A COMPARATIVE ANALYSIS OF THE ECONOMICS OF PULP PRODUCTION IN NORTH AND SOUTH AMERICA FOR THE EUROPEAN MARKET

by

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SYMBOLS AND CONVERSION FACTORS

ADMT	-	air dry metric ton (10% moisture)
Bbl	-	barrel
Ha	-	hectare
KW	-	kilowatt
KWH	-	kilowatt hour
MCal/Hr	-	thousand calories/hour
MCF	-	thousand cubic feet
Mill	-	$.001
$US	-	United States dollar
WRME	-	wood raw material equivalent

Length

1 metre - 3.281 feet
1 kilometre - 0.621 miles

Area

1 square metre - 10.76 square feet
1 hectare - 2.471 acres
" - 10,000 square metres

Volume

1 cubic metre - 35.31 cubic feet
1 metre/hectare - 14.29 cubic feet/acre

Mass

1 kilogram - 2.205 pounds
1 metric ton - 1,000 kilograms
" - 2,204.6 pounds
" - 1.1023 short tons
" - 0.9842 long tons

I

INTRODUCTION

Rapid increases in the consumption of paper, paperboard and other wood based products have resulted in a shortage of wood fibre in regions of the world such as Western Europe and Japan. To ensure continued supplies of wood fibre, multi-national pulp and paper corporations serving these fibre-deficit areas have been forced to extend their pulp operations to other areas of the world with surplus forest resources. Consequently, many of these fully integrated corporations operate paper plants located in the major market areas and pulp mills located close to available forest resources. This symbiotic interdependence of markets and resource regions is characteristic of the international pulp and paper industry and presents the industry with unique problems in locational decision making.

In the process of evaluating new pulp mill prospects, managers of multi-national pulp and paper corporations are faced with a number of alternative investment opportunities in both developed and developing economies. One of the objectives of this study is to develop a number of locational factors common to the pulp industry which would provide a systematic framework for a comparative analysis of potential locations.

A second major objective of the study is to apply the locational factors to a current situation in the international pulp and paper industry. For this purpose, five major pulp producing areas in North and South America are examined on the basis of their ability to produce pulp for the European market. By utilizing the "hypothetical mill technique" for comparative economic analysis, hypothetical mills located in each area may be evaluated in terms of the locational factors and an attempt can be made to determine the relative attractiveness of each site in a quantitative and qualitative manner. On the basis of assumptions outlined in the model, sites may then be ranked in terms of both manufacturing and non-manufacturing costs developed in the analysis.

The study commences with an overview of industrial wood supply requirements in Europe. A comparison is made of regional demands relative to forest resource capabilities and supply demand balances for paper grade market pulp are examined. In Chapter III, the forest resource potential and the pulp industry in North and South America are discussed briefly.

The setting of the study is outlined in Chapter IV which presents locational factors used in the comparative analysis, hypothetical mill locations and basic operating data. Pulp prices and the product market are also established in this chapter.

In Chapter V, the hypothetical mills are compared in terms of ten basic locational factors. The relevance of each factor to the pulp industry is discussed prior to the comparison.

A comparative analysis of the economics of pulp production at each site is presented in Chapter VI. Cases are ranked on the basis of both manufacturing and non-manufacturing costs established in the preceding chapter and the return on investment is calculated for each site. The concluding chapter presents a summary of study findings.

II

EUROPEAN INDUSTRIAL WOOD BALANCE

Increasing consumption of wood products in Europe has led to unprecedented demands on its forest resources. Industrial wood requirements in Europe (Table I) rose from 178 million cubic meters (WRME) in 1950 to 291 million cubic metres in 1965 - an increase of over sixty per cent.[1] By 1980 wood requirements are predicted to increase by a further 140 million cubic metres to reach a total of 431 million cubic metres.[2]

The growth in European industrial wood requirements is partially a result of rapidly increasing domestic demand for paper and paperboard products.[3] This is reflected in a derived demand for wood pulp which is the major component of paper and paperboard products. The volume of wood required for pulp production to meet European demands for paper, paperboard, and dissolving pulp (Table II) is estimated to increase from 91 million cubic metres (WRME) in 1965 to 200 million cubic metres in 1980.[4] Wood fibre required for these products alone will represent approximately 46 per cent of European industrial wood requirements by 1980.[5]

Industrial Wood Balance
Europe

(Million Cubic Metres – Wood Raw Material Equivalents)

	1950	1955	1960	1965	1970	1975	1980
A. Apparent Consumption of Sawnwood, Plywood and Veneers	103	123	138	158	166	175	182
European Removals of Sawlogs, Veneer Logs, etc.	100	114	118	132	139	146	154
Apparent Deficit	–3	–9	–20	–26	–27	–29	–28
B. Apparent Consumption of Other Industrial Wood Products	75	91	109	133	163	203	249
European Removals of Pulpwood, Pitprops, Misc. Roundwood and Residue Transfers	79	94	108	125	150	178	210
Apparent Surplus or Deficit	+4	+3	–1	–8	–13	–25	–39
C. Total Apparent Consumption	178	214	247	291	329	378	431
Total European Removals plus Residue Transfer	179	208	226	258	289	324	364
Surplus or Deficit	+1	–6	–21	–34	–40	–54	–67

Notes:

1. Surplus indicated by +
   Deficit indicated by –
2. Historical data covering 1950–65 based on three year averages.
3. Figures may not add due to rounding.

Source: Food and Agricultural Organization of the United Nations, United Nations Economic Commission for Europe, European Timber Trends and Prospects, 1950–1980 – An Interim Review, Geneva, 1969.

Table II

Apparent Consumption of Paper, Paperboard and Dissolving Pulp, Europe

	Paper, Paperboard & Dissolving Pulp			All Industrial Wood Products	
	Total	Woodpulp Equivalent	Wood Raw Material Equivalent	Wood Raw Material Equivalent	Paper, Paperboard & Dissolving Pulp Products as a % of All Industrial Wood Products - WRME
	Million Metric Tons	Million Metric Tons	Million Cubic Metres	Million Cubic Metres	
1950	11.6	8.5	35	178	20
1955	16.4	12.1	50	214	23
1960	22.9	16.4	68	247	28
1965	30.7	22.5	91	291	31
1970	40.3	29.4	118	329	36
1975	53.3	38.8	155	378	41
1980	69.2	50.3	200	431	46

Note:

Historical data covering 1950-65 based on three year averages.

Source: Food and Agricultural Organization of the United Nations, United Nations Economic Commission for Europe, European Timber Trends and Prospects, 1950-1980 - An Interim Review, Geneva, 1969.

Although European forest resources still support the major proportion of domestic wood demands, industrial wood removals are steadily falling behind domestic requirements. The balance between domestic wood consumption and supply (Table III) has turned from a surplus of 1 million cubic metres (WRME) in 1950 to a deficit of 34 million cubic metres in 1965. By 1980, the deficit is expected to grow to 67 million cubic metres and will account for approximately 15 per cent of Europe's industrial wood requirements.[6] The greatest impact of the imbalance will be felt in the European Economic Community which may be experiencing a deficit of 157 million cubic metres by 1980.[7]

Greater emphasis on silvicultural measures designed to increase wood output in Europe would probably have only a limited effect on reducing the deficit as removals at the intensive margin would lead to increased wood costs. Although domestic forest resources in Europe are relatively close to major markets it is doubtful whether Europe could increase wood costs and still remain competitive when other areas of the world already possess surplus soft wood resources or environments suitable for producing low cost plantation wood.

One of the largest imbalances in European wood requirements stems from the shortage of pulpwood required for the manufacture of paper and paperboard products. Consequently, Europe will be forced

Table III

Industrial Wood Balance By Region

Europe

(Million Cubic Metres - Wood Raw Material Equivalents)

	Apparent Consumption						Roundwood Removals and Wood Residue Utilization						Industrial Wood Surplus or Deficit[1]					
	1950	1960	1965	1970	1975	1980	1950	1960	1965	1970	1975	1980	1950	1960	1965	1970	1975	1980
Northern Europe	20	26	31	34	38	41	64	85	98	113	130	150	+44	+60	+67	+79	+92	+109
European Economic Community	64	97	119	135	158	181	43	56	63	68	74	80	-21	-41	-56	-68	-85	-101
British Isles	28	38	44	49	55	62	3	3	4	4	5	6	-25	-35	-41	-45	-50	- 56
Central Europe	12	15	19	21	24	28	20	21	24	26	29	33	+ 8	+ 6	+ 5	+ 6	+ 6	+ 5
Southern Europe	9	13	19	24	32	42	4	9	12	18	24	30	- 4	- 4	- 6	- 6	- 8	- 12
Eastern Europe	44	57	59	65	71	77	44	52	57	60	62	65	-	- 6	- 3	- 6	- 8	- 12
Total Europe	178	247	291	329	378	431	179	226	258	289	324	364	+ 1	-21	-34	-40	-54	- 67

Notes:

1. European regional groupings are as follows:

   Northern Europe: Denmark, Finland, Iceland, Norway, Sweden
   European Economic Community: Belgium-Luxembourg, France, Italy, Netherlands, Western Germany
   British Isles: Ireland, United Kingdom
   Central Europe: Austria, Switzerland, Yugoslavia
   Southern Europe: Greece, Portugal, Spain, Turkey
   Eastern Europe: Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Poland, Romania

   The European Economic Community region includes the original member countries and excludes the United Kingdom, Ireland and Denmark.

2. Surplus indicated by +
   Deficit indicated by -

3. Historical data covering 1950-65 based on three year averages.

4. Figures may not add due to rounding.

Source: Food and Agricultural Organization of the United Nations, United Nations Economic Commission for Europe, European Timber Trends and Prospects, 1950-1980 - An Interim Review, Geneva, 1969.

to look beyond its borders for increasing supplies of wood fibre in the form of pulpwood, pulp, paper, and paperboard products. This imbalance will have a marked effect on non-integrated paper producers in Western Europe who will have to turn to non European sources for an increasing share of their market pulp requirements.[8]

The consumption of paper grade pulp in Western Europe has been estimated by the Food and Agricultural Organization to increase from 26.2 million metric tons in 1970 to 52.3 million metric tons in 1985 - an increase of over 56 per cent.[9] Pulp producers in Western Europe will be unable to meet this demand which will result in the widening deficit presented in the following table.

Table IV

Net Trade Balance in Paper Grade Pulp
Western Europe

(Millions of Metric Tons)

	1975	1980	1985
Consumption	33.41	41.77	52.32
Domestic Production	31.07	37.59	44.47
Net Trade Deficit	-2.34	-4.18	-7.85

Source: Food and Agricultural Organization, Outlook for Pulp and Paper Consumption, Production and Trade to 1985, Advisory Committee on Pulp and Paper, Rome, 1972.

As the gap between paper grade pulp consumption and production widens in Europe, new export opportunities are arising in other regions of the world with surplus forest resources or environments conducive to plantation production.

III

FOREST RESOURCE POTENTIAL OF THE AMERICAS

Growing attention is being paid to regions of the world capable of supplying European wood requirements. In this chapter, the potential contribution of North and South America is discussed. The forest resource base and pulp industry in each region is briefly examined and a forecast of the consumption and production of pulp in North and South America is presented to provide an indication of export pulp potential.

3.1 North America

North America encloses approximately one fifth of the world's forest land.[1] Softwood timber volumes within this region are in the order of 39.5 billion cubic metres and represent close to 20 per cent of the world softwood supply.[2] Approximately 8% of the world's hardwood timber volumes are also located within this region.[3]

Prospects for increased pulp exports from North America to European markets are favourable as the forest resource appears to be capable of supporting a major increase in domestic consumption while still yielding a substantial surplus for export markets. J.A. Zivnuska has predicted that the annual harvest from North American forests may increase from 450 million cubic metres in 1971 to 710 million cubic metres in the next fifty years, despite a decline in the area of productive timberland.[4] Close to one third of the future harvest would be available for export markets.[5] This increase in harvest would require that industry adjust to specie mix and location of available timber as pressure on the resource is becoming severe in many areas of the United States. Northern regions of Canada still retain considerable capacity for increased timber production.

The forest industry in North America is among the most advanced in the world. Close to one half of the world's production of pulp and plywood, over 45 per cent of the world's production of paper and paperboard and nearly one third of the softwood lumber originates in Canada and the United States.[6] In addition to surplus forest reserves and the established forest industry base, factors such as technical ability, capital, infrastructural requirements, and political stability are present to contribute towards export pulp expansion.

Production of paper grade pulp in North America increased from 33.5 million metric tons in 1960 to 57.1 million metric tons in 1972--an average annual increase of 4.5 per cent.[7] According to FAO forecasts presented in Table V, paper grade pulp production in North America will reach 90 million metric tons by 1985. This level of production will result in an increasing surplus which may amount to approximately 12 million metric tons by 1985.

Table V

Net Trade Balance for PaperGrade Pulp
North America

(Millions of Metric Tons)

	1975	1980	1985
Production	64.5	76.6	89.9
Consumption	59.2	68.8	78.2
Net Trade Surplus	5.3	7.8	11.7

Source: Food and Agriculture Organization, Outlook for Pulp & Paper Consumption, Production, and Trade to 1985, Advisory Committee on Pulp & Paper, Rome, 1972.

In 1970, Canada and the United States were responsible for close to one half of the world's export pulp trade.[8] Paper grade pulp exports to Europe (Table VII) increased from 814 thousand metric tons in 1960 to 2.4 million metric tons in 1970. As Europe is currently the major export market outside of North America for both Canada and the United States and as demand in Europe for pulp imports is growing, it is likely that an increasing volume of North American pulp will be placed on the European market in the future.

Table VI

PaperGrade Pulp Exports
United States and Canada

(Thousands of Metric Tons)

	United States	Canada	Total
1950	62	1,411	1,473
1955	399	1,847	2,246
1960	666	2,140	2,806
1965	786	3,145	3,931
66	892	3,385	4,277
67	1,010	3,554	4,564
68	1,129	4,175	5,304
69	1,233	4,915	6,148
1970	2,019	4,761	6,780
71	1,256	4,832	6,088
72	1,324	5,252	6,576

Source:

American Paper Institute, Wood Pulp Statistics, 36th Edition, New York, 1972.

American Paper Institute, Monthly Statistical Summary, New York, Volume 51, October 1973.

Canadian Pulp & Paper Association, Reference Tables 1973, 27th Edition, Montreal, 1973.

Table VII

Paper Grade Pulp Exports to Europe
From United States and Canada

(Thousands of Metric Tons)

	United States	Canada	Total
1950	13	78	91
55	228	288	516
60	463	351	814
65	361	539	900
66	431	578	1,009
67	496	720	1,216
68	551	979	1,530
69	618	1,069	1,687
70	1,139	1,278	2,417
71	677	1,380	2,057
72	663	1,534	2,197

Sources:

American Paper Institute, Wood Pulp Statistics, 37th Edition, New York, 1973.

Canadian Pulp & Paper Association, Reference Tables 1973, 27th Edition, Montreal, 1973.

Statistics Canada, Exports by Commodities, Catalogue #65-004, December 1972.

3.2 Latin America

Close to one quarter of the world's natural forest area lies within Latin America; however, only a small percentage of the resource is commercially utilized by the forest industry at present.[9] Less than one third of the total resource is classified as economically accessible and only one third of the economically accessible area, or approximately 120 million hectares is currently utilized by the forest industry.[10] In 1969, the Latin American timber harvest was in the order of 274 million cubic metres with only 17 per cent classified as industrial removals.[11]

Over 95 per cent of the Latin American forest base is comprised of broadleaved species; however, the bulk of the industrial wood presently harvested from the natural forests consists of coniferous species.[12] From the viewpoint of the pulp industry, one of the major problems of the Latin American broadleaved forests lies in the wide mixture of species found in a typical stand.[13] As the physical and chemical properties of the species vary markedly and as it is not usually possible to obtain a sufficient supply of one or more species with similar pulping characteristics, problems arise in maintaining a uniform quality of pulp with a fibre supply containing a mixture of species.

With continued research on the pulpability of mixed tropical species and the development of new pulping technology, increased utilization of these forests may become feasible in the future.[14] At present, expansion will more likely be based on limited areas of natural coniferous forest and rapidly expanding hardwood and softwood plantations.

Manmade plantations have contributed to industrial requirements far in excess of their share of the forest area. They have become particularly important in many areas below the northern temperate zone which are often poorly endowed in terms of commercially usable indigenous forests but possess a favourable climate, suitable land, and inexpensive labour for the development of plantations. Growth rates within the plantations are often five to ten times greater than the northern temperate zone forests where pulp production is currently centralized.[15] Not only may plantations be tailormade to suit the raw material and locational requirements of the user industry but may also generate many indirect benefits in the form of soil conservation, water flow regulation, wildlife protection, and increased recreational values.

Plantations in Latin America, which primarily contain pine and various species of eucalyptus, cover approximately 2.2 million hectares.[16] Coniferous plantations extending over 865 thousand hectares are located predominantly in Brazil, Chile and Argentina.[17] The majority of the hardwood plantations covering nearly 1.3 million hectares are established in Brazil, Argentina, and Uruguay.[18]

The attractiveness of plantations is slightly diminished by several problems associated with their growth. Pure even-aged stands of one species have been found to be more susceptible to insects, diseases, and climate. In addition, monoculture may adversely affect soil conditions. Despite these drawbacks, plantations in Latin America offer a means of quickly providing large quantities of low cost industrial roundwood. Due to the limited opportunities for large scale expansion based on natural broadleaved forests and the paucity of natural coniferous forests, plantations will continue to supply a major share of the fibre supply for the Latin American pulp industry.

The pulp industry in Latin America is concentrated in Brazil, Chile, Argentina, Colombia and Mexico. Pulp production in this region increased from 821 thousand metric tons in 1960 to 2.53 million tons in 1972--an average annual growth rate of 9.8 per cent.[19] According to recent forecasts, production of paper grade pulp will reach 6.3 million metric tons by 1985.[20]

In the past, growth of the pulp industry in Latin American has not been sufficient to keep abreast of domestic demand. However, with the projected rapid increase in pulp production to 1985, the FAO predicts a steady reduction in net import requirements. Supply-demand projections are shown in the following table.

Table VIII

Net Trade Balance for PaperGrade Pulp
Latin America

(Million Metric Tons)

	1975	1980	1985
Consumption	3.42	4.60	6.33
Production	2.75	4.25	6.07
Net Trade Deficit	-0.67	-0.35	-0.26

Source: Food and Agriculture Organization, Outlook for Pulp and Paper Consumption, Production, and Trade to 1985, Advisory Committee on Pulp & Paper, Rome, 1972.

It is unlikely that Latin America will become a major pulp exporter to Europe over the next decade. At present, development of the region's potential for pulp production is primarily directed toward a goal of self sufficiency centered on import substitution. In addition, a scarcity of technical expertise, lack of capital and low level of infrastructure in the more outlying areas presently tends to discourage the development of large production units necessary for entry into export markets.

In the future when domestic demands are met and new plantations are established in areas suited by soil and climate for cheap production of fibre, Latin America could become a leading pulp exporter. Full development of this region's potential will likely come at a time when the remaining surplus reserves in the northern temperate zone forests are more fully utilized and wood costs in the northern region are rising due to increased pressure on the resource.

IV

THE STUDY AND ITS SETTING

In the course of analyzing prospects for the export of pulp from the Americas to European markets, a comparison will be made of the economics of producing pulp in the major pulp producing regions of the Americas. The basic framework for the comparative analysis is introduced in this chapter. Locations of the hypothetical mills are established and locational factors for the pulp industry, which form the basis for regional comparison, are introduced. A brief discussion is also presented on economies of scale in the pulp industry followed by hypothetical mill size selection and basic operating data.

4.1 Hypothetical Mill Locations

For this study, the following locations in North and South America were selected as representative pulp producing regions:

Case A - Western Canada - Central British Columbia
Case B - Eastern Canada - Central Quebec
Case C - Southern United States - Georgia
Case D - Chile - Concepcion Region
Case E - Brazil - Sao Paulo Region

The following northern European site was also selected for comparative purposes:

Case F - Scandinavia - Southeastern Sweden

The location of each site is shown on Map 1.

4.2 Locational Factors

Hypothetical mills at the above sites were compared on the basis of the following locational factors which take into account economic, social, and political elements:

a) fibre supply
b) transportation requirements
c) water supply
d) environmental control
e) chemical inputs
f) energy requirements
g) labour considerations
h) capital - costs and availability
i) social capital
j) political and economic environment

It was reasoned that no site would likely prove to be ideal from the standpoint of all factors. However, by balancing the advantages and disadvantages of each site in both quantitative and qualitative terms, an attempt was made to determine the relative attractiveness of each site in terms of export production for the European market.

4.3 Comparative Data

Regional variations in production, transportation, and other costs provide the major quantitative data for the locational factor evaluation. Recently published cost data was found to be scarce as

Map 1

Hypothetical Mill Locations

Case A - British Columbia
Case B - Quebec
Case C - Georgia
Case D - Chile
Case E - Brazil
Case F - Sweden
G - Rotterdam (hypothetical market)

companies and associations generally refrain from publishing the type of data required for an analysis of this nature. Detailed industry cost information by region is not readily available from government sources due to confidentiality requirements. Consequently, heavy reliance was placed upon cost data obtained from interview or correspondence with forestry, marketing, economic and engineering consultants as well as major forest product companies.

Cost data was predominantly based upon mills recently studied or constructed in the regions under consideration but modified to suit the conditions outlined in each case. Although significant cost variations can occur within regions, the cost figures are believed to be reasonably accurate for comparative purposes. All cost figures are expressed in U.S. dollars, unless noted otherwise, and correspond to price levels prevailing in mid 1973.

4.4 Scale of Operations

For comparative purposes, it is preferable that the mills under examination be of similar size. In order to select a mill size that would be compatible at all sites, the effects of economies of scale in the pulp industry should be taken into consideration.

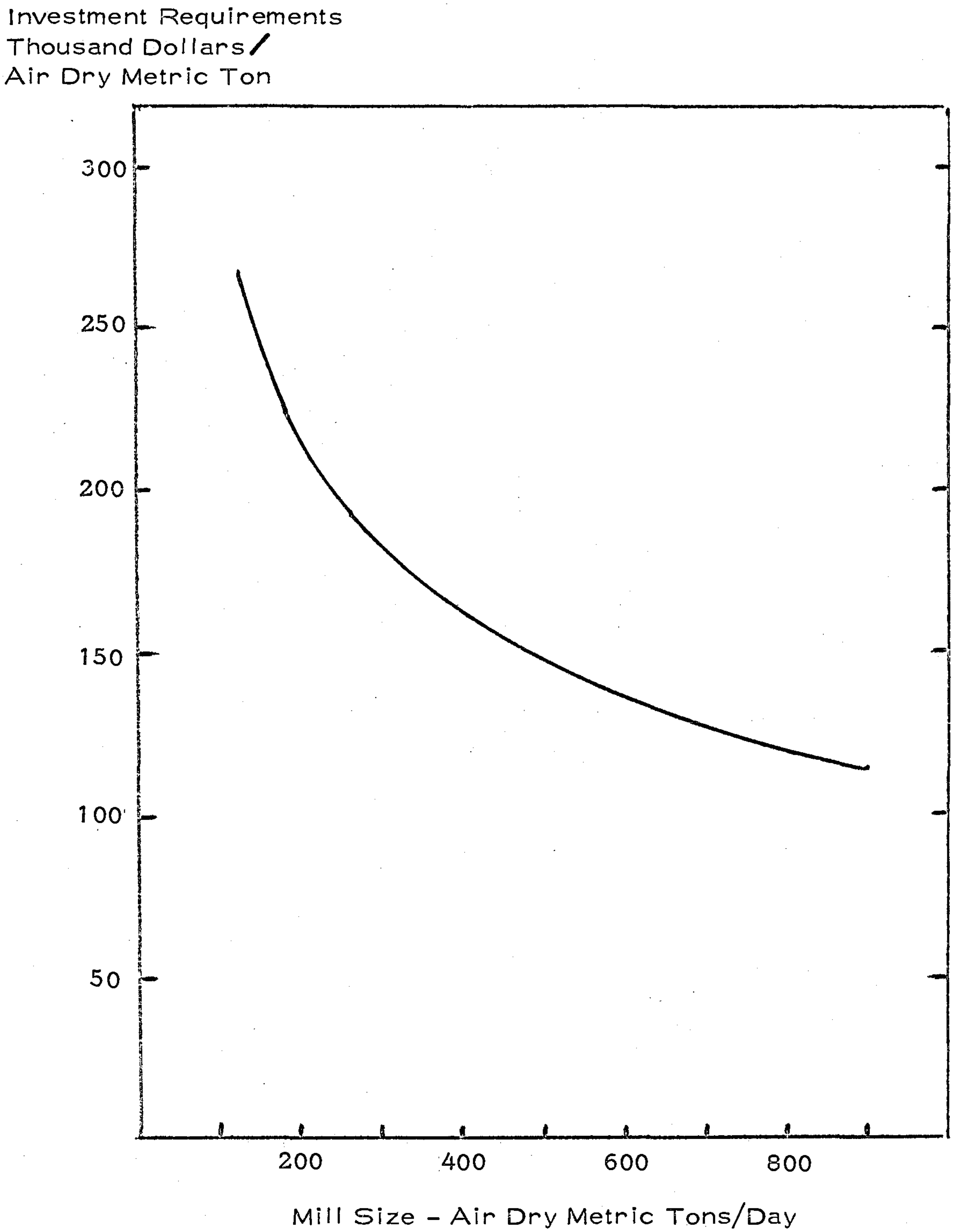
Economies of scale are very pronounced in the pulp industry. As mill capacities increase, total investment requirements per unit of output decline markedly. This is particularly evident in structures, and plant supporting facilities such as onsite roads and railways. In North America, investment costs per daily metric ton of pulp may decrease from approximately $160 thousand for a 400 ton per day mill to under $120 thousand per ton of product in a 800 ton per day mill. The approximate investment requirements expressed as a function of mill size under North American cost levels in 1973 are shown in Chart 2.

Production costs per ton of output also show a marked reduction with increasing mill size until a range is reached where costs decline very gradually. In Chart 3 bleached kraft pulp production costs are presented as a function of mill size under typical North American conditions in 1973.

The reduction in production costs per ton of output is very pronounced in labour, administrative, and overhead costs. For instance, labour requirements rise only moderately with changes in the size of plant as operators are generally oversears of one or more stages of the process regardless of size. By doubling the scale of a pulp mill from 400 to 800 tons per day, personnel requirements may only increase by 30 per cent.[1]

Chart 2

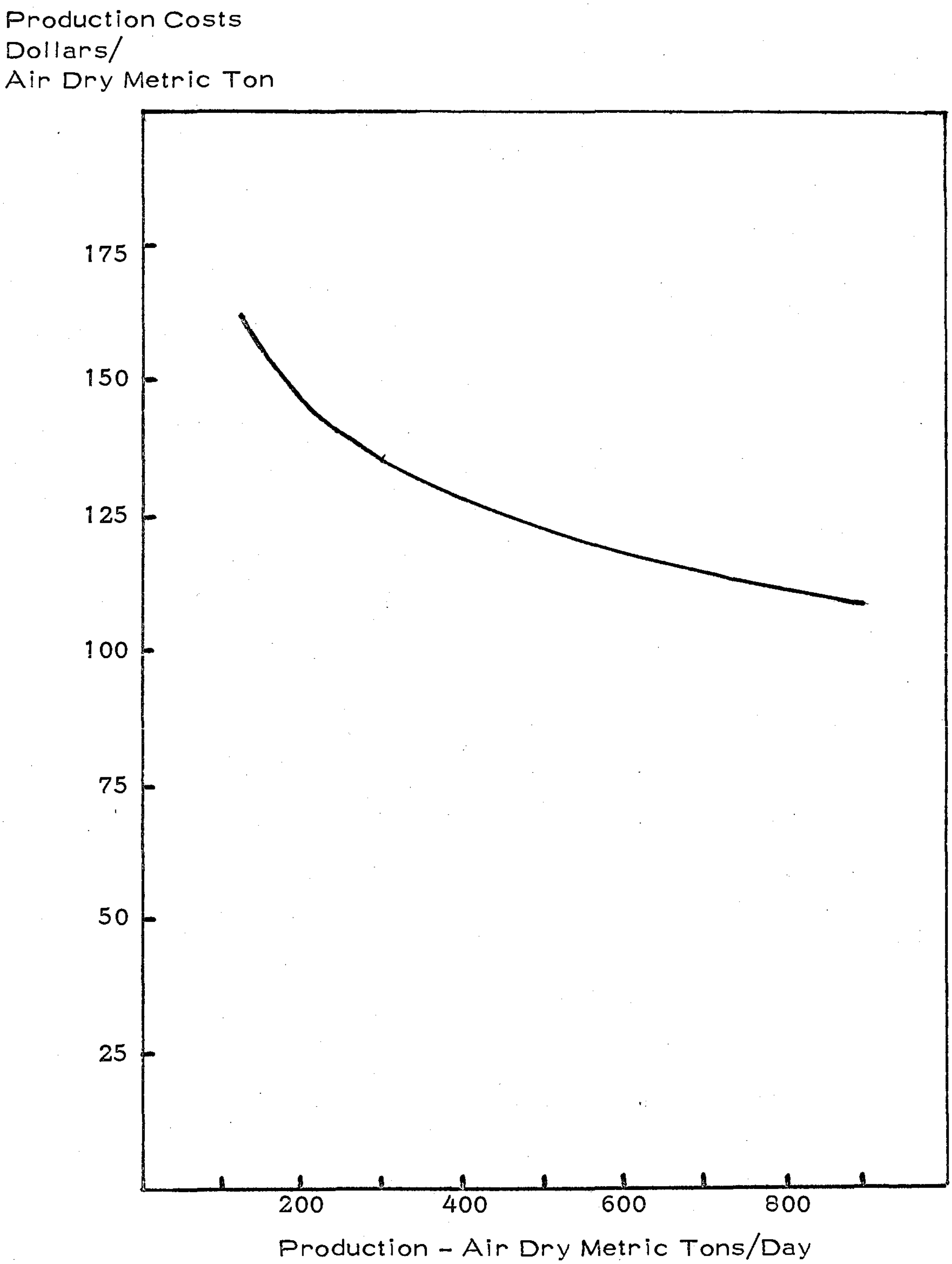
Investment Requirements as a Function
of Mill Size
Bleached Kraft Pulp Production



Source: Jaakko Poyry & Co; adjusted by author to suit current North American conditions.

Chart 3

Production Costs as a Function of Mill Size
Bleached Kraft Pulp Production



Source: Jaakko Poyry & Co.; adjusted by author to suit current North American conditions.

Beyond a certain size of plant, the beneficial effects from economies of scale may be partially offset by other factors. For instance, as wood requirements increase with the size of mill, average haul distances increase which may lead to higher delivered wood costs. With larger mills, problems may arise in obtaining an adequate water supply and disposing of large quantities of effluent. Moreover, the arrangement of adequate financing for large mills may be difficult particularly in developing countries.

The relationship between mill size and its present and potential market must also be considered as the volume of demand may limit the size of the mill. In the past, mills were often limited by the size of domestic markets and were seldom able to take full advantage of economies of scale. However, with increasing international trade in pulp, markets have expanded considerably allowing larger plants to be constructed.

Actual pulp mill operations in the regions under consideration cover a wide range of sizes. At one extreme in British Columbia the pulp industry takes full advantage of export markets, abundant timber supplies, and economies of scale by establishing mills with capacities up to 1,000 tons per day. On the other hand, mills in Brazil and Chile generally are sized at less than 400 tons per day due to a combination of factors such as the lack of basic infrastructure, inadequate timber supplies in close proximity to the mills, financing problems, and limited access to other than domestic markets.

For the purpose of this study, the hypothetical mills were sized at 575 metric tons per day. By current standards, this scale of operation would be on the small size when compared to recently established North American mills and would be considered as rather large in terms of South American mills. However, it was assumed to be a reasonable compromise between the wide range of mill sizes in the areas under examination and could also be considered as a minimum economic size in terms of international competition.

4.5 Mill Operations

It was assumed that the hypothetical mills would utilize the kraft process which is commonly used in the production of chemical pulp today. Mill design was assumed to be in accordance with modern technological developments and would incorporate conventional cooking, washing, screening, bleaching, sheet formation, drying and chemical facilities. The degree of mechanization within each mill was considered to be equal.

In allowing for major maintenance and holiday shutdowns, production calculations were based on 350 operating days a year. Annual pulp production at each mill was assumed to be 200,000 air dry metric tons. By-products of kraft pulping such as turpentine and tall oil were not taken into account as their impact on the comparative economics was considered to be negligible.

4.6 Product Market and Prices

It was assumed that the total production from each mill would be exported to the port of Rotterdam. The pulp would be consumed by paper manufacturers within the European Economic Community.

Prices obtained in Europe for pulp from each hypothetical mill are presented in Table IX. Since each mill's fibre supply is based on different mixes of wood species which reflect the characteristics of a mill's forest base, each mill faces a different price for pulp landed in Europe. The prices vary according to the qualities of pulp produced from the different specie mixes. For instance, a lower price was given to pulp produced from pine species in the southern United States in comparison to prices assigned to premium spruce-pine grades from the Northern Temperate Zone forests of Canada and Sweden.[2]

Table IX

Bleached Kraft Pulp Prices
Western European Market - CIF Rotterdam

(U.S. Dollars/Air Dry Metric Ton)

Producer	Fibre	Price
Case A - Western Canada	spruce, pine	$ 230
Case B - Eastern Canada	spruce	$ 235
Case C - Southern United States	pine	$ 222
Case D - Chile	pine	$ 222
Case E - Brazil	eucalyptus	$ 210
Case F - Southern Sweden	spruce, pine	$ 235

Source: C. J. Bergendahl & Associates AB., Marketing Consultants; prices were adjusted by the author to suit each case.

The prices outlined in Table IX correspond to European market pulp price levels in mid 1973. Throughout the first half of 1973, pulp prices increased sharply following a period of depressed prices stemming from a downturn in European economic activity. As demand for pulp is continuing to strengthen, further price increases are expected during 1973.

V

LOCATIONAL FACTOR COMPARISON

In this chapter, the hypothetical mills are compared in terms of the basic locational factors outlined in Chapter IV. The relevance of each factor to the pulp industry is discussed prior to the comparison.

5.1 Fibre Supply

The size, quality, and economic accessibility of a fibre source is an extremely significant factor in the location of a pulp mill as it is the major cost element in the manufacturing process. In the production of pulp in the northern temperate zone, wood costs usually range from 40 to 60 per cent of total manufacturing costs.[1] Consequently, an inexpensive source of fibre can greatly enhance the competitiveness of a mill.

In the production of kraft pulp large quantities of fibre are consumed. Between 3.8 and 5.7 cubic metres of wood are required for the production of a ton of bleached kraft pulp at the mills under consideration. As over one half of the weight of the wood input becomes waste during the kraft pulping process, mills are generally located as close as possible to their wood source.

In many areas of the world, the influence of the raw material on the location of a pulp mill has declined somewhat due to the increased utilization of wood chips which may normally be transported at less cost than roundwood due to their size, shape, and handling characteristics.[2] Despite this development, locations in close proximity to the wood source are still the normal procedure in pulp mill operations and will probably continue to be in the future. Consequently, the hypothetical mills under consideration are assumed to be located as close as possible to their wood sources.

The species utilized, delivered wood costs, and wood costs per ton of production for each case are presented in Table X. A brief outline of the forest resource base of each of the cases follows.

Case A: British Columbia

The central interior forests of British Columbia provide the fibre source for Case A representing the Western Canadian pulp industry.

In British Columbia, sixty per cent of the land area is classified as forest land which supports close to 7.6 billion cubic metres of mature timber.[3] Over one half of the Canadian forest resource and 73 per cent of the Canadian softwood inventory is located within this area.[4]

Table X

Delivered Wood Costs

Case	Specie	Form	Delivered Cost ($ U.S./Cubic Metre)	Fibre Input/ADMT Bl. Kraft Pulp (Cubic Metres)	Fibre Cost/ADMT Bl. Kraft Pulp ($U.S.)
A. British Columbia	Spruce (65%) Pine (35%)	Roundwood (45%) Chips (55%)	10.00 5.50	5.7	42.70
B. Quebec	Spruce	Roundwood (85%) Chips (15%)	14.00 13.50	5.2	72.40
C. Georgia	Pine	Roundwood (80%) Chips (20%)	9.80 8.50	4.6	43.90
D. Chile	Pine	Roundwood	7.60	4.7	35.70
E. Brazil	Eucalyptus	Roundwood	7.40	3.8	28.10
F. Southern Sweden	Spruce (50%) Pine (50%)	Roundwood (80%) Chips (20%)	16.50 16.00	5.4	88.60

Source:

Council of Pulp and Paper Producers of Quebec, The Competitive Position of the Quebec Pulp and Paper Industry, 1972.

Daly & Company Ltd., The Canadian Forest Products Industry, 1969.

Gilligan, G.S., "Hope & Despair for Canada's Industry," Pulp & Paper, Vol. 47 (April 1973), Part 1, p.51-55.

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Haviland, W.E., Takacsy, N.S., Cape, E.M., Trade Liberalization and the Canadian Pulp and Paper Industry, Private Planning Association of Canada, University of Toronto Press, 1968.

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Streyffert, T., World Pulpwood, Stockholm, 1968.

Data from source documents has been adjusted by the author to suit each case.

Principal species in British Columbia include spruce (24%), western hemlock (22%), balsam fir (18%), lodgepole pine (13%), red cedar (11%), and Douglas fir (7%).[5] Coastal forests are dominated by hemlock while western spruce is the major species in the interior forests.

The forest industries of British Columbia utilized only 57 per cent of the province's potential timber harvest in 1970. Timber removals in 1970 were 55 million cubic metres in comparison to an estimated allowable cut of 96 million cubic metres.[6] On this basis, a considerable increase in timber harvest is possible particularly in the northern and central regions where the majority of forest industry expansion will take place in the future.

The forests in British Columbia supply a rapidly expanding pulp industry as production of pulp increased from 705 thousand metric tons in 1950 to 4.1 million metric tons in 1970.[7] Approximately 55 per cent of the pulp produced in British Columbia in 1970 was exported from Canada and close to 900 thousand metric tons or 22 per cent was shipped to European markets.[8]

In Case A, white spruce and lodgepole pine were selected as the representative fibre furnish. A high quality pulp with characteristics similar to Scandinavian and Eastern Canadian softwood pulps may be obtained from this specie mix.

In the chemical pulp process, wood input per ton of pulp production varies in relation to specie density. Assuming a specie mix of 65 per cent white spruce and 35 per cent lodgepole pine, the average wood density would be approximately 376 kilograms per cubic metre (oven dry green volume). On the basis of a 43 per cent pulping yield, 5.7 cubic metres of roundwood would be required for each air dry metric ton of product.[9]

It was assumed that the fibre supply for Case A would be delivered in two forms - roundwood and chips. Wood chips would be delivered to the mill from lumber and veneer mills in the immediate area. The widespread and efficient use of wood residues in this manner is one of the major factors in the competitive position of the British Columbia pulp industry as residues in the form of wood chips are generally a less costly source of fibre than roundwood.

In 1970 close to 55 per cent of the wood supply for pulp production in British Columbia was in the form of wood residues.[10] The same roundwood/chip ratio was used in the fibre supply for Case A.

The cost of wood chips delivered to the mill site was assumed to be $5.50 per (solid) cubic metre and delivered roundwood was assumed to be $10.00 per cubic metre. With a 45-55 roundwood/chip mix, the wood cost per air dry metric ton of product was $42.70.

Case B: Quebec, Canada

The forests of central Quebec provide the fibre source for Case B representing the Eastern Canadian pulp industry.

Commercial forest covers 42 per cent of the province of Quebec.[11] Approximately 66 thousand hectares of commercial forest are considered suitable for current timber harvest.[12] The volume of merchantable timber exceeds 3.7 billion cubic metres and allowable cut is estimated to be in the order of 60 million cubic metres.[13] As removals in 1970 were 29 million cubic metres or 48 per cent of the allowable cut there is considerable potential for an expanded timber harvest although much of the surplus is in areas of high cost wood.[14]

Close to 60 per cent of the industrial wood harvested in Quebec is directed to the pulp and paper industry. In 1970, this industry consumed approximately 18 million cubic metres of roundwood and 3 million cubic metres of wood residue.[15] In the same year the industry produced 5.9 million metric tons of pulp or 36 per cent of Canadian pulp production.[16]

Black spruce was selected for the wood input at the hypothetical pulp mill. On the basis of an average wood density of 400 kilograms per cubic metre (oven dry green volume) and a 43 per cent pulping yield, 5.2 cubic metres of roundwood would be required for the production of an air dry metric ton of pulp.[17]

The cost of roundwood delivered to this mill was assumed to be $14.00 per cubic metre. Chips would be delivered to the mill for $13.50 per (solid) cubic metre. These wood costs are substantially above those found in other major pulp producing regions of North America and are partially a result of the small size of trees, low stocking per acre, and unfavourable topography and climate.

In 1970, approximately 15 per cent of the wood supply for pulp production in Quebec was in the form of chips.[18] On the basis of this chip/roundwood ratio and the costs presented in the previous paragraph, the fibre cost at Case B was calculated to be $72.40 per air dry metric ton of pulp.

Case C: Georgia

The pulp industry in the Southern United States is represented by Case C where the fibre supply is drawn from the pine forests of Georgia.

In the southern states, commercial forest land covers 78 million hectares.[19] Close to 40 per cent of the commercial forest area in the United States lies within this region.[20] Principal species include shortleaf, loblolly, longleaf and slash pine as well as white and red oak.

The total growing stock on commercial forest land in the south is approximately 4.6 billion cubic metres.[21] One half of the growing stock is softwood species which have increased in volume by 20 per cent since 1963 despite the rising annual harvest.[22] In 1970, the net growth of softwood species on southern forest land was estimated at 153 million cubic metres; some 35 per cent greater than total softwood removals.[23] The combined softwood and hardwood net growth of 244 million cubic metres accounted for nearly one half of the timber growth in the United States.[24]

According to recent studies, the southern region has the biological capacity to produce 445 million cubic metres annually.[25] Consequently, forest industry expansion appears to be possible in this area due to the magnitude of growth over current removals and the apparent upward trend in softwood inventories. There are, however, some pulpwood shortages presently being experienced in a number of heavily utilized areas in the South but these appear to be of a short term nature.[26]

The southern forests have supplied a rapidly expanding pulp industry over the past twenty years. Pulp production in this region rose from 7.3 million metric tons in 1950 to 27.4 million metric tons in 1972 -- an annual average growth rate of 6.2 per cent.[27] In 1972, the southern region accounted for 65 per cent of total pulp production in the United States.[28]

Fibre furnish for Case C in Georgia was assumed to be a mixture of southern pine species which would produce a lower quality pulp in comparison to the hypothetical mills in Canada based primarily on spruce. The average density of the southern pine specie mix was approximately 450 kilograms/cubic metre compared to 376 for the mill in British Columbia and 400 in Quebec. As southern pines are much denser than northern conifers, fibre yield per cubic metre is significantly higher. On the basis of a 43 per cent pulping yield, approximately 4.6 cubic metres of wood would be required for each air dry ton of product.[29]

The cost of delivered wood and chips was assumed to be $9.80 and $8.50 per cubic metre respectively. The cost of roundwood is considerably lower than the previous case in Quebec due to factors such as the forest resource being closer to mills, shorter rotations, relatively high yields per hectare, flat and open terrain, extensive public transportation networks and a favourable climate.[30]

In 1970, twenty per cent of the wood input used in the production of pulp in Georgia, the south's largest pulp producer, was in the form of wood residues and the remainder in roundwood.[31] This proportion of roundwood to chips is used in the fibre supply for Case C. On the basis of the above ratio and the wood costs presented in the previous paragraph, the fibre cost for Case C was calculated to be $43.90 per metric ton of pulp.

Case D: Chile

The fibre supply for Case D in Chile is assumed to be drawn from pine plantations located in the general vicinity of the province of Maule. Plantations provide the majority of the wood supporting the pulp and paper industry in Chile as well as in many other Latin America countries.

Chile contains the largest areas of coniferous plantations in Latin America. The most prominent species used in the production of pulp is insignis pine which occupies more than 90 per cent of the 400,000 hectares of exotic plantations established in Chile.[32] The provinces of Maule, Bio-Bio, and Auracuo contain the largest areas of pine plantations.

Plantation grown _insignis_ pine is one of the fastest growing commercial trees in the world. Average annual yields from the plantations have been conservatively estimated at 20 cubic metres per hectare and annual growth rates as high as 30 cubic metres per hectare have been noted.[33] Under these conditions pulpwood size logs may be harvested on a 12 to 15 year cycle while sawlogs may be obtained in 25 to 30 years.[34] In contrast, up to 60 to 90 years may be required for mixed sawlog and pulpwood production in the northern temperate zone of North America.

The majority of plantations in Chile are privately owned. Due to their widespread success, past administrations supported an ambitious reforestation programme with the objective of planting 50 thousand hectares per year.[35] By 1975, the pine plantations were expected to yield 3.8 million cubic metres of pulpwood annually, however, planting programs are currently falling well behind schedule.[36] Long range plans include the reservation of three million hectares for plantations and if these plans come to fruition the potential annual yield would be in the order of 54 million cubic metres by the year 2050.[37]

Due to the recent heavy increase in the industrial use of plantation wood, little uncommitted pulpwood is presently available for new expansion. However, this appears to be a short term problem and in the next decade increased cut from plantations should allow for fairly substantial increases in pulp capacity.

Chile possesses a well established pulp industry and is the only country in South America which is a net exporter of pulp and paper. Wood pulp production in Chile has increased from 102 thousand metric tons in 1960 to 368 thousand tons in 1970--an average annual increase of 13.7 per cent.[38] In 1972 pulp exports represented 28 per cent of total production.[39] The major markets for sulphate pulp exports are located in the LAFTA countries of Argentina, Mexico, Colombia and Peru.[40]

Insignis pine, the fibre source for Case D, produces a pulp which is slightly superior to softwood pulp from the southern United States but is generally not as well accepted as Scandinavian or Eastern Canadian softwood pulps.[41] On the basis of an average wood density of 450 kilograms per cubic metre (oven dry green volume) and a 43 per cent pulping yield, 4.7 cubic metres of roundwood would be required for each air dry metric ton of pulp.[42] All the fibre supply for the mill was assumed to be in the form of roundwood which is the common practice in the Chilean pulp industry.

In developing countries large regional variations are often found in the cost of delivered pulpwood which generally can be traced to inadequate transport systems. In case D, the cost of delivered pulpwood was assumed to be $7.60 per cubic metre. Consequently, fibre cost per air dry metric ton of pulp was in the order of $35.70.

Case E: Brazil

The fibre supply for Case E in Brazil was assumed to be drawn from eucalyptus plantations in the vicinity of Sao Paulo where the pulp and paper industry is heavily concentrated.

Latin America's largest plantations are found in Brazil.[43] They are primarily eucalyptus which was introduced to Brazil over fifty years ago. At present, the eucalyptus plantations which cover 560 thousand hectares are mainly concentrated in the provinces of Sao Paulo and Minais Gerais.[44]

Eucalyptus plantations have proven to be extremely productive in Brazil. Annual yields of up to 30 to 40 cubic metres per hectare on relatively poor soil are not uncommon and a growth harvest cycle of seven to ten years is possible.[45] As a result of the high yields and low cost of land and labour, they are one of the cheapest fibre sources in the world and consequently, the Brazilian government is actively encouraging plantation expansion through fiscal incentives.[46]

Brazil's pulp industry, which is primarily dependent upon man-made plantations, is the largest in Latin America. Production of pulp in Brazil reached 1.03 million metric tons in 1972.[47] Pulp exports totalling 139 thousand metric tons were only slightly less than imports.[48] As domestic demands are nearly met, the Brazilian pulp industry will likely become a major Latin American exporter due to its low cost wood supply and, in time, may prove to be one of the most competitive export pulp producing areas in the Americas.

Eucalyptus was selected for the fibre furnish at Case E due to its relative availability as there is presently a shortage of coniferous species. It is well suited for the manufacture of chemical pulp and is fully accepted in international markets. Although pulp from most softwood species is a superior product where strength is involved due to its longer fibre lengths, there is currently a healthy demand for hardwood pulp such as eucalyptus for use in many fine paper grades where it tends to enhance sheet formation, opacity, surface smoothness, and printing properties.

The average density of the eucalyptus furnish was assumed to be 520 kilograms per cubic metre (oven dry green volume). Pulping yield would be in the order of 46 per cent. On this basis, 3.8 cubic metres of eucalyptus would be required for each air dry metric ton of product.[49] The delivered cost of eucalyptus roundwood to the site was assumed to be $7.40 per cubic metre which would represent a fibre cost of $28.10 per air dry metric ton of product.

Case F: Southern Sweden

The fibre supply for Case F representing the Scandinavian pulp industry was assumed to be drawn from natural forests in south-western Sweden.

Productive forest land in Sweden covers 23.5 million hectares and the growing stock exceeds 2.3 billion cubic metres.[50] Forests in this region are relatively slow growing. Annual growth rates range from one to three cubic metres per hectare in the far northern regions to six to eight cubic metres per hectare in the southernmost regions.[51]

Annual cut in Sweden was in excess of 70 million cubic metres in 1972.[52] According to recent studies, annual growth is reported to be in the order of 78 million cubic metres.[53] On this basis there appears to be limited room for expansion in Swedish pulp production. In many areas of Sweden pulpwood supply is already limiting industry expansion.

Swedish forest resources support a pulp industry which is the fourth largest in the world and the major pulp exporter in Western Europe. In 1972, Sweden produced close to 8.3 million metric tons of pulp of which 45 per cent was exported. The majority of the export pulp was consumed in the United Kingdom, France and Western Germany.[55]

The major species in Sweden's forests are spruce (45%), pine (40%), and birch (11%).[56] Spruce and pine were selected as the fibre furnish at Case F. On the basis of a 50-50 specie mix, the average density of the furnish would be approximately 385 kilograms per cubic metre (oven dry green volume). Assuming a 43 per cent pulping yield, 5.4 cubic metres of wood input would be required for each air dry metric ton of pulp.[57]

Approximately 20 per cent of the fibre supply for the Swedish pulp industry is in the form of chips from wood processing plants and the same roundwood chip ratio was used for the fibre furnish at the hypothetical mill.[58]

Sweden has the highest wood costs of the sites under consideration primarily as a result of industrial pressure on the resource. Delivered wood costs at Case F were assumed to be $16.50 per cubic metre of roundwood and $16.00 per (solid) cubic metre of wood chips. On this basis, the cost of fibre supply per metric ton of product was $88.60.

5.2 Transportation Requirements

Transportation costs are an important and often decisive factor in locational analysis. This is particularly true in the pulp industry where freight costs represent a major share of total costs and play an important role in determining the relative competitiveness of mills.

In the pulp industry, considerable tonnage of raw materials and products are transported to and from the mill. A mill producing 500 tons of pulp per day may experience daily transport tonnages in excess of 2 thousand tons. Consequently, there is a close relationship between the development of a pulp industry and the state of a region's transportation infrastructure. In developing countries, the lack of adequate transportation facilities close to a fibre source has often ruled out the establishment of a mill which could otherwise be competitive.

The following three major categories of transportation must be considered in the location of a pulp industry:

1) Fibre supply from point of origin to mill
2) Conversion inputs (other than fibre supply) from point of origin to mill
3) Product from mill to market

The first category, the cost of transporting the fibre supply to the mill, normally overrides all other transportation costs and tends to draw mills toward their fibre source. Mills considered in this study were assumed to be centrally located in terms of their pulpwood supply in order to minimize this cost.

Table XI provides a rough estimate of the cost of transporting pulpwood from forest to mill at the sites under consideration. These costs range between $2.00 and $3.30 per cubic metre. At the northern sites A, B, and F, the costs of transporting pulpwood fall within a close range of $2.90 to $3.00 per cubic metre. At Case C in Georgia, the cost was assumed to be only $2.00 per cubic metre due to the relatively flat and open terrain and extensive road networks.

Cases D and E in Latin America were assumed to have shorter haul distances than other sites as a smaller pulpwood supply area is required from plantations with high yields per hectare. However, benefits stemming from the smaller supply areas are usually partially offset in developing areas by inadequate transportation networks and methods. Consequently, pulpwood transportation costs to mill sites in Brazil and Chile were assumed to be $3.20 and $3.30 per cubic metre. These costs represented 43 per cent of the total delivered wood costs.

Table XI

Transportation Component of Delivered Wood Costs

Case	Delivered Wood Cost ($ U.S./ cubic metre)	Transportation Component ($ U.S./ cubic metre)	Transportation Component as a percentage of Delivered Wood Cost (Per Cent)
A - British Columbia	10.00	3.00	30
B - Quebec	14.00	2.90	21
C - Georgia	9.60	2.00	21
D - Chile	7.60	3.30	43
E - Brazil	7.40	3.20	43
F - Southern Sweden	16.50	3.00	18

Source:

Council of Pulp and Paper Producers of Quebec, The Competitive Position of the Quebec Pulp and Paper Industry, 1972.

Daly & Company Ltd., The Canadian Forest Products Industry, 1969.

Streyffert, T., World Pulpwood, Stockholm, 1968.

Data from source documents was adjusted by the author to suit each case.

The second category of transportation costs covering the transport of other inputs such as chemicals and fuel is normally of minor importance when compared to the costs of transporting roundwood and the finished product. The influence of this category on location is slight in North America and Scandinavia. Its significance increases considerably in less developed areas of Latin America where transportation networks are often deficient and inputs are generally transported over longer distances. At sites in Brazil and Chile, production costs per ton of pulp may increase by as much as six dollars over North American sites as a result of higher transportation costs in this category alone.

The third category of transportation cost covering the transport of pulp to market represents a substantial share of total product cost. According to Canadian Pulp and Paper Association estimates, 320 million dollars were expended on transporting Canadian pulp and paper products to their markets in 1965.[59] This outlay represented an average transport cost of $21.90 per ton of pulp and paper.

Advancements in pulp transportation methods are influencing the competitive structure of the pulp industry by reducing long distance transportation costs. Innovations such as specialized bulk carriers and sophisticated cargo handling techniques have increased the potential market areas of many existing mills and created opportunities for new sites.

Product transportation costs for the sites under consideration are presented in Table XII. For comparative purposes, the costs of transporting pulp to market are separated into two components:

a) inland freight cost

b) ocean freight cost

Inland freight covers the cost of transporting pulp from each mill site to the nearest ocean transshipment point. Ocean freight is based on the cost of shipping pulp from the transshipment point to the port of Rotterdam. These costs are based upon conventional methods of transporting pulp and do not fully reflect the cost reductions resulting from more specialized forms of transportation.

5.3 Water Requirements

An adequate water supply in terms of both quantity and quality is essential in the manufacture of pulp and consequently is a critical determinant of location. In terms of quantity, the 575 ton per day bleached kraft pulp mills presented in this study would require a water supply of approximately 24.7 million gallons per day.

Table XII

Product Transportation Costs
Millsite to Rotterdam

(U.S. Dollars/ADMT Pulp)

Case	Ocean Trans-shipment Point	Inland Freight Cost a/	Ocean Freight Cost b/
A - British Columbia	Vancouver B.C.	$ 9.00	$ 28.00
B - Quebec	Trois Rivieres P.Q.	$ 7.00	$ 25.00
C - Georgia	Savannah Georgia	$ 6.00	$ 26.00
D - Chile	Concepcion Chile	$ 9.00	$ 30.00
E - Brazil	Santos Brazil	$ 9.00	$ 27.00
F - Southern Sweden	Karlshamn Sweden	$ 2.50	$ 12.50

a/ Millsite to trans-shipment point.
b/ Trans-shipment point to Rotterdam.

Note: Freight costs include insurance, wharfage and handling charges.

Source:

Daly & Company Ltd., The Canadian Forest Products Industry, 1969.

Government of British Columbia, British Columbia Fabricated Forest Products Exports, 1970., Victoria, Department of Industrial Development, Trade & Commerce, 1971.

Report of the Industrial Inquiry Commission on the Pulp and Paper Industry in New Brunswick, Fredericton, 1972.

Streyffert, T., World Pulpwood, Stockholm, 1968.

Interviews with personnel in transportation departments of forest product companies.

Data from source documents and interviews was adjusted by the author to suit each case.

Qualitative water requirements vary according to intended use. Process water must be of high quality to conform with strict standards covering colour, suspended solids, dissolved minerals, and organic matter. Boiler feedwater requirements are extremely demanding in order to reduce suspended matter and prevent caustic embrittlement, corrosion, and scale formation. Cooling water requirements are also quite rigid as corrosion and the accumulation of scale, sediment, and organic growths must be minimized. In order to meet these requirements, water treatment plants are often installed to upgrade the quality of a local water source.

All sites in the study were assumed to be located adjacent to a ground or surface water supply which was adequate in quantitative terms. It was also assumed that water treatment plants would be required at each site and approximately 1.5 million dollars was included in the capital costs for cases A, B and F in North America and Sweden to cover expenditures on water treatment and pumphouse facilities. Capital expenditures for similar facilities at cases D and E in Chile and Brazil were assumed to be 1.8 and 1.7 million dollars respectively.

5.4 Environmental Control

Effluent control and air pollution abatement regulations vary between locations. In order to conform with these regulations, firms must incur substantial capital and operating costs which can have a marked effect on the economics of pulp manufacture. As concern with environmental pollution increases, more stringent standards are being imposed which are becoming progressively more costly to meet.

In the majority of cases reasonable standards have been set after consideration has been given to the balance between costs and benefits within the overall framework of social and economic goals. Occasionally the political popularity of environmental control has culminated in excessively stringent standards where costs of conforming to the standards have greatly weakened a location's competitive advantage. In some cases, potential locations have been ruled out entirely on the grounds of protecting the local environment.[62]

In the past, the pulp and paper industry has been one of the major sources of stream pollution; however, the industry has recently carried out intensive research and incurred large expenditures on pollution control measures.[63] In the industrialized countries, primary treatment systems to remove suspended solids from the effluent by gravitational settling are normally required to meet basic standards and the use of secondary treatment systems incorporating nutrient addition, activated sludge handling facilities, and aeration lagoon facilities are becoming increasingly common due to more stringent standards. In some cases, tertiary treatment systems are also installed in order to correct undesirable effects such as colour in effluent discharge.

Table XIII presents a rough estimate of capital costs required for effluent control facilities satisfying current regulations in the areas under consideration.

Table XIII

Effluent Control Systems
Capital Costs

(Millions of Dollars)

Case A	British Columbia	4.0
B	Quebec	4.0
C	Georgia	3.8
D	Chile	1.0
E	Brazil	1.4
F	Southern Sweden	4.2

Source:

Food and Agriculture Organization, Brief Note on Effluent Treatment and Disposal Facilities in the Pulp & Paper Industry, Document #5.2, Rome, FAO Advisory Committee on Pulp & Paper, 1968;

Julson, J.A., "Environmental Protection - How Much Will It Cost Your Mill?" Pulp & Paper Volume 43 (April 1969), p. 152;

Organization for Economic Cooperation and Development, Advanced Pollution Abatement Technology in the Pulp & Paper Industry, Paris, Environment Directorate, 1972;

Interviews with engineering consultants specializing in the pulp & paper industry, and forest industry personnel;

Estimates from source documents have been adjusted by the author to suit each case.

As the costs of effluent control facilities are strongly dependent upon local conditions such as the characteristics of the receiving stream, systems must be tailormade for each mill. Consequently, the capital costs indicated above are only general indications of current costs in each region.

Water pollution regulations for mills located in the more industrialized countries are, in general, fairly stringent and are reflected in the relatively higher costs of facilities at cases A, B, D, and F. As requirements at cases D and E in Chile and Brazil are minimal, expenditures on pollution control facilities were assumed to be light. In the future, more sophisticated facilities will be required at cases D and E as public opinion in the developing countries will not likely remain indifferent to the quality of the environment. At present, industrial development appears to be of greater concern than environmental considerations.

Air pollution regulations governing the nature and amount of pollutants discharged into the atmosphere also vary between locations. In the case of kraft pulp mills, air pollution stems from both gaseous emissions and particulates.

The most critical air pollution problem associated with the kraft process is the emission of highly odiferous compounds from gaseous effluents. These odours created by the emission of hydrogen sulphide and mercaptans are detectable at very low concentrations and are extremely difficult to control. As the odour threshold of these gases is in the order of five parts per billion, the emission of even small quantities can seriously affect community relations.[64]

Capital outlays incurred in conforming to air pollution regulations are currently lower than the costs of meeting water standards. Table XIV presents capital cost estimates for air pollution abatement systems considered adequate for the sites under consideration.

Table XIV

Air Pollution Abatement Systems
Capital Costs

(Millions of Dollars)

Case A	British Columbia	1.3
B	Quebec	1.3
C	Georgia	1.2
D	Chile	0.5
E	Brazil	0.7
F	Southern Sweden	1.5

Source:

Julson, J. O., "Environmental Protection - How Much Will It Cost Your Mill?" Pulp & Paper Vol. 43 (April 1969), p. 152;

Organization for Economic Cooperation and Development, Advanced Pollution Abatement Technology in the Pulp & Paper Industry, Paris, Environment Directorate, 1972;

Interviews with pulp mill engineering consultants and forest industry personnel;

Estimates from source documents and interviews were adjusted by the author to suit each case.

The above estimates are very rough since air pollution control costs depend heavily upon the location of each site in relation to local topography, prevailing winds, climatic conditions, and local land use.

As air pollution abatement requirements in the traditional pulp procuding areas of industrialized countries are fairly strict, expenditures on abatement systems at cases A, B, C, and F were relatively high. On the other hand, it was assumed that air pollution abatement requirements at cases D and E in Chile and Brazil were less than the previous sites which accounts for the modest capital expenditures.

5.5 Chemical Requirements

Large quantities of chemicals are required in the production of bleached kraft pulp and, as market demand is strengthening for grades of pulp of higher brightness, the consumption of bleaching chemicals in the process will likely increase. As the cost of chemical inputs represents a significant share of operating costs, variances in delivered chemical costs between sites may influence the locational decision.

In the bleached kraft process, at least 150 kilograms of chemicals are consumed in the production of a metric ton of pulp. The principal chemicals used and quantities consumed in the process are presented in Table XV. Chemicals required for effluent disposal, boiler feedwater treatment and other uses are of a minor nature compared to those listed below.

Table XV

Principal Chemicals Utilized in the Bleached Kraft Pulp Process

(Kilograms/ADMT Pulp)

Saltcake	30 - 55
Lime rock	15 - 45
Chlorine	50 - 65
Caustic	40 - 50
Sodium Chlorate	10 - 20
Sulphur	5 - 10
Sulphuric Acid	10 - 50

Source: Sandwell & Co. Ltd.

An estimate of the cost of chemicals at the sites under consideration is presented in Table XVI.

Table XVI

Chemical Costs

(U.S. Dollars/ADMT Bleached Kraft Pulp)

Case A	British Columbia	17.00
B	Quebec	17.00
C	Georgia	17.00
D	Chile	24.00
E	Brazil	22.00
F	Southern Sweden	17.50

Source:

Daly & Company Ltd., The Canadian Forest Products Industry, 1969.

Estimates from F.L.C. Reed and Associates Ltd., Consulting Economists;

Data from source documents and interviews were adjusted by the author to suit each case.

Chemical costs were assumed to be the same at the sites in North America which are all located in major pulp producing regions. Costs were slightly higher in Southern Sweden.

At the sites in Brazil and Chile, chemical costs were assumed to be at least five dollars greater than in North America. The higher costs at these sites were mainly attributable to increased chemical transport charges. The economics of establishing onsite chemical producing facilities for the production of bleaching chemicals such as chlorine at the sites in Latin America were not examined although this is often a practical alternative when chemical costs are high.

5.6 Energy Requirements

Energy costs may have an influence on the locational decision although the availability of a number of alternative sources tends to minimize cost differentials between sites. For example, fuel types such as coal, oil, or natural gas may be substituted in accordance with their availability and relative cost. In areas where energy costs are relatively high, process design may also be modified to provide more favourable heat and power economies at the expense of higher capital costs.

For comparative purposes, energy requirements will be dealt with under the following two categories:

a) purchased electric power requirements

b) purchased fuel requirements

a) Purchased Electric Power Requirements

Electric power requirements at all sites would be in the order of 700 kwh per ton of product. At Case A in British Columbia, power could be purchased from the public utility for approximately 6.0 mills/[65] kwh. At this rate it is more economical to purchase electric power rather than installing onsite power generation facilities. Consequently, the cost of purchased power would be approximately $4.20 per ton of product.

The cost of purchased power at sites in Quebec, Georgia, and Southern Sweden would range between 6.5 to 8.0 mills/kwh.[66] In this range, the economics of purchasing power or generating onsite power would be quite similar. For the purpose of this analysis, it was assumed that onsite generating facilities would be the preferred alternative.[67] Capital costs incurred in the installation of such facilities would be in the order of 3.0 million dollars.[68] Additional fuel requirements for onsite power generation are accounted for in the following section.

At the sites in Brazil and Chile purchased electric power would be in the order of 10 to 15 mills/kwh.[69] With these rates electric power would be more economically generated on site rather than purchased from a public utility. Capital expenditures on power generation facilities at these sites would be approximately 3.5 million dollars.

b) Purchased Fuel Requirements

In the chemical pulp process, the main source of fuel for the generation of steam is spent cooking liquor which contains used chemicals as well as lignin and other constituents dissolved from the wood material. Bark and other residues from the wood input also supply a portion of the total fuel requirements. Additional fuel must be purchased to make up the balance of the fuel requirements.

Two simplified heat balances which indicate heat demands in relation to sources of supply are presented in Table XVII. Balance A outlines purchased fuel requirements for the hypothetical mill in British Columbia which was assumed to purchase electric power from a public utility.[70] Balance B may be applied to the hypothetical mills which generate onsite electric power.

In actual practice heat balances would differ for each mill. For instance, heat losses would be less at mills in milder climates and the calorific value of hog fuel would vary between sites in accordance to specie mix. However, for the purposes of this study, heat balances allowing for purchased or onsite generated electric power were considered to be sufficiently accurate.

At Case A in British Columbia, heat requirements from purchased fuel would be in the order of 73,700 MCal/hr. The most economical fuel at this site would be natural gas purchased at approximately \$0.48/Mcf.[71] On the basis of an hourly demand of 266 Mcf, the cost of purchased fuel would be approximately \$5.40 per ton of pulp.[72]

Heat requirements from purchased fuel at cases B, C and F in Quebec, Georgia, and Sweden totalled 85,500 MCal/hr. The higher requirements at these sites in comparison to Case A was attributable to onsite power generation facilities. Oil purchased at approximately

Table XVII

Heat Balances and
Purchased Fuel Requirements

	Balance A Purchased Power	Balance B Onsite Power Generation
Heat - MCal/hr.		
Demand:		
for process	145,000	145,000
power generation	-	15,500
	145,000	160,500
Supply:		
from recovery boiler	87,500	87,500
power boiler	49,500	59,500
bark	8,000	13,500
	145,000	160,500
Purchased Fuel Requirements - MCal/hr.		
To power boiler	58,200	70,000
To kiln	15,500	15,500
	73,700	85,500

Note: power boiler efficiency is assumed to be 85 per cent.

Source:

Marsh, R., "Should Your New Mill Generate Electric Power," Pulp and Paper, Vol. 43 (June 1969), p.78.

Nasman, R., "Heat and Power Economy in Pulp and Paper Mills in Developing Countries," Pulp and Paper Development in Africa and the Near East, Rome, Vol. 3, p.1117-1140.

Robb, G.A., "Energy Supply and Utilization - Cost Reduction, Conservation," Pulp and Paper Magazine of Canada, Vol. 74 No. C (March 1973), p. 82.

Estimates from H. A. Simons (International) Ltd., Consulting Engineers.

Data from source documents and interviews was adjusted by the author to suit each case.

$5.25/bbl was considered to be the most economical fuel in these regions.[73] With a demand of 54 bbls./hr. the fuel cost per ton of pulp at these sites would be in the order of $11.90.[74]

Heat requirements at cases D and E in Chile and Brazil were also 85,500 MCal/hr. The most economical fuel at these sites would be oil delivered for approximately $5.50/bbl. in Chile and $5.25 in Brazil. Based on an hourly requirement of 54 bbls., fuel cost per ton of pulp would be approximately $12.50 at the site in Chile and $11.90 in Brazil.

5.7 Labour Considerations

The locational decision is influenced by geographical variations in labour supply, skill levels, remuneration, legislation and labour management attitudes.

Technological advances have substantially reduced the number of staff required in a pulp mill operation. In the United States, the number of production workers in the industry increased by less than eight per cent between 1947 and 1960 while productivity per worker rose by close to 60 per cent.[75] At present, a modern 575 ton per day pulp mill located in North America would require approximately 275 employees of which 55 would be classified as salaried staff, 65 as maintenance staff, and 155 as operating personnel.[76]

Although labour requirements are relatively modest in terms of the actual number of employees, a high level of technical and professional skills are required due to the complexity of operations. If an area did not possess a suitable labour force, compensatory incentives to attract skilled labour and costly training programmes to upgrade the indigenous labour force would have to be considered.

The estimated cost of wages and fringe benefits at the locations under consideration are presented in the following table.

Table XVIII

Wages and Fringe Benefits

(U.S. Dollars/ADMT Bleached Kraft Pulp)

Case A	British Columbia	18.50
B	Quebec	17.00
C	Georgia	17.80
D	Chile	11.50
E	Brazil	11.50
F	Southern Sweden	14.00

Source:

Daly & Company Ltd., The Canadian Forest Products Industry, 1969.

Sowers, L. J., "Labour Costs Abroad," Paper presented at the American Association of Cost Engineers annual meeting, Los Angeles, 1965.

Statistics Canada, Employment, Earnings and Hours, Catalogue #72-002.

Streyffert, T., World Pulpwood, Stockholm, Almquist and Wiksell, 1968.

U. S. Department of Labour, Employment and Earnings, Bulletin 1370-9, Bureau of Labour Statistics.

Estimates from F. L. C. Reed and Associates Ltd., Consulting Economists.

Data from source documents were adjusted by the author to suit each case.

Sites in North America and Sweden are located in well established pulp producing areas where a sufficient supply of skilled labour and managerial personnel are available. Labour costs at these locations were highest at Case A in British Columbia and lowest at Case F in Sweden. Differences in labour legislation and labour management attitudes exist but these were not considered to be significant for the purpose of this study.

An adequate pool of operating personnel and managerial staff would not likely be available at cases D and E in Chile and Brazil. This is common in developing countries where economic and industrial expansion is often handicapped by a paucity of professional and technical skills. It was assumed, therefore, that many of the key operating positions at these sites would be filled by foreign staff attracted to the area by compensatory benefits. Sufficient indigenous unskilled labour would be available but training programmes would be required to upgrade basic skills.

As pulp mills in Latin America are generally overstaffed, it was assumed that the hypothetical mills in Brazil and Chile would have twenty per cent more staff than their counterparts in North America and Sweden. Wages and fringe benefits at these mills were estimated to be approximately $11.50 per ton of product.

5.8 Investment Capital - Costs and Availability

Geographic location has a distinct influence on a mill's capital requirements. For instance, regional variations in the cost and productivity of construction labour are reflected in investment costs as approximately one third of the direct costs of structures and equipment are attributable to construction labour and related overheads.[78] Other factors such as climate and earthquake zoning directly affect the design of structures and hence capital costs. In addition, the cost of land for a millsite may vary significantly between locations.

In remote areas, onsite costs of equipment and materials are higher due to increased transportation costs. Construction camps may be a necessity and premium time allowances may also be required to attract a suitable construction labour force. Investment costs are increased further in isolated locations where extensive maintenance shops and spare part inventories are required. Moreover, costs of materials and equipment may be significantly higher in developing countries if import duties are levied on such items.

An assessment of capital requirements for the hypothetical mills is presented in Table XIX. The lowest capital investment occurred at Case A in British Columbia where on-site power

Table XIX

Investment Requirements

(Millions of U.S. Dollars)

	Case					
	A British Columbia	B Quebec	C Georgia	D Chile	E Brazil	F Southern Sweden
Structures and Equipment	52	55	53	64	60	54
Construction Expenses 1/	17	17	17	20	20	17
Total Plant Capital	69	72	70	84	80	71
Interest During Construction and Working Capital	8	8	8	10	10	8
Total Investment 2/	77	80	78	94	90	79

Note:

1/ Includes construction management and supervision, engineering and contingencies, and startup expenses.

2/ Excludes woods capital.

Source:

Cauvin, D.M. "Measurements of a Forests Contribution to the Economy of Alberta," (unpublished doctorate thesis), University of Washington, 1972.

Daly & Company Ltd., The Canadian Forest Products Industry, 1969;

Estimates by H. A. Simons (International) Ltd., Consulting Engineers

Data from source documents and interviews were adjusted by the author to suit each case.

generation facilities were not required. Capital costs at Case C in Georgia were less than Case B in Quebec due to lower equipment costs and reduced requirements for housing equipment in a milder climate. As the hypothetical mills in the northern hemisphere were assumed to be located in close proximity to fairly well established communities, no additional expenditures would be required for construction camps and long term community developments.

Capital investment at cases D and E in Chile and Brazil was considerably higher than other sites despite lower expenditures on effluent control and air pollution abatement systems. The additional investment required at these sites was primarily attributable to higher onsite costs of equipment and materials, expenditures on community services, and increased working capital requirements.[79] With the exception of cost sharing on basic community services, it was assumed that all facilities external to the plant sites such as roads and railways would be provided from public funds.

The cost of capital seldom varies significantly within industrialized countries when similar pulp mill projects are compared. When considered in terms of projects in both developed and developing countries the cost of capital does take on a degree of geographical expression. For instance, interest rates are generally higher in a country where capital is scarce, the stability of the government is in question, and social and economic conditions are unfavourable.

In many developing countries capital markets are poorly developed and the limited availability of private domestic capital can become an obstacle to industrial development. For example, private loan rates in Brazil generally range between 25 to 40 per cent.[80] However, for projects offering sound investment opportunities, relatively low interest and long term loans are often available from international agencies such as the International Finance Corporation and various regional development banks.

The interest rate on borrowed capital for the hypothetical mills in the northern hemisphere was assumed to be nine per cent. At the sites in Chile and Brazil the interest rate was 7.5 per cent. The latter rate was based on interest charges on loans to developing countries by international financing agencies and, consequently, was lower than current market rates in more highly industrialized countries.

5.9 Social Capital

The social capital factor expresses the relative attractiveness of a location from the standpoint of the mill's personnel. Considerations under this factor include the availability of community amenities such as housing, hospitals, educational facilities, sanitation services, public transportation services, and recreational facilities as well as the climate and other intangible features. These elements have a direct bearing on the ability to attract and retain key personnel and often have a direct influence on the cost of a project if community facilities must be supplied.

The influence of this factor can be assessed by considering the impact of a pulp mill on the surrounding community. In North America, a modern 575 ton per day pulp mill would require a staff of 275 and would likely support a woods operation employing approximately 230 individuals. This forest-based activity tends to create other non-basic jobs within the community. Empirical evidence suggests that a local community multiplier of around two is common for medium-sized forest-based communities in North America.[81] In other words, for every employee engaged in basic forest activities, one other individual is employed in a non-basic activity in the surrounding region.

If the mill was located in a remote area, housing would have to be provided for forest industry employees as well as service personnel attracted to the area by the new development. As the population within reasonable commuting distance of the mill could increase by over two thousand, it would be necessary to create an "instant" town with provision for basic community services and amenities such as non industrial power, sanitation services, schools, and recreational facilities. Consequently, the degree of social capital established within an area can exert a strong locational force as many of the problems and costs of building a suitable community are often borne by the new industry.

Hypothetical mills in the northern hemisphere were assumed to be located in close proximity to existing communities with an established and readily expandable nucleus of services and social amenities. Costs associated with community expansion would not be borne by the new industry with the exception of relatively small expenditures for public relations purposes. The attractiveness of these sites in terms of climate and recreational sources was assumed to be largely a matter of personal preference.

Sites in Chile and Brazil were assumed to be less favourable in terms of this factor. In order to assist in the provision of basic amenities such as housing, domestic water supply and sanitation services, the new industry would likely expend in the order of one million dollars. It was assumed that the major portion of community development costs at these sites would be provided from public funds.

6.0 Political and Economic Environment

General economic conditions and government policies, procedures, and institutional arrangements can exert a positive or negative effect on capital investment. As the pulp industry is highly capital intensive, a climate conducive to private investment is a critical factor when assessing the attractiveness of alternative sites.

The nature and characteristics of an economy in its existing state and the direction and growth of its development in the past has a marked influence on future investment. For instance, conditions such as chronic and uncontrolled inflation and general lack of growth may dampen the incentive to invest in an area which is otherwise suitable for the establishment of a pulp industry.

Government motives, objectives, and methods of control vary between regions and tend to affect the tempo of investment accordingly. Development may be curtailed through government instability and sustained lack of support. Direct and indirect government intervention in a firm's administrative operations also tends to discourage private investment. In addition, a lack of public investment in physical infrastructure such as transportation facilities may often preclude pulp production in desirable locations.

The establishment of pulp and allied forest industries are normally encouraged by governments due to their propulsive effect on the development of a regional economy. A pulp industry tends to create a new growth pole which generates a stream of both tangible and intangible benefits throughout the economy. Through a series of forward and backward linkages, the parallel development of secondary, tertiary and associated industries is encouraged which provides an effective means of promoting regional development.

In many developing countries, the pulp and allied forest industries are among the first group of industries to take advantage of existing natural resources. The production of domestic pulp in lieu of imported pulp in these countries is of key importance due to increasing domestic demands for pulp and paper products. In addition, production for export is also attractive particularly when supplies of foreign exchange are limited.

Once the industry's contribution to the economic and social development of a region is recognized, governments may positively encourage investment in a variety of ways. Investment risks may be reduced through equitable legal and administrative systems, legislative laws, and investment guarantees. Prior or parallel expenditures on basic infrastructure such as roads, harbours, and utilities may improve the relative attractiveness of an area by providing the necessary external economies essential for the establishment of major industry.

Investment may also be encouraged through the introduction of economic incentives such as cash grants, concessions of land and natural resources, low interest loans, liberal depreciation allowances, low taxation rates, periods of tax exemption, and import duty and exchange allowances. As these types of incentives may be the marginal influences which could tip the scales in favour of a particular location, governments and quasi government institutions appear to be developing more interest in these areas than in the past.

Cases A, B, C, and F in the northern hemisphere are located in highly industrialized economies with advanced production, communication and transportation methods. In these locations, social, economic and cultural conditions provide an excellent environment for investment. Governing bodies are generally politically mature and have long-standing policies which are for the most part conducive to private investment. An adequate level of infrastructure for forest product expansion is also present at these locations.

Political, economic and social conditions in Latin America are generally not as conducive to private investment as the regions previously discussed. One of the prerequisites for capital intensive industrial development is long term stability which is lacking in many

Latin American countries. A climate of confidence is difficult to maintain when continuity of basic regulations and policies is frequently disrupted between administrations.

Industrialization in many Latin American countries has also been hampered by a scarcity of investment capital and managerial skills required to attain basic development goals. Other obstacles include chronic inflation which has made forward planning quite hazardous and a low level of infrastructure that has tended to impede production and distribution.

Case E, however, is located in Brazil which is one of the most advanced Latin American countries. Brazil is currently in a period of rapid economic growth with five straight years of gross domestic product increases of nine per cent or more.[82] Business confidence is at a high which has aided in stimulating large inflows of foreign investment. In addition, considerable progress has been made in controlling inflation despite the buoyant economy.

The political climate in Brazil is relatively stable and the present government is actively encouraging private investment in the forest products industry through measures such as fiscal incentives and import duty exemptions. Basic infrastructure is still inadequate in many areas; however, road, rail and port modernization programs are progressing. Of the two Latin American sites under consideration, Brazil would currently be by far the most promising for foreign investment.

Case D is located in Chile which is currently passing through a period of political instability that is severely restricting economic development. A degree of uncertainty surrounds the nature of government policy following the overthrow of the Allende administration. During this administration, foreign investment decreased considerably when many private industrial enterprises were absorbed into the public sector and increasing state control was placed over strategic sectors of the economy.

Chile is currently experiencing runaway inflation, a scarcity of foreign exchange, and labour problems which are plaguing the economy. In addition, a deficiency of basic infrastructure in the form of roads, rail and port facilities is hampering development. At present, Chile does not provide a stimulating environment for foreign investment and will require capable economic policy management and political stability before confidence is restored.

VI

COMPARATIVE COST ANALYSIS

This chapter presents a geographic comparison of the economics of pulp production. The hypothetical mills are ranked in terms of manufacturing and non-manufacturing costs and the return on investment is calculated for each site.

6.1 Cost Structure

A comparative analysis of the economics of pulp production at each site is shown in Table XX. Quantitative data examined in the previous chapter is used as a basis for this comparison. Additional cost components such as finishing materials, operating supplies, maintenance materials, sales, and administrative expenses that have not been previously classified as basic locational factors due to their relatively limited effect on the locational decision-making process are also included in the analysis at this stage in order to present a complete summary of costs at each site.

6.1.1 Manufacturing Costs

A percentage breakdown of the manufacturing cost components for each site is presented in Chart 4. The wood cost component, which

Table XX

Geographic Comparison of the Economics of Pulp Production for the European Market
Manufacturing and Non-Manufacturing Costs

(U. S. Dollars/ADMT Bleached Kraft Pulp)

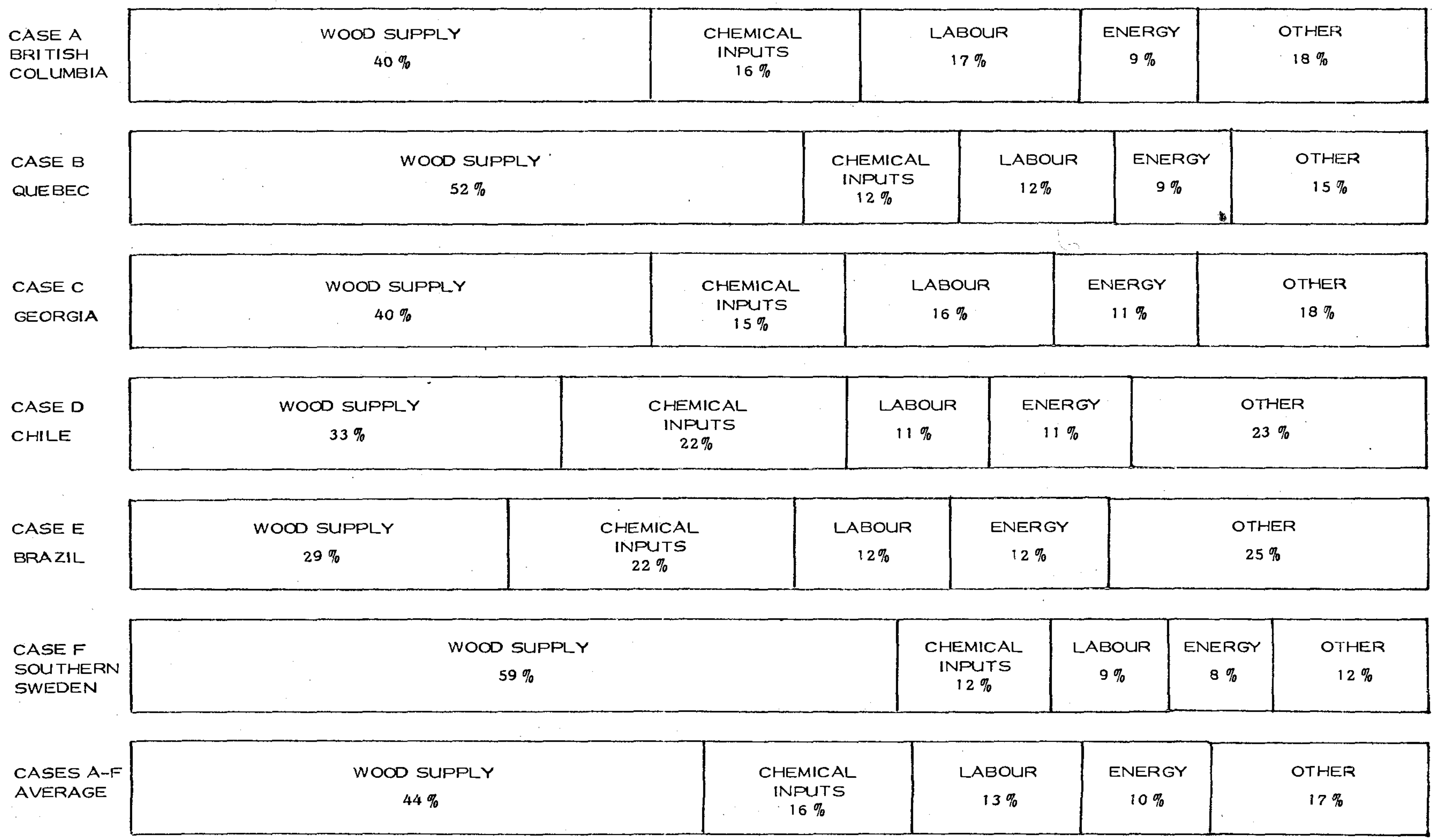
	CASE					
	A British Columbia	B Quebec	C Georgia	D Chile	E Brazil	F Southern Sweden
Manufacturing Costs						
Wood	42.7	72.4	43.9	35.7	28.1	88.6
Fuel	5.4	11.9	11.9	12.5	11.9	11.9
Electric Power	4.2	-	-	-	-	-
Chemicals	17.0	17.0	17.0	24.0	22.0	17.5
Wages & Salaries	18.5	17.0	17.8	11.5	11.5	14.0
Finishing Materials	2.0	2.0	2.0	2.4	2.4	2.0
Operating Supplies & Maintenance Materials	10.0	10.0	10.0	13.5	12.0	10.0
Miscellaneous	8.0	8.0	8.0	9.5	10.0	7.0
Total Manufacturing Costs	107.8	138.3	110.6	109.1	97.9	151.0
Non-Manufacturing Costs						
Sales & Administrative Expenses	3.5	3.5	3.5	4.5	4.5	3.0
Freight (Inland & Ocean)	37.0	32.0	32.0	39.0	36.0	15.0
Total Non-Manufacturing Costs	40.5	35.5	35.5	43.5	40.5	18.0
Total Costs	148.3	173.8	146.1	152.6	138.4	169.0

Source: Tables X, XII, XVI, XVIII

CHART 4

MANUFACTURING COST COMPONENTS

(PERCENTAGE OF TOTAL MANUFACTURING COSTS)



SOURCE: TABLE XX

ranged from 59 per cent of manufacturing costs in Southern Sweden to 29 per cent in Brazil, was by far the major component of manufacturing costs. The next major manufacturing cost components were chemicals and labour which averaged 16 per cent and 13 per cent respectively. The remaining cost components averaged 27 per cent of manufacturing costs.

In terms of total manufacturing costs, the hypothetical mills were ranked in the following ascending order:

Table XXI

Manufacturing Costs
Ranking by Site

(U.S. Dollars/ADMT Bleached Kraft Pulp)

Case E - Brazil	97.9
Case A - British Columbia	107.8
Case C - Georgia	109.1
Case D - Chile	110.6
Case B - Quebec	138.3
Case F - Southern Sweden	151.0

Source: Table XX

The lowest manufacturing costs occurred at Case E in Brazil where extremely low wood costs tended to overshadow all other manufacturing cost components. In this region, pulpwood was assumed to be drawn from fast growing eucalyptus plantations which yield very low cost pulpwood. The second lowest manufacturing costs occurred at Site D in British Columbia. Once again competitive advantage arose from low wood costs but in this case a high percentage of low cost residual wood chips were used in the fibre supply.

Highest wood costs and hence highest manufacturing costs were found in Quebec and Sweden. In these regions, wood costs per ton of product were approximately 185 per cent greater than in Brazil and 90 per cent higher than British Columbia.

6.1.2 Non-Manufacturing Costs

Non-manufacturing expenses include the costs of transporting the final product to market as well as sales and administrative expenses. The sites are ranked in terms of ascending non-manufacturing costs as follows:

Table XXII

Non-Manufacturing Costs
Ranking by Site

(U.S. Dollars/ADMT Bleached Kraft Pulp)

Case F	Southern Sweden	18.0
Case C	Georgia	35.5
Case B	Quebec	35.5
Case E	Brazil	40.5
Case A	British Columbia	40.5
Case D	Chile	43.5

Source: Table XX

As transportation expenses form the major component of non-manufacturing costs, Sweden exhibited by far the lowest costs due to its close proximity to the market in Rotterdam. Conversely, the highest non-manufacturing costs were found at sites on the west coast of the Americas where ocean transport costs averaged 17 dollars per ton more than the site in Sweden. Costs associated with sales and administration, which accounted for approximately 11 per cent of non-manufacturing costs, had little influence on the ranking of sites.

6.1.3 Total Costs

A percentage breakdown of total cost components for each site is presented in Chart 5. The sites are ranked in terms of ascending total costs as follows:

Table XXIII

Total Manufacturing and Non-Manufacturing Costs
Ranking by Site

(U.S. Dollars/ADMT Bleached Kraft Pulp)

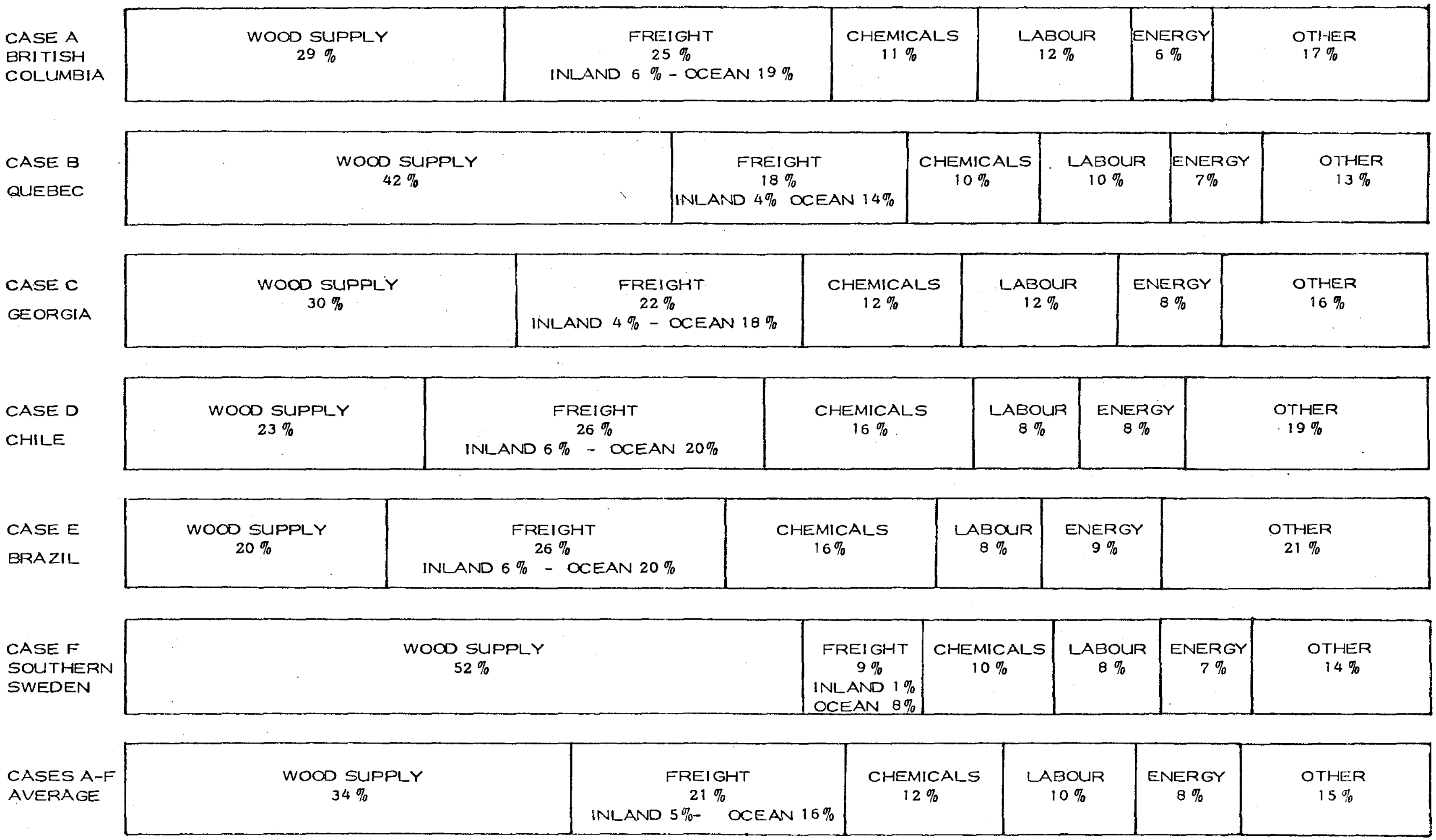
Case E - Brazil	138.4
Case C - Georgia	146.1
Case A - British Columbia	148.3
Case D - Chile	152.6
Case F - Southern Sweden	169.0
Case B - Quebec	173.8

Source: Table XX

CHART 5

TOTAL COST COMPONENTS

(PERCENTAGE OF TOTAL COST)



SOURCE: TABLE XX

The ranking of sites in order of total costs was slightly different from the previous ranking on the basis of manufacturing costs. The site in Brazil ranked lowest in both manufacturing costs and total costs. Although the hypothetical mill in British Columbia possessed the second lowest manufacturing costs, Georgia ranked second in total costs due to lower product transportation costs.

The hypothetical mill in Sweden had the largest manufacturing costs of all sites under consideration, however, in terms of total costs the mill in Quebec ranked highest. In this case, high wood costs at the mill in Sweden were partially offset by low transportation expenses due to its close proximity to the market vis-a-vis producers in the Americas.

6.2 Return on Investment

It was assumed that new export oriented pulp mills in North and South America would be developed by private investors rather than government bodies. From the viewpoint of a private investor, the major influence governing the prospect of each development is its profitability. The traditional criteria of a project's efficiency is measured by the net return on capital employed on the assumption that capital is the limiting factor for which alternative projects must compete. Consequently, in this section, a comparison will be made of the returns on investment for each mill in order to determine the relative attractiveness in terms of profitability.

In this study it was assumed that all hypothetical mills would have the same life span and nearly the same investment schedules. Furthermore, price and cost levels were assumed to remain constant over the lifetime of the projects. For comparative purposes, "snapshot" profitability calculations over a typical one year period were considered to be of sufficient accuracy.[1] These calculations were based on the gross and net return on total investment and the net return on equity capital where:

Gross Return on Total Investment (GRTI)

$$GRTI = \frac{(S - C)\,100}{I}$$

S - net sales
C - manufacturing and non-manufacturing expenses
I - total investment

Net Return on Total Investment (NRTI)

$$NRTI = \frac{(S - D)\,100}{I}$$

S - net sales
D - manufacturing and non-manufacturing expenses plus depreciation, interest on loans, and corporation taxes
I - total investment

Net Return on Equity Capital (NREC)

$$NREC = \frac{(S - D)\ 100}{E}$$

S - net sales
D - manufacturing and non-manufacturing expenses plus depreciation, interest on loans, and corporation taxes
E - equity capital

This method of calculation does not take into account all measures that must be brought to bear when determining the relative attractiveness of a case, as no single methods do. However, it does provide a framework in which major aspects of each case may be evaluated in a coordinated and systematic manner.

In the cases under consideration, depreciation was calculated on a twenty year straightline basis. The amount of equity capital was assumed to be one third of the total investment at each site. Corporation taxes were assumed to be 40 per cent at Sites A and B in Canada, 34 per cent at Case C in Georgia, and 42 per cent at Site F in Sweden. In Latin American countries corporation taxes vary widely and in some cases a new export pulp mill may be tax exempt over lengthy periods. However, for the purpose of this study, corporation taxes at Cases D and E in Brazil and Chile were assumed to be 30 per cent.

The returns on investment for the cases under consideration are presented in Table XXIV. Ranking of sites by returns on investment is shown in the table below.

Table XXIV

Geographic Comparison of the Economics of Pulp Production for the European Market
Net Earnings and Return on Investment

(Thousands of U.S. Dollars)

	CASE					
	A British Columbia	B Quebec	C Georgia	D Chile	E Brazil	F Southern Sweden
Sales	46,000	47,000	44,400	44,400	42,000	47,000
Less Cash Discounts and Rebates	690	705	666	666	630	705
Net Sales	45,310	46,295	43,734	43,734	41,370	46,295
Less – Manufacturing Costs	21,560	27,660	22,120	21,820	19,580	30,200
– Non-manufacturing Costs	8,100	7,100	7,100	8,700	8,100	3,600
Gross Earnings	15,650	11,535	14,514	13,214	13,690	12,495
Less – Depreciation	3,450	3,600	3,500	4,200	4,000	3,550
– Interest on Loans	4,620	4,800	4,680	4,700	4,500	4,740
– Corporation Taxes	3,032	1,254	2,154	1,294	1,557	1,766
Net Earnings	4,548	1,881	4,180	3,020	3,633	2,439
Total Investment	77,000	80,000	78,000	94,000	90,000	79,000
Gross Return on Investment	20.3 %	14.4 %	18.6 %	14.1 %	15.2 %	15.8 %
Net Return on Investment	5.9 %	2.4 %	5.4 %	3.2 %	4.0 %	3.1 %
Net Return on Equity Capital	17.7 %	7.0 %	16.1 %	9.6 %	12.1 %	9.3 %

Source: Tables X, XIX, XX

Table XXV

Return on Investment
Ranking by Case

(Per Cent)

Gross Return on Investment		Net Return on Investment		Net Return on Equity Capital	
British Columbia	20.3	British Columbia	5.9	British Columbia	17.7
Georgia	18.6	Georgia	5.4	Georgia	16.1
Southern Sweden	15.8	Brazil	4.0	Brazil	12.1
Brazil	15.2	Chile	3.2	Chile	9.6
Quebec	14.4	Southern Sweden	3.1	Southern Sweden	9.3
Chile	14.1	Quebec	2.4	Quebec	7.0

Source: Table XXIV

On the basis of the conditions outlined in the model, returns on investment at sites in North America were generally attractive. The highest returns were found at the hypothetical mill in British Columbia where gross return on investment was 20.3 per cent and net return on equity capital was 17.7 per cent. The attractiveness of these returns was primarily a result of very low fibre costs as pulp mills in the interior of British Columbia utilize a high proportion of inexpensive residual wood chips from surrounding forest product operations.

The returns from the case in Georgia were slightly lower than British Columbia. Gross return on investment and net return on equity capital at this site were 18.6 per cent and 16.1 per cent. The competitive advantage of this site also stemmed from relatively low wood costs. On the basis of these returns, sites in British Columbia and Georgia could be considered attractive in terms of export pulp production for the European market under price and cost levels in mid 1973.

In Quebec, gross return on investment was 14.4 per cent and net return on equity capital was 7.0 per cent. These returns were among the lowest of the mills under consideration and reflect high wood costs in eastern Canada. In this case, the European market would be unattractive and production would generally be limited to North American markets.

Returns at the hypothetical mills in Brazil and Chile were lower than the cases in British Columbia and Georgia but higher than Quebec. Gross return on investment was calculated at 15.2 per cent in Brazil and 14.1 per cent in Chile. Net return on equity capital in Brazil and Chile was 12.1 and 9.6 per cent respectively. Low cost plantation wood at these sites tended to buffer increased capital investment requirements; however, on the basis of returns on capital alone, these could only be considered as marginal sites.

The gross return on investment at the site in Sweden was 15.8 per cent and the net return on equity capital was only 9.3%. Despite close proximity to the market in Rotterdam which greatly reduced pulp transport costs, returns were lower than the majority of sites examined in North and South America. This can be attributed to Swedish wood costs which were significantly higher than all other cases under consideration.

In recent years, the pulp industry has been plagued by low returns on investment. This condition was brought about by a weakening of the pulp market due to a downturn in the economies of most of the industrialized nations. Consequently, excess pulp capacity and depressed prices occurred at a time of rapidly rising costs.

A strong recovery in demand in late 1972 was reflected in higher pulp prices. As the worldwide supply demand balance for pulp is continuing to tighten, further price increases above the level outlined in this study will occur by the end of 1973. This will improve the attractiveness of the returns at all sites under consideration and tend to further encourage expansion in market pulp production.

6.3 Qualitative Considerations

Inherent in the approach in the preceding section is the assumption that profitability is the prime factor in the analysis and, consequently, projects will be undertaken if the returns are sufficient to attract investment capital. However, qualitative factors frequently play an important role in locational decision making and must also be taken into consideration when determining a location's prospects. For instance, factors which are qualitative in nature such as the political and economic environment surrounding a proposed development often exert a strong influence on the relative attractiveness of a site and may completely rule out a project that is attractive in terms of profitability.

In this study, the cases in British Columbia and Georgia, which are the two most attractive sites in terms of profitability, are located in areas where economic, social, and political conditions provide an excellent environment for private investment. A strong forest industry base is well established in both areas and the degree of infrastructure required for this type of development is also present. These positive factors are also present at the site in Quebec, however, the low return on investment for export pulp sales from this site tends to rule out development.

On the other hand, political and economic conditions at the cases in Brazil and Chile are subject to a much greater degree of uncertainty. Brazil is currently in a period of rapid economic growth and is experiencing relatively stable political conditions. However, a history of long term stability present at the sites in North America has not been experienced in Brazil which would tend to reduce the attractiveness of this site relative to those in North America.

A climate conducive to private investment is not present in Chile as a period of political instability has dampened economic development. Further development of the pulp industry by private investors at present would likely be ruled out until economic and political conditions stabilize. Of the two Latin American sites under consideration, Brazil presents a much more attractive environment for investment.

In conclusion, the locational decision must be a summation of judgements taking into account both qualititative and quantitative factors. From the viewpoint of the private investor with markets in western Europe, the cases in British Columbia and Georgia are the most attractive in terms of political, social and economic conditions as well as profitability. Although an environment conducive for private investment is present in Quebec, the low returns at this site rule out development.

The case in Brazil is marginal on the basis of profitability and would not be as attractive as British Columbia or Georgia in terms of political, social and economic conditions. Development at the case in Chile must be ruled out at present due to political and economic instability.

VII

CONCLUSIONS

European demand for forest products has increased rapidly in recent years and is expected to continue to rise at a strong rate in the future. The increase in industrial wood requirements is partially a result of growing demand for paper and paperboard products which is reflected in a derived demand for wood pulp, the major component of paper and paperboard products.

Although European forest resources currently support the majority of domestic demands, industrial wood removals are steadily falling behind domestic requirements. According to FAO forecasts, one of the major deficits in European wood resources will be in the form of long fibred pulpwood. In order to supplement fibre production, Europe will be faced with a permanent and growing dependency on pulp imports from other fibre producing areas of the world such as North and South America.

The forest resource in North America could currently support a major increase in domestic consumption and still possess an exportable surplus. Large economically accessible reserves of virgin timber in the northern coniferous forest belt and to a lesser extent stands of hardwood and conifers in the eastern and southern regions are capable of supporting a major increase in export pulp production.

A strong base for forest industry expansion already exists in North America which currently supplies over one half of the world's market pulp and close to one half of the world's paper and paperboard. In addition, the political, social, and economic climate in North America provides an excellent environment for further development of the pulp industry. Considering the risks and uncertainties involved in developing new pulp facilities in many other areas of the world with surplus fibre reserves, North America appears to have a high capacity to satisfy a growing share of European wood pulp demands.

In order to assess the economics of export pulp production in North America, hypothetical bleached kraft mills were examined at sites in the British Columbia Interior, central Quebec, and Georgia. It was assumed that all production would be placed on the European market. The highest returns were found in British Columbia where the gross return on total investment was 20.3 per cent and the net return on equity capital was 17.7 per cent. These attractive returns were primarily a result of very low fibre costs as pulp mills in this region utilize a high proportion of inexpensive residual wood chips from surrounding lumber operations.

The returns at the hypothetical mill in Georgia were slightly less than in British Columbia. Gross return on investment was 18.6 per cent and net return on equity capital was 16.1 per cent. Based on these returns, both cases would support export pulp production for the European market at the level of pulp prices in mid 1973.

At the site in Quebec, gross return on investment and net return on equity capital were 14.4 and 7.0 per cent. The low returns at this site were mainly a result of high wood costs which were approximately 70 per cent greater than the site in British Columbia. On the basis of these returns, the European market would be quite unattractive and production would likely be placed on markets closer to Quebec unless pulp prices increased substantially in the future.

Latin America's potential for entering the international pulp trade in a substantial way at present is not promising. Despite vast forest resources, the majority of the natural reserves in Latin America are either classified as inaccessible or contain a mix of species which are presently unsuitable for pulp production. Natural softwood forests are few and manmade plantations are not large enough at present to sustain both growing domestic and export pulp demands.

The potential for substantial export pulp trade in Latin America lies in the future when forests in the northern temperate zone are more fully utilized and marginal pulpwood costs are higher due to intensified silviculture and harvesting in less accessible areas. At that time, a large portion of the fibre supply for the Latin American pulp industry will likely be drawn from strategically located plantation complexes which have already become a major element in the Latin American forest resource base.

Due to favourable environmental conditions in many areas of Latin America, growth rates within plantations are five to ten times the rates experienced in natural forests of the northern temperate zone where the majority of pulp production is currently concentrated. With a combination of high growth rates, relatively low labour rates, and limited pressure on land, the cost of plantation wood is presently quite low in comparison to roundwood costs in many countries in the northern temperate zone and will likely remain so in the future. With advances in pulping technology, fibre supply from the vast tropical forests may also play an important role in the future development of the Latin American pulp industry.

Both of the hypothetical mills in Latin America were based on plantations. At the site in Brazil, gross return on investment was 15.2 per cent and net return on equity capital was 12.1 per cent. Returns in Chile were slightly lower with a gross return on investment of 14.1

per cent and net return on equity capital of 9.6 per cent. The competitive advantage of these sites stemmed from the utilization of low cost plantation wood. For instance, the wood cost on a per ton of product basis in Brazil was approximately one third that of Sweden. As wood costs in the pulp industry represent a major portion of manufacturing costs, higher costs in South America for inputs such as chemicals, and operating supplies as well as increased capital costs were effectively buffered.

In order to place the returns in proper perspective, the risks and uncertainties inherent in major investment programmes in Latin American countries must be taken into account. For instance, political, social and economic conditions are generally not as conducive to pulp industry development by private capital in Latin America as in the more industrialized areas of the northern hemisphere. Although Brazil is currently in a period of rapid economic growth which is encouraging private investment, a history of long term stability such as found at the sites in North America has not been experienced. A rather perplexing investment climate prevails in Chile as the present political instability has tended to dampen forest industry development.

A less stable investment climate tends to reduce the attractiveness of returns from the viewpoint of a private investor especially when large capital outlays are involved. However, the returns on investment suggest that the cases in Latin America could compete on the European market. Once domestic demands are met and new plantations are established, these areas will likely play a larger role in serving the European pulp market.

In summary, it is probable that North America will continue to supply an increasing share of European requirements as wood resources in North America appear to be of sufficient quantity and quality to supply both export and domestic markets. With a major competitive advantage in wood costs, the pulp industry in selected areas of North America appears capable of successfully competing with Scandinavian countries in European markets despite additional transport costs.

At present, growing domestic demands in Latin America will absorb a large percentage of new pulp capacity. If plantation programs succeed and the relative advantage in wood costs prevails in the future as predicted, the Latin American pulp industry will be in a strong competitive position to supply an expanding share of European pulp requirements.

LIST OF REFERENCES

CHAPTER II

1. Industrial wood includes sawlogs, veneer logs, logs for sleepers, pulpwood, pitprops, poles, piling, posts and other miscellaneous roundwood. It excludes fuelwood used for the purposes of cooking, heating and production of power.

2. Food and Agriculture Organization, United Nations Economic Commission for Europe, European Timber Trends and Prospects - 1950-1980 An Interim Review, Geneva, May 1969, Volume 1, p. 163.

3. Domestic demand is also increasing for lumber, plywood, reconstituted wood panels and other miscellaneous forest products. (See Table 1.)

4. On a worldwide basis, more than 70% of the fibrous materials used to produce paper and paperboard consist of virgin wood pulp. Of the remaining amount of fibrous materials used, about 80% consists of recycled paper and paperboard.

5. Food and Agriculture Organization, United Nations Economic Commission for Europe, European Timber Trends and Prospects - 1950-1980, An Interim Review, Geneva, May 1969, Volume 1, p. 91.

6. Ibid., p. 163.

7. In this case, the European Economic Community includes the original member countries of Belgium-Luxembourg, France, Italy, Netherlands, and Western Germany as well as Ireland and Great Britain, the most recent members. Denmark, another recent member, is excluded as FAO forecasts for this country were aggregated in the Northern European regional grouping.

   Food and Agriculture Organization, United Nations Economic Commission for Europe, European Timber Trends and Prospects - 1950-1980, An Interim Review, Geneva, May 1969, Volume 1, p. 163.

8. Non-integrated paper producers with no backward linkages extending into pulp production and timber supply are heavily dependent upon the volume of pulp placed on the open market.

9. Paper grade pulp includes mechanical, chemical and other pulp used in the manufacture of paper and paperboard products. It excludes dissolving pulp which is a bleached chemical pulp of high alphacellulose content suitable for conversion into rayon, cellophane, lacquers and other specialized non-papermaking uses.

   The following countries are included in Western Europe:

   Austria, Belgium-Luxembourg, Denmark, Federal Republic of Germany, Finland, France, Greece, Iceland, Ireland, Italy, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

   Paper grade pulp consumption forecasts are drawn from the following source:

   Food and Agriculture Organization, Outlook for Pulp and Paper Consumption, Production and Trade to 1985, Advisory Committee on Pulp and Paper, Rome, April 1972, p. 48.

CHAPTER III

1. Forest land in North America covers close to 710 million hectares.

   Food and Agriculture Organization of the United Nations, Supply of Wood Materials for Housing, World Consultation on the Use of Wood in Housing, Secretariat Paper, Section 2, 1971., cited in U.S. Department of Agriculture, The Outlook for Timber in the United States, Forest Resource Report #20, Washington, Forest Service, 1973, p. 133.

2. Loc. cit.

3. Loc. cit.

4. J.A. Zivnuska, "Socio-Economic Factors Shaping the Future of Forestry in North America," Paper prepared for presentation at the Future of Forestry Symposium, University of British Columbia, 18 November 1971.

5. Loc. cit.

6. L. Haas, "World Trends" Pulp and Paper, Vol. 47 (30 June 1973), p. 109.

   Food and Agriculture Organization, Yearbook of Forest Products 1969-70, Rome, 1971, p. 2.

7. American Paper Institute, Monthly Statistical Summary, Vol. 51 (July 1973), p. 12.

   Canadian Pulp and Paper Association, Reference Tables - 1973, Montreal, 1973, p. 10.

8. Canadian Pulp and Paper Association, Reference Tables - 1973, Montreal, 1973, p. 28.

9. The total area under forest cover is estimated to be approximately 900 million hectares.

   Food and Agriculture Organization, "The Forests of Latin America," Paper presented at the Seventh World Congress, Buenos Aires, October 1972.

10. T. Streyffert, World Pulpwood - A Study in the Competitive Position of Pulpwood in Different Forest Regions, Stockholm, Almquist & Wiksell, 1968, p. 65.

11. The remaining 83 per cent of the timber harvest was utilized primarily as fuelwood.

    Food and Agriculture Organization, Yearbook of Forest Product Statistics, 1969-70, Rome 1971, p. 3.

12. D.W. Butts, "LAFTA's Paper Economy - Progress, Problems and Potential," Pulp Paper and Board Quarterly Report, U.S. Department of Commerce, July 1970, p. 7.

13. J.A. Zivnuska, U.S. Timber Resources in a World Economy, Resources for the Future Inc., Maryland, John Hopkins Press, 1967, p.100.

14. According to J.E. Atchison, properties of pulp from various mixtures of tropical hardwoods have proven to be comparable to those of kraft pulps from temperate zone hardwoods.

    J.E. Atchison, "Tropical Forests and Plantations - Key to Future Fibre Shortages?" Paper Trade Journal, Vol. 157 (15 January 1973), p.34.

15. T. Streyffert, World Pulpwood - A Study in the Competitive Position of Pulpwood in Different Forest Regions, Stockholm, Almquist & Wiksell, 1968, p.167.

16. H.H. Keil, "Latin America Must Surmount Many Obstacles in Pulp-Paper Growth," Pulp and Paper, Vol. 44, (August 1970), p.81.

17. Loc. cit.

18. Loc. cit.

19. The annual growth rate of pulp production in the United States over the same period was 5.2 per cent.

    L. Haas, "World Trends," Pulp and Paper, Vol. 47 (30 June 73) p.110.

20. Food and Agriculture Organization, Outlook for Pulp and Paper Consumption, Production and Trade to 1985, Advisory Committee on Pulp and Paper, Rome, April 1972, p.48.

CHAPTER IV

1. By doubling the size of a kraft pulp mill from 400 to 800 tons per day, the number of employees may increase from approximately 245 to 320.

   Estimates by F.L.C. Reed and Associates Ltd., Consulting Economists.

2. The physical differences among species are often sufficiently great to affect the pulping, bleaching, and general papermaking qualities of pulp. Southern pine species utilized in Case C have a higher basic density than the spruce-pine specie mixes used in cases A and F. In general, basic density is closely related to the cell wall thickness of the individual fibres. A lower basic density is associated with a thinner cell wall which greatly facilitates fibre to fibre bonding. This bonding is important for the development of good bursting and tensile strength, folding endurance and other paper strength measures with the exception of tearing resistance. Hence pulp from cases A and F utilizing a low density specie mix may command a higher market price than pulp from Case C.

CHAPTER V

1. See Chart 4.

2. The shipment of wood chips over long distances by ocean transport is a relatively recent development. The volume of chips transported by this method has increased from 184 thousand cubic metres in 1965 to nearly 5 million cubic metres in 1971.

   J.E. Atchison, "Tropical Forests and Plantations - Key to Future Fiber Shortages?" Paper Trade Journal, Vol. 157, (January 15, 1973), p.36.

3. Represents mature timber volumes (18 cm. + dbh, close utilization standards, less decay).

   Government of British Columbia, Forest Inventory Statistics of British Columbia - 1970, Victoria, Forest Service, June 1972, p.8.

4. Government of British Columbia, Financial and Economic Review-1971, Victoria, July 1971, p.42.

5. Loc. cit.

6. Allowable cut based on a 15.2 cm. top, dib.

   Government of British Columbia, Selected Forest Industry Statistics of British Columbia, Victoria, Department of Industry, Trade and Commerce, July 1972, p.7.

7. Ibid., p. 11.

8. Ibid., p. 22.

9. The average wood density is based on the following oven dry densities per cubic metre of green wood:

White spruce	350 kg/m^3
Lodgepole pine	401 kg/m^3

Wood requirements for the production of an air dry metric ton of bleached kraft pulp are calculated as follows:

a) Average wood density

65% white spruce	350 × .65	=	228 kg/m^3
35% lodgepole pine	401 × .35	=	140 kg/m^3
Average wood density		=	368 kg/m^3

b) Wood requirements

- average wood density – 368 kg/m^3
- bleached kraft pulp yield – 43%
- one ton of air dry pulp is equivalent to 0.9 ton of oven dry pulp

$$\frac{1,000 \text{ kg} \times .90}{368 \text{ kg/m}^3 \times .43} =$$ 5.70 cubic metres per air dry metric ton of bleached kraft pulp

10. In 1970 the British Columbia pulp and paper industry consumed 8.8 million cubic metres of pulpwood and 10.4 million cubic metres of wood residue.

Statistics Canada, Pulp and Paper Mills 1970, Catalogue #36-204.

11. P.E. LaChance, "What do we know about the Forests of Quebec," Canadian Pulp and Paper Industry, Vol. 23 (March 1970), p. 36.

12. Ibid., p. 39.

13. L. Lussier, "How Quebec Can Make Better Use of Her Forest Resources," Canadian Pulp and Paper Industry, Vol. 23 (March 1970), p. 34.

14. Statistics Canada, Canadian Forestry Statistics 1970, Catalogue #25-202.

15. Statistics Canada, Pulp and Paper Mills 1970, Catalogue #36-204.

16. Loc. cit.

17. Wood requirements for the production of an air dry metric ton of pulp are calculated as follows:

- average wood density - 400 kilograms/cubic metre
- bleached kraft pulp yield - 43 per cent
- one ton of air dry pulp is equivalent to 0.9 tons of oven dry pulp

$$\frac{1,000 \text{ kg.} \times .90}{400 \text{ kg/m}^3 \times .43} =$$ 5.2 cubic metres per air dry metric ton of bleached kraft pulp

18. The Quebec pulp and paper industry consumed 17.7 million cubic metres of pulpwood and 2.7 million cubic metres of wood residues in 1970.

Statistics Canada, Pulp and Paper Mills 1970, Catalogue #36-204.

19. The Southern States include the following:

Alabama	Oklahoma
Arkansas	South Carolina
Florida	Tennessee
Georgia	Texas
Louisiana	Virginia
Mississippi	North Carolina

U.S. Department of Agriculture, Forest Statistics for the United States by State and Region 1970, Forest Service, 1972, p. 1.

20. Loc. cit.

21. Volume in sound well formed trees that are of commercial species and are larger than 12.7 centimetres in diameter at breast height.

H.S. Sternitzke and J.F. Christopher, "The South: Timber Growth, Trends, Outlook," Pulp and Paper, Vol. 73 (February 1973), p. 76.

22. _Ibid._, p. 77.

23. _Ibid._, p. 77.

24. _Ibid._, p. 77.

25. The Southern Forest Resource Analysis Committee, _The South's Third Forest_, 1969, p. 96.

26. K.E. Lowe, "South: North American Profile 1973," _Pulp and Paper_, Vol. 47 (30 June 1973), p. 31.

27. American Paper Institute, _The Statistics of Paper - 1972_, New York, June 1972.

28. _Loc. cit._

29. Wood requirements for the production of an air dry metric ton of bleached kraft pulp are calculated as follows:

    Average wood density - 450 kg/m^3
    Bleached kraft pulp yield - 43%
    One ton of air dry pulp is equivalent to 0.9 tons of oven dry pulp

    $$\frac{1,000 \text{ kg} \times .90}{450 \text{ kg/m}^3 \times .43} = $$ 4.65 cubic metres per air dry metric ton of bleached kraft pulp

30. A study by the Canadian Pulp and Paper Association indicated that the average transportation distance for pulpwood in the U.S. South is approximately 60 miles in comparison to 90 miles in Western Canada and 156 in Quebec.

    The Council of Pulp and Paper Producers of Quebec, "_The Competitive Position of the Quebec Pulp and Paper Industry_." January, 1972, p. 11.

    Growth in Southern Pine stands normally averages 5-7.5 cords/hectare/year compared to 0.8 cord/hectare/year in the Canadian boreal forests. These rapid growth rates allow a pulp mill to operate on 1/6 to 1/9 the area of forest land required for a Canadian mill.

    M.F. Squires, "Fast Growing Trees and Intensive Forestry in Newfoundland," _Pulp and Paper Magazine of Canada_, Vol. 73 (September 1972), p. 124.

31. Southern Forest Institute, Economic Analysis of the South's Pulp and Paper Industry, December 1971, p. 1.

32. R.F. Billings, E.H. Hosten, and R.I. Gara, "Forest Entomology in Chile: An Example of U.S.-Chilean Cooperation," Journal of Forestry, Vol. 71 (March 1973), p. 164.

33. Food and Agriculture Organization, Pulp and Paper Prospects in Latin America, New York, 1955, p. 212.

34. T. Streyffert, World Pulpwood - A Study in the Competitive Position of Pulpwood in Different Forest Regions, Stockholm, Almqvist and Wiksell, 1968, p. 83.

35. Ibid., p. 70.

36. Food and Agriculture Organization, FAO's Work in the Field of Pulp and Paper, Rome, FAO Advisory Committee on Pulp and Paper, Eighth Session, May, 1967, p. 15.

37. In 1972 Chile exported 98 thousand metric tons of pulp and 42 thousand tons of paper and board.

Pulp and Paper International, 1973 Review Number, Vol. 15 (25 July 1973), p. 171.

38. American Paper Institute, Wood Pulp Statistics, 36th Edition, New York, October 1972, p. 129.

39. Pulp and Paper International, 1973 Review Number, Vol. 15 (25 July 1973), p. 171.

40. American Paper Institute, op. cit., p. 130.

41. The fibre furnish at cases B and F in Quebec and Southern Sweden contains spruce which is considered to be the most desirable softwood species used in the production of pulp.

42. Wood requirements for the production of an air dry metric ton of pulp are calculated as follows:

- Average wood density - 450 kg/m^3
- Bleached kraft pulp yield - 43%
- One ton of air dry pulp is equivalent to 0.9 ton of oven dry pulp

$$\frac{1{,}000\ kg \times .90}{450\ kg/m^3 \times .43} = $$ 4.7 cubic metres per air dry metric ton of bleached kraft pulp

43. T. Streyffert, World Pulpwood - A Study in the Competitive Position of Pulpwood in Different Forest Regions, Stockholm, Almquist and Wiksell, 1968, p. 82.

44. Jaakko Poyry and Company, "An Appraisal of Newsprint Development Opportunities in Latin America," Study prepared for the United Nations Economic Commission for Latin America, January 1970, Annex II, p. 22.

45. J.C. Wallace, "How Latin Americans Look at Wood," Forest Industries, Vol. 99 (February 1972), p. 21.

46. To encourage plantation expansion the Brazilian government approves the use of 35 per cent of corporate income taxes for afforestation. Projects approved since 1966 have provided for the planting of a billion trees in the southern regions of the country.

J.H. Treleaven, "Brazil," Canada Commerce, Vol. 136 (September 1972), p. 13.

47. Pulp and Paper International, "1973 Review Number," Vol. 15 (25 July 1973), p. 167.

48. Loc. cit.

49. Wood requirements for the production of an air dry metric ton of bleached kraft pulp are calculated as follows:

- Average wood density - 520 kg/m^3
- Bleached kraft pulp yield - 46%
- One ton of air dry pulp is equivalent to 0.9 ton of oven dry pulp

$$\frac{1{,}000\ kg \times .90}{520\ kg/m^3 \times .46} = $$ 3.8 cubic metres per air dry metric ton of bleached kraft pulp

50. Official Statistics of Sweden, "Statistical Yearbook of Forestry, cited in American Paper Institute, Wood Pulp Statistics, 36th Edition, New York, Pulp and Raw Materials Group, October, 1972.

51. T. Streyffert, World Pulpwood - A Study in the Competitive Position of Pulpwood in Different Forest Regions, Stockholm, Almquist and Wiksell, 1968, p. 97.

52. K. Kilander, "How Best to Use Swedish Forests," Pulp and Paper International, Vol. 14 (July 1972), p. 34.

53. Loc. cit.

54. Pulp and Paper International, "1973 Review Number," Vol. 15 (25 July 1973), p. 71.

55. Loc. cit.

56. T. Streyffert, World Pulpwood - A Study of the Competitive Position of Pulpwood in Different Forest Regions, Stockholm, Almquist and Wiksell, 1968, p. 98.

57. Wood requirements for the production of an air dry metric ton of bleached kraft pulp are as follows:

- average wood density - 385 kilograms per cubic metre
- bleached kraft pulp yield - 43 per cent
- one ton of air dry pulp is equivalent to 0.9 tons of oven dry pulp

$$\frac{1,000 \text{ kg} \times .90}{385 \text{ kg/m}^3 \times .43} = \text{5.4 cubic metres per air dry metric ton of bleached kraft pulp}$$

58. K. Kilander, "How Best to Use Swedish Forests," Pulp and Paper International, Vol. 14 (July 1972), p. 34.

59. W.E. Haviland, N.S. Takacsy, E.M. Cape, Trade Liberalization and the Canadian Pulp and Paper Industry, Private Planning Association of Canada, University of Toronto Press, 1968, p. 11.

60. Based on the consumption of 42,900 gallons of water per air dry ton of pulp.

J.W. Walter, "Water Quality Needs in the Pulp and Paper Industry," Paper Trade Journal, Vol. 154 (6 July 1970), p. 38.

61. Estimate by H. A. Simons (International) Ltd., Consulting Engineers.

62. For instance, the establishment of new kraft pulp mills is banned in certain inland areas of Southern Sweden.

63. Water pollution from the pulp industry consists primarily of debarking and screening effluent, pulp particles lost in washing and other production stages and small amounts of chemicals which are not economically feasible to recover.

64. "Canadian Industry Viewpoint on Air and Water Pollution," Paper Trade Journal, Vol. 154 (6 July 1970), p. 38.

65. Estimate by F. L. C. Reed and Associates Ltd., Consulting Economists

66. Estimates by F. L. C. Reed and Associates Ltd., Consulting Economists

67. High pressure steam generated in a power boiler would be reduced to process pressure in a steam turbine. Electric power would be obtained as a byproduct.

68. Estimate by H. A. Simons (International) Ltd., Consulting Engineers.

69. Estimate by F. L. C. Reed and Associates Ltd., Consulting Economists.

70. Power generated from bark in Balance A is based on the assumption that close to one half of the fibre supply delivered to the hypothetical mill is in the form of unbarked roundwood and the remainder in the form of chips. In Balance B it is assumed that 85 per cent of the mill's fibre supply is in the form of unbarked roundwood and the remainder in chips.

71. Estimate by F. L. C. Reed and Associates Ltd., Consulting Economists.

72. Based on a natural gas heat value of 277 cal./ft.^{3}

73. Estimate by F. L. C. Reed and Associates Ltd., Consulting Economists.

74. Based on a fuel oil heat value of 1.59 mmCal/bbl.

75. E. Weinberg, Impact of Technological Change and Automotation in the Pulp and Paper Industry, U.S. Department of Labour Bulletin #1347, Washington, October 1962, p.11.

76. Estimate by F.L.C. Reed and Associates Ltd., Consulting Economists.

77. J.A. Datas Panero, Economic Aspects of the Pulp and Paper Industry with Special Reference to Developing Countries, Economics Department Working Paper #51, International Development Association, International Bank for Reconstruction and Development, 1969, p.34.

78. Based on confidential data obtained from three pulp mill feasibility studies in North America.

79. Investment costs were lower in Brazil than Chile as a considerable amount of pulp mill equipment is manufactured in Brazil.

80. Price Waterhouse & Company, Information Guide for Doing Business in Brazil, July 1972, p.6.

81. Government of British Columbia, The British Columbia Forest Industry, Its Direct and Indirect Impact on the Economy, Department of Lands, Forests and Water Resources, 1973, p.48.

82. Lindow, H.A., "Brazil," Commerce Today, U.S. Department of Commerce, Vol. 3 (23 July 1973), p.15.

CHAPTER VI

1. If detailed investment decisions were required, more sophisticated techniques would be used to indicate the present value of future revenue and expenditure flows.

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