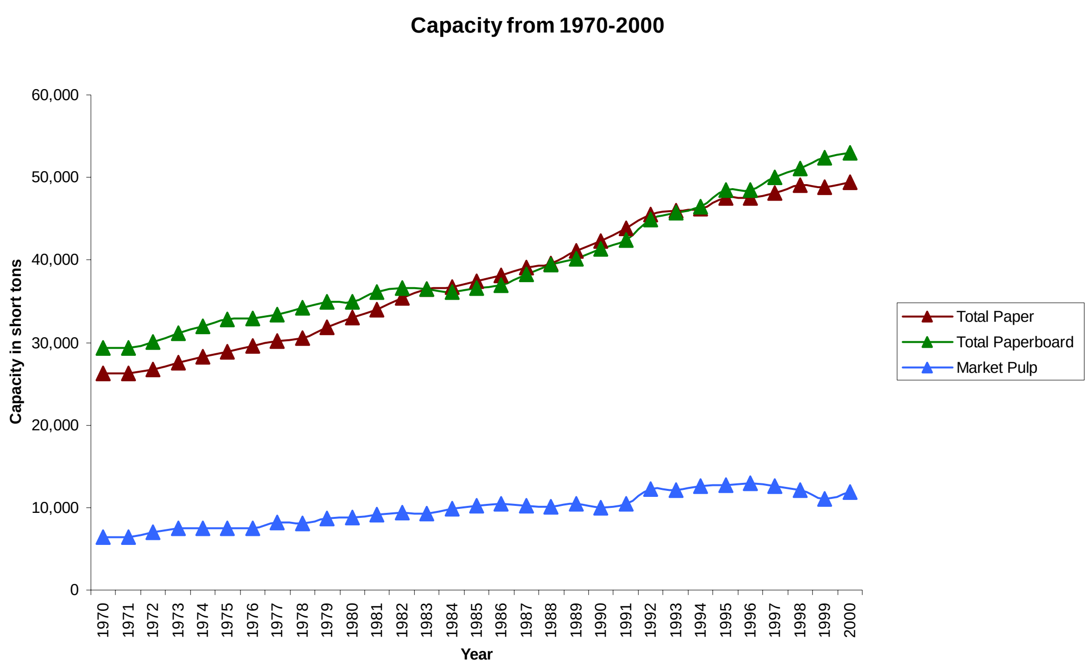

Figure 1.2- Total U.S. capacity of paper, paperboard and market pulp (thousand short tons)

Although total capacity of each commodity groups has increased during the past 30 years, each commodity has distinctly different growth patterns. The capacity trends have also been studied by commodity category, process and region wise.

The first commodity category is newsprint. Newsprint refers to the category of publication papers used mainly for printing daily newspapers, advertising inserts and various other commercial printing applications. It is a lightweight paper, made mainly from mechanical wood pulp, engineered to be bright and opaque for the good print contrast needed by newspapers. From figure 1.3, the newsprint capacity increased from 3.793 million tons in 1970 to 7.282 million tons in 2000, peaking at around 7.6 million tons in mid-1990. The newsprint capacity constituted 7% of the total U.S paper and paperboard capacity in 1970, increased to 9% in early 1980s but again fell back to 7% by 2000. The South has dominated U.S newsprint capacity with the North facing a decline in capacity. The West also showed an increase in the overall period.

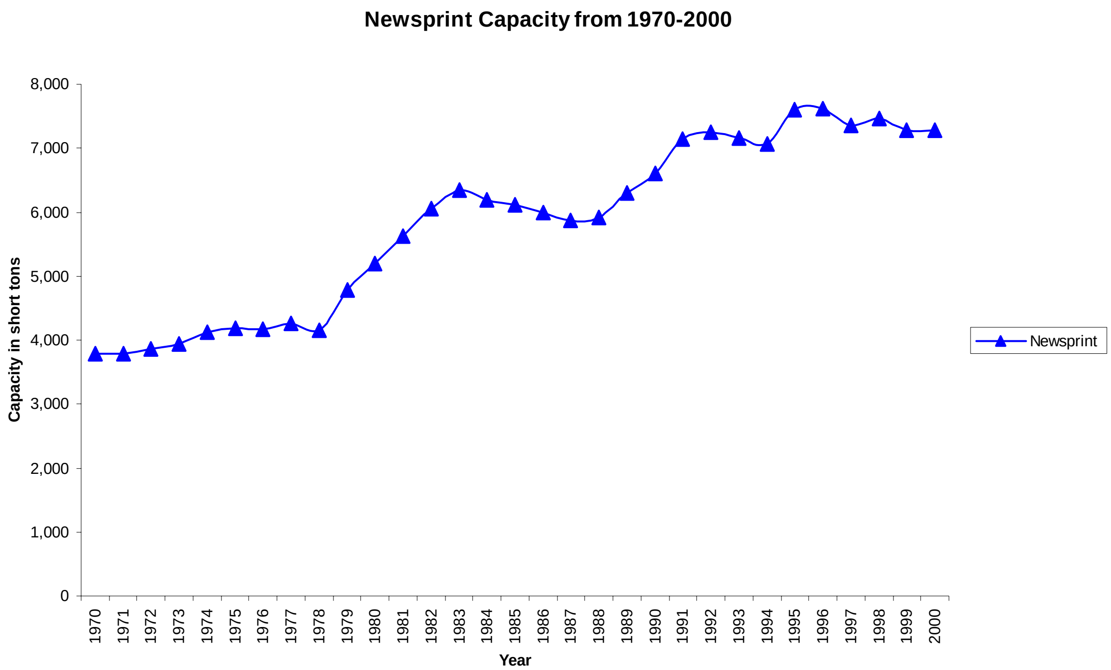

Figure 1.3- Capacity of newsprint in the United States (thousand short tons)

Coated and uncoated groundwood papers are two commodity categories within the broad group of printing and writing paper. Uncoated groundwood paper is primarily used in commercial printing and publication applications. While some of the grades are similar to newsprint, uncoated groundwood usually requires additional processing steps[7]. The capacity increased in the U.S from 1.15 million tons in 1970 to 1.85 million tons in 2000. There is a steady increase from 1970 to 1990 after which the capacity is more erratic in the 1990s. The North dominated the uncoated groundwood capacity in the U.S even though it witnessed a decline in the capacity for the whole period. Capacity in the South expanded rapidly from none in early 1970s to around 20% of total U.S capacity in 2000.

[7] Groundwood paper grades have mechanical pulp fiber content is higher than 10% but lower than 65%. Free sheet paper grades are produced by bleached chemical pulp in which the mechanical pulp content is less than 10%. Newsprint, on the other hand, has more than 65% mechanical pulp content.

Coated groundwood capacity increased from 2.01 million tons in 1970 to 4.51 million tons in 2000.There was a sharp decline in capacity in mid 90's as seen from Figure 1.4. In the case of the coated groundwood capacity also the North dominated with around 75%-80% of total U.S. capacity throughout 1970 to 2000. There was an increase in the capacity in the South. A relatively small amount of coated groundwood capacity existed in the West in the 1970s and 1980s, but capacity in the West declined to zero around 1990.

Coated and uncoated free sheet papers are other two commodity categories within the printing and writing paper group. Figure 1.4 shows that uncoated free sheet comprises more than half of all printing and writing paper capacity throughout 1970 to 2000. Uncoated free sheet is used to produce the office reprographic paper for copiers and printers, business forms and other converted paper products such as envelopes and stationery. The capacity for this increased in the U.S from 6.8 million tons in 1970 to 16.4 million tons in 2000.The North dominated uncoated free sheet capacity in 1970 with around 64% of total U.S capacity. The South witnessed an increase in capacity from 25% in 1970 to 50% in 2000.

Coated free sheet is used generally in commercial printing applications such as annual reports and product sales brochures. The coated free sheet capacity more than doubled from 1970 to 2000 with the growth being concentrated in the North.

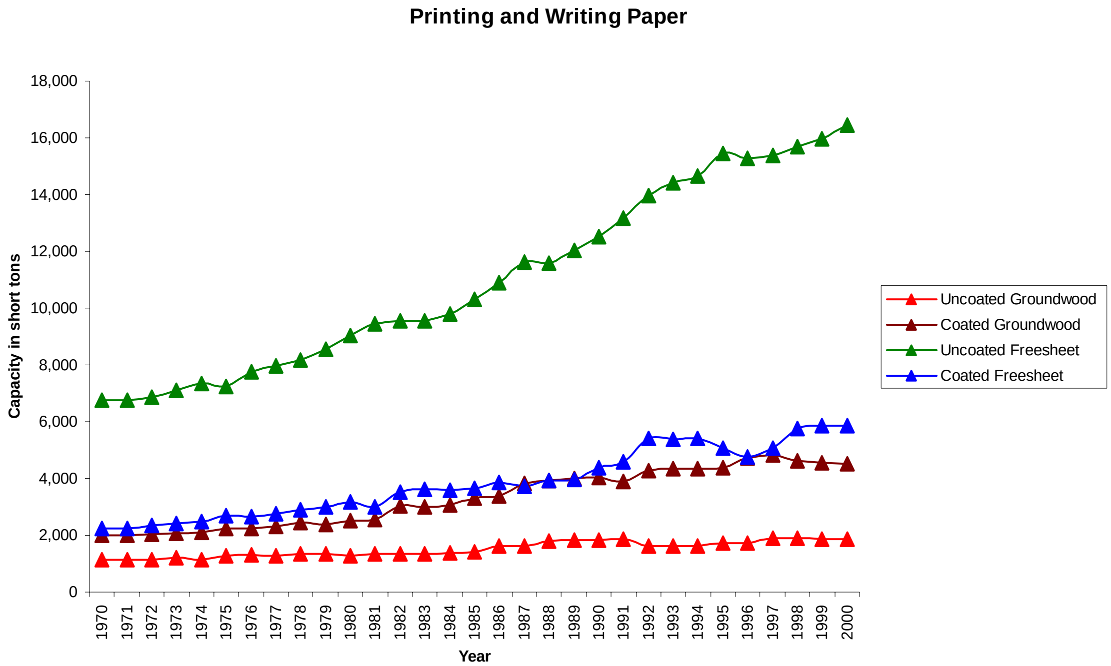

Figure 1.4- Capacity of printing and writing paper in the United States (thousand short tons)

Tissue and sanitary paper include bathroom tissue, paper toweling, facial tissue, napkins and also absorbent sanitary products. Due to consumer orientation of product output and product differentiation, there has been a stable growth rate for the U.S tissue paper producers. Figure 1.5 shows that the growth in capacity has been erratic. Most of the U.S tissue and sanitary paper capacity has been concentrated in the North, but most of the growth in capacity in recent decades has occurred in the South. The capacity located in the North declined from 66% in 1970 to 47% in 2000, while share in the South increased from 17% to 37%.

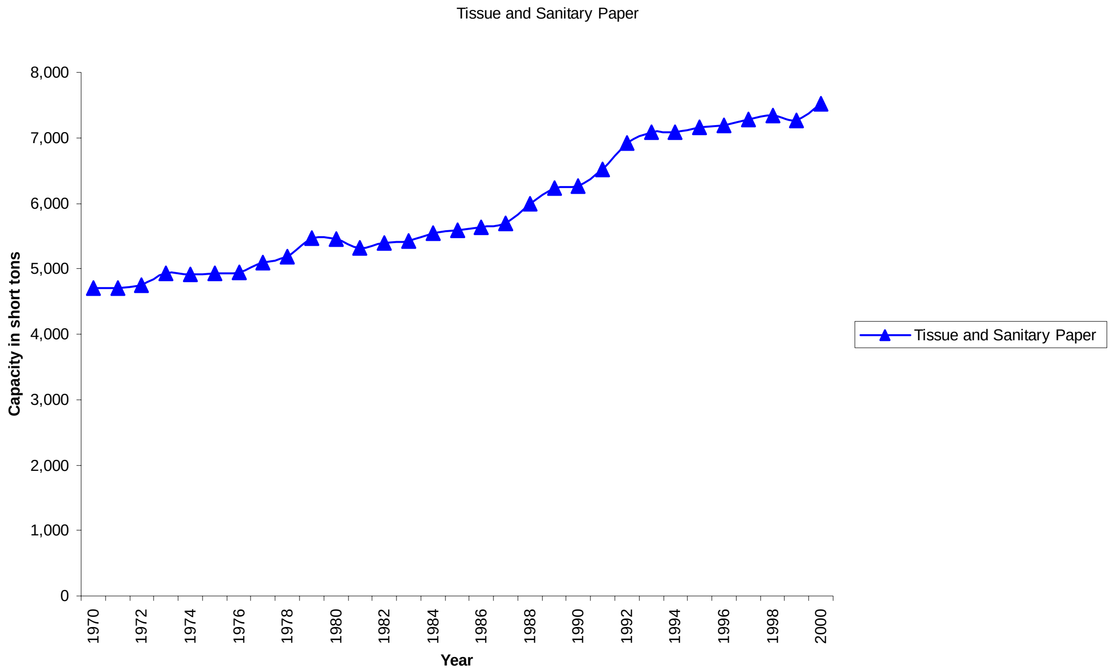

Figure 1.5- Capacity of tissue and sanitary paper in the United States (thousand short tons)

Specialty packaging and industrial papers include a diverse range of paper products used in a variety of industrial and packaging end-uses. Products include pressure-sensitive release paper or release liner, food-wrapping paper such as greaseproof wrapping and many other products. The mills in this sector usually specialize in producing products tailored to meet unique customer requirements and specifications. The 1980's saw large increases in capacity followed by a sharp decline in 1990's (as seen in Figure 1.6). For the entire period, however, there is an overall increase in the capacity. The North's share of total U.S capacity declined from 67% in 1970 to 42% in 2000, while the South's share of capacity increased from 17% to 45%. Capacity in the West remained in the range of 12% and 17% of total U.S capacity.

Kraft packaging paper is a comparatively coarse paper particularly noted for its strength, and in unbleached grades is primarily used as a wrapper or packaging material. It can be watermarked, or striped, and it has an acceptable surface for printing. Its natural unbleached color is brown but by the use of semi bleached or fully bleached sulfate pulps it can be produced in lighter shades of brown, cream tints, and white. In addition to its use as a wrapping paper, it is converted into such products as: grocery bags, envelopes, gummed sealing tape, asphalted papers, multiwall sacks, tire wraps, butcher wraps, waxed paper, coated paper, as well as specialty bags and sacks.

Kraft packaging paper production capacity has been generally declining for the past 20 years. Figure 1.6 shows the two sharp declines are in the years 1984 and 1991 with the 1991 being a sharper one. This is because the markets for unbleached kraft paper, particularly in grocery bags and sack paper, have suffered from significant substitution by plastic bags. The largest capacity was concentrated in the South with a sizeable share located in the West and relatively little capacity was located in the North.

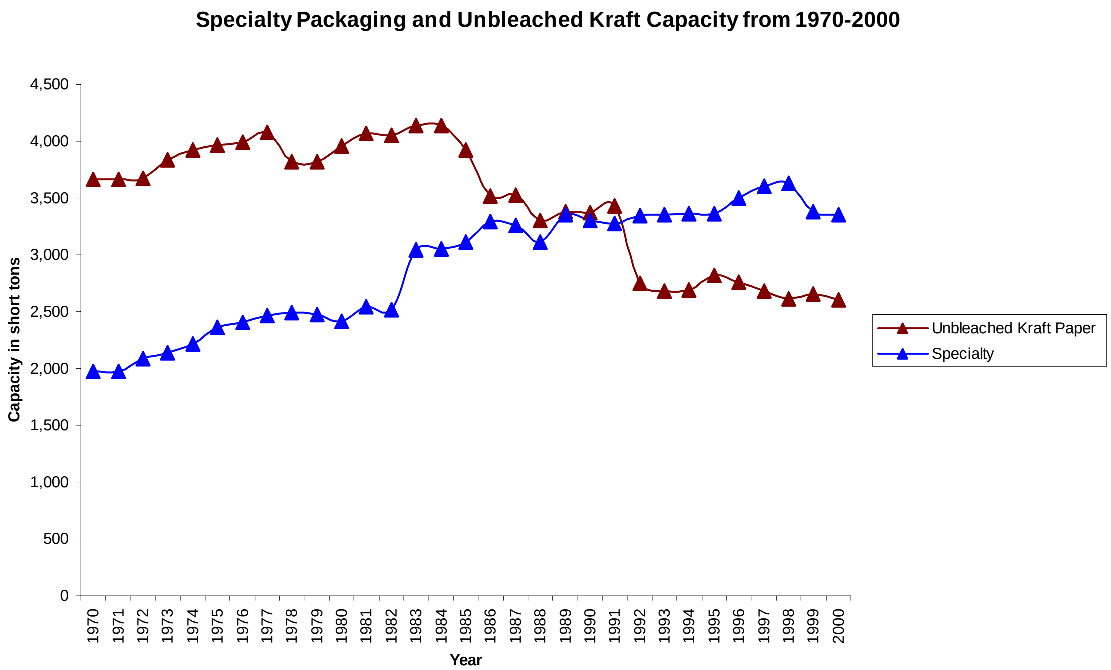

Figure 1.6- Capacity of specialty and unbleached kraft capacity in the United States (thousand short tons)

Linerboard is paperboard used for the flat outer facings of combined corrugated board. Linerboard production capacity in the U.S was the largest among all single commodity categories of paper and paperboard. The United States is the largest producer of linerboard in the world and in recent decades, production capacity has undergone significant growth and evolution in technology. The largest share of U.S. capacity and most capacity growth in recent decades has been concentrated in the South with a sizeable share of capacity in the West. Corrugating medium is used almost entirely in the manufacture of corrugated boxes and containers. In combination with linerboard, corrugated containerboard is produced. This has been steadily increasing form 1970 till 2000 as seen from Figure 1.7. The North has had the largest share of total U.S. capacity and growth.

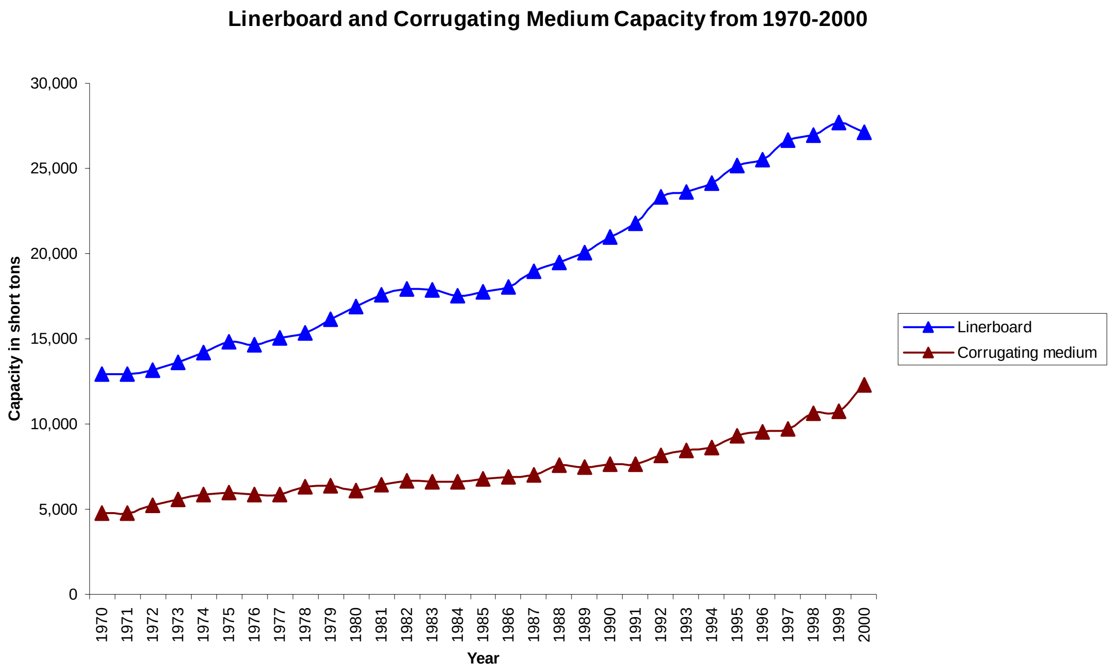

Figure 1.7- Capacity of linerboard and corrugating medium in the United States (thousand short tons)

Solid bleached paperboard is primarily used for boxboards, milk carton and food service applications. To a lesser extent, it is also used for linerboard and other uses. The capacity from 1970-2000 has been increasing with the bulk of the capacity growth concentrated in the South.

Other recycled paperboard includes all paperboard that is made exclusively from recycled fiber. It is primarily produced for boxboard (used in consumer packaging), gypsum liner and converting applications. Figure 1.8 shows that the capacity saw an increase in 1970s but a decline in 1980s and mid 1990s with the decline in 1990s being a sharper one. The North has maintained a dominant share of total capacity but this has been declining gradually. More capacity growth occurred in the South.

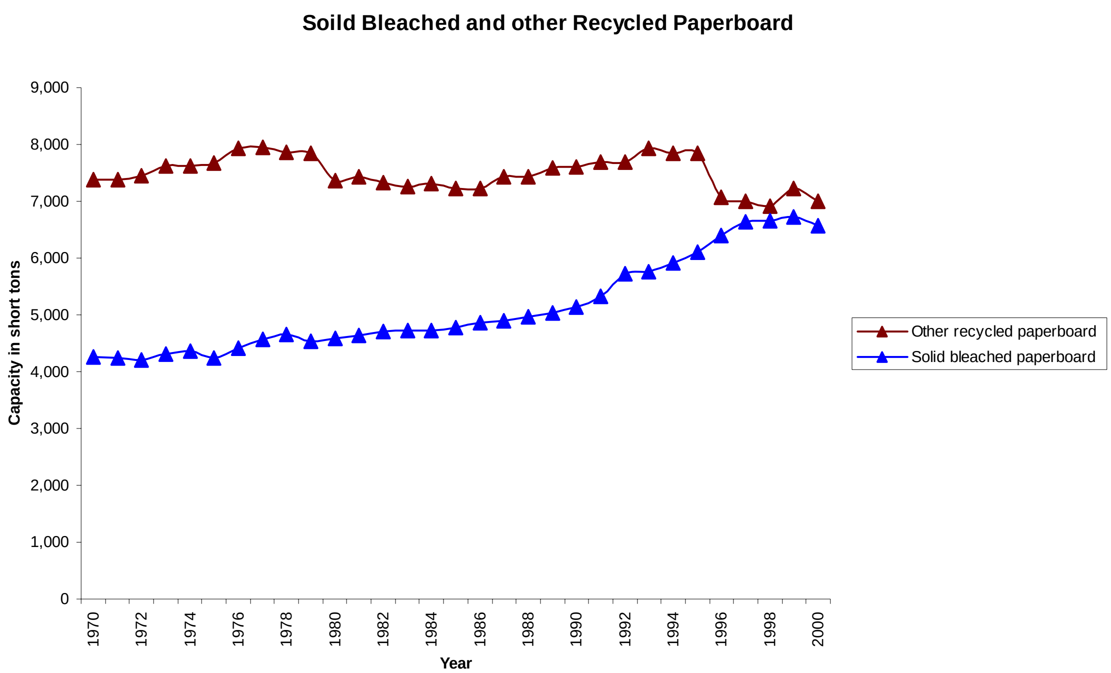

Figure 1.8- Capacity of solid bleached and other recycled paperboard in the United States (thousand short tons)

1.3 Merger Trends in the Paper Industry

In the 1980s the paper industry, like other U.S. businesses, witnessed a large number of merger and acquisition (M&A) activity. There have been 31 major deals in the paper industry since 1983, according to Morgan Stanley & Co[8]. The value of the

[8] Facts and figures of the mergers under this section are from NAFB 1988, 1990 and 2000.

transactions reached $28 billion involving 31 million tons of primary capacity or 33% of U.S. paper capacity. According to First Boston analysts, the average value of transactions in the mid-1980s was about $600 million, with 20 deals in the $100-million range. Through 1987, six multi-billion-dollar deals involved paper companies, beginning with Champion International Corporation's buyout of St. Regis Corp. in 1984 for $1.84 billion.

The merger boom of the 1980s left its mark on the structure of the industry. Nine of the top industry producers (those with capacity for 1000 tpd or more) were acquired by other companies. This accelerated the industry's long-term trend toward higher concentration. In 1987, the top five companies held 45% of kraft linerboard capacity and the top ten 71%. Overall, concentration among the top 15 paper and paperboard producers grew from 54% in 1983 to 68% in 1987. The top 15 pulp producers increased their share form 56% to 70% over the same period. The 1990s also saw a lot of M&A activity as seen from the graph below[9].

[9] The graph has been compiled by Aselia Urmanbetova with the data from NAFB.

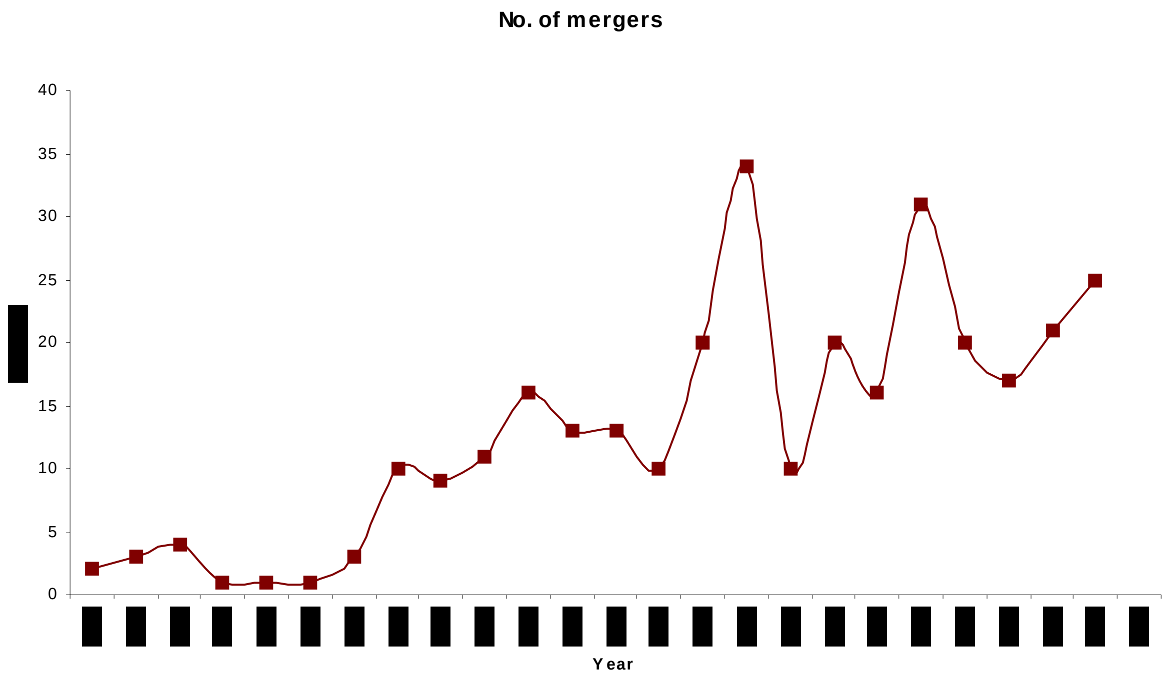

Figure 1.9- Mergers in US Paper and Pulp Industry, 1976-2000

Acquisitions are an inexpensive way to expand plant capacity and timber- holding. A firm considers the build-vs.-buy equation and it has been usually cheaper to buy an existing mill than to build one. First Boston estimated that major transactions were just 30% to 40% of the replacement value. Georgia-Pacific, for example, paid just 41% of replacement cost for Brunswick Pulp & Paper Co. in late 1988.

Another important factor was the threat of takeover. Factors that helped make takeover threat real for the paper industry: undervalued companies, availability of funds to make purchases and a lax anti-trust environment offering a few obstacles to deal making. With ready availability of funds, whole new financial industries sprung up around the leveraged buyout (LBO) and junk bonds. This forced the companies to concentrate their assets in the businesses they knew best and to purchase complementary businesses that can help boost returns. The merger boom got a boost form the lax antitrust environment of the Reagan years. The tax code favored takeovers for the most of the 1980s as well.

However, the junk-bond market fell into disarray in the 1989 due the October 1987 stock market crash. With the funding becoming tight, many deals fell through, and the nature of acquisitions changed. Paper companies themselves entered the fray, searching for synergy and consolidation. With the paper industry prosperity weakening, M&A activity started out the new decade with the first major hostile takeover by a U.S. paper company G-P acquiring Great Northern Nekoosa Corporation. During the 1990s, the U.S. witnessed the sales of many converting plants. Jefferson Smurfit acquired several container plants in 1990 and two from Boise in early 1991.

CHAPTER TWO

LITERATURE REVIEW OF VERTICAL INTEGRATION

2.1 Reviews on paper and pulp industry

A number of authors like Ohanian (1994), Pesendorfer (1998) and Melendez (2002) have studied the paper and paperboard industry. The literature by Ohanian examines the determinants of vertical integration in the paper industry for the period 1900-1940. Using mill level data, she finds vertical integration of pulp and paper industry to be positively associated with regional concentration, paper mill capacity and production of newsprint and board. Pesendorfer studied the implications of horizontal mergers on consumers, rival firms and welfare. He estimated a cost function and found that efficiency of the firms increase after an acquisition. Also, total welfare increases in some of the paper product categories. Melendez also examines the determinants like

Ohanian. Unlike Ohanian, she found that vertical integration was positively associated with lag of regional concentration ratio, paper mill capacity, production of newsprint and forestland regions. Besides examining the transaction cost model, Melendez also proposes a dynamic model of vertical integration from 1975-1995.

2.2 Reviews on transaction cost models

There is a significant amount of literature available on vertical integration and the transaction cost model. Lieberman (1991) studied these models of vertical integration with emphasis on transactions costs and demand variability and tested using logit analysis in a sample of 34 chemical products. Levy (1985) conducted a similar examination except he tested across 37 different industries (69 firms). The literature by Levy (1985) also showed that concentration ratio was positively related to vertical integration.

2.3 Reviews on concentration ratio

MacDonald (1985) attempted to measure vertical integration by proposing that concentration ratios may not accurately reflect the existence of small number bargaining conditions in industries characterized by intensive R&D. However, the results showed that the higher is the buyer and seller concentration, the greater is the extent of vertical integration.

2.4 Comparison of previous research work with this paper

Unlike previous work, this paper studies the integration at the mill level. It updates the study conducted by Ohanian, as the period of study is 1970-2000. Besides the concentration ratio, mill capacity and various paper grades, the effects of the environmental regulations and capacity in three different decades, 1970, 1980 and 1990 are also included in the model to see their influence on a firm's decision to integrate.

CHAPTER THREE

VERTICAL INTEGRATION

3.1 What is Vertical Integration?

Vertical Integration is a merger of two firms at different stages of production wherein the output of one firm is the input of the other. This integration can be classified into two types: "forward integration", which connects the marketing and sales functions with production and "backward integration" which builds up the productive process toward the manufacture of semi-finished products and raw materials.

Under vertical integration, instead of market exchange of goods, a firm's exchange is internal or within its own boundaries. Hence there is complete flexibility regarding investment, employment, production and distribution at all stages. However, internal exchange alone does not fully define vertical integration as even ownership of various assets like capital has to be considered. But there is a debate on the treatment of these assets in altering the degree of integration.

Vertical integration has never been a well-understood phenomenon in spite of the extensive literature available on its theoretical rationale. Economic theories can be classified into two, one that views vertical integration as a response to relatively high costs of market exchange, and another that integration arises as a result of market power on one side of the market. Case studies that have been undertaken either concentrate on a single industry or a broad base of industries. In the first case the results may be applicable for that particular industry, not for all industries in general. Study under the broad base industry fails to establish a clear link between the studies and the theories of vertical integration.

3.2 Causes of Vertical Integration

According to Perry (1992), there are three main factors causing integration: technological economies, transactional economies and market imperfections.

Integration may lead to technological economies on two accounts. First, it replaces some intermediate inputs with the primary input and second, it reduces the requirements of other intermediate inputs. An example from the paper industry is the energy savings from not having to convert the dry pulp to its slush form for the paper production. These economies vary by industry but are available to all firms within an industry. But not all the firms in an industry are integrated suggesting that technological economies may not be alone to be the reason to integrate.

Transactional economies occur when transaction costs reduce as integration replaces market exchange. The firm's costs do not end at the production stage as selling or exchange of goods has its own share of costs. Under contractual exchange, one of the costs is the transaction cost involving the writing and enforcing of a contract. The contract specifies the negotiation between firms on the various features of a product like price, quantity and quality. One firm may take advantage of the other firm or engage in "opportunistic behavior" when the terms of the contract may be unclear, thus making a firm to perform activities itself rather than rely on the market.

These costs are high when the exchange involves specialized assets hence, providing an incentive to integrate. A specialized asset is tailor-made for one or more buyers. The buyer in this case is wholly dependent on the supplier for this asset, both in terms of the price charged and the asset being supplied, hence leading to opportunistic behavior. Asset specificity is of three types: specific physical asset, specific human capital and site-specific capital. Specific physical asset includes buildings and machines that can be used by one or more buyers. Depending on the nature of opportunistic behavior, the firm may own only the specific asset (quasi-vertical integration) or the supplying firm, i.e integrate. Sometimes a firm may require specialized labor for the production of a particular good, i.e. it requires specific human capital. Similarly, when production process involves site-specific capital, vertical integration is likely.

Market imperfection theories focus on avoiding costs attributed to imperfect competition like monopoly or monopsony market power, price controls, and uncertainty. This approach ignores the cost of exchange. Here integration is substituted for exchanges in imperfect markets and this approach ignores the cost of exchange. "However, there is little empirical evidence that pulp and paper markets are consistent with these market imperfections" (cited from Vertical Integration in the US Pulp and Paper Industry, 1900-1940 by Nancy Kane Ohanian, 1993).

3.3 Advantages and Disadvantages of Vertical Integration

One of the biggest advantages of integration is assured and continued supply of important inputs. However, many models of market behavior ignore this topic, even though this is an important issue to the business community. There is an incentive to integrate when instead of price, rationing may be the device used to allocate goods. A firm has an incentive to produce its own supplies to meet its predictable level of demand and to rely on other firms for supplies to meet its less stable demand. “This arrangement, in which outside suppliers bear risky demand, may not be the most efficient system for reliability providing the product, but may provide a strong incentive for a firm to vertically integrate” (cited from Pg.383 in “Modern Industrial Organization” by Dennis Carlton and Jeffrey Perloff).

A firm will lower its transaction costs and may be able to avoid government restrictions, regulations and taxes by integrating. For example, it can avoid price controls, which reduce profit rates by selling to itself.

There are also certain disadvantages of vertical integration. The internal supplier producing for internal use might be at a relative disadvantage in the marketplace as he lacks the experiences in market organization and customer connections. Also the existence of internal source of supply tends to distort procurement decisions as goals of a subgroup or an individual have more weight in relation in overall firm profitability.

The costs of integration do not show up immediately and hence a firm should consider the future distortions. Sometimes the cost of integration and producing with a firm may be higher than purchasing from competitive markets. Also, as a firm expands in size, the difficulty and cost of managing it increase. When a product is purchased form the market, the costs of supervising and managing an organization is borne by someone else. Finally, there are substantial legal fees associated with vertical integration.

3.4 Relevance in Paper and Pulp Industry

Pulp and paper production does enjoy technological economies of integration. The integrated firms save the cost of drying the pulp as they transfer the pulp in slush form to the paper plant. Non-integrated mills, on the other hand, have to dry the pulp before it is shipped. Hence, the integrated mills save the water and energy costs involved in drying the pulp. They save in transporting the dry pulp to paper plant as papermaking is situated near the pulping facility. But they would have to incur shipping costs to transport the paper to the markets. The technological economies are greater for certain grades of papers than others. For example, kraft and newsprint require few grades of pulp and are produced at a large scale thereby increasing the likelihood to be integrated with pulp production. The studies conducted by Ohanian and Melendez attribute vertical integration in the industry to the type of paper grade produced.

Modern studies have explored the transactional economies involved in the integration of pulp and paper production. Ohanian (1992) investigated the trends in integration in the U.S paper and pulp industry using mill level data from 1900-1940.The results showed that more of the paper mills were integrated backward towards pulp production. Vertical integration is positively associated with regional concentration, paper mill capacity and production of standardized grades of paper.

Melendez (2002) takes a transaction-cost approach to explain the observed pattern of integration in U.S paper and pulp industry for the period 1975-1995. Using mill level data, she finds that the lag of regional concentration, paper mill capacity, production of standardized grade of paper and forestland area is positively associated with vertical integration. Since regional concentration was negative and not significant, she tested it against the lag of regional concentration, which was positive. Hence firms respond to the lag of market concentration in terms of their decision to integrate, as this requires investment in the pulp-processing machinery and equipment.

3.5 The U.S. Pulp and Paper Industry, 1970-2000

Under this section, using the mill level data from FPL, statistical summary of the industry and the integrated mills is presented. Tables 3.1 through 3.4 show the different aspects of the industry in terms of number of active paper and paperboard mills and their capacities [10]. Table 3.1 discusses the number of paper, paperboard and pulp mills, companies and percentage of single mill companies. There is a decrease in a number of paper and paperboard mills throughout the period. At the mill level, data of actual owners was recorded and then all the mills under the one owner were taken to be one company. If a company owns only one mill, it is a single mill company. From the table, we can see that an overall a few percentage of companies are single mill but throughout the period there is an increasing trend.

Table 3.1- The U.S. pulp and paper industry, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Number of mills							
Paper only	148	151	143	132	131	130	119
Paperboard only	167	165	154	142	140	144	137
Pulp only	26	24	31	32	29	30	28
Number of companies	264	256	247	224	212	201	184
Percent of single mill companies	32.95	35.16	34.01	36.61	33.02	37.31	36.41

[10] Capacity was reported for 577 in 1970, 573 in 1975,557 in 1980,536 in 1985,530 in 1990,526 in 1995 and 498 in 200.

Table 3.2 looks at the paper capacity only and the percentage of each product comprising the total capacity. The total paper capacity has increased from 26,302 to 49,413 thousand short tons[11]. Hence the capacity has almost doubled in the 30 year period. Uncoated free sheet constitutes majority share of the paper capacity followed by packaging & industrial paper and tissue and sanitary paper. Uncoated groundwood, on the other hand, constitutes a small percentage of the total capacity. With almost a doubling of the capacity in the entire period, most of the product share has also increased.

[11] The Navigation Data Center (NDC) defines it as unit of mass or weight where one short ton=2000 pounds or 907.2 kilograms or 0.9072 metric tons.

Table 3.2- The U.S. paper capacity, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Total Paper Capacity only (in thousand short tons)	26,302	28,849	33,028	37,439	42,314	47,518	49,413
(% of total paper capacity)							
Newsprint	14.42	14.48	15.72	16.34	15.62	16	14.73
Coated Free Sheet	8.58	9.3	9.58	9.76	10.34	10.63	11.83
Uncoated Free Sheet	25.71	25.06	27.36	27.55	30.02	32.48	33.28
Coated Groundwood	7.63	7.76	7.64	8.80	8.90	9.22	9.12
Uncoated Groundwood	4.35	4.37	3.85	3.82	4.29	3.60	3.75
Tissue and Sanitary paper	17.87	17.07	16.52	14.91	14.79	15.08	15.21
Packaging and Industrial Paper	21.44	21.93	19.3	18.8	15.77	13	12.06

Table 3.3 looks at the paperboard capacity. Like the paper capacity, there is an increase in the paperboard capacity in the entire the period as seen from table 3.3. Under this, linerboard constitutes almost 50% of the capacity.

Table 3.3- The U.S. paperboard capacity, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Paperboard Capacity Only (in thousand short tons)	29,354	32,742	34,973	36,546	41,358	48,417	53,016
(% of total paperboard capacity)							
Linerboard	44.11	45.3	48.36	48.66	50.65	52	51.17
Corrugating Medium	25.15	23.42	21.05	19.77	18.37	16.2	13.2
Solid Bleached Paperboard	15	12.97	13.1	13.05	12.43	12.6	12.37
Other Recycled Paperboard	16.25	18.3	17.48	18.51	18.53	19.2	23.25

One interesting fact that can be noted form tables 3.1 to 3.3 is that even though the number of paper & paperboard mills and companies have decreased from 1970-2000, there has been a significant increase in the capacity of both paper and paperboard.

In Table 3.4, the pulping capacity trends are shown. The AF&PA divides wood pulp[12] into four grades; dissolving and special alpha[13], chemical[14], semichemical and mechanical[15]. Chemical grade constitutes majority of the wood pulp capacity. There is a doubling of the pulp capacity with only a slight increase in the number of pulp mills.

[12] Wood pulp is defined as fiber from wood with varying degrees of purification that is used for the production of paper, paper board, and chemical products

[13]Dissolving alpha is a special grade of chemical pulp usually made from wood or cotton linters for use in the manufacture of regenerated or cellulose derivatives such as acetate, nitrate, etc.

[14] Chemical pulping process is pulp obtained by digestion of wood with solutions of various chemicals with the produced paper produced being strong and less prone to discoloration.

[15] Mechanical pulp is the wood pulp manufactured wholly or in part by a mechanical process, including stone-ground wood, chemigroundwood and chip mechanical pulp.

Table 3.4- The U.S. wood pulping capacity, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Total Wood Pulping Capacity (in thousand short tons)	43155.21	47957.92	54253.06	59977.45	66127.21	74672.72	76127.8
(% of total wood pulping capacity)							
Mechanical	12.67	12.38	12.93	13.92	14.01	11.95	12.35
Chemical	75.29	75.62	77.05	77.13	77.98	81.13	81.31
Dissolving Alpha	3.66	3.36	2.83	2.55	2.31	1.92	1.34
Semi-Chemical	8.38	8.64	7.19	6.40	5.70	4.99	5.00

From all the above tables, we conclude that this is a growing industry that displays a tendency towards larger and fewer mills over the years.

For this study, mill data was used to determine the degree of vertical integration. If a mill had positive paper and paperboard capacity and positive pulp capacity, it was denoted as vertically integrated. Tables 3.5 through Table 3.8 look at the integrated mills and their capacities. The number of integrated mills has fallen but the integrated capacity has risen and almost 75% of the total paper and paperboard capacity in the U.S. belongs to the integrated mills.

Table 3.5- Vertical Integration in the U.S. paper industry, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Integrated Paper mills	139	136	135	136	137	129	132
Integrated Paperboard mills	59	60	57	57	54	57	56
Integrated Paper and Paperboard mills	234	232	229	229	228	220	213
Integrated Paper and Paperboard Capacity (% of total paper and paperboard capacity)	73.53	82.18	76.2	77.19	77.24	75.71	75.37

Tables 3.6, 3.7 and 3.8 show the extent of integration product-wise for paper, paperboard and wood pulp capacity. Table 3.6 shows that under the paper capacity; almost 100% of newsprint and coated groundwood capacity is integrated. The integrated paper capacity constitutes more than 75% of the total paper capacity and has increased during the entire period.

Table 3.6- Integrated Paper Capacity in the U.S. paper industry, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Integrated Paper Capacity Only	75.81	75.25	76.7	78.21	76.92	76.28	78.49
Newsprint	13.2	13.18	14.5	15.03	14.37	13.55	13.6
Coated Free Sheet	5.3	6	6.41	6.48	6.74	7.34	9.15
Uncoated Free Sheet	19.1	18.46	21.05	21.34	23.37	26.97	27.9
Coated Groundwood	7.62	7.76	7.64	8.8	9.57	9.22	9.11
Uncoated Groundwood	2.57	2.95	2.77	2.9	2.6	2.14	2.26
Tissue and Sanitary paper	7.32	5.6	5.45	5.31	4.88	4.29	4.61
Packaging and Industrial Paper	7.51	8.18	7.27	8.27	7.76	7.06	6.75
(% of total paper capacity)							

Under paperboard, as seen in Table 3.7, linerboard and solid bleached capacities are almost fully integrated. The integrated capacity has increased for paperboard but not as much as it has for paper. Table 3.7 shows that in the 1980s there was an increase in the integrated paperboard capacity followed by a decline in the 1990s, thereby not witnessing a substantial increase for the entire period. Among the paperboard products, linerboard and solid bleached paperboard are more than 90% integrated.

Table 3.7- Integrated Paperboard Capacity in the U.S. paper industry, 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Integrated Paperboard Capacity Only	71.48	73.4	75.73	76.15	77.56	75.16	72.46
Linerboard	41.76	48.15	46.56	47.08	49.3	48.11	45.9
Corrugating Medium	13.78	16.93	14.47	14.81	14.23	13.5	13.71
Solid Bleached Paperboard	14.48	14.46	13.09	13.05	12.43	12.58	12.78
Other Recycled Paperboard	1.42	2.27	1.56	1.17	1.56	0.95	0.06
(% of total paperboard capacity)							

Therefore, from all the paper and paperboard products, mills producing newsprint, coated groundwood, linerboard and solid bleached paperboard will tend to be more integrated as seen from tables 3.6 and 3.7.

Finally, Table 3.8 focuses on the proportion of the vertically integrated mills in the U.S. by region. In the 1970s, more mills were located in the north. However, by the end of the period, south has higher proportion of mills. The northern region has witnessed a decline in the mills whereas for the southern region, there is an increase. The western region did not witness any major changes in the number of mills.

Table 3.8- Vertical Integration by region: 1970-2000
(Percent of vertically integrated paper and paperboard mills)

Region	1970	1975	1980	1985	1990	1995	2000
North	48	46	46	47	45	42	43
South	39	41	40	40	42	45	45
West	13	13	14	13	13	13	12

CHAPTER FOUR

THE TRANSACTION COST MODEL

4.1 Statistical Methodology

Since the dependent variable, vertical integration (VI), for this analysis takes a value of 0 or 1,probit analysis is an appropriate methodology for estimation. A binary probit has the form:

$$\Pr(y=1|x) = F(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k) = F(x\beta) \qquad (1)$$

where x is the co-efficient and β is the co-efficient is the co-efficient associated with x.

The model will be estimated using cross sectional and panel data formats. Under the cross section, data set will contain observations at five-year intervals between 1970 and 2000. The model in this case will not include the interaction variables and environmental regulations. In the probit model, F is the standard normal cumulative distribution function (CDF), which is expressed as an integral:

$$F(z) = \Phi(z) = \int_{-\infty}^{z} \phi(v)\, dv$$

where $\phi(z)$ is the standard normal density function.

The partial change in the probability or the marginal effect is computed by taking the partial derivative of equation (1) with respect to x_k

$$\partial Pr(y=1|x)/ \partial x_k = \partial F(x\beta)/ \partial x_k = dF(x\beta)/dx\beta * \partial x\beta/\partial x_k = \phi(x\beta)\ \beta_k$$

The marginal effect is the slope of the probability curve relating a change in x_k to $Pr(y=1|x)$, holding all other variables constant.

Pooling all the cross sections gives an unbalanced panel data with 16,852 observations. The random effect probit is used to estimate the model which is of the form:

$$y_{it}^* = x_{it}^*\beta + v_{it},\ i=1,2,3\ldots n\ \&\ t=1\ldots T$$

$$v_{it} = \alpha_i + u_{it}$$

$\&\ y_{it} = 1$ if $y_{it}^*>0$ or else equal to 0,

where y* denotes the unobservable variable, y is the observed outcome, x is observable time varying and time invariant vector, β is the vector of co-efficient associated with the x, α_i is random variable and u_{it} is a random error.

In pooled probit, under the normalization $\sigma_v=1$, marginal effect is given by

$$\partial[Prob(y_{it}=1|x_{it})]/ \partial x_{jit} = \partial[E(y_{it})]/ \partial x_{jit} = \partial[\Phi(x_{it}'\beta)]/ \partial x_{jit} = \phi(x_{it}'\beta)\ \beta_j \qquad j=1,\ldots,k$$

4.2 Methodology Adopted in Deriving the Variables

The primary data source for this paper is the FPL-UW database that is maintained at the USDA Forest Service, Forest Products Laboratory (FPL) in Madison, Wisconsin, in collaboration with the University of Wisconsin-Madison. This report consists of data of annual production capacity for all mill locations in the United States where paper, paperboard or market pulp were produced for each year from 1970-2000. Besides the capacity, company name, city, state, region, local ZIP code and capacity estimates of principal categories of paper, paperboard and market pulp are included. The capacity estimates of each mill are further differentiated by the process type within each category of paper and paperboard.

The paper group is divided into eight categories: newsprint, four categories of printing and writing paper, tissue and sanitary paper products, unbleached kraft paper, and other specialty packaging and industrial paper products. The four categories of paperboard are: linerboard, corrugated medium, solid bleached board, and other recycled paperboard. The market pulp included hardwood and softwood kraft market pulp, deinked market pulp, cotton linter pulp and bleached CTMP. All capacity data in the database are in thousands of short tons per year.

These various paper types are made from different pulp processes. Newsprint is made from high yield mechanical grades of wood pulp, such as thermomechanical pulp (TMP), CTMP or groundwood pulp with some recycled fiber. Coated and uncoated groundwood papers are two commodity categories within the broad group known as printing and writing paper. Uncoated groundwood is produced by integrated mechanical & chemical pulp, mechanical pulp and 100% recycled pulp where as coated groundwood requires only two pulping processes: integrated mechanical & chemical pulp and mechanical. The other two paper types comprising the printing and writing paper are the uncoated and coated freesheet. Uncoated freesheet is characterized by four pulping processes: kraft, market pulp, 100% recycled pulp and sulfite. The coated freesheet is produced by the three processes kraft, market pulp, 100% recycled pulp.

Tissue and sanitary paper is produced by integrated chemical pulp, market pulp and 100% recycled processes. As there is a wide spectrum of product applications and manufacturing requirements in case of specialty packaging and industrial paper, FPL database does not categorize capacity by process type. Production capacity is based on integrating pulping and papermaking facilities, purchased market pulp and recycled fiber. In the case of unbleached kraft paper, two general types of processes were identified: one wherein the capacity is integrated with kraft pulping and second recycled fiber. Linerboard has three general categories of production capacity: capacity based on 100% recycled fiber, integrated kraft pulping using pre-1980's press technology or older press technology and lastly, integrated kraft pulping using new press technology. The pulping processes of corrugating medium are recycled fiber and semichemical pulp. Other recycled paperboard is made exclusively from recycled fiber.

The dependent variable, vertical integration (VI) was assigned two values: one or zero. If a mill reported positive wood pulp and paper/paperboard capacities, the VI in that case was one or else it was zero. A mill had positive pulp capacity when it produced paper using any of the processes: mechanical, chemical, dissolving alpha and semi-chemical. The processes given in FPL, which constitute the mechanical pulping process, are groundwood pulp, TMP and CTMP (used to produce newsprint), mechanical pulp (used to produce uncoated groundwood) and integrated mechanical and chemical pulp (used to produce coated and uncoated groundwood). Chemical pulping process includes capacities of kraft pulp (used to produce coated & uncoated freesheet, kraft and solid bleached board), sulphite (used to produce uncoated freesheet), integrated chemical (used to produce tissue), old & new press technology (used to produce linerboard), softwood pulp and hardwood pulp (used to produce market pulp). Dissolving alpha is used to produce market pulp and finally semichemical process is used for producing corrugating medium. Hence, vertically integration is defined to constitute the wood pulping capacity, which excludes recycled capacity. A mill has positive paper/paperboard capacity if it produced any of the paper or paperboard categories discussed above.

For all the product dummies except kraft value one was assigned if a mill produced the grade and zero if it did not. The dummy variable kraft was defined to include the main paper grade unbleached kraft paper and pulping process kraft used to produce coated freesheet and uncoated freesheet. The value one was assigned if either was positive or else it was taken to be zero.

The environmental regulation dummy in the panel data is assigned the value of one for the years when the regulations were enacted which are 1972, 1974, 1976, 1980 and 1990. The environmental regulations affecting this industry are:

1972 - Clean Water Act (CWA)

1974 - Safe Drinking Water Act

1976 - Resource Conservation and Recovery Act (RCRA)

1976 - Toxic Substances Control Act (TSCA)

1980 - Superfund Act

1990 - Clean Air Act Amendments (CAA)

1990 - EPA establishes pulp and paper cluster group, for the purpose of integrating the processes associated with CWA, maximum achievable control technology (MACT) under 1990 CAA, and to regulate dioxins and furans under TSCA. As for the interaction terms, the 1970, 1980 and 1990 decade dummies were created and then multiplied with capacity and lag of capacity.

A concentration ratio is measured by combined market shares of the top four (CR4) companies expressed as a share of total market sales. These ratios are from 0 to 100 percent. Since the sales data are not available, production capacity data are used. The FPL report divided the mills into three large U.S. regions, the North, South and West. The FPL data just provides the company name without giving any information about the owner company, subsidiary and joint holding. Since this information was needed to develop a four-firm concentration ratio, other sources (primarily *Lockwood Directory of the Pulp, Paper and Allied Trades*) were used to obtain this information[16].

After dividing the mills regionally and using the owner/company information, the regional total capacity of market pulp and paper was attained and then concentration ratios of pulp and paper were separately computed for each region. Taking the product of the pulp and paper CR4, CRPROD was calculated. This takes into account both the seller's (pulp mills) and buyer's (paper and paperboard mills) concentration ratio to look into the effect this has on vertical integration.

[16] Aselia Urmanbetova (1978-2000) and I (1970-1977) jointly compiled the owner data.

4.3 Definition/explanation of the Model

In order to examine the extent to which transaction-costs explain the choice of a paper mill to integrate backward into pulp production, the following model is estimated:

The model is $VI = \beta_0 + \beta_1 CRPROD + \beta_2 LOGCAP + \beta_3 NEWS + \beta_4 CFS + \beta_5 UCFS + \beta_6 CGW + \beta_7 UCGW + \beta_8 TISS + \beta_9 LB + \beta_{10} CORR + \beta_{11} KRAFT + \beta_{12} ENVIRONREG + \beta_{13} LOGCAP70 + \beta_{14} LOGCAP80 + \beta_{15} LOGCAP90 + \beta_{16} SW + \varepsilon_i$

Table 4.1 gives a brief description of the variables in the model.

Table 4.1- Variable Description

Variable	Description
VI	dummy variable denoting whether the mill is integrated or not
CRPROD	four-firm concentration ratio in the market
LOGCAP	logarithm of paper capacity,
NEWS	dummy variable equal to 1 if capacity of newsprint is positive, 0 otherwise.
CFS	dummy variable equal to 1 if capacity of coated free sheet is positive, 0 otherwise.
UCFS	dummy variable equal to 1 if capacity of uncoated free sheet is positive, 0 otherwise.
CGW	dummy variable equal to 1 if capacity of coated groundwood is positive, 0 otherwise.
UCGW	dummy variable equal to 1 if capacity of uncoated groundwood is positive, 0 otherwise.
TISS	dummy variable equal to 1 if capacity of tissue is positive, 0 otherwise.
LB	dummy variable equal to 1 if capacity of linerboard is positive, 0 otherwise.
CORR	dummy variable equal to 1 if capacity of corrugating medium is positive, 0 otherwise.
KRAFT	dummy variable equal to 1 if capacity of kraft is positive, 0 otherwise.
ENVIRONREG	dummy variable when the environment regulations were enacted in the years 1972,1974,1976,1980 and 1990
LOGCAP70	interaction term of LOGCAP and decade 70
LOGCAP80	interaction term of LOGCAP and decade 80
LOGCAP90	interaction term of LOGCAP and decade 90
SW	dummy variable for southern and western regions in the US

The descriptive statistics of the variables are in the following table:

Table 4.2- Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
VI	16852	0.42	0.49	0	1
NEWS	16852	0.04	0.20	0	1
KRAFT	16852	0.14	0.35	0	1
CFS	16852	0.06	0.23	0	1
UCFS	16420	0.19	0.39	0	1
CGW	16852	0.03	0.18	0	1
UCGW	16852	0.03	0.17	0	1
TISS	16852	0.17	0.38	0	1
LB	16852	0.13	0.33	0	1
CORR	16852	0.11	0.31	0	1
RECYC	16852	0.26	0.44	0	1
CR4_PAPER	16852	0.42	0.27	0.16	1
CR4_PULP	16852	0.63	0.18	0.43	1
PRODCR4	16852	0.31	0.29	0.07	1
LOGCAP	15959	4.25	1.32	0.69	7.40
LOGCAP70	15959	1.53	2.27	0	7.40
LOGCAP80	15959	1.36	2.11	0	7.14
LOGCAP90	15959	1.36	2.03	0	6.98
SW	16852	0.40	0.49	0	1
ENVIRONREG	16852	0.17	0.37	0	1

4.4 Justifying the Variables

The dependent variable is vertical integration, VI, which equals one (zero) if a mill is (not) vertically integrated. In case a mill reported positive pulp and paper values, the VI in that case was one or else it was zero. CRPROD is the product of the pulp and paper concentration ratio of the market in which the mill operates. Market concentration, the transaction-cost variable, serves as a proxy for the potential for a small number bargaining problem. High concentration is a proxy for the market condition where there is a greater potential for exploitation in market transactions and hence greater incentive to vertically integrate. This is estimated by a joint seller and buyer market concentration in each regional pulp and paper market. "The product of the concentration ratios at each stage is consistent with the possibility for opportunistic behavior on the part of either party once a contract is negotiated" (cited from Vertical Integration in the US Pulp and Paper Industry, 1900-1940 by Nancy Kane Ohanian, 1993).

Firm size is estimated by paper capacity (thousand of short tons) of the paper mill. The logarithm of capacity, LOGCAP is used in the regression analysis. This is a proxy for firm size, as data such as firm sales or assets are not available for the full sample of firms. The size has an impact on the decision to integrate, as a disruption in the supply of inputs will result in greater loss for a larger firm than that suffered by a small firm.

The interaction variables LOGCAP70, LOGCAP80 and LOGCAP90 take into account the effect of capacity on integration in the 1970, 1980 and 1990 decades. Each of the three periods would affect the integration decision differently due to the changing economic environments in each decade. SW is the dummy variable that takes value 1 whenever a mill is located in the South or West regions, where most of the forestland in the US is found.

The dummy variable ENVIRONREG for Environmental Acts has been added. As noted earlier, the paper industry is one of most environmentally regulated industries. These regulations have a huge impact on the mills in terms of capital expenditures as pulping processes contribute to air and water pollution, and the disposal of solid wastes. For example, with the enacting of Cluster Rule, AF&PA estimated that the costs would be up to $2.6 billion plus the operating costs of $273 million. The environmental regulation for the period 1970-2000 was the Clean Water Act (CWA), 1972. Under CWA, mills were required to control and limit the amounts of pollutants discharged in water. Since pulping processes contribute to the wasted emissions, an integrated firm has to pay for both paper and pulp expenses as opposed to paying for paper only. It can negatively influence the decision of a paper mill to integrate with pulp mill as these regulations have high costs associated with them.

NEWS, KRAFT, CFS, UCFS, CGW, UCGW, TISS, LB and CORR are dummy variables that indicate production for all the standard paper grades. Previous literature included NEWS and KRAFT only but since the past few decades have seen major technological improvements in pulping processes, all the grades have been included to see which are positive and hence enjoy the economies of scale. Another reason they have been included is to avoid the omitted variable bias as production of these paper grades can have a bearing on a firm's decision to integrate. The various grades of paper are a proxy for asset specificity, as the production of paper requires specialization of pulping assets to conform to the requirements of the papermaker.

4.5 Hypothesis Testing

The market concentration is an indicator of the alternative suppliers that a firm may turn to in the event of opportunistic behavior of another firm. A highly concentrated market structure has greater potential for this kind of behavior and hence an incentive for a firm to integrate. This leads to the first hypothesis, which is

Hypothesis 1: An increase in the concentration ratio is expected to increase the likelihood of vertical integration.

A large firm has to suffer more losses due to higher costs incurred when supply is disrupted than those incurred by a smaller firm. Hence, the larger a firm is, the more is its incentive to integrate. The proxy for firm size is the capacity of the mill. The hypothesis on the firm size is

Hypothesis 2: An increase the firm size is expected to increase the likelihood of vertical integration.

Table 3.8 shows that the percentage of vertically integrated has increased in the south and is constant in the west. The reason for this trend is that the mills would be located where they can easily get the raw material for pulp, timber or wood and so, location of the mill influences its decision to integrate. Hence, the hypothesis for the forestland dummy SW is

Hypothesis 3: A mill located in the Southern or Western parts of the country is expected to increase the likelihood of vertical integration.

The coefficients on the dummy variables of the various paper products proxy for different forms of asset specificity except for recycled paper. This is because the wood pulp definition excludes recycled pulp. Hence firms which produce recycled paper do not have any incentive to integrate and hence,

Hypothesis 4: A mill which produces newsprint, kraft, coated and uncoated free sheet, uncoated groundwood, tissue, linerboard or corrugating medium is expected to increase the likelihood of vertical integration. A mill that produces recycled paper will be less likely to integrate.

The interaction term between capacity and decade dummies, LOGCAP70, LOGCAP80 and LOGCAP90 have been include to capture the effect capacity has under changing environments in each decade. The capacity in the industry as w hole and that of the integrated mills has been increasing throughout the period implying that

Hypothesis 5: An increase in the capacity in each decade is expected to increase the likelihood of vertical integration.

The dummy on environmental regulations could be negatively or positively related to integration, as a paper mill would have to bear additional capital expenditures involved in puling processes. On the other hand, if a paper mill does not have to incur any investment costs and so getting a pulp mill would not add to the costs, and then it could be positive.

Hypothesis 6: A mill will have to undertake the environmental expenditure for a pulp mill and this can either increase or decrease the likelihood of vertical integration. Hence this will be a two-tailed test.

4.6 Empirical Results

Estimating the cross section model from 1970-2000 produce the following results reported in tables 4.3 and 4.4.

Table 4.3- Cross Sectional results for the years 1970 – 1985

	1970		1975		1980		1985	
	co-efficients	dF/dx	co-efficients	dF/dx	co-efficients	dF/dx	co-efficients	dF/dx
Constant	(-)0.80		(-)1.11		(-)1.16		(-)1.04	
t-statistic	(-)2.91		(-)3.81		(-)3.95		(-)3.5	
CRPROD	(-)0.84***	(-)0.32	(-)0.30	(-)0.11	(-)0.56	(-)0.22	(-)0.47	(-)0.18
t-statistic	(-)1.41		(-)0.56		(-)1.19		(-)1.03	
LOGCAP	0.48*	0.18	0.53*	0.20	0.48*	0.19	0.47*	0.18
t-statistic	5.75		6.15		5.97		5.83	
NEWS	(-)0.20	0.07	(-)0.40	(-)0.14	(-)0.27	0.10	(-)0.49	(-)0.18
t-statistic	(-)0.47		(-)0.93		(-)0.65		(-)1.23	
KRAFT	1.52*	0.54	1.45*	0.52	1.32*	0.48	1.18*	0.43
t-statistic	5.89		5.56		5.12		4.79	
CFS	(-)0.58***	(-)0.20	(-)0.38	(-)0.14	(-)0.31	(-)0.16	(-)0.17	(-)0.07
t-statistic	(-)1.33		(-)0.9		(-)0.77		(-)0.42	
UCFS	(-)1.11*	(-)0.35	(-)1.24*	(-)0.38	(-)1.01*	(-)0.34	(-)1.05*	(-)0.36
t-statistic	(-)4.98		(-)5.46		(-)4.73		(-)4.98	
UCGW	(-)0.65**	(-)0.21	(-)0.60***	(-)0.20	(-)0.15	(-)0.06	(-)0.21	(-)0.08
t-statistic	(-)1.84		(-)1.58		(-)0.39		(-)0.55	
TISS	(-)1.90*	(-)0.50	(-)1.94*	(-)0.51	(-)1.73*	(-)0.49	(-)1.66*	(-)0.49
t-statistic	(-)8.24		(-)8.44		(-)7.67		(-)7.37	
LB	(-)0.30	(-)0.11	(-)0.49***	(-)0.17	(-)0.57**	(-)0.20	(-)0.33	(-)0.13
t-statistic	(-)0.88		(-)1.53		(-)1.74		(-)0.99	
CORR	(-)0.19	(-)0.07	(-)0.39***	(-)0.14	(-)0.35***	(-)0.13	(-)0.48**	(-)0.18
t-statistic	(-)0.7		(-)1.48		(-)1.36		(-)1.81	
RECYC	(-)2.74*	(-)0.69	(-)2.52*	(-)0.66	(-)2.30*	(-)0.64	(-)2.36*	(-)0.66
t-statistic	(-)10.92		(-)10.88		(-)10.16		(-)10.34	
SW	0.66***	0.25	0.45	0.17	0.62**	0.24	0.48**	0.19
t-statistic	1.58		1.25		1.99		1.73	
Log Likelihood	-162.07		-170.75		-175.67		-174.70	
No. of observations	540		537		514		490	

Notes: * denotes 1% significance level
** denotes 5% significance level
*** denotes 10% significance level

Table 4.4 - Cross Sectional results for the years 1990-2000

	1990		1995		2000	
	co-efficients	dF/dx	co-efficients	dF/dx	co-efficients	dF/dx
Constant	(-)1.10		(-)0.84		(-)1.02	
t-statistic	(-)3.5		(-)2.7		(-)3.24	
CRPROD	(-)0.58	(-)0.23	(-)0.79***	(-)0.30	(-)0.59	(-)0.23
t-statistic	(-)1.13		(-)1.47		(-)1.13	
LOGCAP	0.5*	0.2	0.37*	0.14	0.38*	0.14
t-statistic	6.09		4.89		4.82	
NEWS	(-)0.47	(-)0.17	(-)0.01	(-)0.003	(-)0.11	(-)0.04
t-statistic	(-)1.12		(-)0.02		(-)0.26	
KRAFT	1.31*	0.47	1.19*	0.44	1.08*	0.41
t-statistic	5.09		4.84		4.32	
CFS	(-)0.54	(-)0.20	(-)0.33	(-)0.12	(-)0.37	(-)0.13
t-statistic	(-)1.27		(-)0.67		(-)0.76	
UCFS	(-)1.06*	(-)0.37	(-)0.91*	(-)0.31	(-)0.75*	(-)0.26
t-statistic	(-)4.87		(-)4.24		(-)3.42	
UCGW	(-)0.52***	(-)0.19	(-)0.23	(-)0.09	(-)0.17	(-)0.06
t-statistic	(-)1.44		(-)0.61		(-)0.45	
TISS	(-)1.75*	(-)0.55	(-)1.77*	(-)0.48	(-)1.62*	(-)0.45
t-statistic	(-)7.68		(-)7.85		(-)6.97	
LB	(-)0.24	(-)0.09	(-)0.44***	(-)0.16	(-)0.37***	(-)0.13
t-statistic	(-)0.69		(-)1.53		(-)1.3	
CORR	(-)0.90*	(-)0.31	(-)0.70*	(-)0.24	(-)0.86*	(-)0.28
t-statistic	(-)3.31		(-)2.85		(-)3.51	
RECYC	(-)2.40*	(-)0.67	(-)2.30*	(-)0.62*	(-)2.64*	(-)0.62*
t-statistic	(-)10.16		(-)9.59		(-)8.36	
SW	0.40***	0.16	0.66**	0.25	0.68**	0.26
t-statistic	1.29		2.03		2.01	
Log Likelihood	-171.77		-174.51		-169.33	
No. of observations	485		479		455	

Notes: * denotes 1% significance level
** denotes 5% significance level
*** denotes 10% significance level

The co-efficient on size or LOGCAP is always positive as expected and highly significant, implying that the bigger firms have more incentive to integrate[17]. The co-efficient on the dummy variable, which is a proxy for the forestland, SW is positive but not highly significant for all the years. One of the surprising results is for the dummy variable indicating newsprint production; NEWS is negative, though it is not significant for all the years. This is the contrary result obtained by Ohanian and Melendez. However, the co-efficient on kraft production, KRAFT is always positive and highly significant which is in accordance to the results obtained by Ohanian.

Among the other product groups, uncoated free sheet, tissue and recycled paper are all negative and highly significant. This is not a surprising result for tissue and recycled paper as from table 3.6 we see that hardly any of these products capacity is integrated. The surprising result is for linerboard as from table 3.7 we see that almost whole of linerboard production is by the integrated mills.

Another surprising result is that the co-efficient on the concentration measure, PRODCR4 is always negative though not significant. This is in contrast to the results obtained by Ohanian (1992, 1993), where the coefficient was positive and significant, and Melendez (2002), who obtained a negative and significant coefficient estimate.

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[17] Lag of log capacity has also been included for two reasons. The first is that incorporating only current VI with current capacity implies that integration is not affected by lag of capacity. However, previous period's capacity could have an effect on a mill's decision to integrate backward. Secondly, lag of capacity would be an instrumental variable for controlling endogeniety between LOGCAP and VI. However, the results were insignificant.

The cross sectional data is pooled together to form an unbalanced panel data with 15,527 observations[18]. There are two probit random effects model estimated; model 1 includes LOGCAP but model 2 uses interaction capacity variables, LOGCAP70, LOGCAP80 and LOGCAP90 instead of capacity. Both also include the dummy variable on environmental regulations and exclude the dummy variable on forestland SW. The panel data estimation results are presented in table 4.4. The results from both the models are different from the cross section results. One of the reasons for these differences is that panel data picks up temporal characteristics. Model 1 has a larger co-efficient and t-statistics than model 2 and between these two models also the results vary.

[18] The panel data originally had 16,852 observations. Calculating the log of capacity led to loss of some data leading to 15,959 observations.

Table 4.5- Panel data Results from 1970-2000

	Model 1 co-efficients	Model 2 co-efficients
Constant	-2.29	-5.11
t-statistic	-9.93	-19.40
CRPROD	0.42*	0.07
t-statistic	8.77	0.41
LOGCAP	0.70*	not included
t-statistic	4.28	
LOGCAP70	not included	1.05*
t-statistic		18.58
LOGCAP80	not included	1.27*
t-statistic		20.07
LOGCAP90	not included	1.40*
t-statistic		20.27
NEWS	3.47*	1.52*
t-statistic	13.85	5.64
KRAFT	3.06*	2.89*
t-statistic	20.17	17.92
CFS	5.66*	3.42*
t-statistic	13.12	9.22
UCFS	(-)2.21*	(-)2.14*
t-statistic	(-)13.78	(-)14.49
UCGW	(-)1.28*	(-)0.13*
t-statistic	(-)6.42	(-)0.65
TISS	(-)3.76*	(-)3.65*
t-statistic	(-)21.84	(-)19.07
LB	0.08	(-)0.53*
t-statistic	0.48	(-)3.38
CORR	1.91*	0.4*
t-statistic	12.18	2.90
RECYC	(-)0.63*	(-)1.86*
t-statistic	(-)4.66	(-)12.38
ENVIRONREG	0.33*	0.18**
t-statistic	3.07	1.60
Log Likelihood	-1142.56	-1084.01
No. of observations	15527	15527
No. of Groups	611	611

Notes: * denotes 1% significance level
** denotes 5% significance level
*** denotes 10% significance level

The first difference is the dummy variable on newsprint is positive and highly significant. The second difference is the concentration measure co-efficient is positive and significant in model 1. In model 2, however, it is only positive. The co-efficient on size, both LOGCAP and interaction are positive and highly significant in both the models. The dummy on environment regulations is also positive but not significant in model 2. Hence environmental regulations positively influence's a mill's decision to integrate.

Regarding the products, coated free sheet, CFS and corrugated medium CORR are positive and significant as opposed to the cross section results. Linerboard, LB is positive and insignificant for model 1 but negative and significant for model 2. The differences in the two models could be due to the capacity interaction terms. Capacity does not seem to have had a different affect from one decade to another.

CHAPTER FIVE

CONCLUSIONS

5.1 Summary of the Results

The concentration ratio, as seen in hypothesis 1, was expected to be positive. For the cross section data, it was negative and insignificant. So we fail to reject the null hypothesis. Under panel data estimation, the null is rejected as in model 1 it is positive and significant. However, in model 2, we fail to reject the null.

The LOGCAP variable was positive and significant, for both cross –section and panel data estimation. Similarly the capacity and decade interaction terms, LOGCAP70, LOGCAP80 and LOGCAP90 were positive and significant. Hence the null hypothesis is rejected.

The coefficient on SW, a dummy variable included as a proxy for forestland areas was expected to be positive. It was positive but significant at 10% level. The dummy on environment regulations, ENVIRONREG, was a two-tailed test. It was positive and statistically significant in both the panel data models, thus leading to rejection of the null.

Finally the hypothesis for the paper products was that all grades except recycled paper would be positive. The dummy on kraft production, KRAFT was positive and significant for both cross section and panel data estimation. Hence, the null is rejected. Other consistent results were for tissue and recycled paper. They were negatively significant in all the models. The dummy for newsprint, NEWS was negative but insignificant for all the years in the cross sectional analysis. So, we fail to reject the null. However, it was positive and highly significant in both the models of panel data estimation.

5.2 Policy Implications

Vertical integration increases the pricing ability of the industry as the production costs decrease that could lead to an increase in the pricing power of the integrated firm consequently affecting the consumer welfare. Increased concentration or market share leads to greater integration and potential pricing power, which has short run effect on the operating profits. High concentration could also facilitate collusion at the manufacturing stage and eliminate the buyer. Integration leads to barriers in entry, as entrants have to be competitive enough to operate at all stages of production and distribution, making entry more difficult.

The §2 of Sherman Act takes forward integration as an extension of upstream monopoly into downstream stages of distribution. This downstream monopoly also leads to a price or supply squeeze, which is not viewed favorably by the Sherman Acts. However, there have been arguments that the extension of monopoly does not lead to welfare losses but many times lead to certain efficiencies. One of the reasons that §2 is not effective in challenging vertical integration by firms is the substantial market share requirement.

With the amendments in §7 of the Clayton Act, vertical mergers have been challenged under the Clayton Act rather than the Sherman Act. The theory used to challenge the vertical mergers is that of market foreclosure. A vertical merger inhibits competition at both the stages, as competitors cannot access their buyers or suppliers. Excess capacity can also be one of the reasons for forward integration and the result of integration is barriers to entry and concentration.

5.3 Further Research

One of the interesting topics to research would be the factors that influence the integration decisions for the period 1940-1970. Previous studies have focused at the periods 1900-1940 and 1970-2000. There have been notable differences in the factors influencing vertical integration in these periods and this intermediate period 1940-1970 could explain why the differences in the influencing factors exist.

REFERENCES

Arjona, Marcela Melendez, "A Dynamic Model of Vertical Integration for the American Pulp and Paper Industry," Yale University PhD Dissertation, May 2002.

Carlton Dennis W., Jeffrey M. Perloff *Modern Industrial Organization – Third Edition*, USA: Addison-Wesley, 2000.

Langlois, Richard, Paul Robertson, "Explaining Vertical Integration: Lessons from the American Automobile Industry," *The Journal of Economic History*, Volume 59, Issue 2, the Tasks of Economic History (Jun., 1989).

Levy, David T., "The Transactions Cost Approach to Vertical Integration: An Empirical Examination," *The Review of Economics and Statistics*, Volume 67, Issue 3 (Aug., 1985).

Lieberman, Marvin B., "Determinants of Vertical Integration: An Empirical Test," *Journal of Industrial Economics,* Volume 39, Issue 5 (Sep., 1991).

Ohanian, Nancy Kane, "Vertical Integration in the U.S. Pulp and Paper Industry, 1900-1940," The *Review of Economics and Statistics*, Volume 76, Issue 1 (Feb., 1994).

Ohanian, Nancy Kane, *The American Pulp and Paper Industry, 1900-1940*, West Port: Greenwood Press, 1993

Pesendorfer, Martin, "Horizontal Mergers in the Paper Industry," *RAND Journal of Economics*, Volume 34, Issue 3 (2003).

Perry, Martin K., "Vertical Integration: Determinants and Effects," in Richard Schmalensee and Robert Willig, ed., *Handbook of Industrial Organization- Volume 1*. Amsterdam, The Netherlands: North Holland, 1992.

Williamson, Oliver E., *Markets and Hierarchies: Analysis and Antitrust Implication*, New York: The Free Press, 1975.