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18 The Structural Characteristics of the Pulp and Paper Sector: Economic and Environmental Implications

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THE STRUCTURAL CHARACTERISTICS OF THE PULP AND PAPER SECTOR: ECONOMIC AND ENVIRONMENTAL IMPLICATIONS

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CONTENTS

I. Introduction

In this research note the structural characteristics of the pulp and paper sector will be described and their economic and environmental implications discussed. This will be undertaken by analysing the relative importance of a number of features which are commonly purported to characterize the sector, both on the supply side (production) and the demand side (consumption). In doing so the study will cast some light on the source of one of the most widely recognized attributes of the sector, significant and frequent price cycles. In the following section, the environmental effects of the structural factors cited and the structural effects of measures to mitigate such environmental effects will be examined. And finally, the last section summarizes some of the main conclusions. The study does not represent original research but is merely an attempt to collect some of the relevant data concerning the structural characteristics of the sector, and discuss some of their main economic and environmental implications in a general way.

II. The Supply Side: Technological and Institutional Characteristics of the Sector

The pulp and paper sector is characterized by distinct technological and institutional characteristics. These characteristics will be described in general terms, although it should be emphasized that the sector is not uniform, either spatially (across regions), temporally (across time) or industrially (across sub-sectors). For this reason the discussion can only give a broad outline of some of the basic features of the sector.

Capital Intensity: Data and Description.

In general terms, the sector is often characterized as being extraordinarily capital-intensive. Moreover, capital-intensity is said to be increasing in recent years. It is, therefore, important to examine the basis for these claims in more detail.

In the United States in 1990, the ratio of "fixed tangible wealth"[1] (plant, buildings, machinery, equipment) to sectoral output (measured in terms of sales) in the paper and allied sector (Standard Industrial Classification (SIC) 26) was 3.27. (Calculated from USDOC *SCB* Sept. 1993 and USDOC *SCB* Jan. 1993).[2] This compares to a manufacturing-wide average of 2.17. Thus, production in the pulp and paper sector in the United States requires more fixed physical inputs per unit of output relative to manufacturing as a whole. Expressed in terms of fixed capital per employee in 1990 the figures were approximately $US 177,000 (1987 prices) for paper and allied products. (Calculated from USDOC *SCB* Sept. 1993 and USDOL *HLS* 1993). This compares with a manufacturing-wide average of $US 97,000,

[1] Constant cost gross stock of fixed private capital.

[2] SIC 26 includes the following 4-digit sub-sectors: pulp mills (2611), paper mills and integrated pulp-paper mills (2621), paperboard mills (2631), setup paperboard boxes (2652), corrugated and solid fibre boxes (2653), fibre cans, drums and similar products (2655), sanitary food containers (2656), folding paperboard boxes (2657), paper coated and laminated packaging (2671), bags (2673 and 2674), die-cut paper and board (2675), sanitary paper products (2676), envelopes (2677), stationery products (2678) and converted paper products (2679).

indicating that each employee requires greater physical infrastructure in the production process in the United States than is the case in other sectors.

To get a clearer picture of relative capital-intensity for different sub-sectors some indication can be obtained using data on the "gross book value of depreciable assets"[3] obtained from the Department of Commerce's *Census of Manufactures*. (See Table 1). On the basis of these figures it is found that in 1992 pulp mills had fixed assets of well over $US 600,000 (1992 prices) per employee while the figures for paper (including integrated pulp-paper) and paperboard mills were approximately $US 400,000. Figures for the more processed stages are much lower, with some sub-sectors have as little as $US 35,000 of capital assets per employee. Similar evidence is obtained from the capital/value-of-shipments ratio and the capital/value-added ratio.

Table 1: Capital-intensity of the Pulp and Paper Sector

	Capital/Labour	Capital/Output	Capital/VA
	Ratio	Ratio	Ratio
Pulp Mills	639182	1.86	3.98
Paper Mills	405750	1.62	3.57
Paperboard Mills	437864	1.40	2.75
Paperboard Boxes	54840	0.39	2.52
Corr'd & Solid Fibre Boxes	65058	0.37	1.08
Sanitary Food Containers	79805	0.49	1.17
Fibre Cans, Drums etc	45968	0.30	0.73
Coated & Laminated Paper	85231	0.38	0.85
Die-Cut Paper & Board	35192	0.27	0.65
Sanitary Paper Products	134568	0.35	0.66
Envelopes & Stationery	37616	0.30	0.63
Other Converted	45657	0.31	0.72

Source: USDOC *COM* (1995)

Thus, relative to value of shipments, pulp mills are the most capital-intensive, followed by paper/integrated mills and paperboard mills. In general, it would appear that the milling and manufacturing stages of production of pulp, paper, and paperboard products are much more capital-intensive than most other manufacturing processes in the United States.

[3] Unlike fixed tangible wealth this included rental payments for capital equipment.

Less reliable investment flow data - rather than capital stock data - for other countries confirms this general perception. Taking India, Indonesia, Canada, Finland and Chile as illustrative examples, it appears that capital-intensity - relative to outputs - is not dissimilar internationally, with the notable exception of Indonesia, with investment representing between 11% and 22% of output. (See Table 2). The figure for Indonesia can probably be explained by the recent and sudden emergence of the sector in the country, with investment flows representing new investment (rather than replacement investment), preceding later increases in output to a greater extent than elsewhere. Relative to labour inputs there is considerably more variability, with India being a significant outlier due to the very different nature of production there, both in terms of inputs and scale. For the other countries, investment per employee ranged from $US 17,989 to $US 62,476 (current prices). However, and more significantly, in each case both ratios are considerably higher than is the case in manufacturing in general. Together these figures confirm that the sector is investment-intensive relative to other manufacturing sectors within each country.

Table 2: Investment-Intensity of the Pulp and Paper Sector by Country in 1990

	1) Investment ($ million)	2) Employment (1000s)	3) I/E Ratio	4) Output ($ million)	5) I/O Ratio
Chile					
Pulp,Paper	85.81	4.77	17989.77	771.22	0.11
Manuf	761.11	298.00	2554.08	21212.06	0.04
Indonesia *					
Pulp,Paper	501.10	23.40	21414.60	763.80	0.66
Manuf	3690.19	2247.70	1641.76	32158.64	0.11
India *					
Pulp,Paper	199.59	101.00	1976.10	1724.14	0.12
Manuf	7188.90	6731.00	1068.03	114958.62	0.06
Finland					
Pulp,Paper	1711.84	27.40	62475.99	10363.16	0.17
Manuf	5516.32	300.50	18357.12	74968.42	0.07
Canada					
Pulp,Paper	3379.17	78.00	43322.65	15691.67	0.22
Manuf	14731.67	1869.00	7882.11	287283.33	0.05

Source: UN, ISYB (1993). See S:\eep\nick\paper\intlki.wk3. * Data for India is from 1988 & for Indonesia is from 1989. I = Investment, E = Employment, O = Output.

However, as noted above the long-lived nature of capital and the cyclical nature of investment flows in the sector means that use of investment flows as a proxy for capital stocks is at best illustrative. Therefore it is revealing to find that even in India, where average scale of plant is quite small and total investment is quite low, the pulp, paper and paperboad sector is relatively capital-intensive, with a productive capital/gross output ratio of 0.90 in comparison to 0.63 for all industries in 1988-1989. (India CSO 1994). Expressed per employee productive capital is 50% higher in the sector than in industry on average.

Economies of Scale: Theoretical and Empirical Arguments

Closely related, but conceptually distinct, to the issue of capital-intensity is that of economies of scale. Despite common assertions to the contrary the two are distinct since a large plant may not in fact be capital-intensive, employing relatively more labour per unit of output than a smaller plant. However, it is in fact commonly asserted that the sector is characterized by large plants, due to potentials for perceived increased technological efficiency.

The reason for this perceived increase in efficiency is due in large part to the very nature of production in the sector. Those sectors which are characterized by processes involving space-enclosing structures (i.e. pipes, vessels and tanks, etc...) are able to realize efficiencies by expanding the scale of the constituent parts. This is due to the rather obvious point that a less than proportional increase in material input for production stages involving such space-enclosing processes is required to realize a given increase in physical capacity.[4] Since pulp and paper production possesses a number of such processes for which this is true (i.e. digesters, blow tanks, pulp drying, blending, etc...) one would expect there to be significant economies of scale. (See Amsalem 1983 for an excellent, although somewhat dated, discussion.) The ILO (1992) affirms this, claiming that economies of scale are significant for pulp, paper and paperboard manufacturing, as well as some converting processes.

To a great extent, this is borne out by the engineering-economics literature. In the early 1980s Amsalem (1983) estimated that the capital construction costs *per ton capacity* of a 800 tpd integrated sulphate pulp and paper mill was only half that of a 170 tpd plant. At the 400 tpd level, which the study considered to be the minimum size for an economically viable plant in the same period, a 10% increase in investment results in a 20% increase in capacity. More recently, Jaakko Pöyry (1993) estimate that the optimal size of a pulp mill is in the region of 450,000 - 500,000 tpa. At a capital cost of $US 1,500 - $US 1,800 /tonne this would present capital costs of $US 675 million to $US 900 million. Global Futures/Rocky Mountain Institute (1995) estimate that the minimum efficient economic scale for a kraft pulp plant in the United States in 1990 was 365,000 tpa.

The econometric literature also supports this vies. In a study of the Canadian wood product and pulp and paper sectors Mohnen et al (1993) found that scale elasticities were estimated to be 1.432 for pulp and paper and 1.386 for wood products, indicating that a 10% increase

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4 $K = \lambda \cdot Q^{\mu}$

where, K is capital costs, Q is output, λ is capital-intensity and μ is a coefficient, less than 1 for space-enclosing production processes.

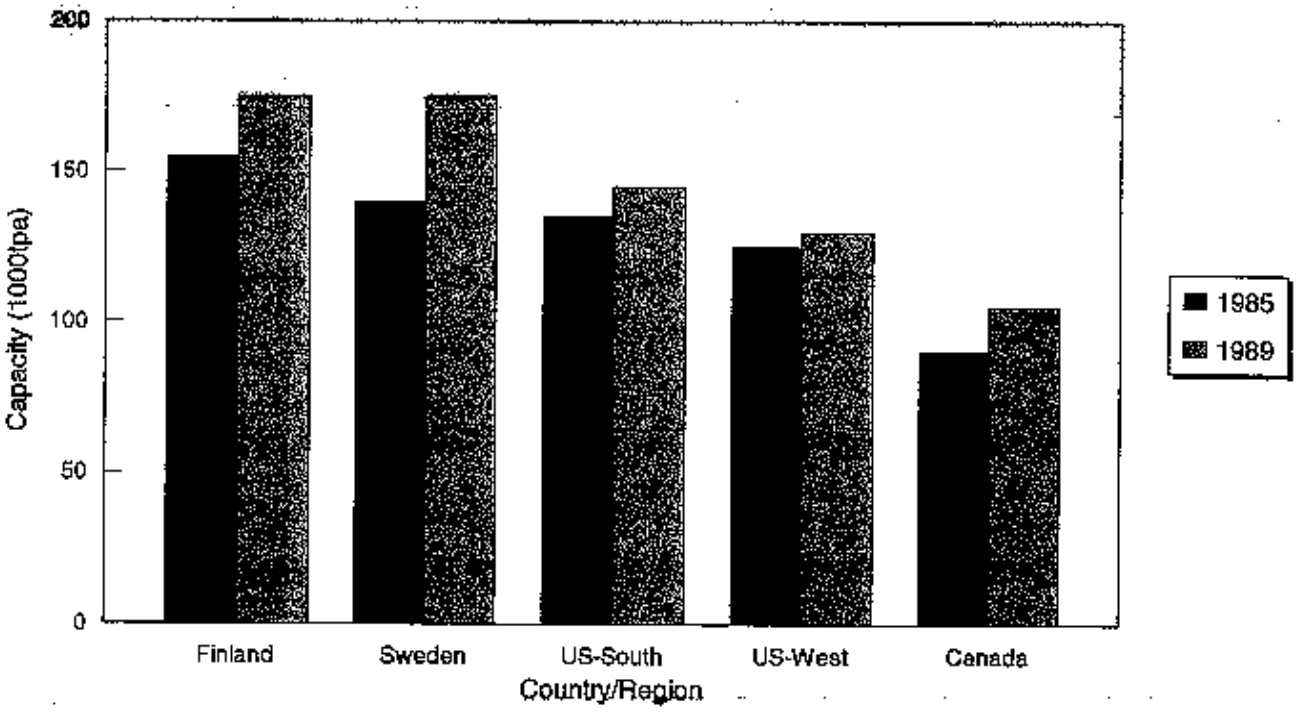
in output would increase production costs by only 7% for pulp and paper. Similarly, in a study of the American pulp and paper industry Stier (1985) found that the elasticity of total costs with respect to output is 0.265, indicating that a 10% increase in output increases costs by only 2.65 %.

Although such studies tend to support the view that large-scale production is economic in the sector, it gives no indication as to whether or not this is the route actually being pursued by firms. One empirical study estimated that in the United States the scale of pulp mills has been increasing, with the share of plants with capacity greater than 450,000 tpa increasing from 40% to 58% between 1980 and 1990 (Global Futures/Rocky Mountain Institute 1995). More systematic data on the scale of production of pulp, paper and paperboard for Sweden in the years 1960-1993 are available from Skogsindustrierna (1993) and are reported in Table 3 below. The figures reflect a 4.9% average annual increase in capacity for pulp mills and 5.6% for paper and board mills, and finally, average scale of newsprint machines in some of the major producer countries increased by between 10% and 20% in the years 1985-1989. (See Figure 1).

Table 3: Average Pulp, Paper and Paperboard Mill Capacity in Sweden (1000 tpa)

	1960	1970	1980	1993
Pulp	45	90	145	225
Paper/Board	30	70	115	185
Source: Skogsindustrierna 1993				

Figure 1 Average Scale of Newsprint Plant



Source: ILO 1992

At a more aggregated level, average plant size for pulp and paper plants in the major producing countries in 1993 are reported in Table 4. It should, however, be emphasized that in many cases such a cross-country comparison may be misleading since mill type and output characteristics are not distinguished. For instance, the case of China is illustrative due to the importance of non-wood fibres. As such, the figures may compare different production processes irrespective of location rather than similar production processes in different locations.

Table 4: Average Pulp and Paper Mill Sizes (tpa) in 1993

	Paper & Board			Pulp		
	Capacity	Mills	Size	Capacity	Mills	Size
Finland	11,446,000	45	254356	11,045,000	43	256860
Sweden	9,385,000	50	187700	10,990,000	50	219800
Canada	19,614,000	112	175125	26,398,000	27	977704
United States	82,597,000	547	151000	61,595,000	203	303424
China	16,880,000	10,000	1688	13,450,000	8,000	1681
Brazil	6,509,000	182	35764	6,103,000	35	174371
Japan	33,016,000	444	74360	15,076,000	55	274109
Indonesia	3,580,000	53	67547	1,880,000	13	144615
Germany	15,255,000	191	79869	2,300,000	22	104545
Mexico	3,816,000	66	57818	1,051,000	11	95545

Source: PPI (1995)

Thus, taking FAO (1995) data on planned construction of new and planned pulp plants[5] for the period 1995-1999 it is clear that plant size depends upon both plant location and fibre source, with recycled tending to be smaller than wood pulp plants, and OECD plants tending to be larger than LDC plants, with the notable exception of Indonesia. (See Table 5). It

[5] Alterations to existing plants were not included.

should be emphasized, however, that this data is based on planned and not actual investment. Moreover, since few investments in established OECD production areas are for new plants rather than alterations of existing plants, the data sample for such countries is limited.

Table 5: Average Capacity of Planned New Pulp Mills by Input and Region (1000 tpa)

	Hard wood	Soft wood	M Wood	Recyc-led	Non-Wood	Mixed Fibre	NA	World
Africa	105	45	300	18	22	30	300	96
India						75	190	133
China	25	136	185		110	50	74	110
Indn'sia	450	300					317	336
O. Asia	93		100	40	109	180	68	93
Europe			325		300	114	154	181
LA	114	185	297	21			74	141
NA				117			150	126
Oceania	250			68	20		433	205
World		159 *		94	107	102	238	

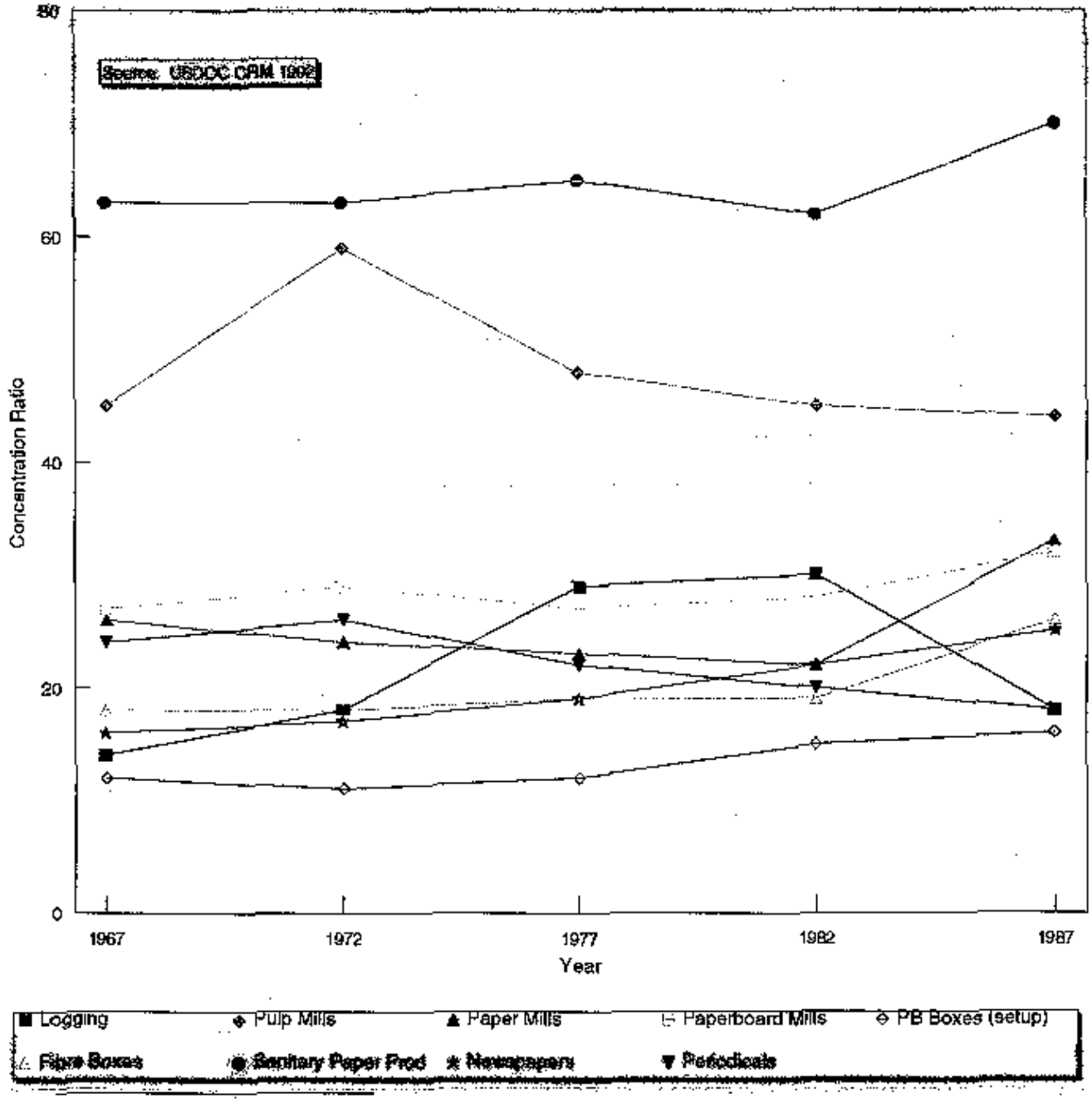
Source: FAO (1995). * Indicates Weighted Average of all Wood

Market Structure: Evidence of Concentration and Market Power

Closely associated to the issues of capital-intensity and economies of scale is the degree of market power enjoyed by firms in the sector. With perfect competition at one pole and pure monopoly at the other, all sectors in all countries tend to fall in between, with market power measured in relative terms. Amongst the most important factors which determine the degree of market power within a sector are capital costs and economies of scale. (See Martin 1990 and Greer 1992 for non-technical discussions). If economically efficient plants are large relative to the size of the market this will tend to result in concentration as economies of scale are realized. In addition, high capital costs will represent a barrier to entry for new firms, giving existing firms considerable ability to preserve market power. The figures cited above would indicate that this is certainly true of the sector. Other factors which may contribute to market power are transport costs and product differentiation, both of which lead to market segmentation. The importance of transport costs in the sector has been discussed in another study (IIED Sub-Study 12), indicating that they may generate geographical market segmentation . The issue of product differentiation, which appears to be of limited but increasing importance in the sector, will be discussed below in the section on demand.

Measures of market power employed in the empirical literature are numerous, all of which have certain methodological weaknesses. The simplest index (the four-firm concentration ratio) will be used in order to given a general indication of market power. The greater the ratio, *ceteris paribus*, the greater the degree of market power. According to the US Department of Commerce (1992) the four-firm concentration ratio for the paper and allied products sector was 18 in 1987 relative to 38 15 years earlier. (See Table 6.)[6] These figures are slightly below the manufacturing-wide averages of 18.8 in 1987 and 39 in 1972. More importantly they are below the Scherer-Ross rule-of-thumb threshold for market power, which is 40.

Figure 2 US Four-Firm Concentration Ratios by Product



[6] Unfortunately data on concentration ratios from the 1992 census are not yet available.

Table 6: Concentration of US Manufacturing in 1987[7]					
	4-Firm	8-Firm	20-Firm	50-Firm	HHI[8]
Food & Kindred	11	18	32	47	68
Tobacco	82	94	99	99+	2345
Textile Mill	15	25	38	52	113
Apparel	10	14	20	29	36
Lumber & Wood	11	16	23	31	45
Furniture, etc...	10	15	25	36	47
Paper & Allied	**18**	**30**	**52**	**68**	**172**
Printing & Publishing	7	13	23	34	34
Chemicals & Allied	14	21	34	53	97
Petroleum & Coal	30	49	72	89	375
Leather	9	13	21	31	46
Rubber & Plastics	13	21	36	55	95
Stone, Clay & Glass	11	18	30	41	62
Primary Metal	17	26	41	55	121
Fab'd Metals	9	13	18	26	33
Industrial Machinery	13	17	26	37	70
Electronic & Electric	19	27	39	52	129
Transportation	52	64	76	85	1044
Instruments & Related	19	28	44	60	150
Misc. Manufacturing	6	10	16	25	19
Average	**18.8**	**26.6**	**38.25**	**45.3**	**255.05**
Source: USDOC *CRM* 1992					

[7] The ratio of output of the x largest firms over market size for a defined commodity.

[8] The Herfindahl-Hirschmann Index, which is the sum of squares of the concentration ratios for each of the largest 50 firms per sector. It is felt that this gives a better indication of market concentration for firms with relatively few companies than a single x-firm concentration ratio.

However, it is important to analyse such figures in closer detail at a more disaggregated level since the degree of sectoral aggregation is not consistent with actual commodity markets. This has been done for a number of sub-sectors at different stages of the production life-cycle. Figure 2 reveals that most market shares have not increased and in some cases they have even declined over the period 1967-1987. Perhaps most significantly market power has been concentrated at the intermediate stages of production (i.e. milling) relative to primary (i.e. logging) stages and final (i.e. publishing) stages. In effect this gives firms at that stage market power with respect to more competitive fibre producers and market power with respect to more competitive final product producers.

In Europe the top 100 paper mills represented only 10% of the productive units in existence, but 40-45% of total output in the late 1980s (ILO 1992). In Japan the situation is more complex since many of the major producers are part of larger conglomerates (Whitham 1994). In Japan the top five pulp firms had 56.4% of the domestic market in 1986. The figures for paper and paperboard were 52.4% and 39.2% respectively. In some sub-sectors such as newsprint the figure rises to 83.2%. (JPA 1993). Other concentration ratios for paper, pulp and paperboard are presented in Table 7. In general cooperation is thought to be quite common in the Japanese case (Whitham 1994.)

Table 7: Market Share in Japanese Pulp & Paper in '89

	Pulp	Paper	Paperboard
5-Firm	60 %	55 %	< 40%
10-Firm	> 80 %	75 %	60 %

Source: ILO (1992)

Market power is also thought to be significant in some LDCs. The ILO (1992) cites the case of Mexico where three to four firms are responsible for 75%-80% of printing and writing paper production. In the case of Brazil the top five firms have 85% of the market pulp market and 87% of the printing and writing paper market while the top three firms have 61% of the containerboard market (CS First Boston 1995). However, since the pulp and paper sector is increasingly global, such national concentration measures may be unsatisfactory indicators of market power. Using physical capacity and output data, rather than value-based data, some indication of global market concentration for both pulp and paper production can be obtained. (See Tables 8 and 9.)

Table 8: Share (1000 tons) in Global Market Pulp Sector in 1993				
Corporation	Country	Production	% Total	% Market
Weyerhaeuser	USA	2,096	1.28	6.25
Georgia-Pacific	USA	1,760	1.08	5.25
Int'l Paper	USA	1,390	0.85	4.15
Stora	Sweden	1,285	0.79	3.83
Aracruz	Brazil	1,020	0.62	3.04
Södra Skogsägarna	Sweden	986	0.60	2.94
Celulosa Arauco	Chile	814	0.50	2.43
Sappi	SA	800	0.49	2.38
Champion Int'l	USA	777	0.48	2.32
Rayonier	USA	702	0.43	2.09
10-Firm Share			7.13	34.70
Source: PPI 1995				

Table 9: Share (1000 tons) in Global Paper & Board Sector in 1993			
Int'l Paper	USA	6,866	2.73
Georgia-Pacific	USA	6,034	2.40
Stone Container	USA	6,116	2.43
Stora	Sweden	5,221	2.07
Nippon	Japan	4,598	1.83
Champion Int'l	USA	4,388	1.74
Enso-Gutzeit	Finland	4,035	1.60
James River	USA	4,000	1.59
SIBV/MS	USA	3,840	1.53
Weyerhaeuser	USA	3,777	1.50
10-Firm Share			19.42

Although it is clear that some firms are very large, it is not clear that they are large enough to exert market power. However, market concentration, and thus power, seems to be increasing in recent years, reversing earlier trends and increasing the likelihood of such power being exerted. According to the American Department of Commerce there have been a spate of mergers and acquisitions in the sector in the United States in recent years (USDOC *ITA* 1992). Moreover, mergers between North American and European firms are also reported to be on the increase. These assertions are broadly supported by a comparison of financial transactions amongst the largest 150 firms in the sector reported in recent issues of *The International Fact and Price Book*. In the twelve months leading up to October 1995 the following mergers took place: SCA and PWA, International Paper & Carter Holt Harvey, Enso-Gutzeit and Veitsuluoto, Kimberley-Clark and Scott Paper, and Repoal and Kymmene. If this generates market power then more anti-trust cases, such as the recent suit launched by American newspaper publishing companies, should follow in short order. In the final analysis it is the frequency and success of these cases which are the best external indicators of power.

Vertical Integration: Trends and Causes

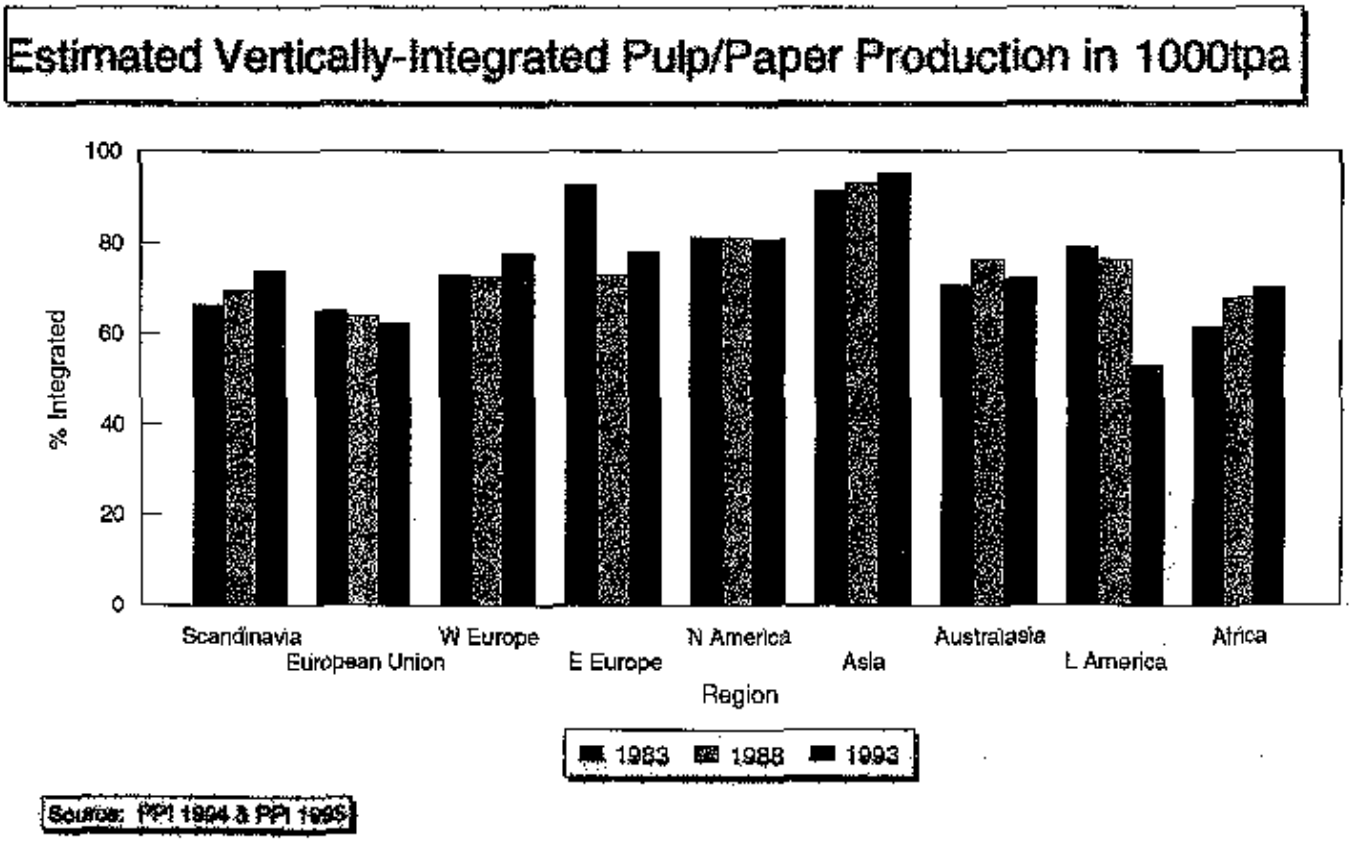
Vertical integration is the acquisition or merger of firms with other firms involved in downstream and upstream sectors in the same production process. This allows the firm to control as many stages of production from the provision of basic inputs to the marketing of final goods. For instance, in the case of paper manufacturing full vertical integration would imply the ownership of forest resources, pulp mills, paper mills, wholesalers, retailers and all associated transportation links. The incentives to bring about such integration are manifold: reduce uncertainty in input prices and quantities from upstream markets, undercut market power enjoyed by competitors in downstream markets and reduce transaction costs associated with arms-length exchange between stages of production. (See Greer 1992 for a general non-technical discussion).

In the pulp and paper sector the most common form of vertical integration has usually been acquisition of upstream fibre sources by mills. The ILO (1992) cites numerous instances of firms securing fibre sources, through acquisition of companies which own land or concessions, in Australia, Canada and Finland. Japanese firms were particularly important in North America, and now Chile and other places as well (Whitham 1994). Integration of paper and paperboard firms with pulp manufacturing has also been common, with the case of Sweden indicative. In 1960 just over 40% of pulp production was integrated with paperboard manufacturing, while in 1990 the figure had risen to over 80% (ILO 1992). Equivalent figures for the United States and Canada were 76% and 66% at the end of the 1980s. Downstream vertical integration, although historically less important, has grown in significance recently. In the United States 75% of corrugated case making is owned by paperboard mills (ILO 1992). In Finland, Sweden and Italy mills have started to purchase paper distribution outlets. Thus, in general it appears that it is the mills which instigate vertical integration, often in both directions.

Some data for pulp production casts light on the importance of vertical integration in the milling stage. Using market pulp proportions as a proxy, a breakdown of estimated vertical integration in terms of pulp-to-paper manufacturing by region for the years 1983-1993 is given in Figure 3. It should, however, be emphasized that the use of market pulp

proportions of total output is, at best, a general indication of vertical integration. For instance, the nature of contractual relations will differ significantly by region, with the COMECON countries prior to 1989 being the most obvious illustration. In general, however, comparing marketed pulp with total pulp over the years 1975-1993 reveals that the proportion has stayed surprisingly constant, with just over 20% entering the market. The distribution across regions is quite different. (See Figure 3.)

Figure 3



Such data captures vertical integration in both its institutional and technological form. Institutional vertical integration is the result of mergers and acquisitions between firms involved in different stages of the same production process. Technological integration involves the actual physical integration of production processes. The former can occur at any and every juncture between different production processes, while the latter is dependent upon engineering potential. It is difficult to disentangle the two statistically, but American evidence casts some light on the issue. Technological vertical integration in the manufacture of pulp and paper can also be documented using American data from the Department of Commerce's *Census of Manufactures*. In 1992, 48 of 127 paper mills were integrated with pulp mills (USDOC *COM* 1995). However, the integrated mills tended to be much larger in value of output terms, with total value of shipments equal to $23.0 billion relative to $9.8 billion for the 79 non-integrated mills. 2.27 million tonnes (30%) of wood pulp consumed by paper mills was "purchased" internally, while 5.31 million tonnes was purchased on the open market (USDOC *COM* 1995). This represented a slight decrease relative to 1987 when 31% was supplied internally.

In general terms, vertical integration appears to be significant in the sector with pulp and paper milling being perhaps most affected. Integration of pulp milling stages with the supply of inputs may also be important. Integration in the other direction (manufacturing-to-retailing) seems to be less common. However, it is difficult to measure such tendencies since contractual relations can take a variety of forms and since ownership may be quite diffuse.

Globalization of Production

A further characteristic which is often associated with the sector is that of globalization. In effect, it is argued that production in individual countries is significantly and increasingly dominated by firms which are based elsewhere. Globalization is usually a function of one of two factors: vertical integration and economic protectionism. The former (vertical integration) is driven by the existence of transaction costs between stages of production. Globalization arises incidentally out of the pursuit of cost reduction. The latter (protectionism) would be more closely associated with globalization across an individual stage of production. Firms locate production of similar goods in different regions in order to gain access to markets.

In the pulp and paper sector both forces seem to have been at work at certain points over recent decades (ILO 1992). Thus, vertical integration associated with attempts to secure fibre sources which are located in other regions has increased globalization. The case of Japanese firms in North America and Latin America is illustrative. Similarly, protectionism has also been important, with the example of Swedish firms prior to joining the EU being illustrative. However, protectionism is certainly a factor of decreasing importance in the recent trend toward globalization since barriers in the sector have been relatively low for some time.

Given the increasingly sophisticated forms of ownership and control which exist, obtaining reliable data for such trends is problematic. For instance, taking the ownership of Brazil-based firms as an illustration, some firms have as many as four significant parent companies and numerous smaller investors, many of whom are based in different countries (CS First Boston 1995). However, taking PPI (various years) data at the level of the firm it is possible to gain some insight into the extent of foreign control in the sector.

In 1992 the top fifty firms in terms of market pulp, paper and board and converted product production operated in an average of 6.6 countries per firm, with three firms operating in more than 20 countries. Unfortunately data for other sectors was not obtained for comparison, but it is perhaps significant that this average fell to 6.2 just two years later. However, within the ranking of firms there is a close correlation between firm size and the number of countries in which they operated (PPI various years). As such, increased concentration may increase globalization.

Other general indicators can be obtained from the secondary literature. Thus, the ILO (1992) states that 20% of Finnish-owned capacity was located outside of Finland. The same report states that over 30% of capacity in France, the United Kingdom and Canada is foreign-owned. Clearly, foreign ownership is important in the sector. Whether or not it is increasing is, however, difficult to say. A casual examination of mergers and acquisitions

in recent editions of the PPI's *International Fact and Price Book* reveals that cross-border transfer of equity has been significant in recent years.

American evidence can be obtained at a more detailed level, comparing the activity of foreign-owned firms in the United States and American multinational and foreign affiliate activity overseas. Data on the former indicates that both the lumber and wood and paper and allied product sectors are considerably less "international" than manufacturing as a whole. (See Table 10). Data on the latter indicates that overseas activity of US firms is less important relative to overall domestic production than in manufacturing in general, although the paper and allied sector is close to the average. (See Table 11).

Table 10: Foreign-Owned Economic Activity in the United States

(% of Total U.S. Sectoral Value Added in 1990)

	Lumber&Wood	Paper&Allied	Manufacturing
Canada	ND	1.3	2
France	0.1	0.2	1.2
Germany	0.2	0.2	1.5
N'lands	ND	ND	0.9
S'land	ND	0.1	1.1
UK	1	1.5	3
Japan	0.3	0.8	1.7
Other	ND	ND	1.9
Total	2.9	7.9	13.4

ND = not disclosed for commercial reasons.

Source: USDOC *SCB*, January 1994

Table 11: American-Owned Economic Activity Overseas				
(Gross Product of Sector in Current $ (m) in 1989)				
	MNCs	MOFAs	USGP	Ratio ((1+2)/3)
Paper&Allied	36,414	7,217	47,100	0.93
Lumber&Wood	12,723	11,738	49,100	0.50
Manufacturing	793,711	207,203	1,004,600.0	1.00
Industries	1,364,878	319,994	4,622,200.0	0.36
MNCs = Multinational Corporations, MOFAs = Majority-Owned Foreign Affiliates Source: USDOC *SCB*, May 1993 & Feb 1994				

The relative importance of Japanese direct overseas investment in the sector relative to manufacturing as a whole can be derived using data from JPA (1993) and UN (1993). There is no systematic trend in the data between the years 1987 and 1991, but the figures are consistently above those for manufacturing as a whole when expressed relative to sectoral output. (See Table 12). This is the converse of the American case, indicating that the Japanese sector is relatively more prone to internationalization of production.

Table 12: Japanese Overseas Direct Investment in Pulp and Paper				
	Pulp&Paper	Manufacturing	% of Pulp &	% of Manuf
	($US million)	($US million)	Paper Output	Output
1987	317	7832	1.52%	0.45%
1988	604	13805	2.43%	0.64%
1989	555	16284	2.19%	0.75%
1990	314	2352	1.27%	0.10%
1991	312	12311	1.17%	0.48%
Sources: JPA (1993) and UN (1993)				

Conclusion

The main characteristics of the supply side of the sector can be summarized. Although the sector may not be perfectly competitive - few manufacturing sectors are purely so - it may well be the case that this is a more valid approximation than a small-number oligopoly. Similarly, economies of scale are apparently important and perhaps efficient, but this varies

significantly by region and product class. The common perception of other supply-side factors (capital-intensity, vertical integration and globalization) is largely borne out by the evidence, although once again this may vary by region to a greater extent than global aggregate data would indicate.

These structural characteristics outlined above (relative capital-intensity, economies of scale, market power, vertical integration and globalization) are significant since they will determine the responsiveness of the sector to changes in market conditions. For instance, an oligopolistic sector will tend to reduce output in the face of falling demand, rather than accept price reductions. Conversely, the effect of economies of scale and capital-intensity will be to make the firm relatively less responsive to downward shifts in demand since the cost savings are relatively lower than would be the case in a sector where operating costs are more important. Vertical integration will have the effect of cushioning supply responses to changes in demand if the output of certain stages of production can be sold on the open market to relatively less adversely affected sectors of the economy. (To see how these factors are translated into supply elasticities see Appendix.)

III. The Demand Side: Product and Process Characteristics

The demand side is equally important to the analysis of developments within the pulp and paper sector. As with the supply side some of the most pertinent characteristics on the demand side are institutional (i.e. contractual relations with suppliers), while others are technological (i.e. input-output linkages in the production chain).

Intermediate Inputs and Derived Demand

The first thing to note about demand for products in the pulp and paper sector is that an overwhelming proportion of goods are sold as intermediate inputs to other manufacturing sectors. Stated differently, demand for goods in the sector is largely derived from demand for goods in downstream sectors. For instance, demand for various qualities of coated paper is derived largely from demand for magazines and demand for newsprint is derived largely from demand for newspapers. More generally, demand for wood-based packaging materials is derived from demand for a wide variety of goods.

The importance of this can be illustrated with reference to input-output data. The United States is illustrative since input-output data is notoriously unreliable for traded inputs, and the size of the American economy is such that there is a much lower ratio of trade/output than in other countries where the sector is important. In 1987 paper and allied products and paperboard containers had much higher proportions of intermediate consumption relative to overall consumption than in industry as a whole. (See Table 13). In terms of the destination of outputs over 50% of inputs (direct and indirect) into the downstream paperboard and container sector come from the paper and allied sectors. Other printing and publishing, newspapers and periodicals and advertising are the next most important, with figures of 22%, 16% and 11% respectively. Lesser, but still significant (greater than 3%) destinations are food and kindred products, tobacco products, educational and social services, miscellaneous textile products, plastic, rubber and glass products, miscellaneous electrical machinery, and miscellaneous manufacturing. Not surprisingly the destination for the output of the paperboard and container sector is much more evenly distributed across sectors. The relative

importance of demand by other industry relative to demand by final consumers means that the sector is very responsive to changes in output elsewhere in the economy. The 'total industry output multiplier', which measures the percentage increase in production by the sector following a 1% increase in output in all other sectors, is 2.18, which is 17th highest of the 79 industrial sectors listed. (USDOC *SCB* May 1994).

Table 13: Destination of Outputs ($ m) in the Pulp and Paper Sector in the US in 1987

	Intermediate Inputs	Final Consumption	% Intermediate Inputs
Lumber & Wood[9]	68635	1820	97.42%
Paper & Allied[10]	69529	11902	85.38%
PB Containers	24501	292	98.82%
Industry Total	3602186	3072252	53.97%

Source: USDOC *SCB*, April 1994

Indonesian input-output data from 1990 gives an indication of the situation in an important developing country, although it should be emphasized that the relatively greater importance of trade in the economy means that the coefficients are somewhat less reliable. Moreover the data is not strictly comparable to American figures since industry classifications differ. Nonetheless the data does reveal some apparent similarities. Only 21% of total output from the paper, paper product and cardboard sector goes to final consumers, which although lower than the American figure is the 13th lowest percentage of the 66 industries listed. (See Table 14). In the case of wood products the figure is even lower, being 8.6%. The destination of outputs for the paper sector is not dissimilar with social and community services (10.3%) being the highest, followed by cigarettes (7.6%). Most of the other sectors which were important in the American data are, unfortunately, aggregated into the sector itself. And finally, the total industry output multiplier for the paper product sector was 2.07, which is the 9th highest figure. (HG Asia 1994).

[9] Logging, sawmills, structural wood products and wood containers.

[10] In the Input-Output tables paper & allied does not include paperboard containers.(SIC 265).

Table 14: Destination of Outputs (Rp bn) in the Pulp & Paper Sector in Indonesia in 1993			
	Intermediate Inputs	Final Consumption	% Intermediate
Wood Products	3614.3	340.0	91.4%
Paper & Board	4017.5	1440.7	73.6%
Source: HG Asia 1994			

The derived nature of demand for products in the pulp and paper sector has significant consequences for consumer responses. Demand is filtered through other industries and not a direct response on the part of final consumers. This means that demand may be a function of a number of apparently unrelated factors in other industries. For instance, market structure for those sectors which use the outputs of the pulp and paper sector as inputs in production will play an important role in determining demand responses. More oligopolistic downstream sectors will tend to be able to pass on input price increases to consumers to a greater extent than more competitive sectors. The ability to pass on input cost increases will also be affected by the proportion of input costs in those final goods for which they are demanded since market power can only be exercised within a certain price range before firm entry undermines the market power.

Product Differentiation and Segmented Markets

Product differentiation is an industrial strategy used to distinguish products within the same general commodity classification from one another. It can take a number of forms, some of which are associated with the firm which manufactures the product and some of which are associated with the product itself. Effectively it allows for market segmentation, the disaggregation of the output of a single sector into separate markets. As with economies of scale and capital intensity this can lead to market power, although the impetus in this case is from the demand side and not the supply side.

Utela (1987) believes that this tendency is generally true of the industry as a whole and that it is driven from the demand side by end use requirements, some of which relate to the final product and some of which relate to production processes lower down the production chain. Specific requirements for the "runnability" of paper/board on high-speed printing/packaging machines as well as four-colour reproduction ability in advertising materials are cited. More generally, de Korver (1989) states that while uncoated paper products remain standardized, coated products are largely differentiated, with many firms specializing in differentiated forms of the latter. This point is also made by the ILO (1992) which states that product differentiation is significant in printing and writing paper and coated papers. It is felt that even bulky products such as newsprint has been affected by such differentiation. The development of brand names, sometimes associated with specific mills, for different qualities of paper has reinforced the process of differentiation.

In its most extreme form such product differentiation can take the form of exclusive

customization. Jaakko Pöyry (1993b) claim that this has been taking place in the pulp sector, where NBSK mills have developed pulp with special combinations of properties (i.e. furnish, weight, strength, etc....) in order to satisfy the requirements of specific customers. In such a case the definition of the "commodity" is restricted to the output from a single plant.

Empirical evidence of the relative importance of product differentiation is limited. A report by de Korver (1989) states that by the late 1980s the Finnish paper sector required one-half the volume of wood inputs and one quarter the labour inputs per unit of output in real value terms relative to 1960. Although much of this is clearly due to increases in technological efficiency (i.e. improvements in pulping and milling technology, reduced required basis weight for newsprint, improved residual recovery, increased recycled fibre use, etc...), the study claims that this is largely due to the shift in the Finnish sector toward increasingly higher value-added products which are differentiated by their functional use, such as supercalendered paper, machine finished coats, and medium-weight coated paper.

In conclusion, although the pulp and paper has not historically been characterized by product differentiation in the way that some other manufacturing sectors have been affected, some observers feel that this has started to change in recent years. The case of paper is illustrative, with a dualistic sector coming into being with uncoated paper being largely homogenous and coated paper being differentiated. This differentiation has given individual manufacturers a larger share of smaller markets, and thus greater control over the price of a more restricted output. Unfortunately the data is necessarily informal and largely anecdotal.

Input and End-Use Substitution

Demand is determined in large part by the degree of substitutability and complementarity with other products. In the case of the pulp and paper sector since demand is derived, substitution has to take place in the form of intermediate inputs and not final consumption.

However, there tend to be relatively few technological alternatives in the production of pulp and paper, with potential substitution arising from different ways in performing the same function (i.e. mechanized vs. manual processes, continuous vs. batch digesters) rather than in terms of different functions altogether. This has repercussions for demand for intermediate inputs since mechanization and automation would affect capital-labour ratios, but material inputs would only be affected to a very limited extent.[11]

Because of this restricted material input substitution potential, substitution can only occur on a system-wide basis with radical restructuring of the technological form of the end-use. To cite one oft-repeated example, it has long been asserted that advances in electronics communication technology represent a significant threat to the paper industry, particularly in the office. Another case would be in media with non-print forms displacing print forms. Although the latter has certainly had some effect over the course of the last four decades, demand for print media has proven to be remarkably durable with non-print being largely complementary. The importance of substitution within the office is not yet clear, but it is quite likely that its main consequence will be in terms of types of paper demanded, rather

[11] The use of recycled wastepaper is a significant exception and will be discussed below.

than volumes. (See Bazett 1993 and Batten and Johansson 1987 for fuller discussions.)

Thus, despite long-standing fears that end-use transformation would affect demand in the sector, this has not yet been reflected in the data, at least at the aggregate level. It may, however, have affected the qualitative characteristics of demand. This would have repercussions on the potential for product differentiation, which has been discussed above.

Contractual Relations and Inventory Adjustment

In addition to vertical integration, which has been discussed above, there are two other principal mechanisms which a buyer of intermediate inputs can employ in order to adjust to uncertainty in the supply and price of an intermediate input: long-term contractual relations and flexible inventory adjustment. The former allows buyers to fix both price and supply in advance, while the latter allows firms to stockpile and disinvest depending upon market conditions. Unlike vertical integration, both are essentially short-run strategies.

It appears that established contractual relations with suppliers is widespread in the sector. Greenslade (1994) states that fully 75% of marketed newsprint is sold in 6-month and 12-month contracts, with only 25% sold on the spot market. As noted in the section on vertical integration above, the figures for pulp are even higher. Although the proportion is likely to be lower for most other products in the sector, the phenomenon is believed to be quite widespread across the production chain.

The degree of potential inventory adjustment is dependent upon product durability. For instance, retailers of perishable goods (i.e. seasonal foodstuffs, volatile chemicals, etc...) are restricted in their opportunities to keep goods in inventory. This means that the dates of production and consumption are close together. However, due to the durability of products in the case of the pulp and paper sector this need not be the case, with inventory adjustment being a potential strategic tool. Such a strategy can be adopted by both sellers (i.e. reducing inventories of outputs when prices are high and increasing inventories when they are low to maximize revenue), and buyers (doing the converse with respect to inputs in order to minimize costs). Unfortunately, inventory data is usually only kept by firms for their primary outputs and not for material inputs.

Conclusion

Thus, in general on the demand side there seems to be a surprising (and increasing) degree of product differentiation. The derived (intermediate input) and incidental (small proportion of end-user sectoral costs) nature of demand is also evident, but it should be emphasized that for some end-use sectors (i.e. newspapers, publishing, etc...) the proportion of intermediate input costs related to the pulp and paper sector can be quite high. In addition, long-term contractual relations with suppliers are clearly important. The use of inventory adjustment seems to be minimal, which is probably a reflection of a relatively adverse storage cost-product value relationship.

These sectoral characteristics will affect demand responses. Inventory adjustment and contractual relations may insulate firms from sudden changes in market conditions, at least in the short-run. Functional product differentiation may reduce price sensitivity by restricting

potential input and product alternatives. The intermediate but relatively low value nature of the products as derived demand may also reduce price sensitivity. The necessity of system substitution may result in discrepancies between short-run and long-run responses, and introduce asymmetries. All of these will be reflected in demand elasticities. (See Appendix for a discussion of the econometric estimates.)

IV. The Supply-Demand Balance and Cyclical Trends in the Sector

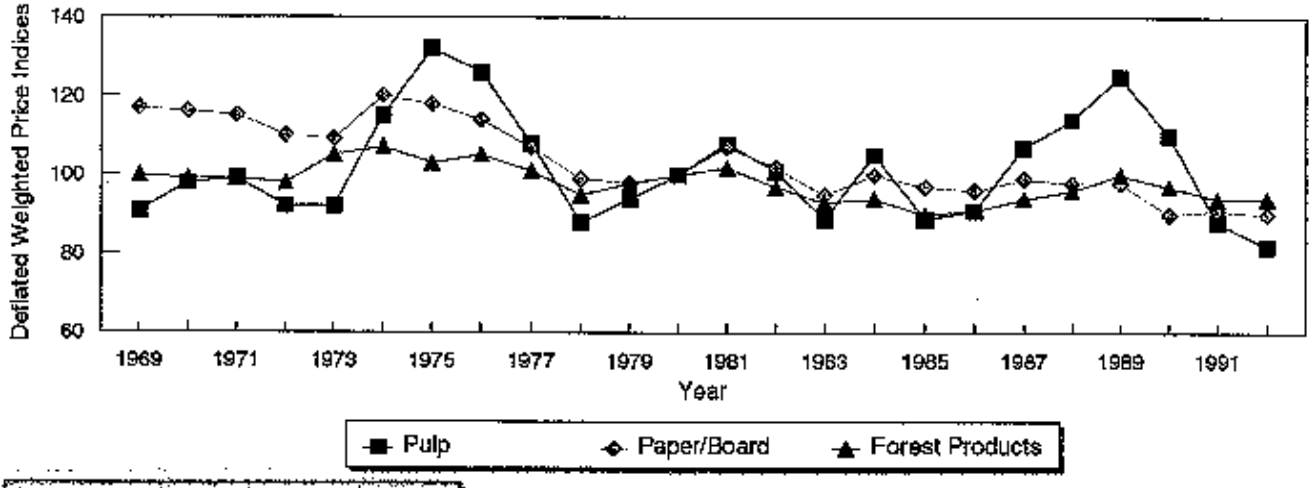
The one characteristic of the pulp and paper sector which is most frequently cited as being of particular significance is its vulnerability to price cycles. In this section the evidence for such tendencies will be reviewed and explanations of its causes will be discussed in relation to the preceding discussion of sectoral characteristics. In the final section, a brief discussion of an alternative hypothesis will be put forth.

Evidence of Price Cycles in the Sector

Price cycles in the sector are often said to be both significant and frequent. Most recently, the price of market pulp increased from less than $400/ton in the summer of 1993 to over $1,000 in October 1995. Newsprint prices have faced an almost equivalent increase over the same time-frame. Over the longer run, there has been significant variability in the real prices for pulp, paper and paperboard. Using FAO price data it is possible to compare variances in international prices at the level of the product. Since the data has been weighted internationally this gives a better indication of global trends. Price indices for pulp, paper and board and forest products in general for the period 1969-1992 are given in Figure 4. Pulp is clearly the most variable with paper and board somewhat less variable. Both are considerably more variable than prices for forest products in general. Moreover, this trend has persisted in recent years. For instance, between 1989 and 1992 the price of pulp collapsed by over 30%, while paper and paperboard fell by almost 10% in 1989-1990.

Figure 4

Deflated Weighted Price Indices for Pulp and Paper



Source: derived from FAO 1989 and FAO 1995
Variances: 175.86, 63.74 and 19.17

The proximate source of the cycles is well-documented and is principally attributed to supply-side factors since demand has been relatively constant, with a general upward trend for most products. In effect, there tend to be large and discrete changes in capacity, with firms often bringing new plants on-line at the top of the business cycle. In 1989-1991 a total of over 5 million tpa in new pulp capacity came on-line (Jaakko Pöyry 1993b).

Although descriptively precise such an explanation says very little about the fundamental causes of price cycles in the sector. Why is it that the sector is subject to such wide and frequent price fluctuations? Why is it that firms in the sector appear to be incapable of coordinating their own business plans with sectoral trends? Some of the answers to these questions are of much wider relevance to the analysis of cycles in the economy as a whole. Rather than discussing this more general body of literature, it is perhaps more useful to relate the existence of cycles to the specific characteristics of the sector discussed above.

Sectoral Characteristics and Price Cycles

Surprisingly, some of the characteristics which are purported to be representative of the sector should have the effect of reducing cycles. For instance, the relatively oligopolistic structure of the industry should lead to relative price rigidity, at least downwardly, since firms will have the power and motivation to resist price decreases by restricting output. Moreover, their incentive to do so is greater if demand is relatively price inelastic since profitability will be relatively greater. There is significant evidence to support this proposition with a number of multi-sectoral cross-sectional studies finding that price variability is negatively related with industry concentration. (See Greer 1992 and Martin 1988 for discussions.)

Time-series studies of concentration and cycles in the pulp and paper sector have not been conducted. However, Jaakko Pöyry (1993b) state informally that cycles for pulp tended to be greater for most products in the 1980s than the 1970s. Some of the market concentration ratio data cited above indicates that this would be consistent with the hypothesis that concentration increases price rigidity. Unfortunately the data is not yet available to examine the price cycle effects of the perceived increase in market concentration in recent years.

Price stability should also be reinforced by the use of inventory adjustment to smooth cycles (See Greer 1992). However, in a study of the European sector, Dauscha (1987) makes the opposite claim, attributing cycles to stock-piling and inventory disinvestment. Thus, although inventory adjustment may be a viable means for buyers to reduce the effects of cycles, it is by no means clear that the strategy has been employed in the past.
The correlation coefficient between inventory/sales ratios (USDOC *SCB* Jan 1993) and real prices (USDA 1990) for the sector in the United States in the period 1977-1988 is 0.39, indicating that they are positively related which would not be consistent with the hypothesis that inventories are being used to smooth price cycles. However, such a result is merely illustrative and in order to examine this issue in detail it is necessary to obtain inventory and price data at a much more disaggregated level.

The effect of supplier contracts has also been discussed. One industry study states that newsprint prices tend to fluctuate rather less than other grades of paper, particularly printing and writing grades, due to the presence of long-term contracts in the newsprint market

(Jaako Pöyry 1992). This point is also made with specific reference to the sector as a whole in Australasia where supplier contracts tend to be both more common and longer in duration (CS First Boston 1992).

Price rigidity may also be reinforced by vertical integration (Greer 1992). This may be particularly important in sectors with long distribution chains such as paper products. Indeed, Utela (1987) believes that the presence of such a chain in the sector has the potential to contribute to price fluctuations since it allows for speculative action by wholesalers and middlemen. This point has been made by others with specific reference to the market for printing and writing paper (Jaako Pöyry 1992). By integrating vertically such effects will be mitigated.

Price cycles are commonly attributed to the combined effects of high capital costs involved in construction of a new plant which necessitate high operating rates in order to finance the investment and the sheer size of such investments in terms of capacity relative to overall size of the affected markets. Thus, Jaako Pöyry (1993b) state that "the impact of even one new mill decision is critical for the profitability of the whole industry."

The source and means of financing employed within the sector may also play a contributing role. The principal sources of finance (debt, equity, retained earnings) are more readily available in upturns and at the peak of the cycle than at the trough of the cycle. In the words of one study "in the peak period of the paper cycle, we see almost unlimited availability of cheap funding." Given the time lags involved in plant construction, this means that much of new capacity comes on-line in the trough of the cycle. In effect the credit cycle and the paper cycle are counter-cyclical, which has the effect of exacerbating price cycles within the industry. (See van Dijk and Dekker (1995) for a detailed discussion of the nature and availability of financial instruments at various points in the paper cycle.) Moreover, since operating rates are required to finance the investments, the capacity is often fully employed.

And finally, the immobility of physical capital in the sector is also certainly a contributing factor to price cycles. Much of the equipment used in the sector is custom-made due to the importance of adjusting the technology required (i.e. chemicals, temperature, pressure) to produce outputs (i.e. pulp and/or paper) of a given quality depending upon input qualities (i.e. wood species, soil characteristics, local climate). In effect this means that the plant is not only physically immobile but, more significantly, sectorally immobile. Combined with the long lead-times involved in the sector this means that capital adjustment is necessarily very slow.

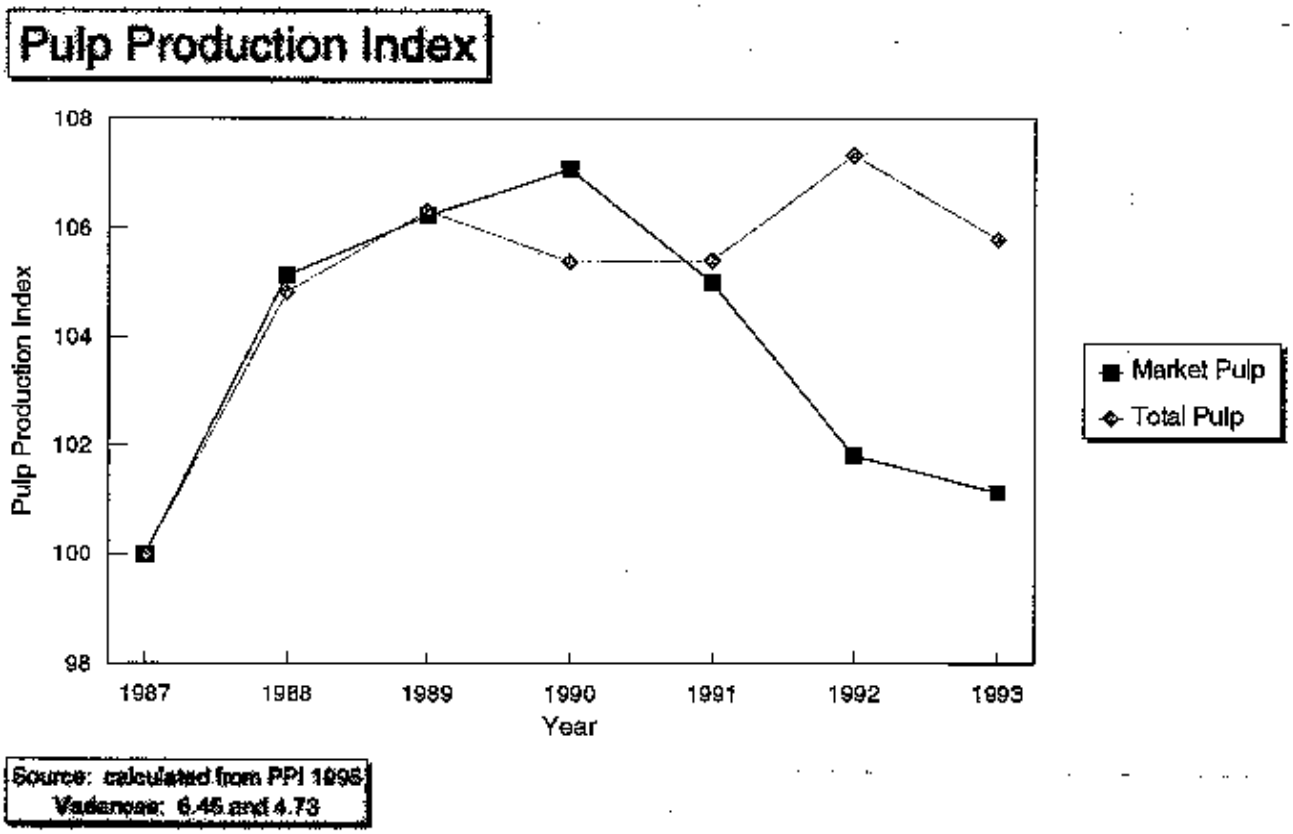
An Alternative Hypothesis

The preceding discussion indicates that some of the characteristics of the sector will tend to accentuate price cycles (i.e. slow capital adjustment, discrete increases in capacity, sources of financing), others will tend to mitigate them (oligopolistic structure, contractual relations with suppliers) and others will have ambiguous effects (i.e. inventory adjustment). Some of these factors are clearly important determinants of cyclical behaviour in the sector. However, and rather paradoxically, cyclical tendencies in the sector may be a consequence of the fact that the description of the sector is only partially accurate: the market structure of the sector is not strictly oligopolistic; nor is it fully vertically integrated; in addition,

supplier relations are by no means permanently contractual. The *partial* nature of these characteristics may actually increase cyclical tendencies.

For instance, incomplete vertical integration may exacerbate price cycles since vertically-integrated firms use the open market as an occasional source of surplus inputs when demand is high and an alternative market for their own production when demand is low. Effectively this makes the market very thin, with the proportion which is bought and sold on the market varying more significantly than that for total pulp. This possibility is borne out by a comparison of variance in indices of production of total pulp and market pulp. (See Figure 5.) Perhaps more significantly, in some years the two pulp classifications move in opposite directions. This may be due to the fact that pulp is put on the market when it is not demanded as inputs internally in production processes.[12]

Figure 5



[12] This also raises an important statistical issue. The presence of vertical integration means that it is important to distinguish between administered prices (within firms) and market prices (between firms). The cycles will be largely a reflection of the rather thin and variable market for the latter. If it were possible to derive a weighted administered-market price index it may well be found that the cycle is rather less variable.

The effect of contractual supplier relations may also be quite different from that which is initially assumed to be the case. Although such relations are certainly likely to increase price stability in the very short-run it is not clear that they are able to do so in the longer-run. This is certainly true if cycles are of longer duration than average contract length since the effect will be merely to delay price increases and price falls. If contracts are normally distributed across the year the effect of contractual relations is likely to be nil. If, however, they are not normally distributed then the widespread existence of contractual supplier relations may even exacerbate cycles since there will be large jumps and drops in prices as contracts are renewed.[13]

The effect of oligopolistic market structure on price cycles may also be ambiguous. Since such structures are inherently unstable, particularly for sectors where firms appear to be at the border of being able to exert market power, price cycles may not be a reflection of responses to market conditions for firms in a given market structure, but rather a reflection of changes in market structure itself. In such a case "price leaders" would be first exerting and then subsequently undercutting their market power. Prices would vary wildly as both market conditions and market structure fluctuated.

In summary, the existence of price cycles may be evidence of a rather cruel paradox which plagues the industry. The very structures, relations and institutions which are being used in an attempt to reduce uncertainty for the individual firm (price-setting, long-term contractual supplier relations, vertical integration, etc...) may increase uncertainty in the sector as a whole, thus generating cycles and undermining their usefulness as firm-level strategies to reduce risk.

V. The Environmental Significance of the Structural Characteristics of the Sector and the Structural Significance of Environmental Regulations

The structural characteristics of the sector have significant consequences for the environment-intensity of pulp and paper production and issues related to regulation of such effects. In addition, efforts to reduce the environment-intensity of production in turn have the potential to affect the structural characteristics of the sector. Many of the issues involved relate directly to the question of wastepaper recycling, while others are more general in nature. Given the complexity of issues involved these can only be discussed in general terms, with some of the most important issues addressed.

Market Power: Input Substitution and Product Differentiation

On the supply side, encouragement of the use of recycled wastepaper as an input into production processes in the sector has the potential to undermine market power significantly. It may do so not only at the level of production affected directly (i.e. virgin fibre inputs), but also in other industries since control of access to virgin fibre inputs may be used as a

[13] Moreover, as with vertical integration the existence of contractual supplier relations raises statistical issues since it is important to distinguish between announced list prices and actual transaction prices. The latter are likely to be more common in sectors with close supplier relations and as such the use of list prices from the open market in empirical studies may be misleading.

means to secure market power in downstream production stages. This control may be reflected in two ways. On the one hand access may be denied explicitly by preventing potential rivals from purchasing vital inputs except from previously unexploited higher-cost forest resources. Alternatively, and more commonly, the firm may exercise market power in the fibre production stage and charge potential rivals at the manufacturing stage a relatively higher price for inputs than the cost which is being borne within the firm.

In such a case the introduction of an alternative input source which is not controlled in an equivalent manner, will reduce potential for the firm to exercise market power. By introducing a substitute input recycling may increase competition, not only at the level of the material input, but more significantly at the manufacturing stage. To some extent the pulp and paper sector is a particularly good example of such potential effects since the original input source (virgin fibre) is dependent upon access to geographically-defined resources while the substitute input source (recycled wastepaper) faces no such restrictions, and as such may be less readily subject to control. Although it is theoretically possible that firms could exercise market power through control of wastepaper sources such as the principal merchants, this possibility seems remote given the diffuse nature of the sources of wastepaper. Moreover, even if there is significant market power in the provision of wastepaper, the mere existence of two potential input sources will serve to undermine the relative importance of market power exercised in the provision of each input.

On the demand side recycled wastepaper use or reduced pollution emissions in production processes may affect the degree of product differentiation existing in the sector, potentially increasing market power. However, the source of product differentiation is rather different than is usually assumed to be the case. Instead of emphasizing marginal differences in product quality or functional use, firms are emphasizing differences in the production processes involved in the manufacture of products which may be qualitatively and functionally equivalent. Indeed this is quite clearly the case since a number of paper firms have explicitly pursued a policy of emphasizing the recycled content of their products. Ince and Zhang (1994) state that in many cases recycled paper products are preferred relative to virgin fibre products. The same may well be true of products advertised on the basis of being chlorine-free.

Product differentiation related to the use of recycled inputs would have the opposite effect on market power to the case of control of access to material inputs. Since firms are able to differentiate their products in terms of consumer perceptions, they are able to segment a previously homogeneous market and exercise a degree of market power. However, the discussion above on intermediate input use and final consumption use by product indicates that this would only represent a small proportion of the total sector, unless consumer preferences can be communicated back up the production cycle for paper/board products such as packaging. The degree to which this is likely depends upon the relative importance of paper products as inputs in other products. Since paper inputs tend to be concentrated in a few industries for which it is an important input, such preferences may be reflected in end-user sectors.

The combined effect of these two forces is ambiguous, however the direction which it takes is significant for issues related to environmental regulation. The more market power is exercised by a firm the better able it is to pass on any cost effects associated with

environmental regulations, since the firm's supply curve will be relatively more elastic than is the case for competitive firms with the same cost structure. The effects of the regulation will largely be borne by downstream sectors (unless they too enjoy market power) and final consumers.

Economies of Scale: Recycling and Pollution Abatement

Wastepaper use also has potentially significant effects on economies of scale. Depending upon differences in the technological aspects of pulp production involving virgin fibre and wastepaper, average mill size may be affected by changes in the primary input source. However, it is important to examine the input complementarity of the two sources of fibre since many plants will use both fibre sources as inputs.

Empirical evidence suggests that wastepaper use will tend to reduce the scale of plants, with the case of mini-mills most commonly cited in the literature. Using data obtained from the American Forest & Paper Association (1995a) the average size of American plants which used wastepaper as an input in 1994 can be compared. The figure for newsprint plants is 143,000 tpa, 48,000 tpa for printing and writing papers, 86,000 tpa for tissue and 43,000 tpa for paperboard. These are much smaller than the figures for virgin fibre plants discussed above. Similarly, the FAO (1995) data cited in Section II above clearly indicates that the average scale of new plants which use recycled inputs is smaller than those which use wood inputs. Global Futures/Rocky Mountain Institute (1995) estimate that the minimum efficient scale of a virgin fibre pulp plant in the United States (365,000 tpa) was over three times the minimum efficient scale of a recycled wastepaper pulp plant (110,000 tpa). Other sources indicate that this tendency may be less important than is often thought to be the case. The *Paper Recycler* (August 1995) lists 26 proposed deinked pulp projects in the United States for 1995-1997, with an average capacity of almost 350,000 tpa.

In addition, economies of scale are, in and of themselves, determinants of environmental resource-intensity. Thus, the evidence cited above indicates that there are significant economies of scale in production, but also appears to indicate that capital and labour costs were the primary cost factors in bringing about such a tendency. Whether or not environmental factors (resource inputs and emission outputs) reinforce or counter such effects is not clear from the discussions cited. If the relationship between the level of output and the ratio of resource inputs per unit of output is positive, then increases in scale will tend to increase environmental effects. If, however, the relationship is negative then the effect of scale will work in the opposite direction, with smaller plants having relatively more effect on the environment per unit of output. This may be true even if the environmental costs of production (externalities associated with pollution emissions and environmental benefits associated with forest resources) are internalized. In such a case the negative cost effects of environmental inputs with respect to scale are not sufficient to over-ride the positive cost effects of other factors with respect to scale.

This can be illustrated clearly in terms of pollution emissions. If pollution emissions per unit of output fall with output levels then the imposition of environmental constraints will tend to increase economies of scale. This tendency will be further supported if the marginal abatement cost curve rises with emissions. If, however, it falls, then the combined effect will be ambiguous. The usual assumption in the literature is that emissions per unit of output

are either constant or rise with output levels, while marginal costs of abatement are either constant or fall with emission levels. This would indicate that environmental inputs related to pollution emissions (i.e. use of the environment as a waste receptacle) would tend to reinforce economies of scale if environmental regulations are applied. However, this is an empirical question and must be examined with respect to the specific pollutant and abatement technology.

With respect to natural resource inputs the situation is similar to that of economies of scale in material inputs in general. If production is less material-intensive (i.e. uses less material input per unit of production) as output increases, then it will probably be so with respect to natural resource inputs as well. This might be due to reduced material wastage or increased processing efficiency. Once again the question is empirical and must be examined in the light of the particular resource input and production process.

However, the environmental, and indeed social, effects of scale can not always be reduced to a simple analysis of pollution emissions and resource inputs per unit of output. Even if there are "environmental economies of scale," plants which are disproportionate to the local area may have relatively more adverse consequences than more decentralized production. At its simplest level this might be reflected in higher damages per unit of pollution emission or resource input. At a more subtle level relatively centralized production might be reflected in greater uncertainty and risk of environmental damage. It must, however, be emphasized that decentralization of production without relocation will not address these issues.

Capital-Intensity: Environmental Improvements and Technological Adjustment

The capital-intensity of the sector raises another set of important issues in terms of the environment-intensity of pulp and paper production. Given the relative capital-intensity of production in the sector and the long-lived nature of the capital involved, both pollution emission outputs and natural resource inputs are potentially closely associated with decisions with very long "tails." This is, however, dependent upon the relationship between environmental inputs and capital expenditures. This relationship is dependent in part upon the nature of production and abatement and in part upon the institutional system of regulation which has been introduced to address environmental problems. Instead of disentangling these two related factors, this section will rely on American evidence of actual behaviour in the sector.

In 1991 the paper and allied sector (SIC 26) had pollution abatement capital expenditures of $1,233 million relative to total abatement expenditures (including operating costs) of $2,867 million, 43% of the total (USDOC *PACE* 1993). In manufacturing as a whole the figures were $7,390 million and $24,777 million, indicating that 30% of abatement costs were in the form of capital expenditures. As such, the pollution abatement intensity of the pulp and paper sector in the United States tends to be more closely related to more general investment plans than is the case in other manufacturing sectors. This would indicate that reductions in pollution-intensity should be closely integrated with investment plans.

However, in the event that abatement-related expenditures are in the form of end-of-pipe additions rather than more fundamental and integrated changes in production processes it is not clear that capital expenditures related to pollution abatement are closely tied to capital

expenditures in general. Using the same source (USDOC *PACE* 1993) it is found that 56% of water pollution abatement capital expenditures involve changes in production processes, while the figure for manufacturing in general is 25%. In the case of air pollution abatement the figures are 35% and 31% respectively.

Thus, it is clear that abatement expenditures in the sector are capital-intensive and closely integrated with capital expenditures in general. Given the long-lived nature of capital in the sector it is, therefore, vitally important that efforts to reduce emissions in the sector recognize the adjustment costs involved. However, once these reductions are achieved they are likely to be retained at relatively low cost and for a considerable length of time. In comparison, in many other sectors reductions in pollution levels will involve relatively low initial costs but relatively high on-going costs. To some extent this makes the pulp and paper sector relatively easier to monitor since incentives to ignore regulations are relatively less important once the investment is undertaken.

Vertical Integration: Wastepaper Markets and Transaction Costs

The motivation for vertical integration is most closely related to the existence of transaction costs. As such the net effect of the use of recycled fibre in the production process depends upon transactions involving virgin fibre relative to recycled fibres. To some extent the effects of relatively high transaction costs in the procurement of secondary fibre would be contradictory. On the one hand they would discourage the shift to recycled fibre use altogether, but on the other hand they would encourage vertical integration if such a shift proved to be economic.

Although this can not be answered *a priori*, it may well be the case that actual transaction costs associated with the use of recycled fibre are higher than those associated with the use of virgin fibre. Systematic evidence is not available, but it does appear that vertical integration is being pursued as an industrial strategy for firms which use recycled fibre. Stefan (1995) mentions the particular case of Jefferson Smurfit and D. S. Smith who have purchased wastepaper merchants specifically in order to secure secondary fibres. Jaakko Pöyry (1993a) suggest that intra-firm "backhauling" from pre-consumer stages (i.e. printers and converters) is increasingly common for large mills in Europe. Moreover, it is clear that this is motivated in large part by transaction costs. The Paper Recycler (August 1995) mentions the case of the Virginia Fibre Company in the United States, which hired three staff to work full-time exclusively on the procurement of recycled fibre.

However, it is important to emphasize that transaction costs in a well-established market (virgin fibre) with transaction costs in a nascent market (wastepaper) are not strictly comparable since transaction costs tend to fall with time as buyers and sellers become accustomed to the workings of the market. As such, it may be important to provide a stimulus to the industry in its infancy since any short-run inefficiencies will be overcome in the longer run. Moreover, the institutions of the market itself may change, further reducing transaction costs. The recent establishment of the Chicago Board of Trade's Recyclables Exchange would represent such a case. As transaction costs associated with recycled papers falls the attractiveness of the wastepaper as an input increases, and the incentives for vertical integration decrease.

Consumption: Derived Demand and End-Use Substitution

Issues related to the environmental consequences of the derived nature of demand and potential for end-use substitution are, to some extent, the consumption equivalent to capital adjustment on the production side. Given that most of the products in the pulp and paper sector are not demanded by final consumers but are instead intermediate inputs into other production processes, adjustment in consumption levels is mediated through a series of production processes and not just through final demand. Similarly, the potential for material substitution in the production process is rather limited. Instead most potential substitution comes in the form of transformed end uses (i.e. print vs. non-print media, paper vs. electronic communication, etc...).

The combined effect of these two factors is to make adjustment on the demand side a protracted procedure. Responses may be quite limited in the short-run, but significant in the long-run. For instance, environmental regulations which make wood-fibre based paper products more costly to produce relative to recycled wastepaper-based paper may have little effect initially, but profound effects in the longer run once the adjustment has taken place fully.

Perhaps more importantly, responses may be assymetrical. Thus, once the adjustment has taken place there may be rather less incentive to return to the initial pattern of demand if relative prices revert to their original levels. The environmental improvement has been locked into the demand pattern and is unlikely to be reversed even if relative prices adjust for other reasons. As such the shift toward a less environment-intensive consumption pattern is best conceived of as a ratchet effect rather than a smooth transition.

Price Cycles, Regulation and Recycling

The effect of price cycles on environment-intensity are two-fold: potentially affecting the development of a market for recycled wastepaper and potentially affecting investment in capital equipment which reduces environmental externalities.

The first issue arises from the effect of price cycles in virgin fibres on prices of substitute recycled inputs. Since wastepaper price cycles are affected by virgin fibre prices, cycles generated within the pulp and paper sector may have an adverse effect on the ability of local authorities to finance a wastepaper collection scheme with some reliability. The relationship between prices can be compared using American data on real prices for woodpulp and wastepaper for the period 1960-1980. This indicates that the variance is much greater for the latter and that the two are negatively correlated. (See Table 15). The negative correlation is not easily explained given that the two are substitute goods, at least in terms of paper production. If, however, a larger proportion of the wastepaper was previously used for incineration there is no reason to expect the two cycles to be positively related. Therefore, since the market for wastepaper as an input in paper production was very young in the early period, variances and correlation coefficients were also calculated for the period 1975-1988. This indicates that wastepaper prices were still much more cyclical than woodpulp prices, but relatively less so. The correlation coefficient for the later period is positive, which is to be expected of substitute goods.

Table 15: Wastepaper and Woodpulp Price Interdependence[14]		
	1960-1988	1975-1988
Ratio (Wastepaper / Woodpulp) of Variances	20.56	13.78
Real Price Correlation Coefficients	-0.53	0.40
Source: USDA 1990.		

Given the relatively more risk adverse nature of local authorities relative to private firms this may serve to undermine the development of the market, at least in terms of residential wastepaper. One solution would be to sub-contract collection to private firms. In this case there is no reason to expect that the firms will be more risk-adverse than firms involved in virgin fibre production and the effects on recycling will be ambiguous. However, since the market for recycled inputs is much younger than that for virgin fibre inputs, and since the firms involved tend to have much shallower pockets, it is possible that cycles will play a disproportionately important role in discouraging investment.

Price cycles may also discourage environmentally beneficial investment. In the event that the uncertainty arising from price cycles restricts the ability of firms to forecast their likely revenues, such cycles may restrict the planning horizon. Since new vintages of capital are frequently less resource-intensive this may have negative consequences for the environment. However, it must be said that since investment in new capital is often the proximate cause of the cycles, such effects can not be determined *a priori*. In this case it is important to distinguish between investment which represents the replacement of obsolete existing capital equipment, investment which represents an alteration of existing capital equipment, and investment which represents an expansion in capacity.

VI. Conclusions: Policy Implications

The principal policy implications arising from this discussion of the structural characteristics of the pulp and paper sector can be summarized. Although some characteristics of the sector (i.e. vertical integration, globalization, contractual relations, etc....) may have important economic and environmental consequences but few policy implications, others are of considerable policy relevance.

As noted, the sector is capital-intensive (particularly at milling stages), the capital stock is long-lived, and a high proportion of reductions in pollution emissions are achieved through general investment in capital equipment and not the specific application of abatement technology. This has implications for price cycles since financing costs may necessitate relatively unresponsive changes in operating rates even if demand changes. This means that it is important that environmental regulations be well thought out since the costs of

[14] There is a missing value for 1983.

inappropriate regulations may be significant, both in economic and environmental terms. However, if there are well conceived then the benefits can be significant, involving large and lasting reductions in emissions as well as relatively low administrative costs of compliance.

Scale economies are important, particularly for pulpwood milling and paper manufacturing. Moreover, the scale of production in many standardized product categories is increasing, although this is not true of some more specialized products. The environmental impact of such scale economies is ambiguous. Although large plants may be damaging in terms of pollution emissions and resource use, it is not clear that the same level of output can be produced with less environmental impact than many small plants. However, if the scale of a given plant exceeds the local environment's assimilative capacity for pollution emissions and the sustainable capacity of the resource base then there is an important role to be played by the land use planning agencies.

Market power has not been exceptionally strong in the past, although this may be changing in recent years and in certain countries. However, the fact that the sector is highly tradeable means that it may be difficult for individual firms to exercise market power in distinct markets unless protectionism is important. Moreover, even if market power is significant, the policy implications in are limited, beyond the simple assertion that existing anti-trust legislation should be applied rigorously.

The policy implications of product differentiation are more significant. If goods are being successfully marketed on the basis of environmental characteristics (i.e. recycled paper content, non-wood inputs, low-emission manufacturing, etc,...) then it may be necessary to ensure that these claims are legitimate. To some extent this would already be covered under product information legislation in many countries. However, recently there have been calls for formal environmental certification schemes. Such schemes may involve significant administrative requirements and be controversial in application.

And finally, the derived nature of demand in the sector has consequences which are analogous to those arising from the capital-intensity of the sector. Since changes in paper use (like changes in paper production) are tied up with more significant structural changes in the market, the short-run effects of changes in market conditions such as price fluctuations may not be significant. However, once the end user characteristics have adjusted the consequences may be both significant and long-lasting.

Appendix: Supply and Demand Elasticities

The structural characteristics of the sector will determine demand and supply responses, which are reflected in estimated elasticities. Some of the main findings are summarized in Tables 16-19, and a brief discussion of the nature of the studies follows.

Estimated Capacity and Supply Responses to Changing Market Conditions

At the level of pulpwood supply Zhang, Buongiorno and Ince (1995) list the supply elasticities (percentage increase in supply for a percentage increase in price) estimated for use in the North American Pulp and Paper (NAPAP) model for two regions (north and south) and two fibre sources (softwood and hardwood). The figures range widely from 0.71 (northern softwood) to 2.98 (southern hardwood). The latter is exceptionally high, indicating that southern hardwood supply is extremely price responsive.

Further down the production cycle the FAO (1986) applies an average elasticity of 0.91 in their model of supply-demand equilibrium in the sector, indicating that the sector is quite, but not highly, responsive. However, at a disaggregated level the figure is very high for printing and writing paper. No reason is given for such a result, but it may well reflect relatively lower average capacity utilization by such machines, allowing for large potential changes in production levels, at least in the short-run. The figures for pulp prices indicate, not surprisingly, that there is some negative supply response to increases in input prices.

The most important effects of capital-intensity and scale economies may be in terms of introducing significant discrepancies between short-run and long-run supply responses, particularly for sectors where investment is both costly and discrete. Moreover, if there are long lead-times between the initial decision to construct a plant to the point where it is operational, the temporal distinction between the short-run and the long-run may be particularly long for the sector.

Estimated Income, Price and Cross-Price Elasticities

Income elasticities for some products in the sector are often assumed to be close to unity, with the packaging products frequently cited as one such case. (See, for example, Dauscha 1987 and USDOC ITA 1992.) In support of this general perception Cardellichio and Adams (1988) list the estimated income elasticities used in the IIASA model, all of which are slightly higher than unity. Andersson and Brännlund (1987) estimate a lower figure (0.92) in an international cross-section estimate of paper demand. And finally, the FAO (1986) estimates generally lower income elasticities, in the range of 0.43 to 0.83 for newsprint, 0.23 to 0.91 for printing and writing paper, and 0.75 to 1.27 for other paper and board.

Aggregate elasticities (estimated in time-series, cross-sectional, or pooled form) may, however, conceal important structural breaks. Thus Andersson and Brännlund (1987) emphasize that their estimate is not reliable for high-income countries. Similarly, Utela (1987) asserts that GDP/capita is a relatively less reliable indicator of growth in board and paper consumption since the oil shocks of the 1970s.

Ewing and Chalk (1988) estimate income elasticities by product (printing and writing paper and other grades of paper), by period (three decades from 1955-1985) and by level of development (LDCs and OECD). They find that elasticities tend to be higher for LDCs for both grades of paper for 1955-1965 and 1965-1975, but with both regions on a downward trend. However there is a break for the third period with the situation reversed for printing and writing paper and partially reversed for other grades. This indicates that there have been structural breaks in demand both chronologically and in terms of income levels. The FAO (1986) also find that income elasticities fall with income levels for newsprint and paper and paperboard, but rises for printing and writing paper. These findings are broadly supported by other international cross-sectional studies, some of which are helpfully collated and summarized by Utela (1987).

In a more recent study which covers 13 paper and board products in the United States, Zhang, Buongiorno and Ince (1995) estimate that income elasticities vary from 0.21 for special industrial packaging to 0.50 for corrugated medium paperboard, newsprint, uncoated free sheet paper, linerboard, corrugated medium paperboard, and recycled paperboard. The figures for tissue and kraft industrial packaging are 0.48 and 0.36.

Overall, price elasticities tend to be quite low. This is certainly due in large part to the nature of the good as a derived demand, but one which rarely constitutes a significant proportion of total output of the final product (Utela 1987). Cardellichio and Adams (1988) list price elasticities used in the IIASA model. The range is from -0.1 to -1.5. In general they tend to fall with income levels, with printing and writing paper falling from -1.2 for low-income countries to -0.2 for high-income countries. Newsprint elasticities fall from -0.8 to -0.3. The FAO (1986) estimate price elasticities of -0.08 for newsprint, -0.45 for printing and writing paper, and -0.39 for other paper and paperboard. Once again Utela (1987) provides a summary of results from other studies, most of which are relatively low.

In their US study Zhang, Buongiorno and Ince (1995) estimate that price elasticities vary from -0.18 for corrugated medium paperboard to -1.18 for special industrial packaging. The figures for newsprint, tissue, and linerboard are -0.54, -0.26 and -0.31. Andersson and Brännlund (1987) use trade data to estimate price elasticities for high income (OECD) countries on the basis of international price differences. The methodology applied gives a better indication of long-run responses to price changes. They find that elasticities for different products range from a low of -1.32 to a high of -2.36 for wood pulp.

Although Utela (1987) summarizes the results for estimates of cross-price elasticities from a number of studies, the t-ratios are such as to indicate that they are not sufficiently reliable to merit reporting. However, on the basis of the low estimated own-price elasticities and the apparent necessity for system substitution in order to have an appreciable effect on inputs it is probable that cross-price elasticities are also low (Utela 1987). Nonetheless, the question of system substitution may indicate that long-run own-price and cross-price elasticities are potentially high and asymmetric once a structural change has taken place in end uses.

In conclusion, it would appear that demand for newsprint is approximately unit income elastic and somewhat higher for other grades of paper. However, there appear to be significant structural breaks. Most importantly it would seem that elasticities tend to fall with income levels and even perhaps exogenously over time. With the exception of Andersson and

Brännlund (1987), who use quite an unorthodox methodology, price elasticities are generally less than unity for all types of paper. They may, however, be high in the long-run if end-use substitution is important, but simple econometric methodology would have difficulty testing this.

Table 16: Supply Elasticities

	Total Paper & Paperboard	Newsprint Paper	Printing & Writing Paper
Paper Price	0.91	0.57	6.36
Pulp Price	-0.60	-0.34	-2.72

Source: FAO 1986

Table 17: Ewing and Chalk (1988) Estimated Income Elasticities of Demand

	1955-1965	1965-1975	1975-1985
Printing & Writing Paper			
Developing Country	2.3	1.5	1.7
Industrial Country	1.3	1.2	1.9
Other Grades of Paper			
Developing Country	2.8	1.5	1.7
Industrial Country	1.1	0.9	0.7

Source: Ewing and Chalk (1988)

Table 18: Range of Cross-Section Estimates of Income Elasticities of Demand

	Newsprint Paper	Printing & Writing	Other Paper & Board
High Income	0.4 - 0.8	1.0 - 1.5	0.3 - 1.2
Med Income	0.6 - 1.2	1.2 - 1.8	1.0 - 1.6
Low Income	0.7 - 1.5	0.7 - 1.5	1.4 - 2.0

Source: Utela (1987)

Table 19: Price Elasticities of Demand from Cross-Sectional Studies					
Study	Form	Period	Newsprint	P&W Paper	Other
Buongiorno (1978)	lagged endogenous	1963-1973	-0.7	-0.5	-0.7
Suhonen (1984)	lagged endogenous	1965-1980	-0.3	0	-0.1
Wibe (1984)	static	1970-1979	-1.1	-0.8	-0.9

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