EMPLOYMENT AND TECHNIQUE CHOICE:

CANADIAN PULP AND PAPER

THE EMPLOYMENT EFFECTS OF TECHNIQUE CHOICE: THE CANADIAN PULP AND PAPER INDUSTRY 1951-1973

by

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ABSTRACT

Three central considerations form the basis of the present thesis. The first of these concerns the effects of technique choice on employment patterns in the Canadian pulp and paper industry over the period 1951 to 1973. The second relates to the fundamental determinants of technique choice of the same period. The final deals with the prediction of changes in employment patterns related to changes in technique choice, over the next decade.

The theoretical specification, used in the analysis of the technique choice effects on employment patterns, represents a departure from the Neoclassical analyses of productivity and employment determination. Specifically, the methodology and assumptions utilized avoid the major theoretical and empirical problems which are embodied in the Neoclassical analysis.

The basic predictions resulting from the theoretical and empirical analysis of the employment pattern effects of technique choice could be summarized as follows. At the national level, a much faster decline, relative to the 1951 to 1973 period, seems quite likely over the next decade. The trend in employment per unit output, will moreover involve a compositional shift to relatively higher skilled employment. At the regional level, the past employment per unit output level and structure differential, between the eastern and western sectors, will be reduced. A relatively faster decline in employment per unit output, accompanied by a more marked shift to higher skilled employment, in the eastern sector underlies this prediction.

PRECIS

Trois considérations nous ont portés à cette étude. D'Abord, nous avons expliqué comment, dans l'industrie canadienne de la pâte à papier et du papier, la structure technique détermine celle de l'emploi, pour la période de 1951 à 1973. Ensuite, nous avons voulu indiquer les déterminants fondamentaux de la structure technique. En dernier lieu, nous avons tenté de prévoir les modifications dans la structure de l'emploi qui sont directement liées aux changements dans la structure technique. Ces prédictions ont envisagé la décennie à venir.

Afin d'analyser les effets que la structure technique a eu sur la structure de l'emploi, nous nous sommes éloignés de la démarche néo-classique concernant la détermination de la productivité et de l'emploi. En d'autres termes, notre méthodologie et nos hypothèses ont eu pour but d'éviter les problèmes théoriques et empiriques qu'incarne l'analyse néo-classique.

Nous avons résumé les prédictions qui résultent de notre analyse théorique et empirique de la façon suivante. Sur le plan national, nous avons prévu un declin dans la proportion entre emploi et production beaucoup plus rapide que celui qui s'est produit dans la période de 1951 à 1973. De plus, cette nouvelle orientation nous a semblé manifester un mouvement vers une plus large compétence technique dans la composition de l'emploi. Sur le plan régional, nous avons vu que les différences dans la proportion entre emploi et production seraient réduites entre les secteurs de l'est et de l'ouest. Cela est à cause d'un déclin relativement plus rapide dans le secteur de l'est dans la proportion entre emploi et production, accompagné d'une orientation prononcée vers la compétence technique.

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INTRODUCTION

Three central considerations form the basis of the present thesis. The first of these concerns the effects of technique choice[1] on employment patterns in the Canadian pulp and paper industry over the period 1951 to 1973. The second relates to the fundamental determinants of technique choice over the same period. The final, and most interesting, deals with the prediction of changes in employment patterns related to changes in technique choice, over the next decade.

The examination of employment patterns and their determinants solely at the national level would almost certainly result in the derivation of rather limited conclusions. During the course of the study, it should become evident that the analysis must also differentiate between the eastern and western sectors of the industry, due to the markedly different structural and technical characteristics of these sectors. In the analysis, the eastern sector is defined to include Quebec, Ontario and the Maritime provinces and the western sector to consist of British Columbia and the Prairie provinces.

The fundamental differences existing in the respective sectors of the industry are primarily related to variations in product-structures, cost-revenue structures and in age structures of mills and machinery. In terms of

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[1] Technique choice is here defined to include both the decision to implement and the actual implementation of a certain technique or process of production. A more comprehensive definition of the term technique will be given at a later point in the introduction.

the differences in product structure, the eastern sector of the industry tends to concentrate on the production of mechanical pulp (for shipment to other mills in Canada and/or for export abroad) and mechanical pulp related papers and paperboards, such as newsprint and groundwood printing and specialty papers. On the other hand, the western sector of the industry tends to produce more chemical pulp and chemical pulp related papers and paperboards. Second, as regards the respective age structures of mills and machinery, the western sector of the industry tends to consist of newer and higher capacity mills and, consequently, utilizes more modern techniques of production.[2] Finally, revenue (demand) and cost patterns have produced a relatively more expansive situation in the western sector of the industry, which would tend to imply differences in investment and technique choice patterns between the two sectors of the industry. In light of the above considerations, we might expect rather marked differences in both the type of techniques used in mills and in the type and size of mills in the respective sectors of the industry and, consequently, in the respective employment structures. Therefore, to the extent that the required data are available, the employment pattern of the eastern and western sectors of the industry will be examined.

In light of the above stated objectives of the study, we can speculate on some of the practical deductions that result from the analysis. First some understanding will derive as to why employment in the Canadian pulp and paper industry has been increasing at relatively slower rates in the 1960's, as compared to the pre-1960's periods, and has even been decreasing

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[2] The terms technique of production and production process are defined in the broad sense to include the specific machinery, employment, materials and organization used to produce a given type of output.

in the 1970's. The two important questions, here, are related to the technique choice effects on employment patterns and the sectoral composition characteristics of these effects. These would appear to be rather important questions given the fact that the pulp and paper industry has traditionally been considered a leading employment sector in Canada and especially in Quebec and Ontario. Second, in anticipating changes in technique choice over the next decade, some insight may be offered as to whether the prevalent employment patterns of the 1951 to 1973 period may be expected to continue over this period.

The specific analysis is carried out in five basic sections. The first and second sections briefly discuss the necessary definitional, historical, institutional, structural and technical background material to be used in explaining and predicting the employment pattern effects of technique choice. Section I offers a definition of the relevant product sector and a discussion of the product and organizational structure of the industry and of the labour organizations within the industry. The second section deals primarily with the technical structure within the industry and its implications for the employment structure. First, it offers a brief description of the existing techniques of production (and the related machinery or equipment) available to produce the various types of output. Second, it outlines the more fundamental changes that have taken place in the basic techniques and machinery over the period 1951 to 1973. Moreover, various changes that have not yet been implemented on a commercial and/or large scale basis in the industry, but that are anticipated to have a potentially important role over the next decade, are also considered in this section. Finally, the section discusses the related

employment structure of the various techniques, dealing specifically with the extent and nature of employment offered by each technique of production.

Section III explains the employment pattern effects of technique choice in the Canadian pulp and paper industry, over the period 1951 to 1973, primarily on the basis of the material presented in the first two sections. First, a hypothesis is presented and its relation to existing theories of employment determination is discussed. Second, the basic aspects of the national and regional employment per unit output structures[3] are analyzed in terms of this hypothesis. At both the national and regional levels, the secular and cyclical patterns in employment per unit output are considered. Moreover, at the regional level, differences in the levels of employment per unit output are analyzed.

Next, in section IV, we will identify the fundamental explanatory variables or determinants of technique choice over the period 1951 to 1973. In this section, the analysis will tend to rely more heavily on theoretical considerations relating to decisions concerning technique choice and investment. However, institutional, historical and industrial structure factors play an important role, here, too. In this section, as in section III, the analysis will be carried out at both the national and regional levels of the industry.

Finally, in section V, an attempt will be made to utilize the various relationships developed in sections III and IV in order to anticipate changes in employment per unit output structures related to technique choice,

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[3] As will become clear in the analysis, the variable employment per unit output is used in order to be able to isolate the effects of technique choice on employment patterns from the effects of output changes.

over the next decade. Again, at both the national and regional levels of analysis, the secular and cyclical patterns in employment per unit output will be considered. Moreover, at the regional level, the trend in the sectoral difference in the level of employment per unit output will also be examined. Unfortunately, the analysis must be carried through using alternative assumptions about trends in demand or output growth, since an analysis of the determinants of demand would run beyond the bounds of the present study. This section will also serve as a summary and conclusion of the thesis.

I. THE PRODUCT AND ORGANIZATIONAL STRUCTURE

The first two sections of this thesis basically present relevant background material necessary to analyze employment per unit output trends in terms of their determinants and changes in these determinants. In this section specifically, the organizational, historical and product structures of the Canadian pulp and paper industry will be discussed, both at the national and regional levels. First, a definition of the relevant product sector will be outlined. Second, a historical and product examination of mills in the industry will be presented and existing mill-firm structures will be discussed. Finally, a description of the degree of unionization and of its organizational structure will be outlined.

1. Definition of the Product Sector

The relevant product sector must be defined in order for the structural limits of the analysis to be made clear. The definition of the product sector for the purposes of this study, is derived directly from the Standard Industrial Classification (S.I.C.) 271 category, listed as Pulp and Paper Mills. As it is described in Statistics Canada publications,[4]

> "The Pulp and Paper Mills Industry includes pulp mills producing chemical and mechanical pulp; and combined pulp and paper mills and paper mills manufacturing newsprint, book and writing paper, Kraft paper, paperboard and building and insulation board."

A complete detailed listing of the relevant pulp, paper and paperboard products

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[4] Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual), p. 1.

appears in Table 1. Excluded from this definition are all forestry and paper converting operations, such as Asphalt Roofing Manufacturers, Manufacturers of Folding Cartons and Set-Up Boxes, Manufacturers of Corrugated Boxes, Paper Bag Manufacturers and Miscellaneous Paper Converters, all of which are included in the Paper and Allied Industries Classification, S.I.C. 510. This specific classification was selected for two interrelated reasons, one substantive and the other practical. On the one hand, during the period under consideration, it appears that employment structures resulting from specific techniques used have differed, and are expected to differ, most drastically in pulping and related activities (specifically the wood room operations in mills), as opposed to the paper and paperboard manufacturing activities. As such, in attempting to analyze the employment effects of technique choice, this area of the pulp and paper industry is the most interesting and relevant one. However, in terms of reporting establishments, the S.I.C. 271 category represents the smallest or most basic unit for which the relevant data on employment and several of its determinants are available and, therefore, sets the practical limit to which the analysis is tied.

Within this specific product sector, we can proceed to examine the product, organizational and, to a certain extent, historical structure of the Canadian pulp and paper industry. Given the importance of the sectoral composition and its implications for the national structure, the analysis will also examine the various relevant sectoral structural characteristics. The discussion will serve to set the basis for the analysis of organizational behaviour factors related to technique choice, such as the degree of vertical integration of mills, the average size of mills (relating to the

TABLE 1

PULP, PAPER AND PAPERBOARD PRODUCTS COMPRISING THE S.I.C. 271 CATEGORY; PULP AND PAPER MILLS

A. Pulp

1. dissolving and special alpha
2. sulphate paper grades
   - bleached softwood
   - bleached hardwood
   - semi-bleached
   - unbleached
3. sulphite paper grades
   - bleached
   - unbleached, strong
   - unbleached, news grade
4. mechanical (groundwood; semi-chemical)
   - bleached
   - unbleached
5. other pulps
   - screenings
   - defibrated/exploded

B. Newsprint

1. standard
2. mutilated

C. Paper

1. book, writing, and other printing paper
   - groundwood printing and specialty papers
   - hanging, not printed
   - paper for printing
   - writing and reproduction
   - base stock for coated printing paper
   - fine paper
2. tissue paper, except sanitary
3. sanitary paper
4. wrapping paper
   - bleached sulphite and sulphate
   - unbleached sulphite and sulphate
   - miscellaneous furnishes
   - wrapping
5. waste paper

TABLE 1 (continued)

D. Paperboard (including building board)

1. liner board
2. container board
3. solid bleached and folding boxboard
4. set-up boxboard
5. paperboard
6. rigid insulation board
7. hardboard
8. building board
9. wet machine board
10. roofing and building paper
11. asphalt shingles

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204.

nature of investment decisions) and the pattern of research and development and the resulting technical change. These variables and their effects on employment per unit output patterns will be analyzed in detail in sections III and IV.

2. The Product Structure

A proper discussion of the product structure in the Canadian pulp and paper industry would require a consideration of the relevant trends in both the number of firms and/or mills producing the basic output types in the various regions and the relative levels of production of the basic output types in the various regions of the industry. In this subsection, the former trends will be considered in greater detail. The trends in the relative levels of production of the basic output types will be considered more explicitly in section III, where the determinants of employment per unit output patterns will be analyzed. In this subsection, we will only outline the more fundamental conclusions that will be derived from that analysis. The reason for considering only one aspect of the product structure, here, is that we are interested initially in understanding the historical and regional growth of the industry in terms of the number and type of firms and/or mills.

A second preliminary note relates to the relevant periods of analysis to be used in this subsection and in subsequent sections. In the analyses concerning the national level of the industry, the relevant period is 1951 to 1973. However, due to various data constraints[5], the longest period

[5] Specifically, the data that are not readily available prior to 1961 are the raw data, for some provinces, to calculate output and the data relating to output composition by province or sector. The importance of these variables will become evident in Section III.

for which all the relevant data are available for the eastern and western sectors of the industry is 1961 to 1972. Therefore, although the relevant product structure data (and various other data to be used) are available for years prior to 1961, they will not be analyzed in this study.

Tables 2 and 3 present a breakdown of pulp, pulp and paper, and paper producing mills for the entire industry and for the eastern and western sectors, respectively. Unfortunately, comprehensive and reliable data are only available at the mill level and not at the firm level, where output structure decisions would tend to originate. Although this does present difficulties, an attempt will be made (later in this subsection) to examine mill-firm relationships in the industry, in order to be able to better understand the nature of output structure decisions at the mill level.

From the data in Table 2, the basic trends in the growth in the number and type of mills at the national level can be derived. These results are summarized in Table 4. First, in terms of the total number of mills in the industry, the relative increases were greatest in the 1970's, (i.e. 1969 to 1973) and were greater in the 1960's (i.e. 1960 to 1969) than in the 1950's (i.e. 1951 to 1960). The average annual percentage increase over the period 1951 to 1973 was 0.93%. In comparison to this, the increases for the periods 1951 to 1960, 1960 to 1969, and 1969 to 1973 were 0.16%, 0.78% and 2.25% respectively. Similar results are derived if the average number of mills per period, are considered, in each of the four periods. Second, with respect to the output composition of mills, several conclusions can be drawn. Over the entire period, 1951 to 1973, pulp and paper producing mills represented the largest proportion of mills by a substantial margin. An examination of the average number of mills by product type, over this

TABLE 2

MILL LOCATIONS BY OUTPUT TYPE AND REGION (CANADA) 1951-1973

	Pulp	Pulp and Paper	Paper	Total
1951	34	66	26	126
1952	34	68	26	128
1953	34	69	24	127
1954	31	69	25	125
1955	31	69	25	125
1956	31	70	25	126
1957	31	72	25	128
1958	30	74	24	128
1959	27	74	26	127
1960	25	77	26	128
1961	27	74	24	125
1962	28	73	24	125
1963	28	74	24	126
1964	31	75	25	131
1965	29	74	29	132
1966	30	78	28	136
1967	31	79	28	138
1968	33	79	27	139
1969	35	71	31	137
1970	37	71	32	140
1971	31	83	29	143
1972	34	78	32	144
1973	36	82	37	155

Source: Canadian Pulp and Paper Association, Reference Tables (Annual).

TABLE 3

MILL LOCATIONS BY OUTPUT TYPE AND REGION (EAST-WEST) 1961-1972

East

	Pulp	Pulp and Paper	Paper	Total
1961	19	62	23	104
1962	20	61	23	104
1963	20	62	23	105
1964	23	63	24	110
1965	20	63	27	110
1966	20	64	26	110
1967	21	66	26	113
1968	20	66	25	111
1969	22	59	28	109
1970	23	59	29	111
1971	20	67	26	113
1972	19	64	30	113

West

	Pulp	Pulp and Paper	Paper	Total
1961	8	12	1	21
1962	8	12	1	21
1963	8	12	1	21
1964	8	12	1	21
1965	9	11	2	22
1966	10	14	2	26
1967	10	13	2	25
1968	13	13	2	28
1969	13	12	3	28
1970	14	12	3	29
1971	11	16	3	30
1972	15	14	2	31

Source: Canadian Pulp and Paper Association, Reference Tables (Annual).

TABLE 4

TRENDS IN MILL LOCATION BY OUTPUT TYPE (CANADA) 1951-1973

Period	Pulp	Pulp and Paper	Paper	Total
1. Average Annual Percentage Change				
1951-1973	0.37	1.06	1.78	0.93
1951-1960	-2.95	1.56	0.08	0.16
1960-1969	2.79	-0.32	2.03	0.78
1969-1973	2.22	1.18	6.92	2.25
2. Mean (Number of Mills)				
1951-1973	31.22	73.87	27.04	132.13
1951-1960	30.80	70.80	25.20	126.80
1960-1969	29.70	75.40	26.60	131.70
1969-1973	34.60	77.00	32.20	143.80
3. Proportion in Total Mills				
1951	26.98	52.38	20.64	-
1973	23.23	52.90	23.87	-
Mean 1951-1973	23.63	55.91	20.46	-
Mean 1951-1960	24.29	55.84	19.87	-
Mean 1960-1969	22.55	57.25	20.20	-
Mean 1969-1973	24.06	53.55	22.39	-

period, indicates that 55.91% of total mills were pulp and paper producing mills while 23.63% and 20.46% were pulp producing and paper producing mills, respectively. However, in terms of relative growths of mills by output type, over this same period, pulp and paper producing mills ranked second to paper producing mills. The average annual percentage increases were 1.78%, 1.06% and 0.37% in paper producing, pulp and paper producing, and pulp producing mills, respectively. Similar results are derived by comparing the proportion of each mill type in 1973 to their proportions in 1951. The growth pattern of each mill type were, however, quite different over the specific subperiods. Over the period 1951 to 1960, the greatest relative increases were in the pulp and paper producing mills, followed by the paper producing mills. The average annual percentage increases were 1.56% and 0.08%, respectively. Pulp producing mills actually declined in number over this period at an average annual rate of 2.95%. Over the period 1960 to 1969, pulp producing mills increased at the fastest rate, followed by paper producing mills. The average annual percentage increases were 2.79% and 2.03%, respectively. Pulp and paper producing mills declined at an average annual rate of 0.32%. Similar patterns, for this period, can be derived by a comparison of the average number of mills and/or the proportion of each mill type in total mills over the periods 1951 to 1960 and 1960 to 1969. Finally, over the most recent period 1969-1973, paper producing mills exhibited the greatest increase, followed by pulp producing and pulp and paper producing mills. The average annual percentage increases were 6.92%, 2.22% and 1.18%, respectively. Again, similar patterns are evident in a comparison of the average number of mills and/or the

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[6] The specific sub-periods were selected due to their relation to the cyclical pattern in output in the industry. As will be seen in section III, the periods 1951 to 1960 and 1960 to 1969 comprise two cycles each, while the period 1969 to 1973 is comprised of one cycle. Over the period 1951 to 1973, the average length of cycles was approximately five years.

proportion of each mill type in total mills over the periods 1960 to 1969 and 1969 to 1973.

The basic trends in the growth in the number and type of mills in the eastern and western sectors of the industry are summarized in Table 5. First, in terms of the total number of mills, the eastern sector of the industry represented a markedly larger proportion than the western sector, in the total mills in Canada. Over the period 1961 to 1972, the average number of mills per year in Canada was 134.66. Of these, 109.41 were located in the eastern sector and 25.25 in the western sector. However, the western sector expanded relatively much faster than the eastern sector over this period. The average annual percentage increase in Canada was 1.00% between 1961 and 1972. In comparison, the western sector increased at an average annual rate of 3.45%, while the eastern sector expanded only at a rate of 0.40%. Second, with respect to the output composition of mills, pulp and paper producing mills represented the largest proportion of total mills in both sectors, however, their share in both sectors decreased over the period. In the eastern sector, the average annual number of pulp and paper producing mills over the 1961 to 1972 period was 57.58. Compared to this, the average annual number of paper producing and pulp producing mills was 23.61 and 18.81, respectively. In the western sector, the average annual number of pulp and paper producing mills was slightly lower, at 50.50. Moreover, on the average, pulp producing mills were markedly more prevalent than paper producing mills. The average annual number of pulp producing and paper producing mills was 41.94 and 7.56 respectively. In terms of the secular patterns, the greatest expansion in the eastern sector was in the number of

TABLE 5

TRENDS IN MILL LOCATION BY OUTPUT TYPE (EAST-WEST) 1961-1972

Period and Region	Pulp	Pulp and Paper	Paper	Total
1. Average Annual Percentage Change				
Canada				
1961-1972	2.87	0.30	2.04	1.00
East				
1961-1972	-0.09	0.27	2.15	0.40
West				
1961-1972	11.35	0.89	5.56	3.45
2. Mean (Number of Mills)				
Canada				
1961-1972	31.17	75.75	27.75	134.66
East				
1961-1972	20.58	63.00	25.83	109.41
West				
1961-1972	10.59	12.75	1.91	25.25

TABLE 5 (continued)

Period and Region	Pulp	Pulp and Paper	Paper	Total
3. Proportion in Total Mills				
Canada				
1961	21.60	59.20	19.20	-
1972	23.61	54.17	22.22	-
Mean 1961-1972	23.43	56.04	20.53	-
East				
1961	18.27	59.62	22.11	(83.20)
1972	16.81	56.64	26.55	(78.47)
Mean 1961-1972	18.81	57.58	23.61	(81.25)
West				
1961	38.10	57.14	4.76	(16.80)
1972	48.39	45.16	6.45	(21.53)
Mean 1961-1972	41.94	50.50	7.56	(18.75)

Note: Bracketed figures relate the proportion of total mills in the east and/or west to the total mills in Canada.

paper producing mills, followed by the pulp and paper producing mills. The average annual percentage increases were 2.15% and 0.27%, respectively. Pulp producing mills decreased at an average annual rate of 0.09%. The trends in the western sector were quite different. The number of pulp producing mills exhibited the greatest increase, followed by the paper producing and the pulp and paper producing mills, respectively. The related average annual percentage increases were 11.35%, 5.56% and 0.89%, in each case. Similar secular trends can be derived for the eastern and western sectors by comparing the proportions of each mill type in total mills in 1961 and in 1972.

In considering the product structure in terms of the relative levels production of each output type, the product breakdown must become more specific.[7] The reason for this is related to the technical and employment structure of the industry, which will be discussed in detail in section II. Moreover, the relevant data are available only at the national level and a proxy variable is used for the sectoral analysis. The basic trends at the national level are derived from Table 10. First, over the period 1951 to 1973, the ratio of chemical pulp and predominantly chemical pulp using paper and paperboard production to total production increased markedly. Second, this ratio increased at an increasing rate over this period. With respect to eastern and western sectors of the industry, the relevant data are presented in Table 19. Over the period 1961 to 1972, the western sector produced relatively more chemical pulp and predominantly chemical pulp using paper and paperboard, while the eastern sector

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[7] The two basic product classifications, here, are chemical pulp and predominantly chemical pulp using paper and paperboard production, and groundwood pulp and predominantly groundwood pulp using paper and paperboard production, which includes newsprint production.

concentrated a relatively greater proportion of production on groundwood pulp, groundwood printing and specialty papers, and newsprint.

3. The Age and Size Structure

In proceeding to the age and size structure of the Canadian pulp and paper industry, it should be noted that very little specific description is possible. In terms of the age structure, the data on the type and age of machinery, although available to some extent,[8] are not comprehensive and detailed enough to render meaningful results. The only inference that could be made, from the data available and from a general understanding of developments in the industry, is that the western sector of the industry had developed more recently than the eastern sector and, as such, would tend to consist of newer and more automated mills and machinery.

With respect to the size structure of the Canadian pulp and paper industry, no comprehensive and reliable data on productive capacity exist for the eastern and western sectors of the industry and data only from the late 1960's and onwards are available at the national level. However, Tables 13 and 21, which relate average production of mills at the national and regional levels respectively, can be used as proxy variables in attempting to understand the size structure of the industry. Although the data in these tables will be analyzed in section III, certain conclusions can be discussed here. First, at the national level, Table 13 indicates that average production per mill increased substantially over the period 1951 to 1973. Moreover, the rate of growth for the period 1960 to 1969 was markedly greater than the rate of growth for the period 1951 to 1960,

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[8] National Pulp and Paper Directory (Annual).

while the rate of growth for the period 1969 to 1973 dropped below that of the period 1951 to 1960. Second, at the regional level, it is clear from the data in Table 21 that the average production of mills in the western sector was higher than that of the eastern sector, over the period 1961 to 1972. Moreover, absolute differences in average production tended to increase, albeit slightly, over this same period. The basic explanation that can be given for these patterns is again related to the more recent development in the western sector. Simply stated, newer mills have tended to imply newer techniques and machinery which, in turn, have tended to imply higher capacity techniques and machinery. However, it is essential to remember that relatively more favourable economic conditions are the underlying assumption in the latter explanation, insofar as they are the basic determinants of changes in investment and technique choice.

4. The Organizational Structure

Most of the discussion to this point has been at the mill level. However, as was mentioned earlier, it is felt that the various relevant decisions tend to be more centralized, along firm lines ratherthan along mill lines. Given the fact that most of the relevant data in sections III and IV are also available only at the mill level, an examination of firm-mill relationships would appear to be necessary in order to better understand the nature of these basic decisions at the mill level. More specifically, it is felt that an understanding of concentration in the industry will give some insight into the relation between the firm and mill levels of analysis.

In terms of the published data, concentration data are available

for employment structures only at the mill level.[9] The basic problem with the data is that they do not give an indication of the concentration of control of employment decisions and other fundamental decisions, such as those related to product structure, extent of vertical integration in mills, investment and technique choice, all of which can affect the employment structure.

However, the National Pulp and Paper Directory[10] publishes capacity figures in tons, annually, for over ninety per cent of the mills in the industry and, furthermore, lists these mills by firm. By aggregating the data across firms, a rough measure of capacity concentration along firm lines can be derived. Several problems do however exist in this measure of concentration. First, the resulting data represent only concentration of productive capacity in tons and not of the value of total sales or the implied value of total capacity. As such, the price differences, to whatever extent they exist between product types and between firms, are not considered. Second, the product breakdown (with meaningful results) is restricted to pulp; paper and paperboard; and total pulp, paper and paperboard production. This is due to the fact that in many cases no distinction is made between newsprint, fine papers and paperboards in the reporting of productive capacities of mills. Third, the prevalence of inter-regional firms limits the usefulness of the resulting data to the national level of analysis. Moreover, the data are only available between the period 1961 and 1973. Finally, a different proportion of mills and firms represents the reporting units in the two sample years, 1961 and 1973. Although

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[9] Statistics Canada, Type of Organization and Size of Establishment, Cat. 31-210 (Annual).

[10] National Pulp and Paper Directory (Annual).

these problems do exist, it is felt that they do not substantively affect the results and that the resulting data do, in fact, give a rough indication of the concentration of decision making structures in the Canadian pulp and paper industry.

The conclusions to be derived concern the level of concentration in the Canadian pulp and paper industry and the secular patterns in terms of concentration. For the year 1961, 45 pulp producing and 50 paper and paperboard producing firms represented the reporting sample. In terms of total firms reporting, the number was 73.[11] The pulp and paper and paperboard productive capacity of these firms was 7,953,150 and 11,971,720 tons, respectively, and the total productive capacity was 19,924,870 tons. With respect to the pulp producing firms, the top 5% of the firms (i.e. the 3 largest) represented 29.97% of the total pulp productive capacity. The top 10% (i.e. 5 firms) represented 41.10% of productive capacity. Finally, the top 25% and 50% of the firms (i.e. 12 and 23 firms) represented 68.03% and 88.09% of productive capacity, respectively. In terms of the paper and paperboard producing firms, the concentration figures are somewhat higher. The top 5% and 10% of the firms (i.e. 3 and 5 firms) represented 33.77% and 46.06% of total paper and paperboard productive capacity, respectively. The top 25% and 50% of firms (i.e. 13 and 25 firms) represented 72.89% and 93.83% of productive capacity, respectively. Finally, in terms of total productive capacity, the top 5% and 10% of firms (i.e. 4 and 8 firms) represented 34.04% and 49.20%

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[11] In many cases, an individual firm produces both pulp and paper and paperboard products.

of productive capacity, while the top 25% and 50% of firms (i.e. 19 and 37 firms) represented 75.05% and 91.30% of total productive capacity, respectively.

In 1973, the number of reporting firms decreased in each of the basic product classifications. This fact was basically due to an increasing trend towards mergers amongst firms in the industry. Forty-three pulp producing firms and forty-eight paper and paperboard producing firms comprised the reporting sample in the latter year. This represented a total of 70 reporting firms. Pulp productive capacity in this year was 12,287,520 tons while paper and paperboard productive capacity was 17,872,310 tons. Total productive capacity in the industry, therefore, was 30,159,830 tons. The top 5% and 10% of pulp producing firms (i.e. the 3 and 5 largest) comprised 24.35% and 34.78% of total pulp productive capacity, while the top 25% and 50% of these firms represented 56.84% and 80.73% of productive capacity, respectively. In terms of paper and paperboard production, the top 5% and 10% of firms (i.e. 3 and 5 firms) represented 35.63% and 51.13% of total paper and paperboard productive capacity. The top 25% and 50% of firms (i.e. 12 and 24 firms) comprised 76.21% and 81.92% of productive capacity, respectively. Finally, as regards total productive capacity, the top 5% and 10% of firms (i.e. 4 and 7 firms) comprised 31.33% and 46.09% of total productive capacity, while the top 25% and 50% of firms (i.e. 18 and 35 firms) represented 65.86% and 89.55% of productive capacity, respectively.

Several conclusions can be drawn from the preceeding data. First, fairly high levels of concentration of productive capacity were evident in 1961 and in 1973, for all basic classifications discussed. Second, in terms of the secular patterns, the changes have been rather slight,

in both directions, in the three basic product classifications. The greatest decrease in the concentration of productive capacity occurred in the pulp producing firm groups, where each group in the top 50% of firms suffered decreases in concentration. In the paper and paperboard group, the top 25% of the firms increased their share slightly and the bottom 50% of the firms increased their share at the expense of the middle 25% to 50% of the firms. Finally, the total productive capacity data show that each relevant centile group suffered a slight decrease in its share of total productive capacity.

Before leaving the discussion on mill-firm relationships, we might point out that similar evidence of high concentration in the Canadian pulp and paper industry is presented in a doctoral thesis by J.M. MacFarland.[12] The discussion, here, basically concerns the oligopolistic structure and behaviour of the newsprint, fine papers and paperboard sectors of the industry.[13] Specific reference is made to the anti-trust case brought against the fine papers sector of the industry in 1962.[14]

5. The Labour Organization Structure

The final aspect of the non-technical structure of the Canadian pulp and paper industry that must be considered is the degree and nature of unionization in the industry. The discussion, although quite cursory, stresses an important institutional variable that must be considered in attempting to predict employment per unit output changes. More specifically,

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[12] MacFarland, J.M., Linder and Demand-Led Theories of the Pattern of Trade: A Review in the Canadian Context, McGill University (Ph.D. thesis), 1971.

[13] Ibid., pp. 206-279.

[14] Ibid., p. 245.

the nature of the job security clauses in collective bargaining agreements in the various sectors in Canada could affect the direction and extent of change in employment in a very definite way.

Currently almost 100% of production and office workers in the Canadian pulp and paper industry are unionized.[15] The office workers primarily belong to the Office and Professional Employees' International Union (O.P.E.I.U.). With respect to the production workers, the basic unions are the Canadian Paperworkers Union (C.P.U.), the Confederation of National Trade Unions (C.N.T.U.) and the Pulp and Paper Workers of Canada (P.P.W.C.). Regionally, the membership is split roughly equally between the C.P.U. and the C.N.T.U. in the eastern sector of the industry, with the C.N.T.U. being more prevalent in Quebec. In the western sector of the industry, the C.P.U. accounts for roughly 80% of the production workers, while the P.P.W.C. represents the remaining 20%.

The nature of collective bargaining in the industry is basically that of pattern bargaining. The attitudes, however, with respect to job security differ quite markedly amongst the various unions and even amongst the various locals regionally. To this date, this fact has not had important implications, given the relative insignificance of job security clauses in the collective bargaining agreements. The implications of this prevailing attitude will be discussed when the employment per unit output predictions are considered in section VI.

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[15] The following information was obtained primarily from discussions with officials at the Canadian Paperworkers' Union and individuals at Domtar Ltd. in Montreal.

II. THE TECHNICAL STRUCTURE

Section II presents the relevant technical characteristics of the Canadian pulp and paper industry. First, it relates the product structure discussed in the preceeding section to the available techniques of production and the related machinery. In order to facilitate this discussion, the basic input-output relationships are described for the relevant product classifications. Second, it delineates the major changes in the techniques and machinery over the period 1951 to 1973, and discusses the potential or anticipated changes over the next decade. Finally, it relates the techniques (and the changes in the techniques) to the nature and extent of employment offered by each.

The specific product classifications used in section I were useful for definitional purposes and for understanding the organizational structure of the industry in relation to employment patterns. However, as was mentioned, a different product classification is relevant in discussing the technical structure of the industry in relation to employment patterns. Employment per unit output patterns, in this context, are primarily related to the type of pulp produced and/or used in the production of paper and paperboard.[16] As such, the most relevant product distinction should be between chemical pulp and predominantly chemical pulp using paper and paperboard production, on the one hand, and groundwood pulp and predominantly groundwood pulp

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[16] This is the basic technical characteristic to be illustrated by the material presented in this section.

using paper and paperboard production, on the other hand. In terms of the available data, the two product classifications can be further broken down, as follows. First, the chemical pulp and predominantly chemical pulp using paper and paperboard production is defined to include all types of sulphite and sulphate pulps, refiner pulp, and all paper and paperboard production using at least fifty percent chemical and/or refiner pulp. Although refiner pulp is basically a mechanical pulping technique, it will become evident that it should be included in this classification, due to the nature of its employment structure. Second, groundwood pulp and predominantly groundwood pulp using paper and paperboard includes all types of groundwood pulp and all paper and paperboard production using at least fifty percent groundwood pulp. In the latter case, the two basic products are newsprint and groundwood printing and specialty papers. Newsprint production involves approximately 80% groundwood pulp[17] while groundwood printing and specialty paper production is defined as paper production using fifty percent or more groundwood pulp.[18]

1. The Input-Output Relationships

The description of the technical structure of the Canadian pulp and paper industry is greatly facilitated by an understanding of the basic input-output relationships for each product classification.[19] The nature of these relationships is closely related to the nature and sequence of the

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[17] Refiner pulp could also be used in newsprint production, although this has not been the case to any great extent over the 1951 to 1973 period. However, as will be seen in section III, the implications of refiner pulp use in newsprint production for employment patterns are quite important.

[18] Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

[19] The discussion will offer some understanding of the raw material (specifically wood type) requirements in the production of the various pulp types and of the relationship of these basic pulp types to different paper and paperboard classifications.

basic techniques used in mills. In essence, the kind of paper and/or paperboard desired fundamentally determines the type of pulp required. The pulp type, to a lesser extent, determines the nature of the material input (i.e. wood or other type of cellulose fibres) to be used.[20] In each case, the relevant properties are related to some aspect(s) of strength, texture and yield or cost.

Although cellulose (the basic material input in the production of paper and paperboard) can be obtained from various types of rags and straw, the primary source is wood fibres. Wood fibres are derived from hardwoods such as poplar and aspen and softwoods, such as spruce, balsam, jack pine and hemlock. In general, softwoods produce superior fibres in terms of strength and texture. The fibres are longer and therefore stronger and they exhibit a finer and denser texture than hardwoods do.[21]. Moreover,

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[20] A technical discussion of the preceeding description can be found in the following consulted references:

Ainsworth, J.H., Paper, Thomas Printing and Publishing Co., Wisconsin, 1967, pp. 32-78;
Casey, J.P., Pulp and Paper, Volume 1, Interscience Publishers, New York, 1960, pp. 15-77;
Stevenson, L.T., The Background and Economics of American Papermaking, Harper and Brothers Publishers, New York, 1940, pp. 1-40;
Witham, G.S., Modern Pulp and Paper Making, Reinhold Publishing Corp., New York, 1942, pp. 15-76.

Less technical description can be found in the following consulted information pamphlets:

Canadian Pulp and Paper Association, From Watershed to Watermark, Montreal, 1974, pp. 5-11;
Domtar Pulp and Paper Ltd., (Howard Smith Division), Papermaking, Montreal, pp. 3-4;
de Montigny, R., La Fabrication du Papier, L'Institute Canadien de Recherche sur les Pates et Papiers, Pointe Claire, pp. 9-45.

[21] In actual fact, the length of fibres is affected by the age of the wood and its texture is determined by climatic factors, in the case of both hardwoods and softwoods. Longer fibres are obtained 10 to 20 feet above the ground. Finer and denser fibres are obtained from dry and cold climates, while warmer and moister climates tend to produce coarser and more brittle fibres.

softwoods produce a higher yield of cellulose per weight and exhibit a higher density per cord of wood. As such, they tend to be more economical than hardwoods. A final important quality of material inputs is bleachability. Here, the relevant distinction is between specific wood types. The most bleachable wood types are spruce and poplar, while the most difficult wood to bleach is balsam. In conclusion, softwoods tend to be more useful than hardwoods in the production of paper and paperboard, because they can be used in all processes. As will be seen, hardwoods are not conducive to groundwood pulping processes, due to the shortness and brittleness of the fibres. Moreover, softwoods offer a higher quality and lower cost wood fibre than hardwoods do.

Historically, the tendency had been to utilize softwoods predominantly due to their relative abundancy as compared to hardwoods. However, the more recent trend has been towards the increasing use of hardwoods, for a number of reasons. First, the increasing relative shortage of softwoods has presented a natural constraint. Second, the consequent technical changes have made the use of hardwoods increasingly more economical.

In describing the relevant properties of wood pulp, the distinction is made between chemical and mechanical pulps. The terminology relates to the manner in which the wood fibres are separated. Chemical pulps include all types of sulphate and sulphite pulp and alpha and dissolving pulp. Mechanical pulps consist of groundwood and refiner pulp. The relevant properties are again related to the strength, texture and yield or cost of the specific pulp. In describing these general properties, however, we must remember that the nature of the specific pulp produced is substantively affected by the type of wood used. First, as regards the relative strengths

of different pulp types, chemical pulps are markedly superior to mechanical pulps.[22] Amongst the chemical pulps, sulphate pulping produces a fairly stronger and more elastic fibre than does sulphite pulping, in general. However, the strength, quality and yield of the various processes is affected by the nature of the cooking process and by the cooking time allowed. In the case of mechanical pulp, refiner pulping tends to yield slightly stronger fibres than does groundwood pulping. Second, chemical pulping generally yields a much higher quality of pulp than does mechanical pulping. However, specific pulp types embody different quality related characteristics. Dissolving and special alpha pulps are exceptionally pure grades of bleached sulphite and sulphate pulps. Sulphite pulps, in general, are of a higher quality than sulphate pulps. They are characterized by a higher pliability of fibres and a lighter, purer and more brillant texture. Moreover, sulphite pulps are relatively more readily bleachable than are sulphate pulps. Mechanical pulps are noted primarily for their opacity, high fibre damage and low purity or high lignin content. These properties are more evident in groundwood pulp than in refiner pulp, which tends to be of a slightly higher quality and more easily bleachable. Finally, in terms of yield and/or cost, mechanical pulping is much more inexpensive than chemical pulping. Groundwood pulping yields (i.e. approximately 95% of the original wood weight) are roughly double those of sulphate and sulphite pulping. Refiner pulping produces high yields, but slightly lower yields than

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[22] The relative strength and yields (discussed below) of the different pulp types is greatly affected by the type and age of the specific technique used in each case. As such, data on absolute differences in strength and yield vary according to the period discussed. Contained in the references cited in the first part of footnote 20 are the specific data and general description on these differences for various periods between the early 1940's and the late 1960's.

those obtained from groundwood pulping. Moreover, chemical pulping entails relatively higher costs in production. First, more energy is required in the wood preparation stage to chip the wood inputs.[23] Second, high costs are involved in the upkeep of large chemical plants, in terms of both initial and maintenance costs. In the case of sulphate pulping, however, marketable by-products such as methyl alcohol and resins are derived.

Finally, the relevant inputs in the production of specific paper and paperboards can be considered in light of the properties of the various pulp types. For the technical and data constraint reasons stated above, the basic classifications are newsprint, groundwood printing and specialty paper, and other paper and paperboard production. Newsprint production requires a relatively inexpensive and bulky pulp input. Furthermore, it necessitates properties such as high opacity and good ink absorption. Mechanical pulp is most suited to producing these properties. In the production of newsprint, anywhere between 80% and 90% of the pulp used is mechanical pulp. Depending on the strength and quality of the mechanical and chemical pulp, more or less chemical pulp is added. Groundwood printing and specialty papers are distinguished by the fact that they consist of a greater proportion of mechanical pulp. Again, their primary property is their relative inexpensiveness, lack of strength, and low quality, in terms of colour and texture. As in the case of newsprint production, varying degrees of chemical pulp are added in accordance to the desired strength and/or quality of the chemical pulp, mechanical pulp, and of the specific paper or paperboard being produced. Included in this class of

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[23] This is also the case in refiner pulping.

paper and paperboard are cheap book, catalogue, rotogravure, magazines, cheap drawing, toilet tissue, toweling and hanging stock papers, and cheaper grades of wall and paperboard. In contrast to groundwood printing and specialty papers, other paper and paperboard production includes specific paper and paperboard types that are composed of relatively greater proportions of chemical pulp. Where brightness and high quality texture are the required properties, dissolving and special alpha, and sulphite pulps are used. This class of paper production tends to be the most expensive. If high strength and relatively lower quality paper and/or paperboard is desired, sulphate pulp is the most appropriate input. In both cases, the quality can be varied either by bleaching or by the addition of fillers, such as clay, to the finish of the paper or paperboard. Moreover, the strength and quality of specific paper and paperboards can be affected by altering the proportions of chemical and mechanical pulp used. The range of products included in this category is delineated in Table 1, under the paper (excluding groundwood printing and specialty papers) and paperboard headings.

2. The Techniques of Production

The discussion of techniques used in the production of pulp, paper and paperboard is carried out on two levels. First, the possible range of techniques or processes of production is examined at the mill level. The term 'mill', in this context, represents the range of techniques necessary to produce a certain type of pulp and/or paper and/or paperboard. However, the same term is used in a different context to represent a distinct set of techniques or processes, within the broad range of techniques. Where the term is used in the latter context, it will be prefaced by the type of

techniques described e.g. saw mill, sulphite mill...etc...Second, the specific machinery used in each technique will be considered. This will be done in the next subsection.

A classification or categorization problem exists in the description of techniques related to the basic product classifications. Generalizations must be made, with respect to the type of techniques and related machinery (and to the nature and extent of changes in these techniques and machinery), for a number of reasons. First, in the engineering sense, the techniques and machinery are quite complex. References will however be made to technical texts describing these techniques and their related equipment in a detailed manner. Second, in the applied sense, the specific mill processes and machinery in the Canadian industry are considerably heterogeneous.

The production of different classes of pulp and/or paper and/or paperboard is related to distinct types of mill scenarios. In order to delineate the more relevant possible mill layouts, the description of a fully integrated mill (able to produce all types of pulp, paper and paperboard) is necessary. The operations in the saw mill represent the initial set of processes in such a situation. Here, the logs are hauled into the mill and cut into blocks of required length, using various types of sawing methods. The wood from the saw mill is then either carried directly on conveyers to the wood room, or else, stored in large piles until it is used. In the former case, the wood is treated in the wood room before it is converted into wood pulp. If mechanical pulp is being manufactured, the wood blocks must be cleaned and must have their barks removed. However, where chemical pulp is being produced, the cleaned and

debarked blocks must be chipped into appropriately sized pieces. These chips are screened for sawdust and chips that are too large and are placed by means of a conveyer into a chip bin. The wood blocks or chips are then reduced into mechanical or chemical wood pulp, respectively. The former process is carried out in a groundwood mill and the latter either in a sulphite or sulphate mill. In the groundwood mill, the pulp is screened and thickened before being placed in a stock chest. In the sulphite or sulphate mills, the pulp is washed and screened before being placed into a stock chest. Some ancillary processes that might exist in the pulping mills are those related to the bleach plant, the acid plant and the recovery plant. These processes involve the bleaching of mechanical and chemical pulps and the manufacturing and recovery of solutions required in chemical pulping. At this stage, the different pulps are transported from the stock or storage chests to the stock preparation mill. Here, the different pulps are blended or proportioned and fillers and colours are added (if necessary) to produce the required type of paper or paperboard. The fibres are then refined or brushed and washed to remove any residual dirt. The resulting pulp is transported to the paper mill where the actual paper and paperboard are formed, dried, given a smooth finish and cut to various width requirements. The resulting paper roll is then cut, counted, trimmed, sorted, wrapped and loaded in the finishing room.

The extent to which any of the preceeding basic techniques or processes would exist in a given mill would depend on the type of output produced and on the extent of vertical integration in the mill. In terms of the most general product classification, a paper producing mill would consist of a stock preparation mill, a paper mill and a finishing room.

A pulp producing mill would have wood storage facilities, pulping processes necessary to produce any given pulp types, pulp forming and drying facilities and a finishing room, at minimum. In the case of mechanical pulp production, complete vertical integration would necessitate saw mill and wood room operations. Moreover, if bleached pulp was being produced, bleaching facilities would have to exist. Complete vertical integration in chemical pulp production would require saw mill, wood room, acid plant and recovery plant operations. Again, if bleached pulp was being produced, bleach plant facilities would be necessary. Finally, in the case of pulp and paper producing mills, the same two determinants are relevant. At minimum, wood storage facilities, pulping operations, a stock preparation mill, a paper mill, and a finishing room must be present. The existence of any remaining processes is determined by the desired degree of vertical integration and the type of paper and/or paperboard produced. Newsprint and groundwood printing and specialty paper production would require relatively larger groundwood mill operations. The production of other paper and paperboard would require the existence of relatively larger sulphite and/or sulphate mills. Saw mill, wood room, bleach plant, acid plant, and recovery plant operations, in the case of where they are relevant, would be a question of desired vertical integration.

3. The Machinery

The second level of description concerns the specific machinery that comprises the basic techniques discussed above. Here only those machines that contribute considerably to the employment in mills will be considered. Moreover, only the most basic characteristics of these machines

will be outlined, due to the existing categorization problems, set out in the preceeding subsections.[24] The specific order to description will follow that of the techniques in the preceeding subsection. The discussion will begin with the saw mill operations and end with the finishing room operations.

Saw mill operations require the two basic types of machinery. One of these is the log haul-up or jack ladder, which transports the logs into the saw mill from the stock pile or river. Pollution legislation has resulted in overland transportation replacing river floating as the primary means of transporting logs to the mill. As a consequence, crane operations have become necessary in saw mills to place the incoming wood onto the stock piles. The second major type of equipment in saw mills are the saws, themselves. The two chief types are slashers and swing saws. The former are used on long logs of nearly uniform length, while the latter are employed on logs of extreme length and/or of varying lengths. The logs are usually cut, in either case, into two to four foot long blocks. In terms of the Canadian industry, swing saws tend to predominate in

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[24] Technical discussion on the machinery of the entire range of techniques or processes outlined in the following paragraphs can be found in the following consulted references:

Ainsworth, J.H., Paper, Thomas Printing and Publishing Company, Wisconsin, 1967;
Casey, J.P., Pulp and Paper, Volumes 1 and 2, Interscience Publishers, New York, 1960;
Witham, G.S., Modern Pulp and Paper Making, Reinhold Publishing Corp., New York, 1942;
de Montigny, R., La Fabrication du Papier, L'Institute Canadien de Recherche sur les Pâtes et Papiers, Pointe Claire.

Technical discussion on the machinery of the more important specific processes can be found in the following consulted references:

Gavelin, N., Sciences and Technology of Mechanical Pulp Manufacture, Lockwood Corp., New York, 1966;
Wenzl, F.J., Kraft Pulping - Theory and Practice, Lockwood Corp., New York, 1967;
----------, Sulphite Pulping Technology, Lockwood Corp., New York, 1965.

the western sector, where the logs are much longer, while slashers tend to be more common in the eastern sector.

As in the saw mill, wood room operations require the use of cranes and conveyors to transport the wood blocks from the stock pile into the wood room. Inside the woodroom, the types of machines used is dictated by the type of pulp being produced. In all cases, either a barking machine, or more commonly, a barking drum is required to debark the wood blocks. Where either chemical or refiner pulp is being produced, the wood blocks must be reduced to chips 1/8" to 1/4" in thickness and 1/2" to 1" in length. From the barker, the blocks are carried by conveyer to the chipper which reduces them to chips of appropriate size. The chips are then screened to remove chips that are oversized or undersized and sawdust. The oversized chips are returned to a reclipper, while the acceptable chips are transported by another conveyer to chip bins located above the digesters. The capacity of the chip bins must be regulated so as to provide for the desired charge of the digesters and for the fluctuations in chip production in the wood room.

The next set of processes deals with the various forms of mechanical and chemical pulping. With respect to the chemical pulping processes, the basic machinery is to some extent similar. In both sulphite and sulphate pulping, the wood chips are fed into large pressure cookers called digesters, which are large cylindrical vessels of steel. The sulphite process employs a solution which is derived from adding cooled sulphur dioxide gas to water and limestone, in an acid tower. The sulphate process uses a solution of sodium hydroxide (caustic soda) and sodium sulphide. Two basic types of digesters exist. One type produces

pulp in batches and the other produces pulp as a continuous process. The wood chips, in both types of digesters, pass directly from the chip bin to the digester, where the wood fibres (cellulose) are separated from the lignin in cooking. The cooked chips then pass into a blow pit or tank where large steel plates reduce the chips into virtually pure cellulose fibres. The fibres are then washed and possibly bleached by slightly different processes in the sulphite and in the sulphate processes. The resulting pulp is finally placed in large storage chests, before passing into the stock preparation mill. Related to the sulphite process is the acid producing process which consists of an entire set of equipment to produce and transform the relevant gas into the required solution. In the sulphate process, various types of machinery are used to recover the spent liquid, which is treated and used again in the digesters. However, a more specific description of the relevant machinery in the acid and recovery plants does not seem necessary, since it would not contribute much to an understanding of the basic processes and their relation to employment structures.

The groundwood pulping process, and its related equipment, differs quite drastically from the chemical pulping processes. The essential characteristic of the process is the placing of the debarked and washed wood block under pressure, against the surface of a revolving stone. The basic equipment that performs this task is appropriately called a grinder. The two basic types of grinders that exist are the pocket or hand-fed grinders and the magazine charged grinders. The most common hand-fed grinder is the three-pocket grinder which, as its name would imply, has three openings through which wood blocks are manually inserted. Magazine charged grinders vary in terms of the degree of manual operation

that is involved (i.e. continuity of process) and in terms of productive capacity (by process type and not by specific machine make). However, in all cases, the productive capacity is higher in magazine charged grinders than in hand-fed grinders. One of the reasons is that relatively larger wood blocks can be used in magazine-charged grinders. Another reason is that more of the grindstone (also larger) surface is usefully employed in the latter equipment. Once the pulp is produced, it is passed through equipment that screens and thickens it. The pulp is then transported to a stock or storage chest. If required by the type of paper produced, the pulp can also be bleached before being placed in the storage chest. The description of the screening, thickening and bleaching equipment does not contribute much to the understanding of the basic processes and their relation to employment structures.

Finally, refiner pulping and its more recent derivative thermo-mechanical pulping can best be described as a mixture of chemical and mechanical pulping processes. However, the greater part of the process must be categorized as mechanical. On the one hand, the wood in the form of chips is subjected to the millstone-like action of rotating discs and is in one sense grinded. The wood chips, however, are chemically treated to loosen the cellulose fibres from the lignin before being grinded. As such, the fibres tend to be picked-off rather than ground-off in the process. An important difference from groundwood pulping is that hardwoods can be used in this process, as a consequence of the nature of the grinding.

In discussing the machinery in the remaining basic processes or techniques, the description is quite brief for a number of reasons. First, each of these processes is related to the paper and/or paperboard producing section of the mill. As will be seen, the different techniques and

machinery used to produce alternative types of paper and paperboard do not substantively result in differing employment patterns. Second, it will also be seen that technical changes in these techniques have not fundamentally affected the extent of employment offered. However, to the extent that technical change has increased the productive capacity of these techniques, they have affected the employment per unit output patterns in the industry.

The two major types of machinery in the stock preparation mill are the pulpers and the beaters. The pulpers are basically steel vats in which different pulp types are blended or proportioned and/or supplemented (i.e. with filters, colours, etc...) to produce different paper and paperboard types. The pulper is connected to the various pulp storage chests, which provide the pulp inputs. The beater is very much like the pulper. The only basic difference is that the beater is used in paper producing mills where the required pulps are purchased (already formed and dried) and not produced. The various pulps are liquified in the beater and then transported to the paper mill. In many cases, refiners (described above) are also used in stock preparation mills to brush certain pulp mixtures that are used in the production of fine papers.

From the stock preparation mill, the pulp mixture passes on to a paper machine. Three basic types of paper machines can be distinguished; the Fourdrinier, the cylinder machine and, more recently, the twin-wire former. In all cases, the basic principle is the same. An even layer of pulp mixture is placed on a screen that permits much of the water to drain. The rest of the water is removed by pressure and heat, causing the fibres to band and become a compact sheet. Moreover, the same general functional components are evident in each type of machine. The head box

delivers an even layer of pulp mixture to the moving wire screen. The wet end of the paper machine basically forms the sheet and draws away a large part of the water from the pulp mixture. This is done by means of table rolls, hydrofoils and suction boxes along the wire(s) and by metal cylinders, equipped with vaccuum boxes, called suction couch rolls. The sheet then passes on to the dryer section and to the dry end, which smooths the surface of the paper and cuts and rewinds the sheet. This is done by a set of large dryers, a calendar stock, and a slitter and rewinder respectively. In a cylinder machine, the operations on the wire differ from those described above. The sheet is formed by combining a number of layers of pulp. The wire consists of a series of cylinder molds which revolve in separate vats containing mixtures of pulp and water. A felt passes by each mold, picking up each layer of pulp in turn. In the twin-wire former, the nature of the wet end of the machine is again different. The sheet is formed between two travelling wires and water is removed from both sides of the sheet simultaneously. The result is sheets with more uniform surfaces and production at relatively higher speeds. Whereas the Fourdrinier and twin-wire machines are used predominantly in the forming of pulp and paper, cylinder machines are usually employed in the production of paperboard.

Finally, the formed sheets pass on to the finishing room where they are cut, trimmed, counted, wrapped and loaded. The extent of mechanization in all the latter processes varies by mill. However, various types of machinery are available to perform each of the above functions. At minimum, finishing rooms in all mills are equipped with some kind of cutting and trimming facilities.

Before proceeding to the discussions of the technical changes in and

the employment structures of the various processes, some indication can be given of the prevalence of the more relevant types of machinery in the Canadian pulp and paper industry. Tables 6 and 7 present the data for 1961 and 1972, the first and last years of the period for which data are available. The figures in the brackets represent the share of each technique in the total, in each year and in each region. The data represents a rough indication of the technical structure for a number of reasons. First, the technical structure is discussed only with respect to the number of mills employing a given technique and related equipment. No inferences can be drawn concerning changes within specific mills, changes in the number of machines and/or changes in the make and size of machines. Second, the data reportings are far from being comprehensive and reliable. Some mills in a given year and/or region do not report their equipment. Other mills submit only partial reports. As a result, two important pieces of data become even more unreliable. On the one hand, the nature and extent of woodroom operations are usually not set out clearly enough. On the other hand, the reportings of refiners is ambiguous. This fact arises from the possible use of refiners as a means of producing mechanical pulp and as a means of refining chemical pulp mixtures. In the above data, it is obvious that we are interested in refiners as producers of mechanical pulp.

Several conclusions can be drawn from the data, for the industry as a whole and for the regional sectors. First, at the national level, there was a slight increase in the percentage of pulp and paper producing mills that employed woodrooms only as storage facilities over the period 1961 to 1972. Regionally, the percentage change was the same in both the eastern and western sectors. Second, the trend in the industry was towards a

TABLE 6

BASIC TECHNIQUE UTILIZATION (CANADA) 1961, 1972

	1961		1972	
	Number of Mills	Percent of Total Mills	Number of Mills	Percent of Total Mills
Total Number of Mills	101	100	112	100
1. Woodroom Operations				
- storage only	28	28	32	29
2. Chemical Pulping	68	68	87	78
- batch digesters	64	64	55	49
- continuous digesters	4	4	32	29
3. Mechanical Pulping	107	107	92	82
- grinders	69	69	49	44
- pocket	29	29	7	6
- magazine charged	40	40	42	38
- refiner	38	38	43	38
- thermo-mechanical	0	0	0	0

Source: National Pulp and Paper Directory, 1961-62; 1972-73

Note: 1. The total number of mills excludes paper producing mills since woodroom and pulping operations are not present in the latter.

2. Percentages may exceed 100 since one mill can use chemical as well as mechanical pulping techniques and can also employ different types of chemical and/or mechanical processes simultaneously.

TABLE 7

BASIC TECHNIQUE UTILIZATION (EAST-WEST) 1961, 1972

1961

	East		West	
	Number of Mills	Percent of Total Mills	Number of Mills	Percent of Total Mills
Total Number of Mills	81	100	20	100
1. Woodroom				
- storage only (excluding paper mills)	24	30	4	20
2. Chemical Pulping	55	68	13	65
- batch digesters	53	65	11	55
- continuous digesters	2	2	2	10
3. Mechanical Pulping	94	116	13	65
- grinders	60	74	9	45
- pocket	24	30	5	25
- magazine charged	36	44	4	20
- refiner	34	42	4	20
- thermo-mechanical	0	0	0	0

(TABLE 7 (continued)

1972

	East		West	
	Number of Mills	Percent of Total Mills	Number of Mills	Percent of Total Mills
Total Number of Mills	83	100	29	100
1. Woodroom				
- storage only (excluding paper mills)	26	31	6	21
2. Chemical Pulping	59	71	28	97
- batch digesters	46	55	9	31
- continuous digesters	13	16	19	66
3. Mechanical Pulping	80	96	12	41
- grinders	43	52	6	21
- pocket	5	6	2	7
- magazine charged	38	46	4	14
- refiner	37	45	6	21
- thermo-mechanical	0	0	0	0

Source: National Pulp and Paper Directory, 1961-62; 1972-73.

Note: See notes 1 and 2 in Table 6.

greater use of chemical pulping techniques, as opposed to mechanical pulping techniques. This trend proceeded at a relatively faster rate in the western sector of the industry. Third, at the national level, a relatively higher proportion of continuous digesters and magazine charged grinders and refiners were employed in chemical and mechanical pulping, respectively. The changes within chemical pulping techniques were relatively more evident in the western sector, while the changes within mechanical pulping techniques were more prevalent in the eastern sector.

4. Technical Change in the Industry

Having described the basic technical structure in the industry, we can proceed to discuss the more fundamental changes that have taken place in these techniques and in the related equipment over the period 1951 to 1973. The changes to be considered are those most affecting employment and productive capacity.[25]

A number of important changes have occurred in the saw mill and woodroom operations since the early 1950's. However, even more relevant changes appear on blueprints for adoption over the next decade. Since the mid - 1950's a prevalent trend (especially in the western sector of the industry) has been the integration of sawmill and woodroom operations. This trend is primarily a result of the integration of lumber and pulpwood production. In this situation, tree lengths are hauled from the forests to the woodroom. The process involves modern sawing techniques (i.e. chip and saw) which produce both lumber and woodchips for pulp production. The important implication, here,

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[25] The following information was obtained through discussions with engineering specialists at the Domtar offices in Montreal and at the various mills observed. Moreover, the following reference was consulted; International Brotherhood of Pulp, Sulphite and Paper Mill Workers, Automation, 1964, Appendix G, pp. 450-452.

is that employment is shifted from the woods to the mill. Two other important changes have taken place over the 1951 to 1973 period. First, barking techniques have increased in speed as a result of their ability to handle greater log lengths. Second, crane operations have become more prevalent, as a result of pollution control legislation which has greatly decreased the extent of river floating as a means of transporting logs to mills. The most relevant change, however, has yet to be implemented on a large scale, commercially. This process relates specifically to chemical and refiner pulping and involves the chipping of pulpwood at the forest. The wood is cut, delimbed, debarked and chipped and, then, transported to the mill woodroom for storage. As a result of the marked technical improvements in foresting operations, this process would decrease labour requirements in general and, especially, in the woodroom. A major problem that still exists is that the debarking process is not as thorough in the forests as it is in the woodroom and the existing woodchip using techniques have difficulties pulping this type of wood input. However, research is presently being carried out to improve the barking operations and to adapt the various pulping techniques.

With respect to the pulp mills, few substantive changes took place during the period 1961 to 1973. The basic techniques and related machinery were discussed in the preceeding paragraphs. The more relevant technical changes were in the productive capacities of the chemical pulping techniques, arising from the increased size of digesters and from changes in cooking techniques used. Over this same period, the productive capacity of new batch and continuous digesters increased substantially. Moreover, in batch digesting, changes relating to the automation of blowing processes (i.e. the placing

of chips into digesters) occurred. With respect to the mechanical pulping processes, the most drastic changes have yet to be implemented on a large scale commercial basis.The changes in ground wood pulping processes and in the relatedmachinery were minimal over this period. The more fundamental change occurred in the refiner pulping processes and, specifically, in the related technique of thermomechanical pulping. Although the latter technique has existed on blueprints since the 1930's, it never received serious consideration until the early 1970's, as a result of the increasing use of refiners to produce mechanical pulp. Although different systems do exist, the thermo-mechanical process is functionally almost identical to the refiner process described above. As a result of the superiority of thermomechanical pulp (relative to groundwood pulp), the possibility arises that newsprint production could employ 100% thermomechanical pulp.

Technical changes in the paper mill affected both the quality of paper and paperboard produced and the productive capacity of paper machines. Here, we are primarily concerned with the changes in productive capacity. The most relevant change was the consideration of twin-wire formers in the 1970's. The speed of this type of paper machine is almost twice that of the conventional single wire machines. Other basic changes over this period involved the increased speed and longer running time (i.e. up-time) of the paper machines. The use of hydrofoils instead of table rolls along the wire, was primarily responsible for the much increased speeds of the paper machines produced in the 1970's as compared to those produced in the 1950's. With respect to increases in running time, down-time on paper machines was decreased quite markedly, over this period. This represents a considerable equivalent increase in productive capacity, since an average wire and felt change involves

roughly four hours of down-time per machine. The increased running time of paper machines was primarily a result of improved wires, felts, couch rolls and cleaning methods.

Finally, several important technical changes took place in the finishing room over the 1951 to 1973 period. These changes related primarily to the various cutting, sealing, wrapping and loading operations performed. Although varying degrees of automation developed in each of the operations, they tended to be incorporated more quickly into the newer mills in the industry. Even by the early 1970's, a sizeable number of mills (predominantly in the eastern sector of the industry) had not converted to automated processes in the finishing room operations mentioned above.

5. The Employment Structure of Techniques

The final part of this section deals with the employment structure (and changes in the latter) that is related to the technical structure described in the preceeding subsections. First, the nature and relative extent of employment offered by each basic process will be considered. In discussing skill requirements, here, the distinction made is between less than one year experience and more than one year's experience requirements. The latter case is seen to imply a detailed knowledge of the specific technique(s) on the part of the employee.[26] Second, the relative employment structures of the basic pulp, paper and paperboard product classifications (specified at the outset of this section as being relevant to the technical structure) will be

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[26] The skill requirement data was derived from job evaluation studies done by the Canadian Paperworkers' Union for selected mills. The employment structure data was obtained partly from the latter source and partly from information provided by the Canadian Pulp and Paper Association.

compared. Due to the existing differences in mill structures and machinery types, the discussion in both cases must be in fairly general terms.

The operation of the saw mill and woodroom require a sizeable number of employees. The primary functions performed relate to the storing, barking, washing, reclaiming and chipping (in the case of chemical and refiner pulping) of wood and to the maintenance of the saw mill and woodroom. The related employment can be broken down into two categories. The relatively more skilled employees are the foremen in each operation and the crane, bulldozer and other heavy equipment operators. The less skilled employment categories include the conveyormen in each operation, stackermen, sorters, truckdrivers, sawyer, barking drum operator, chipperman, axeman, chip bin operator and labourers with no specific skill requirement. In mills where all of the above operations are performed, the employment in the chipping operations would represent roughly one-fifth of the total employment offered in the saw mill and woodroom. The employment changes over the 1951 to 1973 period have basically been related to the increasing use of cranes and conveyers for unloading and transporting purposes. The more important changes, however, would arise in the situation where the chipping of wood was carried on in the forests. Except in the case of groundwood pulping, the entire operation at the mill would be restricted to the storage of chips, which would require two or three employees[27] to monitor the unloading, woodpile and blowing processes.

In terms of the pulp mills, the groundwood pulping processes are markedly more labour intensive than the chemical and refiner pulping processes.

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[27] Any specific figures used are on a per shift basis. A seven day operation would involve four times the figure specified plus an additional employee as a switchman.

Moreover, they require a relatively much greater proportion of unskilled employees. The two relatively skilled employees are the foreman and the stonesharpener. The less skilled employees include the grindermen and the grinder changers. Each grinderman is responsible for roughly ten stones. The number of changers per grinder usually varies between one and three, depending on the equipment used. In general, hand-fed grinders involve more labour than magazine charged grinders. In the situation where thermomechanical pulping processes were used, the reduction in the required labour would be quite drastic. The process would require a foreman and one or two unskilled employees for roughly every six refiners. The resulting pulp production is roughly comparable to that obtained from 6 grinder lines, employing between six and eighteen chargers. Obviously, the scale factors become very important with respect to employment in such a situation. The possible reduction in employment is increased to an even greater extent, if the fact is recognized that saw mill and woodroom operations could conceivably be eliminated under such a process.

In contrast to the employment structure in the groundwood pulping process, the chemical pulping processes utilize much less, but higher skilled, labour. In sulphite pulping, the relatively skilled employees are the cook (digester room) and the acid maker and the sulphur man (acid plant). The relatively less skilled employees include the cook's helpers (from one to three depending on the type, size and/or number of digesters), blowpit man, stock runner, and a towerman (in the acid plant). The sulphate process involves a slightly larger number of employees. As in the sulphite process, the cook, helpers and a blowpit man are required. In the recovery room, the relatively more skilled employees include the evaporator operator, recovery operator, lime kiln operator and the assistant lime kiln operator.

The relatively less skilled employees are the two or three helpers to the above operators.

In both chemical and mechanical pulping, a certain amount of employment is offered in the related screening, washing and bleaching operations. The screening room requires a skilled head screenerman and relatively less skilled first and second screenermen, oiler and cleaner. The employees of the bleaching room are all highly skilled and include an operator, chemical preparer and tester.

The employment structure in the stock preparation mill is quite similar for both pulper and beater operations. The relatively more skilled employees are the beater (pulper) engineer, paper inspector and broke beater (pulper). The less skilled employment requirements are a beaterman (pulperman) and one or two stock runners.

The extent of employment in the paper mill varies according to the type of machine used and the kind of paper and paperboard produced. In all cases, a machine tender and back tender, both highly skilled, are required. The other possible employees are the third up to seventh hands, some of which are relatively more skilled, and the wet machine man, cutter and balerman. The larger paper machines are, the greater the number of hands required. Also, fine paper production usually requires one more hand than does other paper and paperboard production.

The employment structure is most variable between mills in the finishing room operations. As was already mentioned this is a direct result of the differing degrees of existing automation that prevail in the various mills. The specific employment relates to the various functions performed in the finishing room, which were discussed above. The relatively more skilled

employees include the foremen, the head finisher and the marker, weigher and checker, where they exist. The other employees are the roll pushers, finisher, wrapping machine operator, breaker headerman, core preparer and helper, truckdrivers and car preparers. Several basic technical changes have affected the employment structure over the 1951 to 1973 period. First, marker and weigher functions have been replaced by automated computer operations. Second, these same operations have reduced checker employment by roughly one-fifth. These changes have resulted in the potential reduction of skilled employment in the finishing room. Third, various types of cutting, trimming, wrapping, sealing, carrying and loading machines have served to potentially reduce the number of relatively less skilled employees.

Finally, a large amount of overhead or indirect employment exists in various forms in mills.[28] These functions range from supervisory, maintenance, and quality and production control operations to the operations of steam generating plants, in primarily the medium and larger sized mills. In almost all cases, the employment requires highly skilled personnel. The employment categories include pulp and paper testers, lab helpers, pollution control researchers, water treatment operators, foremen, head steam operators and assistants, firemen, pumpmen, filtermen, mechanics and helpers, painters and helpers and various specialist plant and mill engineers and their assistants, amongst others.

The preceeding discussion on the employment structure is both far from complete and not relevant to any one specific mill. Moreover, the actual changes in employment structure described for the period 1951 to 1973 might have also arisen from improved organization and structure of mills as well as

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[28] The indirect labour discussed here, relates only to production operations. Included in the total overhead labour of the mills in the industry are the administrative, clerical and [illegible] staffs.

from changes in the techniques and related machinery.

The most relevant method to summarize the above employment structure data is to examine the relative employment structures of the various types of pulp, paper and paperboard producing mills specified above. In this discussion, we will abstract from the general classes of overhead or indirect labour which were described above. First, as regards pulp producing mills, chemical and refiner pulp producing mills would tend to offer markedly less employment than groundwood producing mills. Under similar saw mill and woodroom operations, chemical and refiner pulp producing mills would require a slightly greater amount of employment. However, the employment differences in the pulp mills would more than compensate for this difference in the saw mill and woodroom operations. Moreover, in the case of refiner and, to a greater extent, chemical pulp producing mills, the proportion of relative higher skilled employees would be much greater. Second, in pulp and paper producing mills, similar employment structures would tend to exist. In the predominantly chemical pulp using paper and paperboard production, relatively less employment would be offered. Furthermore, a higher proportion of the employment would be higher skilled. Conversely, newsprint and groundwood printing and specialty producing mills would involve relatively less and relatively lower skilled employment. Finally, the employment structure of paper producing mills would not tend to vary drastically between the various types of paper produced since the woodpulps are purchased and not produced in the mills. In all of the above classifications, the employment structures of specific mills would obviously also vary according to the size and type of machinery employed.

III. THE EMPLOYMENT PATTERN EFFECTS OF TECHNIQUE CHOICE

This section will consider the basic determinants of the employment per unit output structure in the Canadian pulp and paper industry over the period 1951 to 1973. In deriving these determinants, it will draw upon the structural and technical characteristics of the industry, discussed in the preceeding sections. First, the relevant hypothesis will be presented and its relation to existing theories of employment determination will be discussed. Second, the basic aspects of the national and regional employment per unit output structures will be analyzed in terms of this hypothesis. At the national level, the secular and cyclical patterns in employment per unit output will be examined for the period 1951 to 1973. In the examination of the secular pattern, the trends in total employment per unit output will be considered. In the analysis of the cyclical patterns of total employment per unit output, reference will also be made to the changing composition of employment. Specifically, the type of employment offered and the related skill requirements of each employment type will be examined. At the regional level, data limitations restrict the analysis to the period 1961 to 1972. As in the analysis at the national level, the secular and cyclical patterns of total employment per unit output will be considered. However, the analysis here will also explain differences in the level of total employment per unit output between the eastern and western sectors of the industry. The analysis at the regional level will be less rigorous than the analysis at the national level. The unavailability of certain key data at the provincial

or regional level necessitated the use of possibly inaccurate proxy variables in the analysis. In addition, the period of analysis, at the regional level, is not long enough to allow an examination of secular and cyclical patterns of employment per unit output over individual or specific cycles.

1. The Hypothesis

In considering the relevance of the existing employment and productivity and technical change analyses, the critical evaluation will be both general and eclectic in nature. On the one hand, the basic assumptions and methodology used in these analyses are quite similar in most cases. Therefore, instead of refering to each analysis individually, the discussion will derive primarily from two survey articles, one by C.J. Roberts[29] and the other by M.I. Nadiri.[30] The C.J. Roberts survey article reproduces the major employment models up to 1972 under various classifications and analyzes the assumptions and methodology employed in each case.[31] Given the employment relationships, the determinants of employment per unit output can be derived. The M.I. Nadiri article considers the assumptions and methodology of the existing productivity and technical change analyses. These analyses are quite relevant to the present study, since the productivity measures analyzed are closely related to employment per unit output variable.

The employment and productivity analyses are all basically Neoclassical

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[29] Roberts, C.J., "A Survey of Employment Models," Centre for Industrial and Business Research, University of Warwick, Coventry 1972 (Working paper).

[30] Nadiri, M.I., "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey." Journal of Economic Literature, 1970, pp. 1137-77.

[31] The C.J. Roberts survey article considers short and long-run employment models. Given the nature of this study, only the long-run models are relevant, here.

in terms of the assumptions and methodology used. First, the assumption of profit-maximizing or cost-minimizing firms is made. Several variations in the assumption, in the C.J. Roberts article, allow for cost minimizing over time and for cost minimizing in cases of variable capital stock utilization. However, in each case the minimization relates to employment costs with the aggregate capital stock given exogenously in the short-period and, often, in successive short-periods. The cost-minimization or profit maximization, moreover, is carried out with given wage rates relative to capital costs.

Second, an aggregate production function is specified, using labour and capital as inputs to production, to represent the technical possibilities at a given point in time. In most cases, some form of a Cobb-Douglas specification with its associated unitary elasticity of substitution is employed for the production function. Several noteworthy assumptions and theoretical techniques are implicit in this type of specification. These assumptions and techniques are also implicit in other neoclassical production functions (i.e. C.E.S.) and their consequences are often more marked in the latter specifications.

To illustrate the relevant assumptions and theoretical techniques, we can use the example of the Cobb-Douglas production function,[32]

(1) $Q = Ae^{\lambda t}K^{\beta}L^{\alpha}$

where Q represents the level of output, K the size of the capital stock, and L the level of employment, all measured in physical units (or represented by an index). The symbol t represents a time trend. A is a constant, and

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[32] The properties of the Cobb-Douglas production function are described generally in the M.I. Nadiri article. Moreover, the Cobb-Douglas production function, in this specific form, is used by R. Solow in the analysis of productivity and technical change. Solow, R., "Technical Change and the Aggregate Production Function" Review of Economic Studies, 1957, pp. 312-20.

e is the base of the natural log. From the above relationship, we can solve for,

(2) $L = (Q/Ae^{\lambda t})^{1/\alpha_K - \beta/\alpha}$

Moreover, in terms of employment per unit output, we get,

(3) $L/Q = (Q^{1-\alpha}/Ae^{\lambda t})^{1/\alpha_K\ \beta/\alpha}$

In each of the above equations, the values for three variables are unknown. These are λ, α and β. The theoretical foundation of a simultaneous estimation of these three variables, using the single equation is quite tenuous. As such, two assumptions are made. First, the values of α and β are constrained to equal unity representing the assumption of constant returns to scale. Second the assumption is made that the rate of profit and the real wage are equal to the marginal products of capital and labour, respectively, in equilibrium. The result of these assumptions is that the ratio of the labour and capital elasticities of output, α/β, is made equal to the ratio of the distributive shares of labour and capital. The above problem and the consequent manipulation are illustrated quite clearly algebraically. From the initial Cobb-Douglas specification (equation (1)), we see that,

(4) $\alpha/\beta = (L/K)(\partial Q/\partial L)/(\partial Q/\partial K)$

In order to obtain values for α and β (or α/β), values for $\partial Q/\partial L$ and $\partial Q/\partial K$ must be obtained (the values of K and L are those that are used in the production function). However, these variables are not observable

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[33] This relationship is derived in the following manner:

$\partial Q/\partial L = Ae^{\lambda t}K^{\beta}\alpha L^{\alpha-1}$ where $\partial Q/\partial L$ equals the marginal product of labour
and, $\partial Q/\partial K = Ae^{\lambda t}\beta K^{\beta-1}L^{\alpha}$ where $\partial Q/\partial K$ equals the marginal product of capital
therefore, $\partial Q/\partial L/\partial Q/\partial K = \alpha/\beta \cdot K/L$
or, $\alpha/\beta = \partial Q/\partial L/\partial Q/\partial K \cdot L/K$

and their values, therefore, cannot be obtained directly, as are the K and L variable values. As such, the assumption of the equality of the marginal products of capital and labour to the rate of profit and real wage, respectively, is made. The values for the real wage (w) and the rate of profit (r) can be observed directly and a value for α/β is therefore derived which is equal to the ratio of distributive shares of labour to capital (i.e. wL/rK).[34] Therefore, given the values for α and β, only λ or the rate of autonomous or disembodied technical advance needs to be estimated.

Several characteristics of the neoclassical employment and productivity analyses can be deduced from the above specifications. First, the possibility of input substitution, with a given set of machinery and equipment, exists at any one point in time, under the conditions of diminishing marginal productivity of each input. The concept of malleable capital is therefore implicitly used in these production functions. Second, the effects of capital and technical change on output (and/or on employment) are treated as being independent of each other. The effects are represented by β the capital elasticity of output, and λ, the "rate of technical change." A further characteristic of this assumption is that the relative and absolute effects of capital and technical change on labour productivity (or on employment per unit output) are quite sensitive to the specific elasticity of substitution implied by the production function used. Different results are obtained if a Cobb-Douglas specification, with an elasticity of substitution equal to unity, or a C.E.S. production function, with an estimated constant

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[34] Given equation (4) and the marginal productivity determination of factor returns, a different specification for a Cobb-Douglas production function could be derived by replacing L/K by $\alpha/\beta \cdot r/w$ in the equations:

$L = (Q/Ae^{\lambda t})^{1/\alpha} K^{-\beta/\alpha}$ or $L/Q = (Q^{1-\alpha}/Ae^{\lambda t})^{1/\alpha} K^{-\beta/\alpha}$

which are themselves derived directly from equation (1).

elasticity of substitution, are used. Moreover, the specific elasticity of substitution, implied by the production function used, also determines the degree of complementarity that exists between the capital and technical change inputs. The degree of complementarity between capital and technical change is represented by the residual measure of the total change in labour productivity (or in employment per unit output) which results after the separate contributions of capital and technical change on labour productivity (or on employment per unit output) are calculated. The relative contributions of capital (or technical change) are defined as the percentage of the total change in labour productivity (on employment per unit output) that would have occurred if only capital (or technical change) had changed. The degree of complementarity increases as the elasticity of substitution declines and is non-existent only in the case of a linear production function with an infinite elasticity of substitution.[35] Third, the contribution of capital to output (or employment) in the Neoclassical production functions is dictated by the relative distributive share of the capital input. As we have already seen, this is so because of the Neoclassical assumption that the rate of profit is equal to the marginal product of capital in equilibrium. For example, given the assumption that the real wage and the rate of profit are equal to the marginal products of labour and capital, the ratio of output elasticities of labour to capital equals the ratio of distributive shares of labour to capital in the Cobb-Douglas specification. If we take the distributive shares of labour and capital to

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[35] This characteristic of Neoclassical production functions is clearly illustrated in, Davenport, P., The Sources of Economic Growth in Twentieth Century Canada, McGill University, (Mimeo) pp. 3-14. A paper presented to the Seventh Conference on Quantitative Methods in Canadian Economic History, Guelph, February 28, 1975. The case of the Cobb-Douglas production function is dealt with specifically in, Davis, L.E., et al., American Economic Growth: An Economist's History of the United States, Harper and Row, New York, 1972.

equal 0.75 and 0.25, respectively, equation (2) becomes,

$L = (Q/Ae^{\lambda t})^{4/3}K^{1/3}$

As such, these assumptions dictate a priori that a reduction of labour by one half would require the capital stock to be increased eight-fold, other things being equal. Fourth, capital stock or investment decisions in the Neoclassical production functions (with equations (2) and (3) as examples) are not related explicitly to employment or employment per unit output decisions. This fact arises from either of two assumptions used. In some cases, the capital stock is assumed fixed in the short-period and investment decisions are not considered explicitly. In other cases, the capital stock is assumed to grow at an exponential rate and is, therefore, seen to be exogenous over successive short-periods. The use of these assumptions is quite evident in the employment models surveyed by C.J. Roberts. The final salient feature of the Neoclassical analysis of employment and productivity is the autonomous technical change effects on output (or on employment) are represented by some form of time trend factor. In the Cobb-Douglas specification, technical change is seen to proceed at an estimated rate, λ.[36]

Based on the above discussed assumptions and theoretical techniques of the neoclassical analyses, employment can be seen to be some function of the level of output and/or the size of the capital stock, the extent of autonomous or disembodied technical change, and the relative input prices (i.e. the wage-rental ratio.) The implication, therefore, for employment per unit output is that it is affected by the size of the capital stock, either by itself (i.e. equation (3)) or relative to employment (i.e. see footnote 34),

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[36] The properties of the C.E.S. production function are described in detail in the M.I. Nadiri survey article, pp. 1151-56, and the above discussed characteristics can be seen in the description.

the extent of autonomous technical change, and relative input prices.

Several basic problems are, however, evident in the Neoclassical analyses, discussed above. First, the high levels of aggregation evident in the production function specifications are definitely inadequate for the analysis of employment per unit output at the industry level (and, most likely, at the sectoral or national levels of analysis). At the industry level, a proper analysis of a multi-product industry should take into consideration the product structure of the industry and its related technique and machinery structure. As such, it should consider the nature, as well as the size, of the existing capital stock. The important point, here, is that the pattern of demand can independently affect the nature of techniques used in the industry. This situation is quite different from the one where new techniques of production are adopted on the basis of cost-revenue considerations, given the product to be produced. Second, the separate specification of the relative input price, capital stock, and autonomous technical change variables presents a problem insofar as technique choice and investment decisions are treated as being independent of each other. As was already noted, an important implication of this type of specification is that capital stock or investment decisions are not explicitly related to employment decisions. Third, the neoclassical analyses do not take into account organizational factors that might affect employment and employment per unit output. Instead, these factors (and probably the composition of output factor) are relegated to a trend variable that is left unexplained, for the most part. The latter technique is quite unsatisfactory in view of the fact that secular changes in employment and in employment per unit output are being analyzed. Finally,

the empirical validity of several of the neoclassical assumptions need to be questioned. More specifically, the assumption of the rate of profit and the real wage equalling the marginal products of capital and labour, in equilibrium, appears to be suspect.[37] Moreover, the substitutability of inputs and the related diminishing marginal productivity assumptions need also to be examined at the empirical level. The most important question here concerns the nature of the average product of labour (which can be observed directly) and whether it is constant or rising over different levels of production, up to productive capacity of a given set of machinery and equipment. If this is the case, then the marginal productivity and substitutability of input assumptions would rest on very tenuous grounds.[38]

In light of these shortcomings of the traditional analyses, a different methodological approach comprising an alternative set of assumptions will be postulated. This approach will eliminate the basic problems implicit in the neoclassical analysis of employment per unit output structures.

The analysis begins by assuming that firms in a multi-product industry produce a desired level of output at least cost. The determinants of output and pricing decisions can vary between industries given structural and historical conditions. Firms in an industry do not necessarily maximize profits in a given short-period. No behavioural assumptions are specified here since the analysis of output and pricing decisions lies beyond the scope of the

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[37] The theoretical validity of this assumption is questioned in the following sources, Samuelson, P.A., "A Summing Up," Quarterly Journal of Economics, 1966, Robinson, J. and Nagvi, K.A., "The Badly Behaved Production Function," Quarterly Journal of Economics, 1967, pp. 579-91.

[38] The use of a constant marginal cost, implying a constant average product of labour, appears in the following analysis, Kalecki, M., "The Supply Curve of an Industry Under Imperfect Competition," Review of Economic Studies, 1939, pp. 91-109.

present study. The firms, in producing the desired level of output, can operate one or more plants or mills in any given short-period. The firms, moreover, are faced with a set of given input prices and have at their disposal a finite set of linear production processes or techniques of production with which to produce each product type. These production processes are well defined in terms of their productive capacities and their required labour and non-labour inputs, in both the qualitative and quantitative sense. In any given short-period, the techniques of production in a specific mill are given by the investment decisions undertaken in previous short-periods. To produce a given output type and quantity, a specific process or linear combination of several processes (where several processes exist in a mill) can be used. In successive short-periods, the potential range of linear production processes may be expanded through new investment embodying the technical changes of that period. Whether the new techniques of production are actually implemented depends on a number of factors, such as the relative costs of the new and old techniques of production and the confidence that the firms have in the new techniques of production. These factors will be examined in greater detail in section IV. Alternatively, the investment decision of the given short-period might involve higher capacity existing techniques. However, once the investment decisions are implemented in any given short-period, the available production processes are dictated by the nature of these and past investment decisions undertaken. Finally, related to the operation of the specific techniques and of the mills, in general, the firms are faced with a given organizational structure in the short-period, which dictates the indirect variable or overhead labour requirements and the relative efficiency of the firm in terms

of employment allocation and utilization. As a result of these conditions, the firm and consequently the industry are faced with a specific employment per unit output structure in the short-period.[39]

The actual specification of the determinants of the employment per unit output structure is specific to the Canadian pulp and paper industry in this case. However, the variables are described in a general enough form so that they may also be useful in explaining and predicting employment per unit output patterns in other large multi-product industries. In general, three basic determinants are seen to be relevant in explaining employment per unit output structures. The first variable is the product structure of the industry, reflecting the alternative employment requirements of the techniques or processes used to produce each product type. The second determinant is the degree of vertical integration of mills in the industry. This variable relates primarily to the organizational structure in the mills and, consequently, in the industry and has important implications for the extent of overhead or indirect variable employment and for the proportion of skilled to non-skilled employment that is offered. The above organizational and product structure related variables serve to explain a certain part of the autonomous or trend technical changes, in employment per unit output structures, of the Neoclassical analysis. The final determinant of employment per unit output structures is the level of gross investment per employee. This variable serves to represent the effects of investment and technical change (or changes in both the level and the nature of the capital stock) on employment per unit output structures. As was mentioned earlier,

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[39] Two other variables that might affect employment per unit output structures are the quality of the material inputs and of the labour inputs, through education and training. These variables are difficult to quantify and analyze and are, as a consequence, neglected in this, as well as in traditional, analysis.

the effects of these two factors cannot be legitimately separated, since technical changes are implemented, for the most part, through investment in new machinery and equipment. The specific theoretical construction reflects the assumption of the existence of linear production processes and represents a weighted average of all such processes across the various mills in the industry. The use of gross investment per employee rather than capital per employee (as in the Neoclassical analysis) is a result of two considerations. The first of these is the problem of the measurement of a heterogeneous capital stock, ex ante and independent of the distribution of income, at a given point in time. Specifically, the problem is one of arriving at a value for the capital stock in an initial period, since consequent additions to this measure reflect accumulated investments measured at cost and, therefore, do not present a problem. The second consideration relates to the greater suitability of the gross investment per employee, as a theoretical as well as empirical measure of the nature of technique choice decisions in the industry. The argument for the use of gross investment per employee as the appropriate variable is stated clearly and effectively by W.E.G. Salter,

> Because technique decisions relate to additions or replacements to the pre-existing capital stock, the appropriate means of measuring capital in the production function is in terms of real investment, and there is no need to consider directly the capital equipment already in existence.[40]

As specified therefore, the gross investment per employee variable would serve to represent various effects, related to technique choice, on employment per unit output structures. First, it would incorporate the

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[40] Salter, W.E.G., Productivity and Technical Change, Cambridge, 1969, p. 26

effects of changes in technique choice (through investment), other than those related to the composition of output (i.e. changes in the techniques of production available to produce a given output type). Second, it would reflect changes in the productive capacities of the various machinery, related to a given technique and employment structure. More specifically, as the capacity of a given piece of equipment in a given technique of production was altered, the level of investment per employee would vary proportionally with the level of employment per unit output. Finally, it would incorporate any economies of scale effects that might accrue through changes in investment. The important consideration, here, is the changes in the maintenance, repairs, etc... requirements of the specific technique of production.

Algebraically, the alternative specification, embodying the assumptions and methodology described above can be stated as,

(4) $Q = \gamma L$ or

(5) $L/Q = 1/\gamma$

where γ represents a constant in a given short period. Changes in ∂, over successive short periods, are conditioned by the equation,

(6) $\gamma = L/Q = a_0 + a_1 C + a_2 D + a_3 I/L$

where C, D, and I/L represent some form of composition of output, degree of vertical integration of mills and gross investment per employee variables, respectively, and a_1, a_2 and a_3 represent their respective coefficients.

In the case of the Canadian pulp and paper industry, the above variables

can be cast in a more specific form.[41] As a measure of the composition of output, the most appropriate variable that could be used would be some measure of the ratio of groundwood pulp production to total pulp production. In describing the technical structure in section II, we saw that the employment and employment per unit output structures differed most drastically between the mechanical pulping (not including refiner pulping) and chemical pulping techniques. Other things being equal, groundwood pulp and predominantly groundwood pulp related paper and paperboard producing mills would require relatively more labour than chemcial pulp and predominantly chemical pulp related paper and paperboard producing mills. Moreover, given the extent of employment offered in each case, chemical pulp and predominantly chemical pulp related paper and paperboard producing mills would require a higher proportion of skilled to non-skilled labour and of non-production to production-related employment. As such, several implications can be drawn about the resulting employment per unit output structures, given alternative trends in the ratio of groundwood pulp and predominantly groundwood pulp using paper and paperboard production to total production. First, in terms of the level of employment per unit output, a lower ratio would tend to imply a lower level of employment per unit output, other things being equal. Second, as regards the secular pattern of employment per unit output, a relatively more quickly declining ratio would tend to result in a relatively faster declining employment per unit output, other things being equal. Finally, with respect to the cyclical pattern of employment per unit output, a lower and/or relatively more quickly

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[41] The actual data for each variable, for the national and regional levels, will be discussed in the next subsection.

declining ratio would tend to imply a more volatile pattern of employment per unit output, again, other things being equal. The justification, here, is behavioural as well as technical. Over any given cycle, the higher the skilled to non-skilled (and, to a lesser extent the non-production to production) employment ratio, the greater would tend to be the number of employees retained in a downturn and the smaller would tend to be the number of employees hired or rehired in the upswing. Therefore, given the variation in output over a cycle, employment per unit output would tend to be more volatile in this case where employment is less volatile.[42]

The degree of vertical integration in the Canadian pulp and paper industry may be represented by either of two variables. The first of these is some form of the ratio of production of paper (and paperboard) producing mills to the total mills in the industry. The second is some form of the ratio of production of pulp producing and paper producing mills to the total mills in the industry. In the first case, the specific nature of the demand structure of the Canadian pulp and paper industry is taken into account explicitly. Given the fact that both pulp and paper production in the Canadian industry is geared primarily to foreign market demands, the proportion of pulp producing mills to total mills (of any given size in terms of productive capacity) is dictated to a great extent by the structure of this foreign demand. As such, the only substantive changes in the degree of vertical integration that can take place in the short-run concern the proportion of paper producing mills to the total number of mills in the industry. On the other hand, the second specification of the degree of

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[42] Offsetting this cyclical pattern, to a certain extent, is the fact that the relatively less efficient workers would be laid-off and hired or rehired over the cycle. As such, the fluctuations in output tend to also be dampened, in a relative sense.

vertical integration is much more flexible. In this case, the structure of demand is allowed to change between pulp and paper and paperboard. Such changes would tend to occur over relatively longer periods of time and would tend to exhibit relatively more irregular patterns, given the multitude of variables that can affect the foreign demand structure.[43] In either case, a substantial decrease in employment would tend to accompany a shift to integrated pulp and paper mills from pulp producing and/or paper producing mills, other things being equal. As was seen in section II, a decrease in the proportion of paper producing mills to total mills, would eliminate the employment previously existing in the beater room, finishing room and steam plant (where it exists) of the paper mill. Moreover, a certain amount of overhead labour related to maintenance, engineering and supervision would be eliminated. A decrease in the proportion of pulp producing mills would, at minimum, eliminate employment in the finishing room and in the woodroom and steam plants (where the latter existed). Moreover, in the case of chemical pulping, acid and/or recovery plants in the pulp mills would be eliminated. Finally, as in the case of the paper producing mills, various types of overhead labour would tend to be eliminated in the pulp producing mill. As such, alternative trends and/or patterns in the aforementioned ratios would tend to affect the different employment per unit output patterns in various ways. First, in terms of the level of employment per unit output, lower ratios would tend to imply a lower employment per unit output level. Second, as regards the secular pattern in employment per unit output, relatively more quickly decreasing ratios would tend to imply a relatively faster declining employment per unit output. Finally, with respect to the cyclical

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[43] Evidence of a higher variability in the first ratio, relative to the second, can be seen by considering the standard deviations from the mean value for the 1951 to 1973 period. The standard deviations are 6.68% and 5.54% for the first and second ratio, respectively.

pattern of employment per unit output, the effects of decreasing ratios is not as clear as it was in the case of the product structure variable. However, given the employment structure described in section II, some evidence appears to exist to support a more volatile employment per unit output pattern. The greatest proportion of the employment decrease would be in the woodroom and/or finishing room and most of the employment in these areas tends to involve relatively unskilled labour. It should be noted that the ratio of pulp producing and paper producing mills to total mills is used to represent the degree of vertical integration of mills variable in the following analysis. However, the ratio of paper producing to total mills is also referred to, in order to distinguish the relative importance of the shorter and longer-term effects of the degree of vertical integration of mills variable over the period under consideration.

The final determinant of employment per unit output, related to technique choice, is the level of gross investment per employee. Two types of specification were attempted. The first specification was the ratio of aggregate gross investment to the number of employees, in a given year. The second specification differentiated between construction investment and investment in machinery and equipment and explicitly considered differences in construction and implementation lags that might exist between the two types of investment.[44] Based on technical considerations, the variable that was selected represented the ratio of the sum of the average of construction investment in the current and previous two years and of machinery and equipment investment in the current year to the number of employees in the current

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[44] Other forms of disaggregated and/or lagged variables were attempted (see Appendix A) and used in a regression analysis. However, the specifications presented above appear to represent (in an aggregated and disaggregated form) the structural parameters of the industry most closely, based on the results of Appendix A.

year. Algebraically, the first specification could be written as I/L, while the second specification could be represented by I_{c_2m}/L, where subscripts c and m represent construction and machinery and equipment investment, respectively, with the appropriate lags. In either form, the gross investment per employee variable, is related to specific changes in technique choice previously outlined in this section and described in detail in section II. These would include changes in technique choice in the woodroom and finishing room operations and changes in the productive capacities of the various machinery and equipment, such as in the grinders, digesters, beaters, paper making and paper drying machines. In order to understand the direction of the relationship between gross investment per employee and employment per unit output, several theoretical considerations must be examined. The theoretical scenario[45] involves a cross-section of mills in an industry. The mills have been constructed at various dates and consist of different rates of normal output (or different capacities) and different average values of gross investment per employee, comprising machinery and equipment of different types and age. In the case of the Canadian pulp and paper industry, several such scenarios, each producing a different type of output, would constitute the industry as a whole. The weighted average of all mill gross investment per employee values would represent the relevant industry value. Also related to every mill would be a certain employment per unit output structure and the weighted average of these structures would represent the relevant employment per unit output value for the industry. Given the rate of technical change and investment

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[45] This type of theoretical analysis is derived from W.E.G. Salter, op. cit., pp. 48-64.

criteria (analyzed in section IV) the changes in the gross investment per employee ratios in new mills (or in old mills implementing new machinery and equipment) and the scrapping of obsolete mills (or obsolete machinery and equipment in operating mills) determine the new value for the industry gross investment per employee value and in the industry (and mill) employment per unit output values. The direction of the relationship between gross investment per employee and employment per unit output, therefore, depends on the nature of the technical change. From the technical description in section II, we can conclude that virtually all past and anticipated technical changes were of the labour saving variety, causing gross investment per employee to increase with investments in new techniques of production.[46] Moreover, W.E.G. Salter presents two reasons why this might be the case in general,

> It should be noted that there is no a priori reason why younger plants should have the lowest unit labour requirements. But there are two strong reasons why any other situation would be rare: first, few technical advances do not save labour absolutely; and secondly, the pressures for substitution generated by technical progress in the capital goods industries tend to encourage progressively greater savings of labour.[47]

As such, the basic effects of changes in gross investment per employee on the level and the secular patterns of employment per unit output would be as follows. First, a higher value of gross investment per employee would tend to be associated with a lower employment per unit output level, other things being equal. Second, a relatively faster growing gross investment per employee variable would tend to be related to a relatively more quickly

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[46] This conclusion would also refer to investments in higher capacity machinery and equipment.

[47] Salter, W.E.G., op. cit., p. 53.

declining employment per unit output, other things being equal.

A specific element of the gross investment per employee variable is the economies of scale that might accrue to an individual mill with the expansion of productive capacity. Although these economies of scale are not evident explicitly in the gross investment per employee variable due to its aggregate nature (i.e. valued at the industry level), they can be seen through a consideration of some form of an average productive capcity (per mill) variable. The economies of scale that we are concerned with, here, relate specifically to the relative employment reduction of indirect variable or overhead labour, as average productive capacity increases in the industry. First, with respect to the level of employment per unit output, a higher average productive capacity would tend to be associated with a lower employment per unit output level, other things being equal. Second, in terms of the secular pattern, a relatively faster growing average productive capacity would tend to be related to a relatively more quickly declining employment per unit output, other things being equal. Finally, as regards the cyclical pattern of employment per unit output, a higher and/or relatively more quickly growing average producitve capacity would tend to imply a less volatile employment per unit output. This would derive from the technically observed fact that the greater proportion of overhead labour tends to be relatively more skilled, as was seen in section II. As such, a higher and/or more rapidly increasing average productive capacity would be associated with a relatively lower proportion of skilled to non-skilled employees.

In the following sections, we will relate the above specified determinants to the employment per unit output structures, at the national

and regional levels. However, the analysis will be complete only after the determinants of the aforementioned variables are considered in section IV.

2. The Data

Prior to analyzing the employment per unit output trends, we must examine the nature of the specific data used in the following analyses. As will be seen, certain data problems do exist in attempting to quantify the various theoretical relationships outlined in the hypotheses. The problems relate both to the unavailability of certain required data and to the nature of the relevant data available in the various statistical sources. As such, we will consider the specific quantitative nature that the basic theoretical variables must necessarily assume in the ensuing analysis. Moreover, the description will differentiate between the national and sectoral data, given the availability of different type of data at these two regional levels.

The first variable that must be considered is employment per unit output. In all cases, this variable represents the ratio of the total number of employees to total production. Given the basic objectives of this study, the number of employees, and not the number of man-hours worked, is the relevant employment variable to be used. However, the fact that changes in the average hours worked per employee trend affects the actual number employed over time cannot be denied. Short-period changes in the average number of hours worked per employee does not seem to present much of a problem because the analyses deal with periods of time equivalent to a specified cycle or a number of consecutive cycles. Over periods of this length, overtime practice effects either do not vary significantly, or more

realistically, average out over upswings and downturns. The more serious problem concerns the trend nature of average hours worked per employee which are affected by institutional and behavioural factors, such as part-time employment trends and collective bargaining agreements. The period being examined (1951 to 1973) is definitely long enough for a downward trend to be apparent. However, in terms of the analysis, little can be done to isolate and effectively incorporate these effects. All that can be said is that, where these changes in average hours worked per employee have occurred, they would tend to increase the level of employment offered, given a certain level of output. As such, in these instances the employment per unit output variable would have been lower than the one that actually existed in that period. Moreover, over time, the decrease in the employment per unit output trend would have been greater had the changes in average hours worked per employee not taken place. With respect to the output variable, total production is the appropriate measure to be used. Since we are dealing with an industry that produces the basic input (i.e. pulp) as well as the final product (i.e. paper and paperboard), the value of shipments or sales is not as comprehensive a measure of output as is total production.

The employment data for the national and regional levels appears in Appendix A, Tables 3 and 9, respectively. The figures reported in these tables refer to the total number of employees annually. Tables 15 and 24, in this section, provide a compositional breakdown of total employment into production, production and related, administrative, and sales related employment. The distinction between production and production and related activity is that used by Statistics Canada. Production and related activity employment, as distinct from production employment, is defined to include,

"...storing, inspecting, handling, packing, warehousing,...maintenance, repair, janitorial, watchmen services,...(and) working foremen."[48] The distinction can roughly correspond to that of direct as opposed to indirect variable employment.

In deriving the output or production data, the ideal measure would have been a weighted average of the production of each output type, with the weighting factor being the price or average revenue of each product.[49] Gross production figures are available at the national level.[50] However, industry selling price indicies are calculated only for the years 1956 to 1973.[51] As such, an alternative method had to be used to calculate production data at the national and regional levels. At the national level, total production represents a weighted average of the six basic product classifications set out in section II. The annual production and weighted price levels for these product classifications are presented in Tables 1 and 2, respectively, in Appendix A. Given the nature of the analysis, these seemed the most appropriate product distinctions to be used. At the regional level, this type of breakdown is not possible. The only distinction that can be made is between pulp, and paper and paperboard production. Moreover, the price data used are available only at the national level. The production and weighted price level data are presented in Tables 7 and 8, respectively, in Appendix B. Several implications can be drawn about the resulting weighted

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[48] Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual)

[49] Algebraically, this measure can be specified as $\sum_{i=1}^{n} A \cdot R_i \cdot Q_i / \sum_{i=1}^{n} A \cdot R_i$ where i represents the specific product type.

[50] Canadian Pulp and Paper Association, Reference Tables, (Annual)

[51] Statistics Canada, Prices and Price Indexes, Cat. 62-002, (Monthly)

production data, given the various raw data problems at the regional level. First, as a result of national prices being used, total combined production would tend to be biased downwards. The rationale, here, is that weighted pulp, and paper and paperboard prices would tend to be higher in the western sector, given the greater proportion of higher priced chemical pulp and predominantly chemical pulp related paper and paperboard. Second, due to the different product categories used, the absolute total weighted production data in the eastern and western sector is not comparable to the same data at the national level. However, the cyclical and secular trends, between the two sectors, can be compared in a more meaningful manner.

The second variable that must be considered is the composition of output, as it reflects the various techniques of production and the related employment structures of the relevant product types. As was mentioned in the previous subsection, the appropriate measure to represent the composition of output variable is the ratio of groundwood pulp production to total pulp production. The specification is based on the observation that the employment and employment per unit output structures differed most drastically between the mechanical pulping (not including refiner pulping) and the chemical pulping techniques. Moreover, given the fact that production data (rather than value of shipments) is being used, the proportion of predominantly groundwood pulp to predominantly chemical pulp using paper and paperboard production need not be considered, since the pulp production data includes the proportion of pulp used in paper and paperboard production (i.e. not exported directly). As such, if the ratio of groundwood pulp and predominantly groundwood pulp using paper and paperboard production to chemical pulp and predominantly chemical pulp using paper and paperboard production

were used, the problem of double counting would be present. The raw data for the composition of output variable is presented in Appendix B - Table 4. At the regional level, however, production data for the above product groups cannot be issued by Statistics Canada. As such, the only available proxy measure is the ratio of groundwood pulp producing to the total number of mills, in each sector. The raw data are presented in Appendix B - Tables 10 and 12. The obvious problem, here, is that the relative size of the different mill types is unknown.

The third variable that must be considered is the degree of vertical integration of mills in the industry. The basic problem is that the required data, at the national and regional levels, are available only in terms of the number of mills producing pulp, paper, and pulp and paper and not in terms of the relative production levels of these types of mills. The limitation of this situation is identical to that discussed in the previous paragraph and need not be repeated here.

The final two variables to be considered are the level of gross investment per employee and the average mill productive capacity, providing a measure of economies of scale. Two specifications of the gross investment per employee are used in the analysis and these were discussed in the previous subsection. Both of the specifications are derived from the raw data in Appendix B - Table 5, for the national level, and Appendix B - Table 11, for the regional level. Since the nature of the employment data was already discussed, only the gross investment data need be considered, here. First, the gross investment data represents the reported costs of total investment outlays (i.e. new and replacement investment less scrapping) during the calendar year. Second, a constant 1961 dollar series was used,

since all other variables in the analysis were specified in real terms. The specific deflator, used by Statistics Canada in constructing the series, was a provincial investment goods price deflator. Finally, it should be noted that the sum of the regional total component values for gross investment in any given year does not usually correspond to the national value for the same year. This is because a revised data series was made available during the course of this study. The revised data, however, had not been broken down on a provincial basis. In terms of the average mill productive capacity variable, comprehensive data are not available at the national and regional levels. Instead, average mill production will be used as a rough proxy in this situation. The implicit assumption is that utilization rates across mills are roughly equal, in any given year or over any given cycle. Given the variability, from year to year, in the productive capacity of the relatively less efficient mills, this assumption might present a problem on an annual basis. However, over a cycle, the variability would tend to average out, making the assumption somewhat less suspect.

3. The National Analysis

The analysis at the national level will deal with the period 1951 to 1973. Over this period, both the secular and cyclical patterns in employment per unit output will be considered. In the secular analysis, the two relevant statistical measures that will be employed are the compound annual rate of growth and the average of annual percentage changes. The analysis will illustrate the various relationships that existed, over various periods of time, between the aforementioned measures related to employment per unit output and those related to the basic determinants. Although both measures

provide an indication of the trend growth or decline of the specific variables, the average annual percentage change is a more appropriate measure because it explicitly takes into account the year to year variability in the levels of the variables.[52] As such, only the average of annual percentage changes measure will be considered explicitly in the analysis. Moreover, for the sake of brevity, it will be referred to as the trend rate. However, where drastic differences are evident, in a specific period, in the two relevant measures, they will both be cited and analyzed.

The analysis will first consider the absolute trends in employment per unit output and its basic determinants over the entire period 1951 to 1973. Second, the latter period will be broken down into the 1950's and1960's decades and into the early 1970's period and the relative trends in employment per unit output and its determinants will be examined. In the case of the two decades, we shall see that they each consist of two cycles, which average five years in length. Finally, the 1951 to 1973 period will be further broken down into its five component cycles and the relative trends in employment per unit output and its determinants will be analyzed in each cycle separately. The rationale for analyzing the different sets of periods is that the relative effects of the variables over the 1951 to 1973 period will be better understood and the various relationships will, therefore, have been more thoroughly examined.

In terms of the cyclical analysis, the relevant measure of variation in

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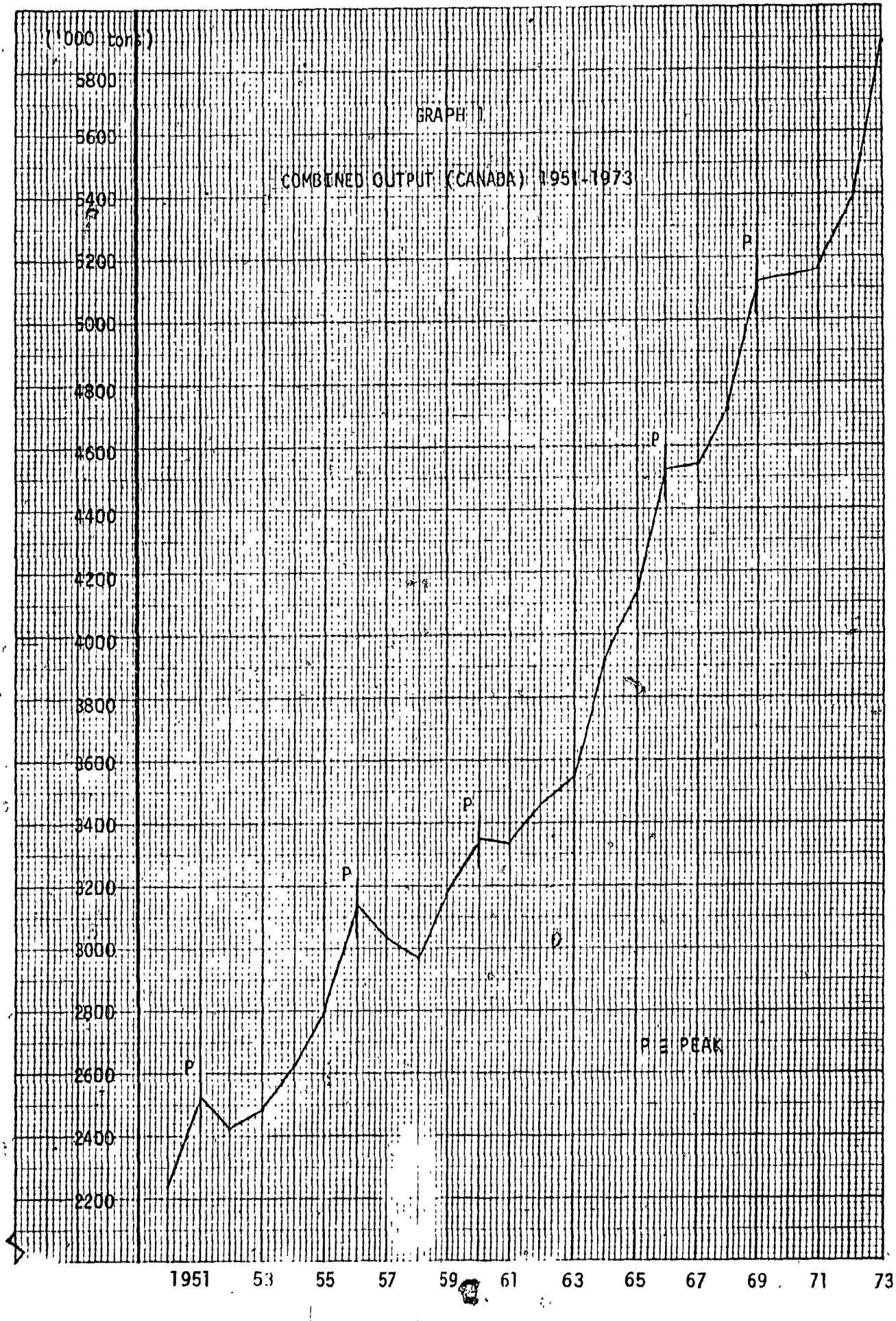
[52] Given the method of calculation of this measure, it should be noted that a upward bias exists (relative to a more accurate indication of the actual growth trend). That is, given identical changes in the level of a variable over two periods of time, but in opposite directions, the percentage increase resulting in one period will be greater than the percentage decrease in the other period. As such, the resulting average annual percentage change is positive where in fact the level of the variable is unchanged, over the two periods

employment per unit output is the standard deviation from the mean or average level of employment per unit output, in a given period. This measure is represented as a percentage of the mean value. The periods to be examined are the same as those in the secular analysis and the rationale for their analysis is identical to that presented in the preceding paragraph. As was mentioned in the hypothesis, we will relate the cyclical pattern in employment per unit output to the mean values of those variables which can affect the skill composition of employment and the proportion of indirect to direct variable employment.

One implicit limitation of this type of statistical analysis is that the exact magnitude of the various relationships between employment per unit output and its basic determinants is not established in any absolute sense. This basically results from the fact that several explanatory variables are being examined simultaneously. To alleviate this problem, a regression analysis is presented in Appendix A, involving the most relevant explanatory variables. This analysis derives some absolute measure of the relative impacts of the various explanatory variables on the employment per unit output variable. Moreover, it confirms the direction of the various relationships, the explanatory significance of each of the independent variables and, finally, their ability to explain between them the employment per unit output trends. Accompanying the analysis in Appendix A will be a discussion of its various limitations.

Table 8 and Graph 1 present the secular and cyclical patterns in the combined output variable at the national level. The specific trends will be analyzed in detail in the ensuing analysis of this subsection. The reason that they are presented here is to discern the various cycles over the



GRAPH I

COMBINED OUTPUT (CANADA) 1951-1973

TABLE 8

COMBINED (WEIGHTED) OUTPUT (CANADA) 1951-1973

	(,000 tons)	
1951	2,516.857	(11.58)
1952	2,431.275	(-3.40)
1953	2,483.250	(2.14)
1954	2,621.197	(5.56)
1955	2,797.371	(6.72)
1956	3,122.286	(11.62)
1957	3,035.772	(-2.77)
1958	2,977.478	(-1.92)
1959	3,174.058	(6.60)
1960	3,351.675	(5.60)
1961	3,327.859	(-0.71)
1962	3,482.324	(4.64)
1963	3,551.487	(1.99)
1964	3,917.436	(10.30)
1965	4,153.408	(6.02)
1966	4,512.792	(8.65)
1967	4,523.504	(0.24)
1968	4,728.826	(4.54)
1969	5,120.187	(8.28)
1970	5,137.083	(0.33)
1971	5,156.813	(0.38)
1972	5,397.178	(4.45)
1973	5,885.347	(9.04)

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

1951 to 1973 period Measured from peak to peak, five basic cycles can be observed These are related to the periods 1951 to 1956, 1956 to 1960, 1960 to 1966, 1966 to 1969, and 1969 to 1973. The first two cycles can be seen to comprise the 1950's decade while the next two cycles can be seen to make up the 1960's decade These cyclical periods in combined output establish the setting in which the technique choice effects on employment per unit output can be analyzed at the national level

Tables 9-13 present the annual values for employment per unit output and its basic determinants over the 1951 to 1973 period. The specific nature of the data and their theoretical justification were discussed in the preceeding subsections of this section. Included in these tables are the annual percentage change values, which are represented by the bracketed figures The relevant cyclical and secular characteristics of these variables are summarized in Table 14 for the 1951 to 1973 period and for the various reference cycles and groups of cycles. The ensuing analyses at the national level will refer to the data presented in the latter table.

The secular relationships between employment per unit output and its basic determinants will be examined first. Over the entire 1951 to 1973 period, employment per unit output declined at a trend rate of 2.04%. During this period, the composition of output variable also showed a declining trend rate of 1.52%. Both the gross investment per employee variables exhibited an increasing trend. In terms of the trend rate, the aggregate specification proceeded at a slightly faster rate of 5.43%, as compared to 4.67% for the disaggregated and lagged specification. However, the growth rate measures indicated a relatively faster increase for the disaggregated and lagged

TABLE 9

EMPLOYMENT PER UNIT COMBINED OUTPUT (CANADA) 1951-1973

	(number employed per ,000 tons)
1951	22.763
1952	23.775 (4.45)
1953	23.435 (-1.43)
1954	23.210 (-0.96)
1955	22.237 (-4.19)
1956	21.134 (-4.97)
1957	21.763 (2.98)
1958	21.562 (-0.92)
1959	20.530 (-4.79)
1960	19.624 (-4.41)
1961	19.278 (-1.76)
1962	18.633 (-3.35)
1963	18.313 (-1.72)
1964	17.289 (-5.59)
1965	16.829 (-2.66)
1966	16.287 (-3.22)
1967	16.355 (0.42)
1968	15.543 (-4.96)
1969	14.731 (-5.22)
1970	15.645 (6.20)
1971	15.396 (-1.59)
1972	14.632 (-4.96)
1973	13.608 (-7.00)

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

TABLE 10

COMPOSITION OF OUTPUT BY TONNAGE (CANADA) 1951-1973

	Ratio of Groundwood Pulp Production to Total Wood Pulp Production
1951	0.5553
1952	0.5771 (3.93)
1953	0.5643 (-2.22)
1954	0.5518 (-2.22)
1955	0.5386 (-2.39)
1956	0.5332 (-1.00)
1957	0.5347 (0.28)
1958	0.5303 (-0.82)
1959	0.5221 (-1.55)
1960	0.5131 (-1.72)
1961	0.4990 (-2.75)
1962	0.4856 (-2.69)
1963	0.4689 (-3.44)
1964	0.4688 (-0.02)
1965	0.4796 (2.30)
1966	0.4716 (-1.67)
1967	0.4572 (-3.05)
1968	0.4358 (-4.68)
1969	0.4131 (-5.21)
1970	0.4178 (1.14)
1971	0.4061 (-2.80)
1972	0.3992 (-1.70)
1973	0.3939 (-1.33)

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

TABLE 11

EXTENT OF MILL INTEGRATION (CANADA) 1951-1973

	Paper Producing Mills As A Percentage Of Total Mills	Pulp Producing and Paper Producing Mills As A Percentage Of Total Mills
1951	0.2064	0.4762
1952	0.2031 (-1.56)	0.4688 (-1.56)
1953	0.1899 (-6.97)	0.4567 (-2.57)
1954	0.2000 (5.83)	0.4480 (-1.90)
1955	0.2000 (0.00)	0.4480 (0.00)
1956	0.1984 (-0.80)	0.4444 (-0.79)
1957	0.1953 (-1.56)	0.4375 (-1.56)
1958	0.1875 (-4.00)	0.4219 (-3.57)
1959	0.2047 (9.18)	0.4173 (-1.08)
1960	0.2031 (-0.78)	0.3984 (-4.52)
1961	0.1920 (-5.48)	0.4080 (2.40)
1962	0.1920 (0.00)	0.4160 (1.96)
1963	0.1905 (-0.78)	0.4127 (-0.79)
1964	0.1905 (-0.16)	0.4275 (3.58)
1965	0.2197 (15.15)	0.4394 (2.79)
1966	0.2059 (-6.28)	0.4265 (-2.94)
1967	0.2020 (-1.46)	0.4275 (0.25)
1969	0.1942 (-4.29)	0.4317 (0.96)
1969	0.2263 (16.53)	0.4818 (11.61)
1970	0.2286 (1.02)	0.4929 (2.31)
1971	0.2028 (-11.27)	0.4196 (-14.87)
1972	0.2222 (9.57)	0.4583 (9.24)
1973	0.2387 (7.42)	0.4710 (2.76)

Source: Canadian Pulp and Paper Association, Reference Tables (Annual).

TABLE 12

GROSS INVESTMENT PER EMPLOYEE (CANADA) 1951-1973

	Investment Per Employee	Disaggregated and Lagged Investment per Employee
	($,000 constant 1961)	
1951	2.782	2.547
1952	2.840 (2.08)	2.849 (11.86)
1953	2.265 (-20.25)	2.440 (-14.3)
1954	1.647 (-27.28)	1.754 (-28.11)
1955	2.587 (57.07)	2.463 (40.42)
1956	4.527 (74.99)	3.910 (58.75)
1957	4.348 (-3.95)	4.341 (11.02)
1958	2.047 (-52.92)	2.560 (-41.03)
1959	2.022 (-1.22)	2.185 (-14.65)
1960	2.484 (22.85)	2.414 (10.48)
1961	2.448 (-1.45)	2.365 (-2.03)
1962	2.581 (5.43)	2.538 (7.32)
1963	3.034 (17.55)	3.011 (18.64)
1964	4.497 (48.22)	4.208 (39.75)
1965	5.249 (16.72)	4.822 (14.59)
1966	6.370 (21.36)	6.088 (26.25)
1967	5.342 (-16.14)	5.523 (-9.28)
1968	3.170 (-40.66)	3.607 (-34.69)
1969	3.968 (25.17)	3.864 (7.13)
1970	5.276 (32.96)	5.041 (30.46)
1971	5.313 (0.70)	5.261 (4.36)
1972	4.217 (-20.63)	4.355 (-17.22)
1973	3.326 (-21.13)	3.618 (-16.92)

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada (revised).

TABLE 13

AVERAGE MILL OUTPUT (CANADA) 1951-1973

	(,000 tons)
1951	19.9751
1952	18.9943 (-4.91)
1953	19.5531 (2.94)
1954	20.9696 (7.24)
1955	22.3790 (6.72)
1956	24.7800 (10.73)
1957	23.9037 (-3.54)
1958	23.4447 (-1.92)
1959	25.1909 (7.45)
1960	26.6006 (5.60)
1961	26.6229 (0.08)
1962	27.8586 (4.64)
1963	28.1864 (1.18)
1964	29.9041 (6.09)
1965	31.4652 (5.22)
1966	33.4281 (6.24)
1967	33.0183 (-1.23)
1968	34.5170 (4.54)
1969	37.3736 (8.28)
1970	36.9574 (-1.11)
1971	36.3156 (-1.74)
1972	38.0083 (4.66)
1973	41.7400 (9.82)

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

TABLE 14

SECULAR AND CYCLICAL PATTERNS IN EMPLOYMENT PER UNIT OUTPUT AND ITS DETERMINANTS (CANADA) 1951-1973

		1951-73	1951-60	1960-69	1969-73
Employment Per Unit Output					
	(1)	-2.31	-1.64	-3.14	-1.96
	(2)	-2.04	-1.58	-3.12	-1.83
	(3)	16.85	5.77	8.96	4.12
Composition of Output					
	(1)	-1.55	-0.87	-2.38	-1.18
	(2)	-1.52	-0.86	-2.35	-1.17
	(4)	0.4877	0.5421	0.4693	0.4060
Degree of Vertical Integration of Mills					
	(1)	-0.05 (0.66)	-1.96 (-0.17)	2.13 (1.21)	-0.56 (1.35)
	(2)	0.08 (0.96)	-1.95 (0.12)	2.20 (1.51)	-0.14 (1.68)
	(4)	0.4400	0.4417	0.4269	0.4647
Gross Investment Per Employee					
	(1)	0.82	-1.25	5.34	-4.32
	(2)	5.43	5.14	8.47	-2.03
Disaggregated and Lagged Gross Investment Per Employee					
	(1)	1.61	-0.82	5.37	-1.63
	(2)	4.67	3.81	7.52	0.17
Average Mill Output					
	(1)	3.41	3.23	3.85	2.80
	(2)	3.38	3.36	3.89	2.91
	(4)	28.75	22.57	30.90	38.08

Note: (1) annual compound rate of growth
(2) average of annual percentage changes
(3) standard deviation as a percent of mean value
(4) mean value

TABLE 14 (Continued)

		1951-56	1956-60	1960-66	1966-69	1969-73
Employment Per Unit Output						
	(1)	-1.47	-1.84	-3.06	-3.29	-1.96
	(2)	-1.42	-1.78	-3.05	-3.25	-1.83
	(3)	3.57	3.73	6.49	4.20	4.12
Composition of Output						
	(1)	-0.81	-0.96	-1.40	-4.32	-1.18
	(2)	-0.78	-0.95	-1.38	-4.31	-1.17
	(4)	0.5534	0.5267	0.4838	0.4444	0.4060
Degree of Vertical Integration of Mills						
	(1)	-1.37	-2.69	1.14	4.15	-0.56
		(-0.78)	(0.59)	(0.22)	(3.20)	(1.35)
	(2)	-1.37	-2.68	1.16	4.27	-0.14
		(-0.70)	(0.71)	(0.46)	(3.60)	(1.68)
	(4)	0.4571	0.4239	0.4184	0.4419	0.4647
Gross Investment Per Employee						
	(1)	10.23	-13.93	16.99	-14.60	-4.32
	(2)	17.32	-8.81	17.96	-10.54	-2.03
Disaggregated and Lagged Gross Investment Per Employee						
	(1)	8.95	-11.36	16.67	-14.06	-1.63
	(2)	14.11	-8.55	17.42	-12.28	0.17
Average Mill Output						
	(1)	4.41	1.79	3.88	3.79	2.80
	(2)	4.54	1.89	3.91	3.86	2.91
	(4)	21.11	24.78	29.15	34.58	38.08

Note: (1) annual compound rate of growth
(2) average of annual percentage changes
(3) standard deviation as a percent of mean value
(4) mean value

specification. This discrepancy is basically the result of the markedly greater variability of the aggregate data (see Table 12) and the upward bias implicit in the calculation of the trend rate (see footnote 44). During this period, the economies of scale variable also showed an increasing trend rate of 3.38%. With respect to the degree of vertical integration variables, a slight positive trend rate of 0.96% was evident in the ratio of paper producing to total mills (in brackets in Table 14). The ratio of pulp producing and paper producing mills to total mills showed an even slighter trend. The growth rate was -0.05%, while the trend rate was 0.08%. The implication would appear to be that the secular trend in the number of paper producing mills would have resulted in a relatively slower declining trend rate in employment per unit output than was the actual case, given the trends in the other basic determinants. However, the effect was partially or totally cancelled out by the implicitly decreasing secular trends in the number of pulp producing mills. The net effect of the trends in the latter variable on the trends in employment per unit output appear to have been negligible in either the negative or positive direction.[53] Summarizing the basic relationships; we see that the trends in the composition of output and in the gross investment per employee, and the related economies of scale, variables contributed positively to the declining trend in employment per unit output over the 1951 to 1973 period. The other technique choice variable, the degree of vertical integration of mills, had a negligible influence on employment per unit output trends over this period.

In contrast to the relationships derived for the period 1951 to 1973 in its entirety, we can examine the relative secular trends in employment per unit output and in its basic determinants for the 1950's and 1960's

[53] Given the arithmetic nature of the average annual percentage change measure (see footnote 44), it is quite conceivable that a negative or decreasing trend was actually the case in the degree of vertical integration variable.

decades and for the early 1970's. During the 1951 to 1973 period, employment per unit output declined at a trend rate of 1.58%. The composition of output variable over this period exhibited a similar declining trend. The actual rate of decline was -0.86%. The gross investment per employee variables exhibited opposing trends, depending on the measure of growth used. In terms of the trend rate, the aggregate and disaggregated and lagged specifications showed increasing trends of 5.14% and 3.81%, respectively. However, the corresponding annual compound rates of growth for the two specifications showed a declining trend of -1.25% and -0.82%, respectively. Again, the corresponding trend rates are relatively much higher, in both the specifications, due to the high variability in the variable and the upward bias of the trend rate calculation. This difference will be seen to exist in all the subsequent periods which will be examined. However, in this specific period, it is difficult to deduce the true direction of the gross investment per employee variable trend, since the extent of the upward bias of the trend rate measure is not known. The average mill output variable, indicating the extent of the economies of scale effects, increased at a trend rate of 3.36%. Finally, with respect to the degree of vertical integration of mills variable, the two ratios showed opposite trends, over the 1951 to 1960 period. The trend rate in the ratio of paper producing mills to total mills was 0.12% while the rate for the ratio of pulp producing and paper producing mills to total mills was -1.95%. This would imply that the decline in the number of pulp producing mills was great enough to offset the increase in the number of paper producing mills over this period. As such, it would appear that the basic technique choice related causes of the declining trend in employment per unit output over the 1951 to 1960 period were the declining

trends in the composition of output and in the ratio of pulp producing and paper producing mills to total mills and the increasing trends in average mill output. The effects of the gross investment per employee variable are uncertain during this period. If the trend rates are seen to be appropriate, then the gross investment per employee variable contributed positively to the declining trend in employment per unit output. Moreover, if the annual compound rate of growth is taken to represent the more accurate measure, the declining trend in the gross investment per employee variable would have resulted in an increasing trend in employment per unit output, other things being constant. The final decison depends on the extent of the upward bias in the trend rate measure, which results from the fact that the variability in the variable is being explicitly considered by the latter growth measure.

Employment per unit output declined at a faster rate over the 1960 to 1969 period, relative to the 1951 to 1960 period. The trend rate during this period was -3.12%. Similarly, the composition of output variable declined at a relatively faster rate of -2.35% over the 1960 to 1969 period. The gross investment per employee variables increased at a relatively faster rate in terms of the trend rate. The aggregate and disaggregated and lagged specifications proceeded at rates of 8.47% and 7.52%, respectively. Moreover, the annual compound rates of growth were also positive for both specifications during the 1960 to 1969 period. Similarly, the economies of scale variable increased at a faster rate of 3.89%, relative to the 1951 to 1960 period. Finally, as regards the degree of vertical integration of mills variable, both ratios exhibited increasing trends relative to the 1951 to 1960 period. The trend rates were 2.20% and 1.51% in the ratios of pulp producing and

paper producing mills to total mills and paper producing mills, respectively. This would imply a relatively faster increase in the number of pulp producing mills, as compared to paper producing mills. In summary, for the 1960 to 1969 period, the relatively faster declining trends in employment per unit output resulted from the more quickly declining trend in the composition of output variable and from the relatively faster increasing trends in the gross investment per employee and economies of scale variables. The degree of vertical integration of mills variable, over this period, served to place an upward pressure on employment per unit output, other things being constant.

Over the 1969 to 1973 period, employment per unit output declined, but at a much slower rate relative to the 1960 to 1969 period. The trend rate over this period was -1.83%. The composition of output variable exhibited a similar relative trend this period, with a trend rate of -1.17%. Similarly, the gross investment per employee and economies of scale variables exhibited slower rates of increase (or even of decline) during the 1969 to 1973 period, relative to the 1960 to 1969 period. The trend rates for the aggregate and disaggregated and lagged specifications of the gross investment per employee variables were -2.03% and 0.17%, respectively. The economies of scale variable proceeded at a trend rate of 2.91%. Finally, as regards the degree of vertical integration of mills variables, the ratio of paper producing mills to total mills exhibited a relatively higher trend rate of 1.68% during the 1969 to 1973 period, compared to the 1960 to 1969 period. However, the ratio of pulp producing and paper producing mills exhibited a declining trend of -0.14%, as compared to the 2.20% trend rate of the 1960 to 1969 period. The implication of the two ratio trends is that the relative

decline in the number of pulp producing mills during the 1969 to 1973 period, as compared to the 1960 to 1969 period, was great enough to offset the relative increase in the number of paper producing mills. In summary, we see that the prevalent relations of the 1969 to 1973 period were identical to those of the 1960 to 1969 period. The basic contributors to the relatively slower decreasing trend in employment per unit output were the relatively slower declining trend in the composition of output variable and the relatively slower increasing trends in the gross investment per employee and economies of scale variables. The degree of vertical integration of mills variable trends, on the other hand, would have resulted in a relatively faster decline in the composition of output variable, other things being constant.

Finally, the secular relationships between employment per unit output and its basic determinants can be examined on a cyclical basis. For the period 1951 to 1956, employment per unit output declined at a trend rate of -1.42%. The composition of output variable also showed a declining rate of -0.78%. The gross investment per employee variables increased at trend rates of 17.32% and 14.11%, in terms of the aggregate and disaggregated and lagged specifications, respectively. Moreover, the economies of scale variable increased at a trend rate of 4.54%. Finally, the degree of vertical integration of mills ratios both showed declining trends. The trend rate, in the ratio of pulp producing and paper producing mills to total mills, of -1.37% was greater than the corresponding rate of -0.70% for the ratio of paper producing mills to total mills. As such, the relative decline in the number of pulp producing mills was greater than the relative decline in the number of

paper producing mills In summary, the basic contributors to the declining trend in employment per unit output, over this period, appear to have been the declining trends in the composition of output variable and in the degree of vertical integration of mills variable and the increasing trends in the gross investment per employee and economies of scale variables.

Relative to the 1951 to 1956 period, employment per unit output exhibited a more quickly declining trend of -1 78% between 1956 to 1960. The composition of output variable decreased at a relatively faster rate of -0 95%, as compared to the 1951 to 1956 period. Contrary to the 1951 to 1956 period, the gross investment per employee variables exhibited a declining trend over the 1956 to 1960 period. The trend rates for the aggregate and disaggregated and lagged specifications were -8 81% and -8 55%, respectively Moreover, the economies of scale variable increased at a much slower trend rate of 1.89%, relative to the 1951 to 1956 period. Finally, the degree of vertical integration of mills ratios exhibited opposing trends over this period. The ratio of paper producing mills to total mills increased at a trend rate of 0.71%, as compared to the trend rate of -0.70% during the 1951 to 1956 period. However, the ratio of pulp producing and paper producing mills to total mills decreased at a relatively faster rate of -2.68%, relative to the 1951 to 1956 period, offsetting the relative increase in the number of paper producing mills. In summary, the basic contributors to the relatively faster declining trend in employment per unit output were the relatively more quickly declining trends in the composition of output and degree of vertical integration of mills variables. The decreasing trends in the gross investment per employee variables and the relatively slower increasing trend in the economies of scale variable

would have resulted in a relatively slower decline (or even an increase) in employment per unit output, other things being constant.

The analysis of the 1951 to 1956 period, individually, produces a more thorough understanding of the results derived from the analysis of the 1951 to 1960 period, in its entirety. The relationships between employment per unit output and the composition of output and degree of vertical integration of mills variables were similar in the analysis of the 1951 to 1956 and 1956 to 1960 periods, separately, and in the analysis of the 1951 to 1960 period, in its entirety. However, whereas the effects of the gross investment per employee variables on employment per unit output were inconclusive in the analysis of the 1951 to 1960 period, the effects were identified in the analysis of the 1951 to 1956 and 1956 to 1960 periods. Moreover, the analysis of the 1951 to 1956 and 1956 to 1960 periods, showed opposite relationships between the economies of scale variable and employment per unit output in each of the two periods, while the analysis of the 1951 to 1960 period brought out only the net result.

During the 1960 to 1966 period, employment per unit output declined at a faster rate, relative to the 1956 to 1960 period. The trend rate was -3.05%. Similarly, the trend rate of decline of -1.38% in the composition of output variable was relatively greater than that of the 1956 to 1960 period. The gross investment per employee variables exhibited increasing trends during the 1960 to 1966 period, contrary to the decreasing trends of the 1956 to 1960 period. The aggregate and disaggregated and lagged specifications indicated trend rates of 17.96% and 17.42%, respectively. Moreover, the economies of scale variable increased at a much faster rate,

relative to the 1956 to 1960 period. The trend rate was 3.91%. Finally, the degree of vertical integration of mills ratios exhibited opposing relative trends during the 1960 to 1966 period. The ratio of paper producing mills to total mills increased at a relatively slower trend rate of 0.46%. The ratio of paper producing and pulp producing mills to total mills, on the other hand, exhibited an increasing trend of 1.16%, as compared to the decreasing trend of the 1956 to 1960 period. As such, the increase in the number of pulp producing mills was markedly greater than the increase in the number of paper producing mills, during this period. In summary, the basic contributors to the relatively faster declining trend in employment per unit output, during the 1960 to 1966 period, were the relatively faster decline in the composition of output variable and the increasing trends in the gross investment per employee and economies of scale variables. The increasing trends in the degree of vertical integration of mills variable would have resulted in a relatively slower decline in employment per unit output, other things being constant.

Relative to the 1960 to 1966 period, employment per unit output declined at a faster trend rate of -3.25%, over the 1966 to 1969 period. Similarly, the composition of output variable declined at a relatively much faster rate of -4.31%. The gross investment per employee variables exhibited declining trends, contrary to the increasing trends of the 1960 to 1969 period. The aggregate and disaggregated and lagged specifications decreased at trend rates of -10.54% and -12.28%. The economies of scale variable increased at a slightly slower rate of 3.86%, relative to the 1960 to 1966 period. Finally, the degree of vertical integration of mills ratios exhibited relative increasing trends during the 1966 to 1969 period. The trend rates

in the ratio of paper producing mills to total mills and in the ratio of pulp producing and paper producing mills to total mills, were 3.60% and 4.27%. Given the trend rates for the 1960 to 1966 ratios, the conclusion that follows is that the relative increase in the number of non-integrated mills was brought about, almost entirely, from the increase in the number of paper producing mills. In summary, the basic determinant of the relatively faster declining trend in employment per unit output over this period was the relatively much faster decline in the composition of output variable. The latter relative decline was great enough so as to offset the trends in the other determinants, which served to place an upward pressure on employment per unit output, other things being equal.

In relating the analysis of the 1960 to 1966 and 1966 to 1969 periods to the analysis of the 1960 to 1969 period, several conclusions can be drawn. First, the composition of output variable trends were a contributing factor to the relative declining trends in employment per unit output over both the 1960 to 1966 and 1966 to 1969 periods. Second, the relative trends in the gross investment per employee variable were a contributing factor only over the 1960 to 1966 period. However, the net effect of the gross investment per employee trends over the 1960 to 1966 and the 1966 to 1969 periods was such that the latter variable trends contributed positively to the relatively faster decline in employment per unit output over the 1960 to 1969 period, as compared to the 1951 to 1960 period. Moreover, this same pattern applies to the economies of scale variable, in its relationship to employment per unit output trends. Third, the degree of vertical integration of mill variable trends tended to place an upward pressure on employment per unit output trends in each of the 1960 to 1966 and 1966 to

1969 periods.

During the most recent cycle, the 1969 to 1973 period, employment per unit output declined at a slower rate, relative to the 1966 to 1969 period. The trend rate of decline over this period was -1.83%. A similar trend was exhibited by the composition of output variable over this same period, with the trend rate at -1.17%. The gross investment per employee variables exhibited opposing trends, over the 1969 to 1973 period. The aggregate specification declined at a trend rate of -2.03%. The disaggregated and lagged specification increased at a trend rate of 0.17%. However, relative to the corresponding trend rates of the 1966 to 1969 period, both specifications represented increasing trends in the 1969 to 1973 period. The economies of scale variable increased at a relatively slower rate over this period, with a trend rate of 2.91%. Finally, in terms of the degree of vertical integration of mills ratios, the ratios of paper producing mills to total mills and of pulp producing and paper producing mills to total mills proceeded at trend rates of 1.68% and -0.14%, respectively. The implication of these trends is that the decline in the number of pulp producing mills was great enough to offset the increase in the number of paper producing mills. As such, over the 1969 to 1973 period, the basic contributors to the relatively slower declining trend in employment per unit output were the trends in the composition of output and in the economies of scale variables. The gross investment per employee and the degree of vertical integration of mills variables, other things being constant, tended to promote a relatively faster decreasing employment per unit output trend.

In examining the cyclical pattern of the employment per unit output

trend, we will relate the standard deviation of the employment per unit output variable (as a percentage of its mean value over a specific period) to the mean values of the composition of output, the degree of vertical integration of mills and the economies of scale variables. As was already discussed in the hypothesis, the trends in these determinants affect the skill composition and the direct to indirect variable employment composition, which affect the variability of the employment per unit output trends. The periods to be examined are those considered above in the secular trend analysis. However, since we are interested in the relative changes in the variability between periods, reflecting changes in the skill and employment compositions, no conclusions can be derived from an analysis of the 1951 to 1973 period in its entirety. As such, we will first consider the relative change in variability between the 1950's and 1960's decades and then examine the relative changes in variability between the various cycles individually.

The variability in employment per unit output was higher in the 1960 to 1969 period than in the 1951 to 1960 period. The standard deviation of the employment per unit output variable was 5.77% in 1951 to 1960 and 8.96% in 1960 to 1969. The basic cause of this increased variability in the latter period appears to have been the lower value of the composition of output variable in the 1960 to 1969 period, compared to the 1951 to 1960 period. The mean values for the composition of output variable were 0.5421 and 0.4693 in the 1951 to 1960 and 1960 to 1969 periods, respectively. Moreover, another important determinant of the higher variability was the higher value of the degree of vertical integration variable in the 1960 to 1969 period, compared to the 1951 to 1960 period. The mean value in the earlier period

was 0.4417 while it was 0.4269 in the later period. The trend in the economies of scale variable, contrary to the effects of the composition of output and the degree of vertical integration variables, tended to promote a relatively lower variability in the 1960 to 1969 period, as compared to the 1951 to 1960 period. The mean values for the 1951 to 1960 period and for the 1960 to 1969 period were 22.57 and 30.90, respectively.

Similar effects, in terms of the cyclical patterns of the employment per unit output trends, are derived from the analysis of the relative changes in variability between the individual cyclical periods. Two basic patterns are distinguishable here. First, the variability in employment per unit output increased between the 1951 to 1956 and 1956 to 1960 periods and between the 1956 to 1960 and 1960 to 1966 periods. The standard deviations over the three cyclical periods were 3.57%, 3.73% and 6.49%, respectively. Over the same periods the composition of output variable contributed to the increased variability in the employment per unit output variable. The mean values in the composition of output variable declined in each period, from 0.5534 in the 1951 to 1956 period, to 0.5267 and more drastically to 0.4838 in the 1956 to 1960 and 1960 to 1966 periods, respectively. Similar trends were exhibited by the degree of vertical integration variable. The mean values decreased in each of the periods. In the 1951 to 1956 period, the mean value was 0.4571 while in the 1956 to 1960 and 1960 to 1966 periods, it was 0.4239 and 0.4184 respectively. As in the comparison of the 1951 to 1960 and 1960 to 1969 periods, the economies of scale variable trends tended to promote a lower variability in employment per unit output, other things being constant. The mean values were 21.11, 24.78 and 29.15 over the three periods, respectively.

Second, the variability in employment per unit output decreased between the 1960 to 1966 and 1966 to 1969 periods and between 1966 to 1969 and 1969 to 1973 periods. The relevant standard deviations, here, were 6.49%, 4.20% and 4.12%, respectively, over the 1960 to 1966, 1966 to 1969 and 1969 to 1973 periods. The basic determinants of the declining trend in variability were the trends in the degree of vertical integration and the economies of scale variables. Contrary to the pattern over the first three cycles, the degree of vertical integration variable increased between the 1960 to 1966 and 1966 to 1969 periods and between the 1966 to 1969 and 1969 to 1973 periods. The mean values were 0.4.84, 0.4419 and 0.4647, respectively, over the 1960 to 1966, 1966 to 1969 and 1969 to 1973 periods. The economies of scale variable continued to exhibit an increasing trend. The mean values for the three relevant periods were 29.15, 34.58 and 38.08, respectively. The composition of output variable continued to decline over this period, tending to promote a higher variability in employment per unit output, other things being constant. The mean values were 0.4838, 0.4444 and 0.4060, respectively for the 1960 to 1966, 1966 to 1969 and 1969 to 1973 periods.

In Table 15, the employment composition data for the national level are presented for the 1961 to 1972 period.[54] From the analysis of the previous section, we saw that the variability in employment per unit output declined between the 1960 to 1966 and 1969 to 1973 data. This fact would tend to imply a decreasing proportion of relatively more skilled to less skilled individuals and/or of direct to indirect variable employment. Specific skill data are not available, however, the data in Table 15 tends to support the fact of a decreasing trend in the proportion of indirect to direct variable production employment. Over the 1962 to 1972 period, the ratio of production

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[54] These are the only years for which this type of data is available.

TABLE 15

DISTRIBUTION OF EMPLOYMENT (CANADA) 1961-1972

	Production Workers as a Percentage of Total Activity Employment		Administrative and Office Employees as a Percentage of Total Activity Employment	Sales and Distribution Employees as a Percentage of Total Activity Employment
	(1)	(2)		
1961	83.28	N.A.	N.A.	N.A.
1962	82.83	84.93	14.76	0.31
1963	83.00	84.82	14.88	0.30
1964	83.32	85.08	14.56	0.36
1965	83.09	85.17	14.62	0.21
1966	82.79	84.67	14.99	0.34
1967	82.77	84.25	15.35	0.40
1968	82.04	83.62	15.88	0.50
1969	82.61	83.89	15.70	0.41
1970	77.17	78.50	20.44	1.06
1971	77.37	78.59	20.26	1.15
1972	77.49	78.56	20.26	1.12

Note: (2) includes indirect variable or overhead employment as well as production employment.

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

employment to total employment decreased by 6.45%. Over the same period, the ratio of production and related employment to total employment (which includes overhead labour) decreased at a faster rate of 7.50%.

4. The Regional Analysis

As was discussed at the beginning of this section, the regional analysis of necessity is less rigorous and covers a relatively shorter period of time than the national analysis. The level and secular and cyclical patterns of employment per unit will be examined over the period 1961 to 1972 in terms of the trends in the basic determinants. Moreover, the analysis will deal with differences in the trends in the eastern and western sectors rather than over specific periods of time or cycles in each sector. The latter type of analysis would not seem to offer any fruitful conclusions given the relative length of the period for which data are available. Tables 16 to 21 present the data for the relevant variables over the 1961 to 1972 period.

The differences in the level of employment per unit output will be examined first. Table 22 summarizes the basic differences in the mean or average values in employment per unit output and its basic determinants over the 1961 to 1972 period for the eastern and western sectors. The mean value for employment per unit output over this period was higher in the eastern sector than in the western sector. In the former sector the mean value was 5.738 and in the latter sector it was 4.830. A basic contributing factor to this difference was the relatively higher value of the composition of output variable in the eastern, as compared to the western sector. The gross investment per employee variable was another important factor in accounting

TABLE 16

COMBINED (WEIGHTED) OUTPUT (EAST-WEST) 1961-1972

	East	West
	(,000 tons)	
1961	8,307.73	1,814.16
1962	8,462.53 (1.86)	1,922.48 (5.97)
1963	8,651.56 (2.23)	1,993.99 (3.72)
1964	9,482.45 (9.60)	2,273.94 (14.04)
1965	9,900.67 (4.40)	2,613.87 (14.95)
1966	10,797.03 (9.05)	2,880.01 (10.18)
1967	10,504.20 (-2.71)	2,942.20 (2.16)
1968	10,700.61 (1.87)	3,201.84 (8.82)
1969	11,685.34 (9.20)	3,658.73 (14.27)
1970	11,752.52 (0.57)	3,519.64 (-3.80)
1971	11,374.59 (-3.22)	3,789.55 (7.67)
1972	12,082.18 (6.22)	3,893.50 (2.74)

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. National Pulp and Paper Directory (Annual).

TABLE 17

EMPLOYMENT PER UNIT COMBINED OUTPUT (EAST-WEST) 1961-1972

	East	West
	(number employed per ,000 tons)	
1961	6.524	5.488
1962	6.441 (-1.27)	5.399 (-1.62)
1963	6.312 (-2.00)	5.230 (-3.12)
1964	5.964 (-5.53)	4.917 (-6.00)
1965	5.840 (-2.08)	4.622 (-5.99)
1966	5.569 (-4.63)	4.643 (0.46)
1967	5.696 (2.28)	4.810 (3.60)
1968	5.514 (-3.20)	4.528 (-5.87)
1969	5.146 (-6.67)	4.180 (-7.68)
1970	5.434 (5.59)	4.692 (12.24)
1971	5.417 (-0.31)	4.693 (0.03)
1972	5.003 (-7.63)	4.765 (1.34)

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. National Pulp and Paper Directory (Annual).

TABLE 18

COMPOSITION OF OUTPUT BY MILL (EAST-WEST) 1961-1972

	Number of Groundwood Pulp Producing Mills As A Percentage Of Total Mills	
	East	West
1961	0.6827	0.4286
1962	0.6827 (0.00)	0.4762 (11.11)
1963	0.6857 (0.44)	0.4286 (-10.45)
1964	0.6909 (0.76)	0.4286 (0.00)
1965	0.6727 (-2.63)	0.4545 (6.04)
1966	0.6091 (-9.45)	0.3462 (-23.83)
1967	0.5752 (-5.57)	0.3600 (3.99)
1968	0.5315 (-7.60)	0.3214 (-10.72)
1969	0.5688 (7.02)	0.2857 (-11.11)
1970	0.4955 (-12.89)	0.3103 (8.61)
1971	0.4956 (0.02)	0.3000 (-3.32)
1972	0.5044 (1.78)	0.1613 (-46.23)

Source: Unpublished data obtained from Mr. G.W. Barrett, Head, Furniture, Paper and Allied Products Unit, Industry Statistics Branch.

TABLE 19

EXTENT OF MILL INTEGRATION (EAST-WEST) 1961-1972

	East		West	
	Paper Mills as a Percentage of Total Mills	Pulp and Paper Mills as a Percentage of Total Mills	Paper Mills as a Percentage of Total Mills	Pulp and Paper Mills as a Percentage of Total Mills
1961	0.2212	0.4038	0.0476	0.4286
1962	0.2212 (0.00)	0.4135 (2.40)	0.0476 (0.00)	0.4286 (0.00)
1963	0.2190 (-1.35)	0.4095 (-0.97)	0.0476 (0.00)	0.4286 (0.00)
1964	0.2182 (-0.37)	0.4273 (4.35)	0.0476 (0.00)	0.4286 (0.00)
1965	0.2455 (12.51)	0.4273 (0.00)	0.0909 (90.97)	0.5000 (16.66)
1966	0.2634 (-3.71)	0.4182 (-2.13)	0.0769 (-15.40)	0.4615 (-7.70)
1967	0.2301 (-2.66)	0.4159 (-0.55)	0.0800 (4.03)	0.4800 (4.01)
1968	0.2752 (-2.13)	0.4054 (-2.52)	0.0714 (-10.75)	0.5357 (11.60)
1969	0.2569 (14.08)	0.4545 (12.11)	0.1071 (50.00)	05714 (6.66)
1970	0.2613 (1.71)	0.4643 (2.16)	0.1034 (-3.45)	0.5864 (2.59)
1971	0.2301 (11.94)	0.4035 (-13.09)	0.1000 (-3.29)	0.4667 (-20.39)
1972	0.2655 (15.38)	0.4298 (6.52)	0.0645 (-35.50)	0.5484 (17.51)

Source: Canadian Pulp and Paper Association, Reference Tables (Annual).

TABLE 20

GROSS INVESTMENT PER EMPLOYEE (EAST-WEST) 1961-1971

	East	West
	($,000 current)	
1961	2.289	3.222
1962	1.746 (-23.73)	6.893 (113.94)
1963	2.092 (19.80)	7.970 (15.63)
1964	2.999 (43.38)	10.240 (28.49)
1965	3.696 (23.23)	12.681 (23.84)
1966	3.947 (6.80)	17.261 (36.12)
1967	3.686 (-6.62)	9.848 (-42.95)
1968	2.445 (-33.66)	6.369 (-35.33)
1969	3.341 (36.67)	6.433 (1.00)
1970	4.283 (28.20)	9.121 (41.79)
1971	3.966 (-7.40	9.978 (9.40)

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. Unpublished data obtained from Mr. P. Koumanakos, Chief, Capital Stock, Construction Division, Statistics Canada.

TABLE 21

AVERAGE MILL OUTPUT (EAST-WEST) 1961-1972

	East	West
	(,000 tons)	
1961	79.8820	86.3886
1962	81.3705 (1.86)	91.5467 (5.97)
1963	82.3958 (1.26)	94.9519 (3.72)
1964	86.2041 (4.62)	108.2829 (14.04)
1965	90.0061 (4.41)	118.8123 (9.72)
1966	99.0553 (10.05)	115.2004 (-3.04)
1967	94.6324 (-4.47)	117.6880 (2.16)
1968	97.2783 (2.80)	118.5867 (0.76)
1969	107.2050 (10.20)	126.1631 (6.39)
1970	106.8411 (-0.34)	121.3669 (-3.80)
1971	102.4738 (-4.09)	122.2435 (0.72)
1972	109.8380 (7.19)	125.5968 (2.74)

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. National Pulp and Paper Directory (Annual).

TABLE 22

MEAN VALUES OF EMPLOYMENT PER UNIT OUTPUT AND OF THE BASIC DETERMINANTS (EAST-WEST) 1961-1972

	East	West
Employment Per Unit Output	5.738	4.830
Degree of Vertical Integration of Mills	0.4230 (0.2381)	0.4887 (0.0737)
Composition of Output	0.5996	0.3585
Gross Investment Per Employee	2.874	8.335
Average Mill Output	94.765	112.236

for the relatively higher level of employment per unit output in the eastern sector of the industry. The mean values for gross investment per employee for the eastern and western sectors of the industry were 2.874 and 8.335, respectively. Moreover, the economies of scale effects were relatively much greater in the western sector than in the eastern sector. The mean value over this period in the average mill output variable was 94.765 in the eastern sector and 112.236 in the western sector. The net effect of the degree of vertical integration of mills variable over this period was to produce a relatively higher level of employment per unit output in the western sector, other things being constant. The mean value in the ratio of paper producing mills to total mills was markedly higher in the eastern sector of the industry. However, given the relatively larger number of pulp producing mills in the western as compared to the eastern sector, the ratio of pulp producing and paper producing mills was relatively higher in the western sector than in the eastern sector. The mean values in the latter ratio over this period were 0.4230 and 0.4887 in the eastern and western sectors respectively.

In terms of the secular trends over the 1961 to 1972 period, the relevant trends in employment per unit output and in its basic determinants are summarized in Table 23. Employment per unit output declined at a relatively faster rate in the eastern sector than in the western sector of the industry. The trend rates over this period were -2.31% and -1.15%, respectively, in the eastern and western sectors. From the available data, we see that the basic contributor to the relatively faster decline in the eastern sector was the degree of vertical integration of mills variable. The trend rates in the eastern and western sectors were 0.75% and 2.81%, respectively. All other

TABLE 23

CYCLICAL AND SECULAR PATTERNS IN EMPLOYMENT PER UNIT OUTPUT AND IN ITS BASIC DETERMINANTS (EAST-WEST) 1961-1972

	East	West
Employment Per Unit Output		
(1)	-2.38	-1.29
(2)	-2.31	-1.15
(3)	8.19	8.45
Composition of Output		
(1)	-2.71	-8.50
(2)	-2.56	-6.90
(4)	0.5996	0.3585
Degree of Vertical Integration of Mills		
(1)	0.57 (1.67)	2.27 (2.80)
(2)	0.75 (4.10)	2.81 (6.96)
(4)	0.4230	0.4887
Gross Investment Per Employee		
(1)	5.65	11.97
(2)	8.67	19.21
Average Mill Output		
(1)	2.94	3.46
(2)	3.04	3.58
(4)	94.77	112.24

Note: (1) annual compound rate of growth
(2) average of annual percentage changes
(3) standard deviation as a percent of mean value
(4) mean value

variables tended to promote a relatively faster decline in employment per unit output in the western sector rather than in the eastern sector. The composition of output variable declined at a relatively faster rate in the western sector. The trend rates for the eastern and western sectors over the 1961 to 1972 period were -2.56% and -6.90%, respectively. However, given the nature of the data, some serious doubt could be expressed as to the relative magnitude of these trends and, possibly, as to the relative direction of these trends. The gross investment per employee variable increased at a relatively faster rate in the western sector, as compared to the eastern sector. The trend rates for the eastern and western sectors were 8.67% and 19.21%, respectively. Finally, the trend rate for the economies of scale variable was slightly higher in the western sector, at 3.58%, than in the eastern sector where the trend rate was 3.04%.

Finally, in considering the cyclical aspects of the secular trend, we see that a slightly greater variability in employment per unit output was evident in the western sector than in the eastern sector. From Table 23, we see that the standard deviations were 8.19% and 8.45% in the eastern and western sectors respectively, over this period. The basic contributing factor to the relatively higher variability in the western sector was the relatively lower mean value in the composition of output variable in that sector. The mean values over this period were 0.5996 and 0.3585 in the eastern and western sectors, respectively. Partially offsetting the latter effect were the relatively higher mean values in the degree of vertical integration and in the economies of scale variables in the western sector. In the case of the former variable, the mean values were 0.4230 and 0.4887 in the eastern and western sectors, respectively. In the case of the latter

variable, the mean values in the two sectors over this period were 94.77 and 112.24.

The trends in variability presented in the preceeding paragraph would tend to imply a relatively greater proportion of direct variable to indirect variable employment in the eastern as compared to the western sector over the 1961 to 1972 period. The data in Table 24 would tend to support this conclusion. It is quite evident from the latter table that the mean value in the ratio of production employment to total employment was relatively higher in the eastern sector over the 1961 to 1972 period. The mean values were 82.14 and 78.78 in eastern and western sectors, respectively.

TABLE 24

DISTRIBUTION OF EMPLOYMENT (EAST-WEST). 1961-1972

	Production Workers as a Percentage of Total Activity Employment				Administrative and Office Employees as a Percentage of Total Activity Employment		Sales and Distribution Employees as a Percentage of Total Activity Employment	
	East		West		East	West	East	West
	(1)	(2)	(1)	(2)				
1961	83.91	N.A.	79.82	N.A.	N.A.	N.A.	N.A.	N.A.
1962	83.46	85.28	79.51	83.13	14.51	16.06	0.21	0.81
1963	83.15	85.23	82.18	82.66	14.53	16.70	0.24	0.64
1964	83.43	82.43	82.93	83.36	14.34	15.66	0.23	0.98
1965	83.27	85.46	82.20	83.76	14.32	15.46	0.22	0.78
1966	83.17	85.29	81.12	81.87	14.52	17.08	0.19	1.05
1967	83.42	85.09	80.05	80.69	14.70	18.12	0.21	1.19
1968	82.56	84.37	79.89	80.58	15.30	18.30	0.33	1.12
1969	83.14	84.65	80.51	80.90	15.03	18.31	0.32	0.79
1970	78.68	80.16	71.36	72.05	18.84	26.62	1.00	1.33
1971	78.70	80.10	72.75	73.36	18.75	25.49	1.15	1.15
1972	78.85	80.02	73.06	73.80	18.80	25.03	1.18	1.17

Note: (2) includes indirect variable or overhead employment as well as production employment.

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

IV. DETERMINANTS OF TECHNIQUE CHOICE

This section will basically identify and analyze, where possible, the determinants of the technique choice related variables. The analysis will enable the derivation of possible future trends in the technique choice related variables and, consequently, the prediction of the levels and the secular and cyclical trends in employment per unit output over the next decade.

From the analysis in section III, three basic technique choice related variables, which affect employment per unit output patterns, were specified. These were the composition of output, the degree of vertical integration of mills in the industry and the level of gross investment per employee, which included any economies of scale effects that accompanied increases in productive capacities of mills. First, the determinants of each of the above variables will be identified and examined in a theoretical context. Second, the relevant trend relationships between each variable and its determinants will be analyzed, in the cases where the required data are available. The analysis will be carried out at both the national and regional levels. At the national level, the analysis will cover the period 1951 to 1973. At the regional level, the relevant period will be 1961 to 1972, as it was in section III. Third, an attempt will be made to predict the levels or ranges in the levels, of the technique choice related variables over the next decade, given the trends in their determinants. In cases where the past relationships between a variable and one of its determinants cannot be

analyzed, the relevant theory will be discussed briefly and the relevant assumptions to be used, regarding the future trends in the variable, will be specified. This situation will arise where either the necessary data are unavailable, or, the relationship between the variable and its determinant(s) is too complicated to be considered in this study.

1. The Composition of Output

The composition of output variable trends are basically related to the trends in two determinant variables. The first of these is the pattern of demand and the second is the relative availability or supply of the various wood inputs.

An examination of the relationship between the composition of output and the pattern of demand is beyond the scope of this study. In a theoretical context, the pattern of demand can be seen to be related to the price levels of the various pulp, paper, and paperboard products, to the income level and population of the relevant geographic region, to the tastes of consumers, etc...The analysis of these variables for the Canadian market would present a sizeable problem by itself. Such an analysis, however, is made even more difficult by the fact that the greater part of the Canadian pulp, paper, and paperboard production is directed towards the export market. Over the period 1951 to 1973, foreign demand represented anywhere between 70% and 80%[55] of the total demand for Canadian pulp, paper and paperboard production. As such foreign prices, income levels, population levels, tastes etc..., would also have to be considered in any thorough analysis of the demand pattern and its relationship to the composition of output.

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[55] Canadian Pulp and Paper Association, Reference Tables (Annual).

On the other hand, the relationship between the relative availability or supply of the various wood inputs and the composition of output can be examined in a relatively more detailed manner. The a priori considerations are derived from the technical discussions in section II, where the input-output relationships for the various products were examined. In that discussion, two facts were mentioned that are relevant to this relationship. First, groundwood pulp production is limited to the use of softwoods as material inputs, since hardwood fibres are too short and brittle for the purposes of grinding. Second, in the case of groundwood pulp production, wood blocks are used as inputs while in the case of chemical and refiner pulp production chipped blocks or wood residue (which includes sawmill chips, edgings, reject lumber, veneer cores, etc...) can be used. As such, given a trend towards increasing shortages in hardwoods and/or towards the greater use of wood residue (due to trends in integration of sawmill and/or lumber operations to pulping operations), there would be a tendency to shift from groundwood pulp production to refiner or thermo-mechanical pulp production. The latter trends would represent economic pressures in the form of relatively increasing material costs in groundwood pulp and related paper and paperboard production, as compared to refiner pulp production.

In examining the past relationships between the composition of output variable and its basic determinants, the trends in the composition of output variable will be considered first and then the trends in the determinants.

At the national level, we saw in section III that the trend rate of decline in the composition of output variable was greatest in the 1960 to 1969 period and greater in the 1969 to 1973 period as compared to the 1951 to 1960

period. The data in Appendix Table 1 provide a finer breakdown of the compositional aspects of the latter trend. First, the proportion of pulp production in total production increased over the 1951 to 1973 period, basically at the expense of newsprint production. In 1951, the proportions of pulp, newsprint, and other paper and paperboard production in total production were 56.3%, 33.6% and 10.1%, respectively. In 1973, the relevant proportions were 59.2%, 27.1% and 13.7%. The greatest relative increase in pulp production was over the 1960 to 1969 period. The proportion of pulp production in total production increased from 56.3% in 1951, to 56.7% in 1960, to 59.1% in 1969, and finally to 59.2% in 1973. Similarly, the greatest relative decrease in newsprint production was evidenced over the 1960 to 1969 period. The relevant proportions, here, were 33.6% in 1951, 33.1% in 1960, 28.9% in 1969 and 27.1% in 1973. The proportion of other paper and paperboard production in total production increased steadily over each decade from 10.1% in 1951, to 10.2% in 1960, to 12.0% in 1969 and to 13.7% in 1973. Second, the increasing trend in pulp production was composed of a relatively much faster increase in chemical and refiner pulp production than in groundwood pulp production. Moreover, the greatest shift from groundwood to chemical and refiner pulp production came over the 1960 to 1969 period. The proportion of chemical and refiner pulp to total pulp production increased from 44.47% in 1951 to 48.61% in 1960, to 57.97% in 1969, and finally to 60.61% in 1973.

As regards the regional analysis, we saw in section III that, in terms of production levels, the only distinction of product types possible was between pulp production and paper and paperboard production. The data in Appendix Table 7 indicate the relevant trends over the 1961 to 1972 period. In the eastern sector, the proportions of pulp production and

paper and paperboard production to total production remained almost constant over this period. The relative gain in pulp production was quite nominal, with the proportion of pulp production to total production increasing from 55.85% in 1961 to 55.86% in 1972. In the western sector, the proportion of pulp production to total production increased much faster, relative to the eastern sector, at the expense of paper and paperboard production. The proportion of pulp production increased from 65.35% in 1961 to 70.59% in 1972. Moreover, given the conclusions in section III that the trend rates in the composition of output variable were negative in both the eastern and western sectors, several inferences can be made about the product composition changes in the two sectors over the 1961 to 1972 period. First, given the almost constant proportions of pulp production and paper production in the eastern sector, the implicit conclusion would be a shift to other paper and paperboard production from newsprint production over this period. Moreover, this would tend to also imply a shift to chemical and refiner pulp from groundwood pulp. Second, the trend in the western sector was from paper and paperboard to pulp production. It would appear that newsprint production and groundwood pulp production also exhibited a relatively declining proportion in total production in the western sector.

In attempting to understand the aforementioned trends in the composition of output variable, the trends in the demand pattern variables and in the relative availability or supply of the various wood inputs must be considered. As was mentioned above, an analysis of the former trends is beyond the scope of this study. However, given these trends, we can examine the possible relationship between the trends in the relative availability or supply of the various wood inputs and the

above analyzed trends in the composition of output variable. The data to be used are the level of pulpwood consumption by species of wood and by region. The three basic species of wood are softwoods, hardwoods and wood residue (defined above), which includes both hardwoods and softwoods. Optimally, the proper trends that should be considered are the levels of pulpwood production by species and by region, however, such data are not available for the entire 1951 to 1973 period. In considering the consumption and not the production levels, the problem is that the trends will, to a great extent, reflect changes in the demand pattern. However, they should also reflect changes in wood type use arising out of relative shortages in specific types of wood inputs and reflecting changes in the relative prices of the various wood types.

At the national level, two basic trends are evident. First, the use of wood residue, relative to the use of both softwood and hardwood roundwood, was increased drastically over the period 1951 to 1973. The proportion of wood residue, to the total amount of wood used, increased from 2.51% in 1951, to 11.23% in 1960, to 27.01% in 1969, and finally to 36.93% in 1973.[56] Second, the proportion of hardwood use in total roundwood consumption also increased over this period, but at a slower rate. The proportion of hardwoods in total roundwood consumption rose from 3.69% in 1951, to 5.82% in 1960, to 10.54% in 1969, and 10.61% in 1973.[57] The conclusions that can be drawn from the above trends are as follows. On the one hand, the pattern of wood use does reflect changes

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[56] The data presented were calculated from raw data published in: Canadian Pulp and Paper Association, Reference Tables, 1975.

[57] Ibid.

in the pattern of demand over the 1951 to 1973 period. The fact that changes in the proportions of wood residue in total wood consumption and of hardwoods in total roundwood consumption were greatest over the 1960 to 1969 period is partial evidence of this. We can recall that this was the period over which the composition of output variable declined fastest. On the other hand, however, also reflected in the above trends is the partial shift from groundwood pulp to refiner pulp (for export and/or for use in newsprint and other paper and paperboard) over this period. The basic reason for this trend has been the relatively faster increasing prices of roundwood and of softwood roundwood, specifically.

At the regional level, these trends are evident in the western and, especially in the eastern sector over the 1961 to 1972 period. The proportion of wood residue in total wood consumption increased relatively faster in the eastern sector, rising from 4.12% in 1961 to 18.43% in 1972. In the western sector the absolute levels were higher but the relative changes were slower. The proportion of wood residue increased from 41.43% in 1961 to 60.77% in 1973.[58] Similar trends were exhibited in the proportion of hardwood use to total roundwood use. The increases in the eastern sector were relatively greater, with the proportion of hardwoods rising from 6.04% in 1951 to 11.71% in 1972. In the western sector, the increase in the proportion of hardwoods was from 2.63% in 1961 to 3.36% in 1972.[59] As in the case of the national analysis, the trends can be seen to have arisen both from changes in the patterns of demand and from deliberate decisions initiated from changes in the relative prices

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[58] The data were calculated from raw data published in: Statistics Canada, Pulp and Paper Mills, Cat 36-204 (Annual).

[59] Ibid.

of the various wood input types.

In attempting to predict changes in the composition of output variables over the next decade, the trends in the two basic determinants must be considered. First, as regards the pattern of demand, we must make certain assumptions due to the fact that a thorough analysis of the relevant factors is not possible in this study. We shall assume that the pattern of demand, as represented by the relative proportions of the basic pulp, paper and paperboard classifications, will remain fairly constant over the next decade. If the relative demand for groundwood pulp and/or predominantly groundwood pulp using paper and paperboard should increase, the composition of output variable would increase proportionately over this period. Alternatively, if the relative demand should decrease, the composition of output variable would fall proportionately. An implicit assumption in the above specifications is that other things remain constant. Second, given the relatively increasing costs of roundwood and, especially, softwood roundwood, we should expect a substantial shift from groundwood pulp production to refiner pulp production over the next decade. This shift would also have its repercussions on newsprint and other paper and paperboard production, presently using groundwood pulp. Theoretically, refiner or thermo-mechanical pulp could completely replace groundwood pulp in paper and paperboard production. However, the actual rate of replacement would be determined by the rate of adoption of thermo-mechanical techniques over the next decade. The factors that affect this rate of adoption will be considered in subsection 3 of this section.

As such, at the national level, even if the pattern of demand is fairly constant over the next decade, we should expect a decline in the composition of output variable, arising from a shift to refiner pulp production.

The rate of decline is basically a function of economic pressures over the next decade, and will be considered in section V, after these economic pressures have been considered.

At the regional level, given the same assumptions concerning the pattern of demand, we should expect a relatively faster decline in the eastern than in the western sector, arising from the shift to refiner pulping. Given similar economic pressures in the two sectors over the next decade, the above conclusions is based on the existing fact of a higher proportion of groundwood pulp and predominantly groundwood pulp using paper and paperboard production in the eastern sector. The important implication is that a greater possibility for substitution to refiner pulping exists in the eastern sector of the industry. Again, the actual predicted rates of decline will be considered in section V, for the eastern and western sectors.

2. The Degree of Vertical Integration of Mills

The trends in the degree of vertical integration of mills variable present greater difficulties in terms of explanation and prediction than did the trends in the composition of output variable. First, in terms of the theoretical specification, the determinants are not as evident as in the case of the composition of output variable. Second, even in the case where these determinants are identifiable, they are not readily quantifiable. As such, the ensuing analysis will be both cursory and quite descriptive or qualitative in nature.

Amongst others, several important determinants of the trends in the degree of vertical integration variable are the size and age structure of pulp and paper producing, paper producing, and pulp producing mills and

the pattern of demand, to a lesser extent. First, in terms of the age and size structure, the more important potential relationships can be specified, a priori. We would expect that the older and smaller the mills are, the less efficient they would tend to be. The rationale is that older mills would tend to utilize more dated and lower productivity techniques of production and related machinery. Moreover, the smaller mills would not be able to capture any economies of scale effects, related to overhead or indirect variable labour utilization, that usually exist in the larger sized mills. As such, the older and smaller mills would tend to be characterized by higher operating cost structures. Given these conditions, the older and smaller mills would tend to be the most likely mills to shutdown during periods of depressed economic conditions.

Second, the pattern of demand, to some extent, can affect the mill type composition and, consequently, the degree of vertical integration in mills in the industry. The primary effect of the pattern of demand is on the number of pulp producing mills in existence at a given point in time. If the demand for pulp and paper and paperboard products shifts in favour of pulp products (the main impetus coming from foreign demand), then we should expect the ratio of pulp producing mills to pulp and paper producing mills to increase. This conclusion arises from the fact that pulp production can be and is produced quite independently from the level of domestic paper and paperboard production, due to the existence of a large foreign market for pulp. Paper and paperboard production, on the other hand, requires a proportional level of pulp production, provided usually by the domestic market. As such, an increase in the demand for paper and paperboard, relative to pulp, need not necessarily increase the ratio of paper producing mills to total mills.

Instead, the increased demand might be accommodated by an increase in the number of pulp and paper producing mills. In summary, the number of pulp producing mills at a given point in time would appear to be affected by the pattern of demand. However, in the case of the number of paper producing mills, the more important decisions would tend to be the organizational and structural ones.

In light of the above theoretical and structural considerations, we can summarize the basic trends in the degree of vertical integration of mills variable over the 1951 to 1973 period and examine the extent of their relationship to these explanatory variables or determinants. At the national level, the ratio of paper producing mills to total mills exhibited a slight positive trend while the ratio of pulp producing and paper producing mills to total mills exhibited a constant trend over the 1951 to 1973 period. Both ratios exhibited similar trends by decade. Declining trends were evident between 1951 and 1960, and increasing trends characterized the 1960 to 1969 and 1969 to 1973 periods. The increases in the latter period were greater in the ratio of paper producing mills to total mills, relative to the ratio of pulp producing and paper producing mills to total mills. In relating the trends in these ratios to the trends in the number of paper producing and pulp producing mills, reference should be made to the analysis in section I and, specifically, to the data presented in Tables 2 and 4. Over the entire period 1951 to 1973, the net increase in the number of pulp producing mills was quite small. In contrast to this, the increase in the number of paper producing mills over this period was rather marked. The number of pulp producing mills however did exhibit evident trends over the specific decades. Over the 1951 to 1960 period, the number of pulp producing mills

declined, while over the 1960 to 1969 and 1969 to 1973 periods, the number increased. Paper producing mills, on the other hand, increased in number most drastically over the 1960 to 1969 period and in 1973. Over the 1951 to 1960 and 1969 to 1972 periods, the number of paper producing mills was fairly constant.

At the regional level, the ratio of paper producing mills to total mills and the ratio of pulp producing and paper producing mills to total mills increased in both the eastern and western sectors of the industry, over the period 1961 to 1972. However, both ratios increased relatively faster in the western sector. These trends can be related to the number of pulp producing and paper producing mills, in each sector over this period, through the data in Tables 3 and 5 in section I. In the eastern sector, the number of paper producing mills increased drastically, while the number of pulp producing and pulp and paper producing mills remained fairly constant. In the western sector, the number of pulp producing mills increased drastically over this period, while the number of paper producing and pulp and paper producing mills increased slightly.

At this point, we can relate the above trends in the degree of vertical integration variables to the trends in the basic determinants discussed at the outset of this subsection. In considering the trends at the national level, the two basic relationships can be examined separately. First, in terms of the relative age and size structures of the various mill types, generally speaking, the paper producing mills tend to be smaller and older, relative to the pulp producing and the pulp and paper producing mills. Comprehensive data to support this fact in a quantitative manner is not available. However, the

mill reportings on the productive capacity and on the type of machinery presented in the National Pulp and Paper Directory[60] tend to support this fact. Moreover, various interviews conducted at the Domtar offices in Montreal also tended to support this conclusion. Given this fact, we can conclude that the number of paper producing mills would be very much affected by demand conditions at any point in time. This relationship is evident in the data on the number of paper mills, presented in Table 2. The number of paper mills operating in a given year appears to be closely related to the cyclical aspects in combined output, i.e. the number rising in periods of expansion and declining in periods of recession. This trend is evident throughout the 1951 to 1973 period. Moreover, Table 4 shows that the mean or average number of paper mills was highest during the 1960 to 1969 period, which was also the most expansive period over the 1951 to 1973 period. To further support this relationship, we can see from the data in Table 2 that this type of relationship does not appear to apply to the case of pulp producing mills and pulp and paper producing mills. Second, the effect of the pattern of demand, on the degree of vertical integration variable can be seen to be related primarily to the number of pulp producing mills, at a given point in time. From the data presented in the preceeding subsection, we saw that the proportion of pulp production in total production increased most drastically over the 1960 to 1969 period. It was over this same period that the number of pulp producing mills increased most markedly.

At the regional level, the lack of data on the composition of output forces an even more cursory analysis of the basic relationships, relative to the analysis at the regional level. However, one basic conclusion can be

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60 National Pulp and Paper Directory (Annual).

drawn about the relationship between the degree of integration variables and the basic determinants. That is, practically all the paper producing mills are located in the eastern sector of the industry and these mills, in the eastern sector, tend to be relatively smaller and older than those in the western sector. As such, the cyclical characteristic in the number of paper producing mills tends to be more evident in the eastern than in the western sector. This is illustrated by superimposing the trends presented in Table 2 (the number of paper producing mills) on the trends presented in Table 16 (combined output).

In order to predict the trends in the degree of vertical integration of mills variable over the next decade, we must anticipate the trends in the basic determinants mentioned above. However, as in the case of the pattern of demand, assumptions must be made about the growth or trend in demand since the same variables (in aggregated form across product types) are relevant, here. Moreover, we shall make the same assumptions about the pattern of demand as we did in the previous subsection.

In light of these assumptions, we can expect the ratio of paper producing mills to total mills to increase slightly over the next decade, at the national level, as in the 1951 to 1973 period. If, however, the growth in demand (given its composition) proceeds at a relatively faster rate, other things being constant, we should expect a faster rising ratio. Similarly, if paper producing mills are modernized and/or increased in size at a quicker pace, relative to pulp and paper producing mills, we should expect the ratio to rise relatively more quickly, other things being constant. Conversely, if demand growth is relatively slower and cost structures increase, relative to pulp and paper producing mills, the ratio would

tend to rise at a relatively slower rate or it might even decrease. Given the assumptions relating to the pattern of demand and the above trends in the ratio of paper producing mills to total mills, we would expect the ratio of pulp producing and paper producing mills to increase at a slightly faster rate than that over the 1951 to 1973 period. If, however, the pattern of demand continues to shift towards pulp production, as it has between 1960 and 1973, we should expect an even greater trend rate over the next decade in this ratio. Conversely, if the trend is away from pulp production, and towards paper and paperboard production, the ratio should exhibit a relatively slower increase or even a slight decrease, depending on the extent of the shift in the pattern of demand.

At the regional level, given the assumptions made above,[61] we should expect the degree of vertical integration of mills variables to increase faster in the eastern sector relative to the western sector over the next decade, unlike the trends over the 1961 to 1972 period. In the western sector, given the assumptions about the pattern of demand and the relatively small number of paper producing mills, the degree of vertical integration variable would tend to remain constant over the next decade. The basic factor that would affect the degree of vertical integration variable in this sector would be the pattern of demand. If the present trend towards pulp production increases, the ratio of pulp producing and paper producing mills to total mills would tend to rise. Conversely, if the trend is away from pulp production, the ratio might decline. In the eastern sector of the industry, given the assumptions made above, we would expect, both, the ratio of paper producing mills to total mills and the ratio of paper producing and pulp producing mills to total mills to increase at roughly the same rate as that over the 1961 to 1972 period.

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[61] The assumption about the trend rate in demand is, here, related to the 1961 to 1972 period.

However, the basic factors in the eastern sector are the trend rate in demand and the relative cost structures of the paper producing mills, in contrast to the pulp and paper producing mills. If the growth in demand proceeds at a relatively faster rate, we should expect faster rising ratios, other things being constant. Similarly if paper producing mills are modernized and/or increased in size at a quicker pace, relative to pulp and paper producing mills, other things being constant, the ratios would tend to rise relatively more quickly. Conversely, if demand growth is relatively slower and cost structures increase, relative to pulp and paper producing mills, the ratio would tend to rise at a relatively slower rate or it might even decrease.

3. Gross Investment Per Employee

The final trends to be examined are the trends in the gross investment per employee variables and in the related economies of scale variables. The theoretical issues in this case are more closely related to technique choice, in the strictest sense of the term, than were the other variables and, as such, need be examined in relatively greater detail. Moreover, the required data is more readily available and, therefore, the various past relationships can be examined to a relatively greater extent.

As was mentioned in the discussion of the hypotheses in section III, the gross investment per employee variables basically reflect changes in technique choice, other than those arising from changes in the composition of output. This variable would include changes in input proportions arising from technical advances in techniques and/or in the related machinery. Even where employment is not affected in a direct manner, the proportions could be altered by changes in the size, width and/or speed of specific

machinery, affecting the productive capacity of the techniques or processes.

These changes in technique choice, related to both techniques and machinery, would appear to be affected by the rate of technical advance (i.e. blueprints of new techniques) and by the rate of adoption of the new techniques and machinery embodying the latest knowledge. As such, two relevant questions must be asked. First, what are the basic characteristics of technical advance? Second, how are the new techniques adopted in an industry, or, what are the mechanisms through which the technique choice changes are implemented, and what are the economic, institutional and structural barriers to their implementation? Before considering these questions in the case of the Canadian pulp and paper industry, we must consider them in a theoretical context.

The conventional or Neo-classical theory tends to be inadequate in dealing with such dynamic processes of technique choice, as are implied by the two questions posed above, due to its reliance on comparative static equilibrium analysis. As W. Salter explains,

> "The crux of the difficulty lies in the inability of static equilibrium concepts to analyze continuous processes through time...This is an important problem in productivity analysis, for the two elements in this example - continuous disturbance and slow adjustment - are essential features of technical change...The "once-over" analysis of comparative statics is only appropriate to changes in technique, which are sufficiently great to displace completely all pre-existing methods before they themselves are displaced."[62]

As such, in examining the problems in a theoretical context we shall make reference to the methodology and, to a lesser extent, the analytics developed by W. Salter.[63]

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[62] Salter, W.E.G., Productivity and Technical Change, Cambridge, 1969, pp. 4-5.

[63] Ibid., pp. 13-94.

In describing the characteristics of technical advance, we are concerned with the latter term as it relates to those "techniques which are feasible in principle but have not been developed because the necessary economic pressures are absent."[64] This concept is much broader than one which includes only that knowledge which has been developed in detail and has been physically embodied in new techniques and/or machinery.

Within this notion of technical advance, the first characteristic that should be considered is the speed and pattern of technical advance. Other things being constant, the faster the rate of technical advance, the greater would tend to be the changes in technique choice. Moreover, the greater would be affected the gross investment per employee variable. The second relevant feature of technical advance is the extent of the change in the input proportions that accompanies the technical advance. Although, we could not a priori predict the nature of the input bias of the new technique, W. Salter presents two reasons why such a bias would tend to be labour saving.

> "It should be noted that there is no a priori reason why younger plants should have the lowest unit labour requirements. But there are two strong reasons why any other situation would be rare: first, few technical advances do not save labour absolutely, and secondly, the pressure for substitution generated by technical progress in the capital goods industries tend to encourage progressively greater savings of labour."[65]

As such, technical advances would tend to result in lower gross investment per employee values, other things being constant. Third, it is important to distinguish between technical advances that affect techniques or processes, in their entirety, and those that affect only specific machinery or equipment

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[64] Salter, W.E.G., Productivity and Technical Change, Cambridge, 1969, p. 26.

[65] Ibid., p. 53.

within broader techniques. If the technical advance is related to specific machinery, one of two fairly opposite effects may be prevalent. On the one hand, the rate of adoption may be faster because a relatively smaller investment is required to implement the change in technique choice.[66] On the other hand, due to technical complementarity between various machinery in a specific technique, the adoption of a specific piece of machinery may be postponed because the real or actual savings in cost might turn out to be much less than what was initially expected.[67] These problems will be considered in greater detail at a later point in this section. The final aspect of technical advance that must be considered concerns the extent and nature of the economics of scale that accompany the changes in technique choice. Again, this factor will be more fully discussed at a later point in this section.

Given the nature and extent of technical advance, the rate of change of technique choice and, therefore, of the gross investment per employee variable is dictated by the rate of adoption of the new techniques embodying the latest technical knowledge. As was mentioned above, both economic and institutional constraints are relevant in determining the rate of adoption of new techniques. Several institutional and behavioural constraints can be mentioned, although they will not be considered explicitly in the analysis of this section. These include the various patent systems that might exist, the imperfections in transmitting the information on the technical advances, the possible inertia of management, and the potential fears of labour reaction, especially in the case where

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[66] Salter, W.E.G., Productivity and Technical Change, Cambridge, 1969, p. 86.

[67] Ibid., pp. 85-86.

labour is organized to a great extent.[68] A very important consideration which relates to possible management inertia in the Canadian pulp and paper industry is the degree of confidence that firms have in the ability of new techniques to operate profitably on a large scale commercial basis. Since many of the new techniques, discussed in section II 4. were first adopted in the United States industry, the experience of the latter industry is very important, here. Some of these variables will be considered in section V when the predictions in employment per unit output will be attempted.

In considering the economic constraints on the rate of adoption of new techniques, one extremely important fact must be remembered. This is that technical advance is almost always embodied in new machinery. Although some changes, such as improvement in organization and training of workers, might not require this condition, the general case by and large is one where new machinery is required. In light of this important fact, we can conclude that the basic vehicle for the adoption of technical advances is the rate of gross investment in the industry. To be more specific, the rate of gross investment would equal the rate of new or net investment, in mills and/or machinery, and the rate of replacement investment. Subtracted from the latter sum would be the rate of scrapping of mills and/or equipment. Implicit in this type of analysis is the fact that any new investment, either net or replacement, would embody the latest technical knowledge.

Therefore, in order to understand the changes in technique choice and,

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68 Salter, W.E.G., Productivity and Technical Change, Cambridge, 1969, p. 66.

consequently, the movements in the gross investment per employee variable, we must analyze the criteria for or determinants of the various types of investment. W. Salter derives the criteria for new investment, replacement investment and scrapping, both, for techniques in their entirety[69] and for specific prices of machinery.[70] On the cost side, constant marginal costs (up to normal productive capacity) are assumed[71] and account is taken of the scrap value of techniques and/or machinery. On the revenue side, the analysis is carried out for various market structures, in Neoclassical terms. However, simply stated, the criterion for net investment is that the difference between expected proceeds and expected operating costs[72] is sufficient to cover the initial capital costs and a normal rate of return over the life of the investment.[73] The criterion for replacement investment is that the expected savings in operating costs arising from the use of the new technique and/or machinery is sufficient to cover the capital costs of the new machinery and a normal rate of return over the life of the investment.[74] In such situations, therefore, the rate of investment is determined by the relationship of present and expected future price to present and expected future operating costs. The former is determined by the nature of pricing and output decisions

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[69] Salter, W.E.G., Productivity and Technical Change, Cambridge, 1969, pp. 55-57, 65.

[70] Ibid., pp. 84-86.

[71] Given Salter's methodology and analytics, the assumption of constant marginal costs can only apply for the long period in a perfectly competitive industry.

[72] Operating costs are defined to include prime costs as well as indirect variable costs.

[73] Salter, W.E.G., op. cit., p. 55.

[74] Ibid., pp. 56-57, 86.

of firms in a specific industrial structure. The latter is affected by input proportions embodied in techniques and, to a certain extent, input prices. With respect to the latter relationship, W. Salter stresses the role of relative input prices (specifically wage costs relative to capital costs) in affecting the rate of adoption of the new techniques.

From the above analysis, the rate of gross and net investment can be interpreted to be determined by the expected rate of profit. However, the expected rate of profit is not a viable variable for the purposes of analysis, by itself.[75] Instead, some understanding must be had of how expectations concerning the rate of profit are formed, in a specific industry. Several factors enter this explanation. First, it would seem reasonable to assume that firms in an industry base their expectations of future profit rate on the existing rate of profit in any given period, other things being constant. In this type of situation, decisions on the rate of investment in any given period (i.e. a year) would be greatly affected by the rate of profit actually realized in that period. Given some type of implementation lag (perhaps up to a year depending on the nature of the investment), the rate of realized investment in one period would be much affected by the existing rate of profit in the previous period. Second, the historical stage of the industry would tend to affect the expectations of the future rate of profit. A younger and more quickly expanding industry would tend to imply more optimism, as regards future rates of profits, on the part of the firms, relative to the expectations held by firms in an older and less dynamic industry, other things being equal.

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[75] The analysis, from hereon, deviates from that of Salter. One reason is that the data Salter uses are not available in this case. Another reason is that the ensuing theoretical analysis goes beyond the Neo-Classical pricing and output decision framework used by Salter.

Third, investment decisions of the recent past as reflected in the degree of capacity utilization in a given period would also tend to affect the rate of investment in that period. Other things being equal, a lower degree of capacity utilization would tend to imply a lower rate of investment in a given period. Finally, the degree of monopoly or concentration in an industry would also tend to affect the rate of investment. The greater the ability of firms in an industry to control price and costs (through means such as research and development and controls over input supplied) the less risky would tend to be the planned investments. As such, the more willing would firms in the industry be to undertake higher rates of investment which would result in higher rates of profit.

Before proceeding to the analysis of the above relationships in the Canadian pulp and paper industry, a brief note should be made concerning the economies of scale effects. The nature of the economies of scale that might accompany the increased investment were described in section III. What should be added is that these economies of scale effects would increase in the industry if the average productive capacity of mills increases. This could arise from net investment in existing mills and/or investment in new and larger than average mills.

In light of the theoretical considerations discussed above, we can attempt to analyze the relevant relationships between the gross investment per employee variable and its basic determinants. First, past trends in the gross investment per employee variables will be summarized at the national and regional levels. Second, the trends in the basic determinants will be described and related to the trends in the gross investment per employee variables. Since profits data are available only in a current

dollars specification, we shall consider investment and capital stock data in current dollars.

At the national level, the gross investment per employee variable specifications exhibited similar trends. Over the 1951 to 1973 period, the trend rates for the aggregate and disaggregated and lagged specifications were 5.43% and 4.67%, respectively. The trend rates of increase were greatest during the 1960 to 1969 period, where the aggregate and disaggregated and lagged specifications proceeded at rates of 8.47% and 7.52%, respectively. The trend rates of increase was smallest for both specifications during the 1969 to 1973 period, where the latter specifications proceeded at trend rates of -2.03% and 0.17%, respectively. Finally, the trend rates for the aggregate and disaggregated and lagged specifications for the 1951 to 1960 period were 5.14% and 3.81%, respectively.

At the regional level, the gross investment per employee variable increased at a relatively faster rate in the western, as opposed to the eastern sector. The respective rates were 19.21% and 8.67% over the 1961 to 1972 period.

In relating the above trends to their basic determinants, we shall examine the trends in the various determinants separately. First, we shall consider the nature and extent or speed of technical advance over the 1951 to 1973 period. Second, we shall examine the rates of gross investment over this period. Finally, we shall relate the trends in gross investment to their basic determinants, discussed above.[76]

As regards the nature and extent of technical advance in the Canadian pulp and paper industry over the 1951 to 1973 period, the basic trends

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[76] Since the trends between the gross investment per employee specifications in section III were quite similar, the analysis of disaggregated and lagged investment will not be considered separately.

were considered in detail in section II.[77] First, the changes primarily related to specific machinery and not to techniques of production. The only important new techniques that were developed over the 1951 to 1973 period were refiner pulping and wood preparation in the forests. The major changes in machinery were in the chemical pulping, papermaking and finishing operations. Second, in all cases the new technical advances were labour saving. In the case of refiner pulping and wood preparation, the labour requirements declined absolutely, while in the other cases, relative savings in labour were obtained by the development of the new machinery. Finally, in terms of the speed of technical advance over specific periods, very little evidence exists with which to formulate any definite conclusions. The only fact that might be argued is that technical advance was relatively greater in the post-1960 period due to the development of refiner pulping and new wood preparation techniques. Aside from these developments, it would seem that technical advances in improved machinery proceeded at a fairly even rate over the 1951 to 1973 period. The above trends cannot, however, be related to the trends in the gross investment per employee variables alone, since they relate to advances in knowledge, which are separated from the process of implementation or utilization of new techniques and machinery. To understand the trends in the gross investment per employee variables we also must consider the trends in the rate of gross investment.

Table 25 presents the gross investment expenditure data for the national level over the period 1951 to 1973. The bracketed figures represent the percentage increases from the previous year. In analyzing

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[77] Since the flow of information is quite efficient between sectors, the analysis need not distinguish between the national and regional levels.

TABLE 25

GROSS INVESTMENT EXPENDITURES (CANADA) 1951-1973

	Gross Investment ($,000 current)	
1951	122,934.0	
1952	129,982.0	(5.73)
1953	105,390.0	(-18.92)
1954	81,257.0	(-22.90)
1955	135,105.0	(66.27)
1956	268,367.0	(98.64)
1957	266,143.0	(-0.83)
1958	124,553.0	(-53.20)
1959	127,215.0	(2.14)
1960	161,432.0	(26.90)
1961	156,145.0	(-3.28)
1962	168,091.0	(7.65)
1963	205,810.0	(22.44)
1964	333,186.0	(61.89)
1965	423,044.0	(24.97)
1966	557,525.0	(31.79)
1967	465,603.0	(-16.49)
1968	271,057.0	(-41.78)
1969	362,596.0	(33.77)
1970	539,655.0	(48.83)
1971	562,069.0	(4.15)
1972	460,629.0	(-18.05)
1973	394,369.0	(-14.38)

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief, Capital Stock, Construction Division, Statistics Canada (revised).

these trends, we see that they bear a relationship to the trends in the gross investment per employee variables. The trend rate in gross investment was greatest during the 1960 to 1969 period at 13.43%. The trend rate was lowest during the 1969 to 1973 period at 5.14%. During the 1951 to 1960 period, the trend rate of increase in gross investment was 11.54%.

Several variables enter into the explanation of the above investment trends. The first of these is the rate of profit, as reflecting expectations of future rates of profit. Table 26 presents the gross rate of profits for the national level between 1951 and 1971. The gross profit rate represents the ratio of gross profits for a given year to the mid-year gross stock of that year. Gross profits represents the difference between the value of shipments and prime costs (i.e. labour, material and energy costs). Obviously, serious problems are implicit in such a measure. For instance, the capital stock measures are valued at cost, whereas book value measures of capital assets should be used. Moreover, the gross profit variable does not give any indication of the extent and nature of taxation in any given year and over the entire 1951 to 1973 period. However, these are the only measures that are available as indicators of the profitability of the industry's undertakings. Comparing the year to year patterns in the rate of investment and in the rate of profit, we see that some evidence exists to support the fact that the rate of investment in a given year is affected by the rate of profit in the preceeding year. This would appear to support the hypothesis that expectations of future profit are primarily dictated by profit rates in the present period. The second relevant variable is the historical pattern of investment as it is reflected in the average degree of capacity utilization of mills. Although capacity and capacity utilization

TABLE 26

GROSS PROFIT RATE (CANADA) 1951-1973

	Gross Profit Rate
1951	34.10
1952	23.99
1953	22.39
1954	23.90
1955	24.60
1956	22.39
1957	16.92
1958	15.80
1959	17.39
1960	17.45
1961	17.73
1962	18.04
1963	17.77
1964	17.50
1965	15.22
1966	13.31
1967	10.38
1968	10.22
1969	11.52
1970	9.81
1971	7.08
1972	7.81
1973	11.16

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual)

2. Unpublished data obtained from Mr. P. Koumanakos, Chief, Capital Stock, Construction Division, Statistics Canada (revised).

data are not available for periods prior to the mid 1960's, some conclusions can be drawn from the trends presented in Table 25. The investment pattern seems to be one of high rates of investment over a given cycle, followed by low rates of investment over the following cycle. The latter phase of this trend could conceivably be marked by low degrees of capacity utilization. More specifically, with respect to gross investment, the period 1951 to 1956 was characterized by a relatively high trend rate of investment of 25.76%. The period 1956 to 1960 exhibited a negative trend rate of -6.25%. Similarly, the following period, 1960 to 1966, was marked by a trend rate of investment of 24.34%. The trend rate of investment for the period 1966 to 1969 was -8.17%. Finally, the rate of investment picked up slightly in the 1969 to 1973 period at 5.14%. The final important variable that could have affected investment patterns is the desire and ability of firms to control total costs through promoting and implementing technical advances. Table 27 presents data on the average hourly wage rate and on the ratio of wage and salary costs to total prime costs. Optimally, the ratio of wage and salary costs to capital costs would be the best indicator of the degree of incentives for generating labour saving technical advances. However, capital cost data for the various types of processes are not available. In terms of the two proxies, the implications derived from each are quite different. First, the trend rate in the average hourly wage over the 1951 to 1973 period was 5.97%. Roughly the same rate prevailed over the 1951 to 1960 and 1960 to 1969 periods. The trend rates were 5.60% and 5.23%, respectively over these periods. However, the trend rate increased drastically to 8.24% over the 1969 to 1973 period. This fact might have contributed to the relatively greater rates of investment in the latter

TABLE 27

AVERAGE HOURLY WAGE AND RATIO OF WAGES AND SALARIES TO TOTAL PRIME COSTS (CANADA) 1951-1973

	Average Hourly Wage ($ Per Hour)	Ratio of Wages and Salaries To Total Prime Costs
1951	1.39	0.276
1952	1.51 (8.63)	0.282 (2.17)
1953	1.63 (7.95)	0.289 (2.48)
1954	1.72 (6.75)	0.296 (2.42)
1955	1.79 (4.07)	0.294 (-0.68)
1956	1.90 (6.15)	0.290 (-1.36)
1957	2.01 (5.79)	0.296 (2.07)
1958	2.08 (3.48)	0.303 (2.36)
1959	2.15 (3.37)	0.303 (0.00)
1960	2.34 (4.17)	0.310 (2.31)
1961	2.35 (4.91)	0.300 (-3.23)
1962	2.42 (2.98)	0.298 (-0.67)
1963	2.48 (2.48)	0.294 (-1.34)
1964	2.55 (2.82)	0.296 (-2.72)
1965	2.65 (3.92)	0.283 (-1.05)
1966	2.92 (10.19)	0.287 (1.41)
1967	3.11 (6.51)	0.289 (0.76)
1968	3.30 (6.11)	0.288 (-0.35)
1969	3.57 (8.18)	0.288 (0.00
1970	3.77 (5.60)	0.313 (8.68)
1971	4.18 (10.88)	0.318 (1.60)
1972	4.52 (8.13)	0.319 (0.31)
1973	4.90 (8.41)	0.310 (-2.82)

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. Statistics Canada, Review of Manhours and Hourly Earnings, Cat. 72-202 (Annual).

period, as compared to the previous periods. The ratio of wage and salary costs to total prime costs exhibited similar relative trends over the 1951 to 1960, 1960 to 1969, and 1969 to 1973 periods, however, the absolute changes were much more volatile. The trend rates over the latter three periods were 1.31%, -0.49% and 1.55%, respectively. The trend rate over the 1951 to 1973 period, in this case, was 0.56%. In summary, the three variables tend to explain both the cyclical and secular trends in the rates of investment. However, in terms of the secular patterns, the more relevant determinants appear to have been the historical relationships and, during the most recent period, the rising level of wages, in absolute terms and relative to other prime costs, to a lesser extent.

At the regional level, the same relationships between the gross investment and gross investment per employee variables can be seen to exist. The relatively faster rate of increase in the gross investment per employee variable in the western sector could be partially explained by the relatively faster rate of gross investment in this sector over the 1961 to 1972 period. The rates of gross investment in the eastern and western sectors over this period were 19.77% and 30.72%, respectively, as derived from Table 28.

An analysis of the determinants of the rates of investment is also more difficult at the regional level, as compared to the national level, basically due to the length of the period under consideration. From Tables 28 and 29, the year to year relationship between the rate of investment and the rate of profit (as described above) can be seen to exist. However, the pattern at the regional level is not as consistent as it was at the national level. In terms of the secular determinants, the only

TABLE 28

GROSS INVESTMENT EXPENDITURES (EAST-WEST) 1961-1971

	East		West	
	Gross Investment		Gross Investment	
	($,000 current)			
1961	124,069.0		32,076.0	
1962	96,059.0	(-22.58)	72,032.0	(124.57)
1963	119,256.0	(24.15)	86,554.0	(20.16)
1964	198,861.0	(66.75)	124,961.0	(44.37)
1965	246,650.0	(24.03)	176,394.0	(41.16)
1966	282,575.0	(14.57)	274,950.0	(55.87)
1967	259,769.0	(-8.07)	164,264.0	(-40.26)
1968	167,574.0	(-35.49)	107,649.0	(-34.47)
1969	242,644.0	(44.80)	119,952.0	(11.43)
1970	347,352.0	(43.15)	192,303.0	(61.19)
1971	325,150.0	(-6.39)	236,919.0	(23.20)

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

TABLE 29

GROSS PROFIT RATE (EAST-WEST) 1961-1971

	EAST	WEST
	GROSS PROFIT RATE	GROSS PROFIT RATE
1961	14.25	17.81
1962	14.35	18.25
1963	14.13	18.12
1964	16.47	16.66
1965	14.93	14.10
1966	13.95	10.13
1967	10.51	7.91
1968	9.95	8.15
1969	10.20	10.53
1970	8.42	9.62
1971	6.82	5.72

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

variables that can be considered are the wage cost trends and the historical stage of the industry, in the two sectors. With respect to the former, the relatively higher trends in the average hourly wage and in the ratio of wage and salary costs to total prime costs in the western sector might have generated the relatively higher rate of gross investment in that sector. The trend rates for the two measures over the 1961 to 1972 period were 5.98% and 0.57%, respectively, in the eastern sector and 6.70% and 1.47%, respectively, in the western sector. These trend rates were derived from the data in Table 30. The other factor that might have affected the relatively faster trend rate of gross investment in the western sector is the fact that the latter sector is relatively younger and more expansive than the eastern sector.

From the above relationships, we can attempt to predict the changes in the gross investment per employee variables by anticipating changes in its basic determinants. At the national level, we would expect the gross investment per employee variable to increase at a relatively faster rate over the next decade, as compared to its trend rate over the 1951 to 1973 period. Two factors are important, here. First, the technical advances that have been embodied in new techniques and/or machinery appear to be much more significant for the next decade, than they have been over the period 1951 to 1973. These have been described in detail in section II. The most relevant of these are the thermo-mechanical or refiner techniques, the new wood-preparation techniques and the twin-wire former paper machines. The result of an implementation of these techniques would be to lower the gross investment per employee variable value for any given rate of gross investment. Second, the rate of investment required to bring

TABLE 30

AVERAGE HOURLY WAGE AND RATIO OF WAGES AND SALARIES TO TOTAL PRIME COSTS (EAST-WEST) 1961-1972

	EAST		WEST	
	Average Hourly Wage ($ per hour)	Ratio of Wages And Salaries to Total Prime Costs	Average Hourly Wage ($ per hour)	Ratio of Wages And Salaries to Total Prime Costs
1961	2.30	.303	2.58	.283
1962	2.35 (2.17)	.302 (-0.33)	2.61 (1.16)	.279 (-0.14)
1963	2.40 (2.13)	.299 (-0.99)	2.72 (4.21)	.272 (-2.51)
1964	2.45 (2.08)	.293 (-2.01)	2.92 (7.35)	.257 (-5.51)
1965	2.56 (4.49)	.293 (0.00)	3.09 (5.82)	.248 (-3.50)
1966	2.81 (9.77)	.296 (1.02)	3.32 (7.44)	.255 (2.82)
1967	2.97 (5.69)	.295 (-0.34)	3.59 (8.13)	.269 (5.49)
1968	3.20 (7.74)	.297 (0.68)	3.84 (6.96)	.260 (-3.35)
1969	3.43 (7.19)	.298 (0.34)	4.11 (7.03)	.257 (-1.15)
1970	3.67 (7.00)	.316 (6.04)	4.45 (8.27)	.303 (17.96)
1971	4.01 (9.26)	.320 (1.27)	4.83 (9.43)	.312 (2.97)
1972	4.34 (8.23)	.322 (0.63)	5.21 (7.87)	.311 (-0.32)

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual)

forth these changes in technique choice would appear to be forthcoming. The recent rapid increases in wage costs and the desire to reduce total costs by reducing wage costs will most likely serve as incentive to higher rates of investment. Given demand trends similar to those over the 1951 to 1973 period, higher rates of profit can be obtained from these changes in technique choice.

In terms of the regional effects, the rate of increase in the gross investment per employee variables should be relatively greater in the eastern, as compared to the western, sector. First, the potential for implementing the technical advances is greater in the eastern sector, given the existing technique structure (as described in section II). Second, fairly similar wage cost incentives exists in both sectors, however, the opportunity for reducing labour costs (in light of available techniques) is greater in the eastern sector. As such, given demand trends, in either sector, similar to those that marked the 1961 to 1972 period, we would expect that the rates of investment would be higher in the eastern sector, relative to the western sector.

Before leaving this subsection, we should make a brief note about the future trends in the economies of scale variable. We shall assume that the latter variable will proceed at a trend rate, over the next decade, similar to that of the 1951 to 1973 period. If, however, relatively more investment is embodied in new mills of less than average productive capacity, the economies of scale variable will increase at a relatively slower rate. If relatively more investment is embodied in existing mills and/or greater than average productive capacity mills, the economies of scale variable will increase at a relatively faster rate, other things being equal.

V. PREDICTIONS AND CONCLUSIONS

The final section of this study will offer some predictions on the level and cyclical and secular patterns of employment per unit output over the next decade. In order to do this, it will utilize the various relationships developed in sections III and IV and, implicitly, the technical and structural information presented in sections I and II. First, given the anticipated values for the determinants of employment per unit output over the next decade, the basic hypothesis in section III will be used to predict the values for employment per unit output, at both the national and regional levels. The predictions, here, will be qualitative rather than quantitative given the nature of the analysis. However, the results will be quantified in the analysis in Appendix B. Second, the role of some institutional variables that might affect the predictions will be considered briefly. It should be noted that the study also indirectly predicts employment trends in the industry, given either knowledge of or some assumptions about the future trends in output or demand.

At the national level, the secular and cyclical trends in employment per unit output will be examined. In terms of the secular trends, the trend rates in the basic determinants of employment per unit output, over the next decade, must be summarized, as they were derived in section IV. The composition of output, the degree of vertical integration of mills, the capital stock per employee, and the related economics of scale variables are relevant, here. As regards the degree of vertical integration of mills

variable, as represented by the ratio of paper and pulp producing mills to total mills, we concluded that the trend rate over the next decade would tend to be quite similar to the trend rate over the 1951 to 1973 period. Similarly, with respect to the economies of scale variable, the same trends were assumed to continue over the next decade, as were evident over the 1951 to 1973 period. The predicted trends in the composition of output variable and in the gross investment per employee variables are very much interrelated, as was described in section IV. Given the anticipated trends in the rate of gross investment and in the gross investment per employee variable, the implication for the composition of output variable would be for a relatively faster declining trend, relative to the trend over the 1951 to 1973 period. That is, a relatively faster increasing trend in gross investment and in the gross investment per employee variable would tend to imply a relatively greater shift to refiner pulping (also to be used in newsprint production), from groundwood pulp production. The net effect of the above anticipated trends, given the relationships derived in section III, would be to produce a relatively faster rate of decline in the employment per unit output variable over the next decade as compared to the 1951 to 1973 period.

With respect to the cyclical aspects of the secular trend in employment per unit output, the trends in the basic determinants would tend to imply a relatively greater variability over the next decade. The basic element in this prediction is the relatively faster rate of decline in the composition of output variable over the next decade. The other potential determinants of variability, the degree of vertical integration of mills and the economies of scale variables were either argued or assumed to proceed at a trend rate

similar to that over the 1951 to 1973 period. As such, their effect on the relative variability in employment per unit output over the next decade would tend to be neutral. Again, these specific predictions are based on the relationships developed in section III, between the variability in employment per unit output and the trend rates in the relevant determinants.

At the regional level, differences in the levels, as well as the cyclical and secular trends, in employment per unit output will be considered. As regards the difference in the secular trends in employment per unit output between the eastern and western sectors, the trend rate in employment per unit output would appear to decrease relatively faster in the eastern sector, as compared to the western sector, over the next decade. This prediction is based on the following anticipated differences in the relative trends in the composition of output variable between the two sectors. It would appear that the interrelationships between the rate of gross investment, the gross investment per employee variable and the composition of output variable are relevant in the regional analysis, as in the national analysis. From section IV, we saw that the anticipated increases in the rate of gross investment and in the gross investment per employee would appear to be greater in the eastern sector, relative to the western sector. However, these tendencies towards a relatively faster declining employment per unit output variable in the eastern sector would tend to be partially offset by the relative trends in the two sectors in the degree of vertical integration of mills variable. From the analysis in section IV, we concluded that the degree of vertical integration of mills variable would remain constant in the western sector, while it would tend to show an increasing trend in the eastern sector, similar to the trend over the 1961 to 1972 period. Given the relationships set out in section III, it does not appear that the

anticipated differences in the trends in the degree of vertical integration variable could outweigh the effects of the differences in the trends in the composition of output and capital per employee variables. Finally, the economies of scale variable, as in the national analysis, was assumed to have a neutral effect on the employment per unit output trends in the two sectors, over the next decade.

The obvious effect on the difference in the levels of employment per unit output in the eastern and western sectors is for the absolute differences to be narrowed or lessened over the next decade. For various reasons, however, it is anticipated that the level of employment per unit output will still be higher in the eastern sector. First, the existing difference in the levels between the two sectors was fairly large in 1972. Second, the effect of the degree of vertical integration of mills trends in the eastern sector will be to dampen the decrease in employment per unit output in this sector.

Finally, with respect to the differences in the cyclical aspects of the secular trends in employment per unit output, the net effect is uncertain. On the one hand, the anticipated trends in the composition of output variable would tend to imply a greater increase in variability in the eastern sector, relative to the western sector. On the other hand, the anticipated trends in the degree of vertical integration variable would tend to imply the opposite results over the next decade. Given the anticipated greater relative change in the former variable over the next decade, we might infer that the tendency would be towards a relatively greater increase in variability in the eastern sector. However, this result is uncertain due to the lack of knowledge of the relative weights of the two variables in affecting the variability of the employment per unit output trends.

In all of the above cases, the predictions are specific to the assumptions made in section IV. If the assumptions are altered or if the actual trends over the next decade turn out to be different from those assumed, the predictions would be affected within the constraints of the hypothesis specified in section III. The potential situations are quite numerous and their analysis, individually, would not appear to render substantive results. These assumptions concern the trend rates in the growth and pattern of demand, in the number and size of new mills built, and in the level of concentration in the industry, over the next decade.[78]

In the above analysis, the implicit assumption being used is that the non-economic factors remain constant over the next decade. As such, given the assumptions of trends in the economic factors, the predictions still only represent potential trends in the employment per unit output variable. Some of the institutional factors that might affect the actual trends in the employment per unit output variable were mentioned in section IV. The most relevant factor is the role that the labour organizations play in relation to the relatively faster declining trends in employment per unit output. As was seen in the discussion in section I, little concern has been raised in collective bargaining agreements in the Canadian pulp and paper industry about job security and technological change clauses. If this trend continues, little resistance will be presented to the relatively faster declining trends in employment per unit output over the next decade. However, if labour resistance is initiated at the mill, regional or national level, employment per unit output would tend to decrease at a slower rate than the trend predicted above.

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[78] Included in these assumptions about trends in the economic variables are those related to the efficiency of labour and organization (other than the degree of vertical integration effects) as specified in section III.

APPENDIX A

A regression analysis using ordinary least squares estimation is used to supplement the statistical analysis of section III. The purpose is two-fold. First, a test of the direction and significance of the relationships between employment per unit ouput and its specified determinants is desired. Second, an absolute measure of the magnitude of each relationship, which is lacking in the statistical analysis is sought. The resulting equations are also employed to test the non-quantitative predictions offered in section V. The predictions in the regression analysis utilize the values of the independent variables that were derived from the assumptions and relationships specified in section IV.

The dependent and independent variables used in the regression analysis are those specified in section III. To summarize, the dependent variable is employment per unit output, represented here as E/O, measured in the number of employees per thousand combined tons of output. Eight independent variables are used in various combinations[1], seven of which are secular and one of which is cyclical in nature. Two of the secular variables appear in all of the regression equations. These are the composition of output and the degree of vertical integration of mills variables. The former, denoted by C, is represented by the percentage of groundwood pulp production (in tons) in total pulp tonnage produced. The latter variable, denoted by Q,

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[1] Only some of these variables were examined in the statistical analysis of section III. The latter variables were selected on the basis of structural considerations and of the regression results presented here.

represents the percentage of pulp producing and paper producing mills in total mills. The other five secular variables are different specifications of gross investment in constant 1961 dollars per employee, measured in thousands of dollars per employee. The first specification, represented by I/E in the regression equations, does not take into account general construction and implementation time lags involved in investment decisions and does not consider possible differences in these time lags between construction investment and investment in machinery and equipment. The second specification, denoted by I_1/E, takes account of the first problem of the existence of general time lags. The variable represents the ratio of the average of investment in the current and previous years to the number of employees in the current year.[2] Implicit in this formulation is the structural observation that, on average, a two year construction and implementation period is relevant to investment projects. The third specification, consisting of three alternative variables, takes account of the second, more specific problem of differential time lags in different types of investments. The important determinant of the specific formulation of the variables, here, is a knowledge of the technical structure of the industry. The first variable, represented by I_{c_2m}/E, hypothesizes, on the average, a two year lag in construction investment and no lag in machinery and equipment investment. As such it represents the ratio of the sum of the average of construction investment in the current and previous two years and of machinery and equipment in the current year to the number of employees in the current year.[3] In the same manner, the second variable, represented by

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[2] Algebraically, the variable can be seen as $\frac{I_t + I_{t-1}}{2} \Big/ E_t$

$I_{c_2 m_1}/E$ hypothesizes, on the average, a two year lag in construction investment and a one year lag in machinery and equipment investment. The third variable, denoted by $I_{c_1 m}/E$, represents a one year lag in construction investment and no lag in machinery and equipment investment. The cyclical variable used in all of the regression equations is the annual percentage change in combined output represented by $\dot{O}$ in the regression analysis. This variable did not appear in the statistical analysis of section III because the secular trends in employment per unit output and its determinants were being considered. However, it is essential that it be included in the regression analysis, since annual data is utilized, here, and these annual changes in employment per unit output are determined by both cyclical and secular factors. The theoretical justification for the inclusion of this variable arises from the presence of indirect or overhead labour which results in an inverse relationship between employment per unit output and the annual percentage change in output. The gist of the argument is that due to the presence of overhead labour, output increases at a relatively faster rate than employment during periods of expansion and decreases at a relatively faster rate than employment during periods of contraction. Therefore, other things being constant, the higher (lower) the annual percentage change in output, the lower (higher) the value of employment per unit output.

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[3] Algebraically, this is represented by $\left(\frac{I_{c_t} + I_{c_{t-1}} + I_{c_{t-2}}}{3} + I_{m_t}\right)/E_t$

[4] Algebraically, this is represented by $\left(\frac{I_{c_t} + I_{c_{t-1}} + I_{c_{t-2}}}{3} + \frac{I_{m_t} + I_{m_{t-1}}}{2}\right)/E_t$

[5] Algebraically, this is represented by $\left(\frac{I_{c_t} + I_{c_{t-1}}}{2} + I_{m_t}\right)/E_t$

A final note before considering the regression results concerns the absence of the economies of scale variable in the regression analysis. The unavailability of productive capacity data served as an important deterrant to the inclusion of this variable in the regression results. Moreover, if the proxy measure, average mill production, used in section III was used in the regression results the problem of having output or production values on both the left and right hand sides of the regression equation would have been present. This factor contributed to the decison to omit the variable altogether. However, it should be noted that the economies of scale effect is picked up by the investment per employee variable, to a great extent, when the former variable is not included separately in the regression equation.

In all, five regression equations were estimated. The basic results are presented below;

(1) $E/O = \underset{(-3.739)}{-10.023} + \underset{(20.028)}{52.033}\ C + \underset{(2.127)}{10.629}\ D - \underset{(-2.521)}{0.281}\ I/E - \underset{(-1.904)}{0.054}\ O + e$

$\bar{R}^2 = 0.9658$ D.W. = 1.15
$F = 163.81$

(2) $E/O = \underset{(-3.099)}{-8.683} + \underset{(17.999)}{50.584}\ C + \underset{(2.044)}{9.971}\ D - \underset{(-2.728)}{0.358}\ I_1/E - \underset{(-2.625)}{0.075}\ O + e$

$\bar{R}^2 = 0.9673$ D.W. = 1.24
$F = 171.26$

(3) $E/O = \underset{(-3.630)}{-9.747} + \underset{(19.612)}{51.655}\ C + \underset{(2.152)}{10.657}\ D - \underset{(-2.612)}{0.303}\ I_{c_1 m}/E - \underset{(-2.171)}{0.061}\ O + e$

$\bar{R}^2 = 0.9665$ D.W. = 1.19
$F = 166.97$

(4) $E/O = \underset{(-2.904)}{-8.376} + \underset{(17.109)}{50.218}\ C + \underset{(2.007)}{9.848}\ D - \underset{(-2.671)}{0.377}\ I_{c_2 m_1}/E - \underset{(-2.653)}{0.076}\ O + e$

$\bar{R}^2 = 0.9669$ D.W. = 1.27
$F = 169.165$

(5) $E/O = \underset{(-3.446)}{-9.361} + \underset{(18.818)}{51.131}\ C + \underset{(2.163)}{10.642}\ D - \underset{(-2.671)}{0.337}\ I_{c2m}/E - \underset{(-2.229)}{0.062}\ O + e$

$R^2 = 0.9669$ D.W. = 1.22
$F = 169.144$

It is apparent that the differences between the various regression equations are minimal. However, equation (5) was selected as the most appropriate equation based on its superior stability properties as indicated by the t-ratios of the coefficients of the independent variables. As such, we shall concentrate the discussion of the regression statistics on this equation.

In all cases, the signs of the coefficients of the independent variables are correct in the sense that they comply with a priori theoretical and/or technical specifications (see section III 1). The only conceivable problem, here, is the negative sign of the intercept, since a negative value for employment per unit output does not have any meaning. However, in a practical sense, this does not present a problem because the range of values for the independent variables that we are interested in for prediction purposes are such that they do not closely approach this range of negative values for employment per unit output.

As regards the absolute or relative signs of the coefficients, there are no a priori theoretical or structural expectations. However, an examination of the various employment per unit output elasticities of the independent variables indicates that the composition of output variable exerts the greatest relative influence on the employment per unit output variable. The relevant elasticities of employment per unit output were calculated both at the means of the variables and over the range of the

variables comprising the 1951 to 1973 period (i.e. arc elasticity). These are presented in Appendix A - Table 1. In interpreting these elasticities, two points should be noted. First, the relative magnitudes of relative change in each of the independent variables that is expected (as reflected in the analysis of section III 3 and Table 14) are also important considerations in analyzing the relative impacts on employment per unit output of each of the independent variables. Second, the assumption of ceteris paribus that accompanies the use of elasticity concepts should be amended to include the various cross-elasticity relationships that exist between the independent variables.

In all cases, the t-ratios of the independent variables (and of the intercept) exceed 2.074 (with 22 degrees of freedom) and, as such, the coefficients are statistically significant at the 95% confidence level. Moreover, the intercept and the coefficients of the composition of output and investment per employee variables are statistically significant at the 99% confidence level (i.e. t_c=2.508 with 22 degrees of freedom).

The explanatory ability of the regression equation is extremely good. The adjusted R-squared is 0.9669 and the F-value is 169.144. The Durbin-Watson statistic is 1.22 which falls within the inconclusive range in terms of autocorrelation with d_L = 0.83 and d_U = 1.52 for 23 observations. A Hildreth-Lu transformation was tried on the equation without any success.

Several predictions were made using regression equation (5). The relevant prediction year was chosen to be 1985 which comprised a period of thirteen years. Since secular patterns in employment per unit output were of primary concern, intermediate years between 1973 and 1985 were not

APPENDIX A

TABLE 1

INDEPENDENT VARIABLE ELASTICITIES OF EMPLOYMENT PER UNIT OUTPUT

	Mean	Arc
Composition of Output ($E_{/O,C}$)	1.326	1.334
Degree of Vertical Integration ($E_{/O,D}$)	0.249	0.277
Investment per Employee ($E_{/O,I_{c_2m}/E}$)	0.064	0.057
Output ($E_{/O,O}$)	0.014	0.035

considered. Based on the results of the analysis of section IV, upper and lower estimates of anticipated growth rates in the independent variables were employed and absolute values for the independent variables were thus computed for the year 1985. It should be noted that the neglect of intermediate years necessitated the use of growth rates in the calculation of the values of the independent variables for the year 1985. This presents a problem in the derivation of the appropriate rate of growth and consequent predicted value for the investment per employee value, which will be examined later in this appendix. The resulting values for the independent variables were then employed in the regression equation to yield predicted values for employment per unit output for 1985.

Appendix A - Table 2 presents the upper and lower bound estimates for the growth rates of the independent variables and the resulting absolute values for 1985. Moreover, it presents the predicted values for employment per unit output in the same year.

Several comments must be made about the specific data used in the analysis and about the resulting predictions. First, the expected rates of growth of the composition of output and degree of vertical integration of mills variables were simply quantification of the assumptions and predictions discussed in section IV. Second, the gross investment per employee expected rate of growths are much higher than the observed rate of growth over the 1951 to 1973 period. The problem basically concerns the fact that the rate of growth calculation involves only the first and last observations of the relevant period and ignores the extent of variability over the same period. In the case of this analysis, this problem is present only in the

APPENDIX A

TABLE 2

SUMMARY OF REGRESSION EQUATION PREDICTIONS

	Rate of Growth 1951-1973	Expected Rate of Growth, 1973-1985 Lower Bound	Upper Bound
1. C	-1.55	-1.50	-2.00
2. D	-0.05	0.00	-1.00
3. $I_{c_2m/E}$	1.61	5.00	8.00
4. $\dot{O}$	3.94	9.13	9.13
5. $E/_O$	-2.31	-3.09	-5.81

	Actual Values: 1951	1973	Predicted Values (1985) Lower Bound	Upper Bound
1. C	0.6553	0.3939	0.3236	0.3029
2. D	0.4762	0.4710	0.4710	0.4133
3. $I_{c_2m/E}$	2.547	3.618	6.820	9.840
4. $\dot{O}$	11.580	9.040	9.130	9.130
5. $E/_O$	22,763	13.608	9.333	6.635

gross investment per employee variable. If growth rates for high investment periods are considered (see section III Table 14), we see that the resulting growth rates are much higher than the 1.61% observed over the 1951 to 1973 period. Furthermore, given the investment patterns described in section IV and the average length of cycles over the 1951 to 1973 period, we would expect that two of the three cycles comprising the 1973 to 1985 period would be high investment cycles. As an example, if we calculate the rate of growth for the 1951 to 1966 period, which includes two high investment and one low investment cycles, we see that it is equal to 5.98%. The lower and upper bound estimates of expected growth rates in gross investment per man were thus derived, with the above points being explicitly considered. Third, since the annual percentage change in output variable (O) relates to a specific year, a specific value rather than a trend prediction was required. The average value peak year annual percentage changes in output was selected (over the 1951 to 1973 period) since 1985 was chosen to represent a peak year, on the basis of past cycle length estimates. The resulting value of 9.13 is therefore considerably higher than the average value of annual percentage changes, which was 3.94 over the 1951 to 1973 period. However, it should be noted that the resulting relative effect on the employment per unit output estimate is not that much greater, given the relatively low associated elasticity of employment per unit output (see Appendix A - Table 1). Fourth, the analysis assumes that the rate of growth and consequent value of the gross investment per employee variable (as well as of the composition of output variable) is to some extent independent of the rate of growth of output. Different rates of growth for gross investment per employee, given the rate of growth in output, could be accounted for by reference to such

factors as the state of confidence or "animal spirits" of firms, and in the case of the Canadian pulp and paper industry, the observed commercial viability of new techniques of production abroad. This, however, does not deny the fact that the rates of growth of gross investment per employee are also affected by the expected and actual rates of growth of output. The latter relationship is not examined, here, simply because the determinants of the growth and pattern of demand or output were too complex to be considered in the present study and were thus assumed to follow the pattern of the 1951 to 1973 period. It should also be noted that although the difference between the lower and upper bound of the gross investment per employee variables is quite large, it does not imply an equally large difference in the growth rate of investment. Instead, the basic differences in the upper and lower bound estimates of the gross investment per employee variable are basically due to the differences in the input ratios of the various techniques being invested in and in the relative costs of these alternative techniques. As such, generally speaking, the lower bound estimate can be seen to relate predominantly to investment in existing techniques of production, while the upper bound estimate can be seen to relate primarily to investment in new techniques of production (as described in section II 4). To illustrate this point, we can compare the implicit rates of growth for gross investment in the estimated equations for the lower and upper estimates for I_{c_2} m/E. Appendix A - Table 3 summarizes the results. The assumption of a constant growth rate for output is made. From the table, it can be seen that the difference in the expected rates of growth in investment is very small relative to the difference in the expected rates of growth in gross investment per employee. Finally, both the anticipated values of the independent

APPENDIX A

TABLE 3

DIFFERENCES IN THE EXPECTED RATE OF GROWTH OF INVESTMENT

	Employment Per Unit Output ($\hat{E}_{/0}$)	Output ($\hat{0}$)	Employment ($\hat{E}$)	Gross Investment Per Employee ($I_{c_{2m}/E}$)	Investment ($I_{c_{2m}/E}$
Lower Bound	-3.09	3.94	0.85	5.00	5.85
Upper Bound	-5.81	3.94	-1.87	8.00	6.13

Note: $\hat{E} = \hat{E}_{/0} + \hat{0}$ (from $\hat{E}_{/0} = \hat{E} - \hat{0}$)

$\hat{I}_{c_{2m}} = I_{c_{2m}/E} + \hat{E}$ (from $\hat{I}_{c_{2m}/E} = I_{c_{2m}} - \hat{E}$)

variables and the predicted values of employment per unit output exhibit a sizeable difference between the upper and lower bounds. This fact was necessitated by the uncertainty concerning the future growth and pattern of demand and, consequently, the rate of adoption of new techniques of production in investment decisons. As such, the basic purpose of the predictions is to provide an indication of the range of possible trends in employment per unit output.

In light of the above results, the likely alternative trends in employment growth can be deduced. Appendix A - Table 4 summarizes the relevant results. The assumption of a growth in output similar to that over the 1951 to 1973 period is employed. The results of the table clearly indicate that even if the lower bound estimates are taken to represent the most likely future trends, the increase in employment will proceed at a much slower rate than over the 1951 to 1973 period (i.e. 0.85% as compared to 1.53%). However, if the upper bound estimates of the independent variables are accepted as most probable, then a sizeable absolute decrease in the level of employment results.

APPENDIX A

TABLE 4

IMPLIED TRENDS IN EMPLOYMENT

	Employment Per Unit Output		Output		Employment	
	Growth Rate (1973-1985)	Predicted Value (1985)	Growth Rate (1973-1985)	Predicted Value (1985)	Growth Rate (1973-1985)	Predicted Va (1985)
Lower Bound	-3.09	9.333	3.94	9726.29	0.85	89,400
Upper Bound	-5.81	5.224	3.94	9726.29	-1.87	82,658

APPENDIX B

The following tables present the raw data from which the data in the text of the study are derived. The explanation of the raw data and their relation to the data in the text were discussed in sections III and IV.

APPENDIX B

TABLE 1

PRODUCTION OF SELECTED PULP, PAPER AND PAPERBOARD PRODUCTS (CANADA) 1951-1973

	Groundwood Pulp	Refiner Pulp	Chemical Pulp	Newsprint	Groundwood Printing and Specialty Papers	Other Paper and Paperboard
	('000 tons)					
1951	5,172.47	200.11	3,942.27	5,561.12	50.06	1,614.10
1952	5,275.32	177.59	3,515.10	5,707.03	47.45	1,477.32
1953	5,122.60	189.83	3,764.64	5,755.47	47.35	1,573.71
1954	5,337.61	181.40	4,154.01	6,000.90	59.19	1,589.52
1955	5,466.93	209.41	4,474.22	6,186.32	79.77	1,724.12
1956	5,723.00	236.30	4,774.45	6,445.11	93.66	1,928.01
1957	5,574.23	207.37	4,643.40	6,361.65	83.26	1,854.98
1958	5,375.50	212.89	4,549.07	6,030.93	91.64	1,958.72
1959	5,655.00	249.00	4,928.00	6,351.00	107.00	2,092.00
1960	5,881.00	231.00	5,331.00	6,689.00	112.00	2,122.00
1961	5,878.00	281.00	5,484.00	6,718.00	114.00	1,937.00
1962	5,981.51	283.99	5,810.35	6,663.92	108.94	2,107.18
1963	5,849.54	334.09	6,130.90	6,657.01	113.90	2,191.88
1964	6,442.20	372.34	6,742.50	7,380.26	103.57	2,459.83
1965	6,988.67	280.84	7,303.44	7,827.04	127.06	2,518.37
1966	7,525.79	330.98	8,100.83	8,530.31	167.85	2,913.34
1967	7,249.48	278.10	8,329.79	8,192.65	159.51	2,996.45
1968	7,304.91	309.80	9,146.90	8,192.63	168.47	3,099.99
1969	7,680.02	353.38	10,238.24	8,937.59	214.47	3,487.96
1970	7,649.85	396.64	9,975.50	8,814.47	288.85	3,300.43
1971	7,404.79	409.67	10,087.47	8,231.07	299.50	3,478.99
1972	7,679.83	424.47	10,763.61	8,567.76	296.17	3,894.55
1973	7,931.88	440.55	11,764.61	9,212.53	221.74	4,435.85

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual)

APPENDIX B

TABLE 2

PRICES OF SELECTED PULP, PAPER AND PAPERBOARD PRODUCTS (CANADA) 1951-1973

	Groundwood Pulp	Refiner Pulp	Chemical Pulp	Newsprint	Groundwood Printing and Specialty Papers	Other Paper and Paperboard
	($'s per ton)					
1951	41.36	31.06	128.79	101.48	157.51	155.99
1952	41.20	31.75	121.49	105.22	156.16	155.81
1953	40.98	28.84	108.77	110.05	163.77	156.76
1954	40.12	29.23	105.08	109.56	156.53	162.64
1955	39.98	28.86	104.78	111.09	151.00	163.01
1956	68.02	29.88	135.50	114.17	158.28	179.84
1957	69.17	29.18	128.97	114.71	156.87	185.25
1958	68.51	31.73	132.72	116.02	156.34	184.78
1959	67.27	28.32	129.21	115.03	154.35	187.33
1960	68.36	28.36	125.12	117.13	152.10	187.24
1961	67.94	28.12	122.93	120.55	154.86	189.51
1962	70.36	27.76	123.35	123.20	149.43	185.99
1963	68.40	21.91	123.96	121.89	155.08	185.24
1964	68.35	24.10	129.69	120.31	156.26	188.07
1965	67.77	26.30	132.51	118.33	157.94	187.42
1966	69.17	26.33	128.50	120.70	170.35	190.12
1967	63.14	24.91	125.98	123.10	161.35	192.13
1968	61.43	20.83	123.20	123.80	160.27	189.37
1969	62.85	21.71	128.05	125.77	179.15	192.37
1970	65.43	23.37	141.00	126.28	173.34	195.90
1971	60.56	23.10	160.29	128.54	162.74	192.46
1972	65.21	25.21	135.05	131.22	170.28	194.46
1973	77.24	40.87	167.64	145.11	192.36	216.98

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 3

TOTAL ACTIVITY EMPLOYMENT (CANADA) 1951-1973

	Number of Employees
1951	57,291
1952	57,803
1953	58,194
1954	60,837
1955	62,205
1956	65,985
1957	66,067
1958	64,199
1959	65,162
1960	65,772
1961	64,155
1962	64,885
1963	65,040
1964	67,729
1965	69,897
1966	73,501
1967	73,983
1968	73,498
1969	75,427
1970	80,371
1971	79,397
1972	78,969
1973	80,085

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 4

GROUNDWOOD PULP AND TOTAL WOOD PULP PRODUCTION (CANADA) 1951-1973

	Groundwood Pulp ('000 tons)	Total Wood Pulp ('000 tons)
1951	5,172	9,315
1952	5,175	8,968
1953	5,123	9,077
1954	5,338	9,673
1955	5,467	10,151
1956	5,723	10,734
1957	5,574	10,425
1958	5,375	10,137
1959	5,656	10,832
1960	5,881	11,461
1961	5,878	11,779
1962	5,892	12,133
1963	5,850	12,474
1964	6,442	13,742
1965	6,802	14,573
1966	7,351	15,958
1967	7,041	15,857
1968	7,055	16,762
1969	7,680	18,590
1970	7,650	18,308
1971	7,405	18,234
1972	7,680	19,239
1973	8,060	20,462

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 5

GROSS INVESTMENT (CANADA) 1951-1973

	Total Component	Construction	Machinery and Equipment
		($'000 constant 1961)	
1951	159,376.4	38,534.6	120,841.8
1952	164,141.1	29,738.8	134,402.3
1953	131,802.4	18,936.7	112,965.8
1954	100,195.6	14,475.8	85,719.7
1955	160,904.7	28,153.8	132,750.9
1956	298,740.3	82,414.9	216,325.3
1957	287,241.5	55,981.8	231,259.7
1958	131,428.2	19,794.4	111,633.8
1959	131,772.5	21,933.4	109,839.5
1960	163,371.5	27,800.2	135,571.5
1961	156,145.0	32,819.0	123,326.0
1962	166,757.6	34,508.6	132,249.1
1963	197,367.4	35,905.4	161,462.1
1964	304,555.5	64,557.0	239,998.7
1965	366,903.0	95,063.3	271,839.8
1966	468,196.1	110,944.9	357,251.1
1967	395,220.2	82,870.1	312,350.2
1968	232,978.1	48,726.3	184,251.9
1969	299,295.8	77,601.8	221,693.8
1970	424,070.8	91,507.9	332,563.0
1971	421,860.3	90,843.3	331,017.3
1972	333,002.2	74,796.9	258,205.3
1973	266,375.1	47,801.8	218,573.4

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada, (revised).

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TABLE 6

NUMBER OF MILLS (CANADA) 1951-1973

1951	126
1952	128
1953	127
1954	125
1955	125
1956	126
1957	127
1958	127
1959	126
1960	126
1961	125
1962	125
1963	126
1964	131
1965	132
1966	134
1967	136
1968	137
1969	138
1970	139
1971	142
1972	141
1973	141

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 7

PRODUCTION OF PULP, PAPER AND PAPERBOARD PRODUCTS
(EAST-WEST) 1961-1972

	Pulp		Paper and Paperboard	
	East	West	East	West
	(,000 tons)			
1961	9,356.06	2,422.94	7,395.64	1,284.36
1962	9,544.45	2,588.06	7,530.35	1,349.05
1963	9,788.52	2,685.59	7,665.14	1,393.82
1964	10,696.72	3,045.06	8,373.89	1,569.77
1965	11,071.31	3,501.64	8,793.13	1,773.80
1966	12,044.68	3,912.92	9,666.85	1,944.64
1967	11,760.34	4,097.02	9,411.25	1,937.35
1968	12,132.21	4,629.41	9,478.10	1,983.00
1969	13,271.68	5,318.21	10,302.60	2,212.00
1970	13,334.41	4,973.44	10,257.84	2,145.90
1971	12,884.67	5,388.89	10,004.22	2,298.48
1972	13,597.14	5,641.95	10,745.82	2,350.89

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. National Pulp and Paper Directory (Annual).

APPENDIX B

TABLE 8

PRICES OF PULP, PAPER AND PAPERBOARD PRODUCTS
(CANADA) 1961-1972

	Pulp	Paper and Paperboard
	($'s per ton)	
1961	117.74	135.27
1962	118.42	137.45
1963	119.09	137.21
1964	124.33	136.13
1965	127.36	134.60
1966	124.39	137.38
1967	122.45	140.72
1968	120.20	140.80
1969	124.96	143.32
1970	137.02	145.01
1971	136.81	146.73
1972	132.22	149.85

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204.

APPENDIX B

TABLE 9

TOTAL ACTIVITY EMPLOYMENT (EAST-WEST) 1961-1972

	East	West
	(number of employees)	
1961	54,199	9,956
1962	54,506	10,379
1963	54,614	10,429
1964	56,549	11,180
1965	57,816	12,081
1966	60,129	13,372
1967	59,830	14,153
1968	59,000	14,498
1969	60,132	15,295
1970	63,857	16,514
1971	61,611	17,786
1972	60,451	18,518

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 10

NUMBER OF GROUNDWOOD PULP PRODUCING MILLS (EAST-WEST) 1961-1972

	East	West
	(number of mills)	
1961	71	9
1962	71	10
1963	72	9
1964	76	9
1965	74	10
1966	67	9
1967	65	9
1968	59	9
1969	62	8
1970	55	9
1971	56	9
1972	57	5

Source: Unpublished data obtained from Mr. G.W. Barrett, Head Furniture, Paper and Allied Products Unit, Statistics Canada.

APPENDIX B

TABLE 11

GROSS INVESTMENT (EAST-WEST) 1961-1971

	East	West
	($,000 constant 1961)	
1961	124,069.0	32,076.0
1962	95,160.8	71,543.0
1963	114,225.7	83,121.2
1964	169,613.9	114,496.3
1965	213,673.8	153,202.9
1966	237,350.5	230,812.9
1967	220,505.0	139,380.1
1968	144,283.1	92,336.8
1969	200,930.0	98,391.3
1970	273,510.1	150,629.4
1971	244,355.8	177,472.5

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

APPENDIX B

TABLE 12

NUMBER OF MILLS (EAST-WEST) 1961-1972

	East	West
1961	104	21
1962	104	21
1963	105	21
1964	110	21
1965	110	22
1966	110	26
1967	113	25
1968	111	28
1969	109	28
1970	111	29
1971	113	30
1972	113	31

Source: Canadian Pulp and Paper Association, Reference Tables (Annual)

APPENDIX B

TABLE 13

WAGES AND SALARIES (CANADA) 1951-1973

	($,000)
1951	213,169.9
1952	225,353.3
1953	235,741.7
1954	252,598.4
1955	265,298.1
1956	297,571.9
1957	307,828.0
1958	307,595.0
1959	322,480.0
1960	344,410.0
1961	340,857.0
1962	355,245.0
1963	364,513.0
1964	394,136.0
1965	423,732.0
1966	486,249.0
1967	516,724.0
1968	552,162.0
1969	611,591.0
1970	701,395.0
1971	745,608.0
1972	808,869.0
1973	884,243.0

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

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TABLE 14

TOTAL PRIME COSTS (CANADA) 1951-1973

	($,000)
1951	771,809.6
1952	799,139.8
1953	815,472.2
1954	852,746.8
1955	902,418.1
1956	1,026,283.2
1957	1,038,802.0
1958	1,016,409.0
1959	1,064,519.0
1960	1,112,446.0
1961	1,138,109.0
1962	1,193,835.0
1963	1,240,827.0
1964	1,379,003.0
1965	1,499,375.0
1966	1,693,436.0
1967	1,786,558.0
1968	1,916,363.0
1969	2,124,394.0
1970	2,240,129.0
1971	2,342,160.0
1972	2,537,110.0
1973	2,855,813.0

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 15

CAPITAL STOCK (CANADA) 1951-1973

	Mid-Year Gross ($,000 current)
1951	1,366,799.2
1952	1,495,203.5
1953	1,580,990.3
1954	1,626,806.7
1955	1,725,803.4
1956	1,959,643.0
1957	2,238,119.1
1958	2,429,836.3
1959	2,532,118.3
1960	2,671,863.2
1961	2,790,095.6
1962	2,896,313.8
1963	3,108,716.0
1964	3,458,647.9
1965	3,975,307.9
1966	4,539,448.0
1967	4,957,297.8
1968	5,191,443.7
1969	5,616,496.6
1970	6,225,752.9
1971	6,924,778.8
1972	7,556,620.8
1973	8,379,957.4

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada (revised).

APPENDIX B

TABLE 16

GROSS PROFITS (CANADA) 1951-1973

	Gross Profits
1951	466,087.9
1952	358,747.9
1953	364,193.2
1954	388,811.7
1955	424,520.0
1956	438,774.5
1957	378,583.0
1958	383,869.0
1959	440,277.0
1960	466,281.0
1961	494,725.0
1962	522,465.0
1963	552,404.0
1964	605,111.0
1965	605,050.0
1966	604,226.0
1967	514,486.0
1968	530, 11.0
1969	646,882.0
1970	610,707.0
1971	490,107.0
1972	590,019.0
1973	935,126.0

Sources: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

APPENDIX B

TABLE 17

WAGES AND MANHOURS PAID (EAST-WEST) 1961-1972

	Wages ($,000)	Manhours (,000)	Wages ($,000)	Manhours (,000)
1961	228,889	99,727	42,345	16,414
1962	236,249	100,333	45,609	17,450
1963	240,950	100,597	49,157	18,095
1964	259,095	105,787	56,878	19,501
1965	274,766	107,128	64,597	20,878
1966	314,852	112,183	75,883	22,870
1967	327,976	110,545	85,561	23,817
1968	343,633	107,328	93,502	24,325
1969	383,114	111,663	105,740	25,752
1970	406,668	110,689	104,956	23,602
1971	416,435	103,900	129,804	26,866
1972	452,166	104,152	142,125	27,274

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 18

WAGES AND SALARIES (EAST-WEST) 1961-1972

	East	West
	($,000)	
1961	285,879.0	54,960.0
1962	295,908.0	59,337.0
1963	303,093.0	61,420.0
1964	323,199.0	70,937.0
1965	342,922.0	80,810.0
1966	389,867.0	96,382.0
1967	406,243.0	110,481.0
1968	430,723.0	121,439.0
1969	476,249.0	135,342.0
1970	542,520.0	158,875.0
1971	557,097.0	188,511.0
1972	600,334.0	208,535.0

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 19

TOTAL PRIME COSTS (EAST-WEST) 1961-1972

	East	West
	($,000)	
1961	944,142.0	193,967.0
1962	981,535.0	212,300.0
1963	1,014,809.0	226,018.0
1964	1,102,598.0	276,405.0
1965	1,172,917.0	326,458.0
1966	1,316,207.0	377,229.0
1967	1,375,185.0	411,373.0
1968	1,449,749.0	466,614.0
1969	1,598,296.0	526,098.0
1970	1,715,024.0	525,105.0
1971	1,738,522.0	603,638.0
1972	1,866,178.0	670,932.0

Source: Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

APPENDIX B

TABLE 20

CAPITAL STOCK (EAST), 1961-1971

	Mid-Year Gross Stock ($,000 current)
1961	2,039,763.4
1962	2,107,481.8
1963	2,227,986.7
1964	2,435,879.9
1965	2,746,381.2
1966	3,051,928.6
1967	3,251,759.4
1968	3,367,261.7
1969	3,631,371.4
1970	4,006,521.1
1971	4,413,685.0

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

APPENDIX B

TABLE 21

CAPITAL STOCK (WEST) 1961-1971

	Mid-Year Gross Stock ($,000 current)
1961	750,275.3
1962	789,865.5
1963	880,665.0
1964	1,017,882.4
1965	1,218,923.3
1966	1,477,223.4
1967	1,674,619.4
1968	1,773,571.4
1969	1,936,677.9
1970	2,167,500.8
1971	2,458,678.6

Source: Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

APPENDIX B

TABLE 22

GROSS PROFITS (EAST-WEST) 1961-1971

	East	West
	Gross Profits	Gross Profits
	($,000)	
1961	361,106.0	133,619.0
1962	378,329.0	144,136.0
1963	392,836.0	159,568.0
1964	485,524.0	169,587.0
1965	433,160.0	171,890.0
1966	454,543.0	149,683.0
1967	381,945.0	132,547.0
1968	386.042.0	144,469.0
1969	442,871.0	204,011.0
1970	402,219.0	208,488.0
1971	349,366.0	140,741.0

Source: 1. Statistics Canada, Pulp and Paper Mills, Cat. 36-204 (Annual).

2. Unpublished data obtained from Mr. P. Koumanakos, Chief Capital Stock, Construction Division, Statistics Canada.

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