THE FORCES OF THE DEMAND FOR BRITISH COLUMBIA'S MINING LABOUR: AN ANALYSIS OF THE TRENDS OF WAGE RATES AND EMPLOYMENT OF BRITISH COLUMBIA'S MINING INDUSTRY

by

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ABSTRACT

This thesis attempts to analyse the influences of changes in demand for British Columbia's mining labour upon the wage rates and employment of British Columbia's mining industry. The competitive elements of British Columbia's mining industry suggest that changes of wage rates and employment will be sharply affected by changes of metal prices.

The theoretical effects of a change of metal prices indicate that the industry's output varies in the same direction as metal price changes. Furthermore, it is expected that employment will vary directly with output changes. Therefore, the number of labourers employed should vary directly with metal price changes. The trends of employment of British Columbia's mining labour and metal prices are studied to evaluate these theoretical expectancies.

As an element of demand for British Columbia mining labour, the level of metal prices is expected to influence wage rates of British Columbia's mining labour. Wage rates have increased in every year of the twelve year period but one, while metal prices have fluctuated over the period. These phenomena provide questions for further analysis.

The second major topic of the thesis is concerned with influences of changes of productivity of British Columbia's mining labour upon wage rates and employment. The first task is to describe concepts of productivity of mining labour and then to determine the meaning of a productivity index.
Following this, the meaning of a change in the productivity index must be described as the productivity of mining labour has varied considerably over the twelve year period.

The trends of the differentials of employment and the differentials of labour's productivity suggest that an inverse relationship exists between these variables. This relationship is evaluated and its similarity to a theoretical average product curve is described. However, the relationship between the trends of wage rates and mining labour's productivity provides little evidence of any association of these variables. It is suggested that if the changes of mining labour's productivity have influenced wage rates, then this influence has been hidden by other factors of wage determination.
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THE FORCES OF THE DEMAND FOR BRITISH COLUMBIA'S MINING LABOUR: AN ANALYSIS OF THE TRENDS OF WAGE RATES AND EMPLOYMENT OF BRITISH COLUMBIA'S MINING INDUSTRY
INTRODUCTION

The objectives of this thesis are to describe and to analyse the influences of determinants of demand for labour upon trends of wage earnings and employment of labour in British Columbia's non-ferrous metal mining industry\(^1\) for the period 1949 to 1960.

A study of an industry's wage rates and employment is usually interesting and useful for its own sake. It is interesting because it attempts to explain or to describe causes and effects of actual happenings. It is useful because it may contribute knowledge of description or prediction to economic theory. However, an analysis of wage rates and employment of British Columbia's mining industry is interesting not only for the sake of analysis but also for reasons peculiar to this industry. A cursory inspection of available wage rate and employment data for mining suggests the general trends of rising wage rates and falling employment. These trends are curious as little evidence can be found of institutional or other restrictions upon the supply of mining labour. This situation contradicts conventional economic theory and this contradiction poses a question to be answered.

The close approximation of the labour market of British Columbia's mining industry to conditions of open competition is another interesting facet of the proposed topic. The possibility

\(^1\)To avoid needless repetition, "non-ferrous metal mining industry" is abbreviated to "mining industry" unless otherwise indicated.
of relegating the determination of wages and employment to a competitive model is appealing but probably not realistic. Even if a suitable model cannot be found, the competitive conditions of the industry remain interesting and worthy of investigation. Two of the more important reasons for a study of the trends in wage rates and employment of British Columbia's mining industry have been given above. Other reasons will become apparent with the presentation of theory and facts.

Throughout the thesis there is a broad framework which will be described in detail, so that each piece of analysis can be recognized as a part of a whole. This framework is constructed from a single concept which has been described by most labour economists. They have suggested, directly or indirectly, that the wage structure of an industry is found between boundaries which are set by market forces. These economic bounds, while not precise, are very real. The upper bound is determined by the forces of the demand for labour and the lower bound is determined by the forces of the supply of labour. The forces of the demand for British Columbia's mining labour will be analysed in turn. Some references will be made to the supply of British Columbia mining labour. However, the forces of the supply of mining labour will not be studied. In each of the studies

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of the demand for mining labour the impact of changes of the independent variable or force upon wage rates and employment will be assessed and described.

Between the economic limits or boundaries lies a range of alternative possible wage levels. The resultant wage level depends upon institutional factors such as unionism or political pressure. However, except for a limited analysis of the influence of the union upon wage rates, the thesis is almost exclusively concerned with a study of the upper boundary components.

The determinants of the upper bound can be considered as the elements of a derived demand for mining labour. This derived demand will be defined as the product of the marginal revenue of metals and the marginal physical product of labour. The influence of changes in each of these factors upon the wage rates and employment of labour will be studied in a separate chapter.

Before the studies of the component forces of the upper bound are attempted, two aspects of the market structure of

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3. This definition may meet with conceptual difficulties with respect to aggregation and measurement, but for its particular use in this thesis it is sufficient.

4. Increments of capital and labour will probably be simultaneously added or deleted from the mining industry. Therefore the marginal product provided by an additional unit of mining labour should be considered as a marginal net product. Unless the amount of capital is assumed constant, the marginal product curve for mining labour is a marginal net product curve. Throughout the thesis, labour's marginal net product is simply called "marginal product".
British Columbia's mining industry will be described in Chapter I. The competitive determination of prices and the basing point system of prices, while not entering the wage bounds as determinants, influence the position of the upper wage bound. The probable impacts of these two elements upon the wages and employment of British Columbia will be assessed and described.

The proposed method of analysis has one obvious weakness --as each element of the economic wage bound is being studied, the influences of the remaining variables are more or less ignored. Over a period of time the impact of one or all of the neglected variables may change, but any change which is induced upon wage rates or employment will be attributed to the particular variable being studied. However, the alternative to the proposed method of study does not appear to be applicable in this thesis. The complexity and interaction of the wage determining variables prohibit an analysis which permits simultaneous variability in some or all of the variables. Whenever possible, an important change of a neglected variable will be noted and the possible results of the change will be discussed.

In summary, the separate studies of each of the wage determining forces are linked together through their association with the economic wage boundary.

In Chapter I it will be suggested that the competitive determination of metal prices has influenced the position of the upper wage bound. The position of the bound restricts the possible number of wage increases. If the upper wage bound is low, then few wage rate increases are possible unless the
upper wage bound shifts upwards.

Chapter II is concerned with the relationships between changes in metal prices and employment, and with the relationships between changes in metal prices and wage rates. Metal prices are determinants of both the upper wage bound and the demand for mining labour. Emphasis will be placed upon the forces of metal prices as a determinant of the demand for mining labour in British Columbia.

Employment in British Columbia's mining industry will be found to vary directly with metal prices. Furthermore, the absolute yearly differentials of employment will be found to vary directly with the absolute yearly differentials of metal prices.

The wage rates of British Columbia's mining labour have increased in almost every year, but metal prices have fluctuated over the period. Therefore, no relationship can be expected to be found between the trends of wage rates and metal prices. However, a strong relationship between the absolute yearly differentials of metal prices and the wage rates of British Columbia's mining labour will be described. It will be concluded that the degree of the yearly change of wage rates varies directly with the direction and degree of metal price changes.

In Chapter III concepts of the marginal productivity of mining labour will be introduced and the difficulties of selecting an index of labour's productivity will be described.
The marginal physical product schedule of mining labour is the other determinant of both the upper wage bound and the demand for mining labour. It will be suggested that changes in the marginal physical product curve of British Columbia's mining labour have had little influence upon employment and wage rates of the industry.

The absolute yearly differentials of employment in British Columbia's mining industry will be found to be inversely related to the absolute yearly differentials of output-per-man-per-year. Therefore, it will be suggested that this relationship is similar to the expected relationship given by a number of points on a theoretical average product curve.

The trends of wage rates and productivity of British Columbia's mining labour will be found to be related in a "general" fashion. However, this relationship doesn't have very much meaning. The trends of the yearly absolute differentials of wage rates and yearly absolute differentials of metal prices will not be found to be related. It will be shown that the influences of other wage determining variables have probably distorted any possible relationships between the trends of these differentials.

In summary, it will be concluded that the changes of metal prices have had a strong influence upon the trends of both wage rates and employment in British Columbia's mining industry. Furthermore, it will be suggested that the changes of employment in British Columbia's mining industry have affected the
trends of mining labour's productivity, but the influence of changes of mining labour's productivity upon employment has been small. No important conclusions will be offered concerning the relationships between mining labour's productivity and the wage rates of British Columbia's mining labour.

The final issue of the introduction concerns the period of analysis. The twelve year period from 1949 to 1960 was selected as the most suitable interval of time for the study. As there is insufficient data to extend the period beyond 1960, this terminating year was given, not selected, assuming that the immediate years are the most relevant for analysis. A duration of more than ten years was assumed to be necessary to reveal the industry's trends in wage rates and employment. The trends of a period of shorter length may suggest conclusions which are the results of events or happenings of one or two years. On the other hand, a period of more than fifteen years would include the impact of the economic abnormalities generated by World War II. To give these abnormalities a proper perspective, a period of twenty-five to thirty years long would be necessary, but then the effects of a vast depression must be accounted for. Furthermore, the forces acting upon wage rates and employment at the beginning of a thirty year period may be much different from the analogous forces active at the end of the period. 1949 was picked as the period origin because the economic effects and after-effects of war had more or less disappeared and the resultant period was more than the minimal
ten years. Although the period includes the economic effects of the Korean War, these effects are incomparable to the influences of World War II.
CHAPTER I

INFLUENCES ON THE POSITION OF THE UPPER WAGE BOUND OF BRITISH COLUMBIA'S MINING INDUSTRY

The structure of British Columbia's mining industry may have an important influence upon the wage rates and employment of mining labour. This influence is manifested in the position and shape of the upper wage bound. The elements of the boundaries are the same, no matter what the structure of the industry may be, but the positions and shapes that the economic limits assume are definitely influenced by the industry's structure. Rather than suggesting how the upper bound is influenced by various industry structures, it is simpler to describe British Columbia's mining industry and then intimate how some aspects of this industry's structure have affected its economic wage bound.

British Columbia's mining industry is only a part of a world mining industry which influences the structures of its component industries. Therefore, the description begins by discussing briefly some of the relevant facts of the general mining industry. Most of the descriptions of the general mining industry and British Columbia's mining industry have been derived from the Report by Professor J. J. Deutsch: Economics of Primary Production in British Columbia, "The Mineral Industries", "The Marketing of Mineral Products" and "Industrial Relations in the Basic Industries of British Columbia". This Report was the only general reference which provided considerable information concerning British Columbia's mining industry. Many quotations have been taken from this source to develop some of the topics
of the thesis and to support some of the arguments.

To return to the subject of this chapter, metal prices are, more or less, competitively determined in world markets.

That mining is a competitive business was seen for instance . . . when, uncontrolled, some copper mines in the United States closed consequent upon the onset of production in other countries; . . . 4

The supply side of the lead and zinc market is dominated by numerous small producers and potential producers who on the whole are sensitive to price fluctuations. 5

Some of the larger mining companies, such as Consolidated Mining and Smelting Company, could exert some influence upon metal prices by manipulating the supply of ores and metals. During periods of low prices, some of these companies might act as a group to restrict the supply of metals and force prices up. Nevertheless, competition is still the dominating force determining metal prices.

If metal prices are competitively determined, then for any buyer or seller the prices of metals are given. Similarly, for the whole of British Columbia's mining and smelting industry, there is one price for each metal. Each local industry—such as British Columbia's mining and smelting industry—is composed of smaller units which sell refined metals and which cannot, or will not, influence the prices of metals. Aside from the


occasions when the metal market is suffering from relatively low prices, large companies will probably not influence metal prices deliberately.

So great is the importance attached to the maintenance of an orderly metal market that all producers tend to respect quoted market prices, which in any case tend to be a fairly good reflection of the market.

The sellers of metals are usually the smelting companies which, in turn, buy ore from mine-owners. The returns accruing to the mine-owner from the sales of refined ore and metals are described as follows:

Refined metal quotations are used to determine the value of custom ore and concentrate. The amount actually received by a mining company for the metal content of ore and concentrate is less than the metal's market value by two amounts: (1) smelting and treatment charges and (2) marketing charges. Smelting charges appear as a deduction from the metal's quoted market price, while treatment charges are applied against each ton of ore or concentrate treated. Marketing charges are deducted from the gross value of the ore or concentrate's contained metal and consist of the freight from the mine to smelter, other handling costs if any, and in the case of imported ore, customs duties.

Before shipping ore to Trail, for example, the independent mine operator knows what specific charges and deductions the smelter will make from the quoted market prices of the metals contained in his ore. He also knows that the prices used for determining the value of the metal content of his ore are the quotations prevailing at the date the ore arrives at the smelter.

This quotation intimates that competitive prices for metals are the basis for the determination of ore prices. The mine-owner is unable to affect the selling price of his output.

Managers of mines which are vertically integrated with

6Ibid., p. 16.
7Ibid., p. 18.
smelting companies, govern their operations in a slightly different manner than independent mine-owners. The managers of integrated mines are "given" an "accounting price" which must be lower than, or equal to, the ordinary price of ore. For example, "The Consolidated Mining and Smelting Company operates its own mines at the most economical level . . . ." Thus, the accounting prices of each of these mines are equal to the minimum average costs-per-unit of output for each mine. If the smelter were required to pay an accounting price higher than a normal price for ore, then the integrated mine might not be profitable to operate and it may be eliminated from the industry.

To summarize, the prices of metals are given to, and usually not influenced by, the sellers of metals. From these prices, the prices of ores "facing" the mine-owners are determined. The managers of vertically integrated mines are given accounting prices which differ from ordinary prices. However, all mine operators have a given price for their output—a given price which cannot be influenced by the mine operators. The preceding description, while relevant to the wage and employment theory of this chapter, is important for an understanding of the entire thesis.

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8The price calculated by the "owners" of an integrated mining and smelting company is called an "accounting price" to differentiate it from the price of ore described in the last quotation, and because the accounting price is not a price in the usual sense of the word.

9Ibid., p. 10.
It is necessary to diverge from the present topic of market structure and introduce other concepts which are needed to suggest the influence of the market structure of British Columbia's mining industry upon wages and employment. The concept of upper and lower wage bounds may be applied to a firm as well as an industry. The upper wage bound of a firm limits the number of alternative wage levels which are greater than the existing one. If there is a possibility of an increase in wage rates, then there exists at least one alternative wage level above the existing level.

If profits are considered as a potential source of labour income, then the upper wage bound of any mine, which receives economic profits, has at least one alternative wage level above the existing one. Moreover, it is likely that the number of alternative wage levels above the existing level varies with the amount of profit received by a firm. The analysis returns to the study of the impact of competitively determined prices of ore upon the position of the upper wage bound. The profits received by a mine-owner are

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10 Suppose the employed labour of two mines receive identical wage increases which are derived from profits. If one firm is reduced to a marginal firm after the wage increase, then any alternative wage level above the existing wage level of this firm cannot be created by profits. If the other firm still receives profits after the wage increase, then there is an alternative wage level created for this firm by profits. The larger profits of the second firm created at least two alternative wage levels higher than its original wage level. Thus the number of alternative wage levels does seem to vary with the amount of profits received by a firm.
partially determined by the competitive price of ores. If the costs of mining increase, the mine-owner cannot influence the price of ore to keep profits at a constant level. It does seem probable that the competitive nature of price determination in British Columbia's mining industry has tended to restrict the profits of many of the mine-owners. In the mining industry there are always marginal or potentially marginal firms. The given price of ore and the inevitability of rising costs as the mine approaches exhaustion ensures the potential marginality of every mine.\(^{11}\) If there is a preponderance of marginal mines, then the position of the upper wage bound of the industry is relatively low.

In conclusion, as the wage level of the industry cannot be greater than the upper wage bound, the position of this bound has a decided effect upon the degree of possible wage changes for the industry. The position of the upper wage bound for the industry as a whole will depend largely upon the profits received by each firm. If the competitive nature of the determination of the prices of ores has limited the profits of many mine-owners, then the position of the upper wage bound is lower than it would have been if ore prices had been determined in some other manner. No proof can be given to support the preceding analysis but it is probable that competition in the general mining industry has restricted profits in British

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\(^{11}\)Variable costs of production over a period of time are studied in Chapter III.
Columbia's industry.

The mining industry sells ores and concentrates through a basing point\textsuperscript{12} system of prices determined at a few world centers.

The use of base prices in the metal market, particularly for lead, zinc and copper, developed quite naturally. Basing point pricing offers a number of advantages over any other system of pricing, the most important of these being a high degree of price uniformity and the reduction of active price competition \ldots The base price or market quotations for metals serves to keep all buyers and sellers informed of the state of the market, facilitating custom ore purchases.

The base prices introduce order into what otherwise might be an extremely uncertain market. At any moment of time, each metal has only one price for a particular geographical location. Price competition between the sellers of metals is restricted but price fluctuations from changes in market conditions are common.

The influence of base prices upon British Columbia's mining industry is not easily determined.

Under the existing system of pricing metal producers are able to sell in almost any market, a lower net return on metal bearing high transportation costs being the only major discouragement to distant sales. British Columbia on the whole benefits from the basing point pricing of lead and zinc. The market for British Columbia metal products is larger and more diversified as to end use as a result of basing point pricing, and location or remoteness from market tends

\begin{itemize}
  \item \textsuperscript{13}Deutsch, op. cit., p. 21.
\end{itemize}
to be of less importance as a competitive factor. Lower costs of production in British Columbia than in the United States and many other producing countries permit Canadian metal to compete with foreign metal despite high transportation costs and tariff barriers.

It may only be assumed that larger metal markets are fostered by a basing point system of prices than some other system of pricing. As the base prices have been in effect for some time there is no basis for comparing this system to some other hypothetical system of prices. However, the quotation suggests that it is not unreasonable to assume that British Columbia's metal markets are larger under the existing system of prices than under any other system. If the markets are larger then output for the industry will be greater. The elimination of some of the uncertainty of the market encourages low profit and marginal mines to produce. Furthermore, it is probable that base prices encourage a larger output from inframarginal mines. However, profits per mine may not be greater simply because output is greater under a basing point system of prices than under any other system of prices. The number of low profit and marginal mines may be large and the profits of these mines may be small. If this is the case, then the upper wage bound for most mines may be low but for the few large profit mines the upper wage bound may be high. Thus the influence of base prices upon the industry's upper wage bound is indeterminate. The only definite conclusion forthcoming is that employment

\[14\text{Ibid.}, \ p. \ 21.\]
will be greater if output is greater under base prices than under any other price system.

The influence of two elements—the determination of metal and ore prices and the basing point system of prices—upon the upper wage bound of British Columbia's mining industry has been described for two reasons. Firstly, a description of these two elements of market structure provides necessary and interesting information which will be used throughout the thesis. Secondly, the study gives some insight to the determination of the position of the upper wage bound. If the competitive determination of ore prices restricts profits, then the upper wage bound of British Columbia's mining industry is lower than it would be if prices were determined in some other manner. If base prices encourage a greater output than any other price system, then employment is larger but the influence of base prices upon the position of the upper wage bound is indeterminate.

Other elements—such as power costs or transportation costs—of market structure could have been studied to determine their influence upon the position of the upper wage bound of British Columbia's mining industry. While there is little doubt that other elements do influence the position of the upper wage bound, their influence was not considered as important as the influence of the two elements studied in this chapter. It is not important to determine all of the influences on the upper wage bound of British Columbia's mining
industry. Rather, the object of this chapter was to suggest that the position of the industry's upper wage bound can be influenced by elements of the market structure of the industry.

The existing wage level cannot be greater than the upper wage bound. If this bound is low, then the number of possible wage increases is low. Furthermore, if the upper wage bound shifts upwards, then the number of possible levels above the existing wage level increases. Finally, if the upper wage bound of British Columbia's mining industry has tended to be low, wage rate increases will depend largely upon changes of the industry's upper wage bound.
CHAPTER II

THE INFLUENCES OF CHANGES IN METAL PRICES UPON THE TRENDS OF WAGE RATES AND EMPLOYMENT IN BRITISH COLUMBIA'S MINING INDUSTRY

The main forces of the upper wage bound for British Columbia's mining industry were defined as the marginal net physical product of mining labour and the marginal revenues of ores. While these forces are also the two determinants of the defined derived demand for mining labour in British Columbia, the derived demand is not identical to the upper wage bound. The upper wage bound limits the number of alternative wage levels above the existing wage level, but the derived demand for labour is a determinant of wage rates and employment. Both of these concepts—the upper wage bound and the derived demand—are important to the thesis as a whole, but this chapter is primarily concerned with the derived demand for mining labour in British Columbia.

The objectives of this chapter are to study the effects of changes in the marginal revenues of ores upon the trends of wage rates and employment of British Columbia's mining industry. These trends will be described by studying the changes in the supply of, and the demand for, labour in British Columbia's mining industry.

As ore prices are competitively determined, the marginal revenues of ores are equal to the prices of ores. Furthermore, as ore prices are determined by metal prices, it is assumed that ore prices plus a constant amount are equal to metal prices.
This assumption is necessary because the statistics, which are used in this thesis, provide metal prices but not ore prices. The analysis is now reduced to a study of the influences of metal price changes upon the trends in wage rates and employment.

As the marginal revenues of ores are defined as forces of both the upper wage bound and the derived demand for labour, then by definition a change in metal prices changes both the upper wage bound and the derived demand for mining labour. The change in the derived demand for mining labour means that a change in metal prices could result in a change in employment. If British Columbia's mining industry is responsive to metal price changes then rate of output will vary with metal price changes. Therefore, variations in metal prices lead to changes in the rate of output and employment. However, if the rate of output for the mining industry is not responsive to metal price changes, then there is no reason for employment to vary with metal price changes. Thus, before the statistical relationships of wages, employment, and metal prices are explored it would be helpful to understand the general reactions of British Columbia's mining industry to a change in metal prices.

It will be found that the immediate impact of a change in metal prices would be

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1 If wage rates remain constant, then a change in the derived demand for mining labour will change employment, assuming that factor proportions remain approximately the same. An increase or decrease in metal prices may induce some employers to change the proportions of factors employed. However, the influences of changes in the amount or form of capital upon employment are ignored in this chapter.
metal prices is upon the production plans of the mine owner. The amounts and prices of factors of production employed in a mine adjust to the new production plans. For example, an increase in the price of metals will result in an increase in the rate of output of ore. More of all factors will be demanded to facilitate the increase in industry output. Therefore it would be expected that an increase in metal prices would be followed by an increase in employment. The ensuing analysis begins by describing the determination of the rate of output of ore for one mine. Following this, the impact of a change in metal prices upon the rate of output for a mine is described. The analysis concludes with a description of the probable adjustments of British Columbia's mining industry to an increase in metal prices. Given the price of ore and assuming this price to remain constant for the life-time of the mine, the mine-owner must choose between alternative rates of extraction. Assuming the size of the deposit is known or estimated, then the total revenue to be derived from the mine can be determined. Given the relevant factor prices and assuming diminishing marginal returns for capital and labour are phenomena that exist in mining, then total, average total, and marginal cost curves can be constructed. If for every rate of output or extraction the

\[2\text{The following analysis is adapted from Donald Carlisle's "The Economics of a Fund Resource With Particular Reference to Mining", The American Economic Review, 1954, p. 595.}\]

\[3\text{For a further discussion of diminishing marginal returns in mining, see Chapter III.}\]
total costs are summed for all periods, then these totals subtracted from the constant total revenue for every rate output give a total profits curve for every rate of output. This total profits curve has a maximum for the rate of extraction which has minimum average total costs. For any one period, the most profitable rate of output is determined where marginal cost equals marginal revenue. However, by computing the sums of the present values of every period's profits for each rate of profit a new total profits curve is produced. The new total profits curve is lower and has a maximum point for a greater rate of output than rate determined by the maximum point of the previous total profits curve. The mine owner will extract ore at a rate greater than the rate determined by the minimum of the average total cost curve as he will wish to substitute present income for future income. The most profitable rate will probably be smaller than the rate for which marginal costs equal marginal revenue because of the higher average costs at this rate, however this is not certain.  

An explanation of the effects of a change in metal prices requires a slight extension of the given model. An increase in metal prices increases the life time total revenue derived from the mine. The increase in total revenue will not be divided into equal parts and spread over the life time of the mine.

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4The model described above is one of three models that Carlisle presents to illustrate the determination of the rate of output in the mining industry.
Instead, a new discounted total profits curve is constructed. This curve has a maximum for a greater rate of output than the first discounted total profits curve—the mine owner substitutes present income for future income and the rate of output increases.\(^5\)

The preceding description of the determination of the rate of output depends largely upon the assumptions that the size of the deposit can be estimated, and that the mine-owner maximizes his long run profits, regardless of "how long" the long run may be. If the size of the deposit were not known, the mine-owner might maximize short run profits or he might intuitively choose a rate of output slightly lower than the rate which maximizes short run profits. It is possible that the mine-owner's "time horizon"\(^6\) is nearer than the end of the life time of the mine. In this case, the owner will select a rate of output which maximizes profits for the period of time encompassed by his time horizon. On the whole, the model provides informative descriptions of the determination of the rate of output and of the effects of a price change upon the rate of output.

The reaction of a mine which is vertically integrated

\(^5\)The effects of a decrease in metal prices are analogous to the effects of an increase in metal prices with the direction of change reversed.

\(^6\)The "time horizon" is defined here as the period of time beyond which no future plans are made by the mine owner.
with a smelting company may be quite different from the reaction of an independently owned mine to a change in metal prices. If managers of integrated mines produce output at a rate which minimizes costs-per-unit of output, then metal price changes have no effect upon the rate of output for an integrated mine. However, the integrated mining and smelting company will attempt to maximize the profits of its entire operation. There is no reason why the rate of output of an integrated mine will not be varied with metal price changes to achieve this maximizing goal. Nevertheless, it has been suggested that changes in the rate of output of an integrated mine are much smaller than the changes in the rate of output of an independently owned mine for the same change in price.

Declining metal prices, for example, have a particularly severe impact on mining companies selling ore to custom smelters, in contrast to fully integrated companies. The reason this is so is that smelting and marketing charges on custom ore are specific amounts and do not vary in proportion to quoted metal prices. These charges, over short periods of time, represent fixed deductions from the contained metal's quoted market prices, with the result that a fall in metal prices brings about a more than proportionate reduction in the amount received by mining companies for custom ore and concentrate. The following example illustrates this point. Assuming smelting charges alone of 3.5 and 7 cents per pound for lead and zinc respectively, a 10 per cent fall in the quoted price of lead and zinc (from 15 and 13 cents

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7See Chapter I, p. 3.
per pound to 13.5 and 11.7 cents respectively), would result in a decline of 16 per cent in the value of a ton of custom ore containing equal quantities of these metals.

The response of British Columbia's mining industry as a whole to changes in the demand for metals is well described in the following excerpt from the Report by Professor J.J. Deutsch:

The expected response to price increases would be something like the following: existing mines would increase their rates of production, their higher costs being covered by the higher prices. They would also turn to mineral faces in lower quality ore, with higher recovery and milling costs per ton. Employment would probably rise more rapidly, reflecting the higher labour requirements per ton of concentrate. The reaction time for this train of events might be quite short: four to eight months would be sufficient for most mines to make quite large changes in existing production and exploration methods.

The time required to get new mines into production may be quite long. On the whole one would expect new mines to respond slowly (requiring a year or so) to large price increases. However, since new mines are likely to produce at a high rate once they get started, employment may rise rapidly.

Vertically integrated mines tend to dampen the impact of price changes. But as most of the mines in British Columbia's industry are independently owned, the dampening effect on the industry rate of output caused by integrated mines is probably insignificant. The preceding quotation summarizes and concludes the study of variations in the rate of output caused by changes in

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8 Report by Professor J. J. Deutsch, op. cit., p. 22.

the demand for metals. A change in metal prices results in a change in the rate of output in an appreciably short period of time.

The concluding quotation also introduces the next subject for analysis. As the rate of industry output varies with metal price changes and the amount of employment varies with the rate of industry output, it is expected that the amount of employment will vary with metal price changes. In other words, a change in the demand for metals changes the derived demand for mining labour and the amount of employment.

A preliminary analysis of the price, wage rate and employment data of Table I presents a problem which is of fundamental importance to the remainder of the thesis. For this reason, the present study of the relationship between the trends of prices and employment is interrupted and will be continued shortly.

If the changes in employment following a change in metal prices are considered as the result of a shift in the derived demand for labour, then price changes must also influence wages, as wages and employment are functionally related. For example, if the derived demand for mining labour changes, then both employment and wages will change unless the supply of labour is perfectly inelastic or perfectly elastic. Assuming that a conventionally shaped supply curve of mining labour for British Columbia exists and remains constant for the period 1949-1960, then all of the changes in employment and wage rates for the period are caused by changes in the derived demand for mining labour. The data of Table I show that prices and employment
have fluctuated widely but wage rates have increased continually with one exception.\textsuperscript{10} An increase in wage rates and a decrease in employment for the same sub-period (one year) are difficult to explain when changes in the demand for labour are the only variables being considered. The contradiction—rising wage rates and falling employment—of the given model follows naturally from the assumptions concerning the supply curve of mining labour. The assumptions that the supply curve exists and that it is conventionally shaped are not unrealistic because very little information can be found to refute them.\textsuperscript{11} However, the

\textsuperscript{10}The metal prices given in Table I are the weighted averages of lead, zinc and copper prices, given in the Annual Report, Minister of Mines and Petroleum Resources, 1960, pages A16 and A23. The prices were weighted by summing the revenues derived from the sale of each metal in every year and then dividing this total by the total yearly output of the three metals. The employment data was also taken from this report, page A49. These employment figures refer to the employment of lode-mines only.

The Review of Man-Hours and Hourly Earnings, Dominion Bureau of Statistics, provides data of the average hourly earnings of British Columbia's metal mining labour. Average hourly earnings depend upon the number of hours worked per week and the average hourly wage rates. As the number of hours worked per week has remained approximately constant throughout the period 1949-1960, trends of average hourly earnings will be almost identical to trends of average hourly wage rates. Throughout the thesis, average hourly earnings will be referred to as "wage rates".

Finally, the differentials given in this table, and all other tables, are derived by subtracting the statistic of one year from the statistic of the succeeding year. The differentials are yearly, absolute differentials.

\textsuperscript{11}It is possible but highly improbable that the supply curve of mining labour slopes downward or has a peculiar shape. This remote possibility is ignored.
assumption that the supply curve remains constant for the duration of the period is highly unrealistic. The contradiction created by the unrealistic assumption implies that changes in wage rates and employment over a period of time are caused by forces of both supply and demand. While this last conclusion is not startling it infers that a study of the influences of metal prices upon wage rates and/or employment must account for the variations in the supply of labour.

The data given in Table I indicate that the supply curve of British Columbia's mining labour has tended to shift upwards for the period 1949-1960. The Mine, Mill and Smelter Workers' Union has probably exerted an upwards pressure upon the wage rates of mining labour. Also, the rapid increases of alternative occupations for mining labour have shifted the supply curve of mining labour upwards. These two forces are given as likely influences upon the supply curve of mining labour. However, an analysis of the influences upon the supply of mining labour in British Columbia will not be given.

If the derived demand for British Columbia mining labour is described as a derived demand curve, then this curve shifts whenever either of the determinants of the derived demand change. If the demand curve for labour remains constant, then in every year (sub-period) wage rates will increase and employment will decrease. A "downward" shift in the demand curve will accentuate the decrease in employment and dampen or nullify the wage rate movement caused by the shifting supply curve. A change in
metal prices causes the derived demand curve for mining labour to shift in the same direction as the changes in metal prices. It is difficult to distinguish between changes in the derived demand curve for mining labour caused by variations in the marginal physical product of mining labour and changes in the curve caused by variations in metal prices. However, the index\textsuperscript{12} of labour's productivity in British Columbia's mining industry—given in Table IV of Chapter IV—shows a decrease in output-per-man-per-year in 1951, 1954, 1956 and 1957. The marginal physical product of labour is assumed to decrease in these four years and to increase in the other seven years.

Table I reveals that the number of mining labourers employed each year in British Columbia's lode-mining industry has varied considerably for the period 1949-1960. Chart I shows a fairly close correlation between the trends of lagged prices and employment for the period.\textsuperscript{13} In 1954 and in 1956 prices increased but in 1955 and in 1957 employment decreased. The price increase of 1954 and the employment decrease of 1955 are such small changes that a small change in some other force could have produced the discrepancy in the two trends of prices and employment. In 1957, output-per-man-per-year decreased substantially.

\textsuperscript{12}The reasons for the selection of this particular index as a measure of productivity are given in Chapter IV.

\textsuperscript{13}The prices of Chart I and the absolute price differentials of Chart II are lagged by one year. The reasons for lagging prices and absolute price differentials are given later in this chapter. The other variables, wage rates, employment, and productivity are unlagged.
Assuming that the productivity index is an indicator of the change in the marginal physical product of mining labour in British Columbia, then the derived demand curve for mining labour in 1957 has a tendency to shift downwards. The decrease in productivity may have been sufficiently dominant to cause a decrease in employment even though metal prices increased in 1956.

The trends of lagged yearly absolute price differentials and yearly absolute employment differentials are given in Chart II. The obvious relationship between the trends of the two variables indicates that metal price changes actually have influenced the changes in employment in British Columbia's mining industry. In every year except two—1952 and 1954—the differentials of lagged metal prices and employment moved in the same direction. An examination of these two exceptions to the general trends suggests an important modification to the assumption that the supply curve of mining labour in British Columbia shifts by an equal amount in every period. In 1951, metal prices increased by 4.4 cents—the largest metal price increase of the period—and in 1952 the productivity index for British Columbia's mining labour increased by more than the same index in 1951. Wage rates in 1952 increased by 22 cents, the largest wage differential of the entire period. Thus, both components of the derived demand for mining labour in 1952 increased by more than their counterparts of 1951. Nevertheless, employment in 1952 increased by 614—less than the 1,566 increase in employment of 1951. If the supply curve of mining labour shifted by more than the assumed
<table>
<thead>
<tr>
<th>Year</th>
<th>Lead, Zinc, Copper Prices of Metal (Dollars)</th>
<th>Average Wage Rates of Mining Labour in British Columbia (Dollars)</th>
<th>Differential of the Weighted Average Wage Rates</th>
<th>Numbers Employed in the Lode Mining Industry of British Columbia (Units)</th>
<th>Differential of the Numbers Employed</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.150</td>
<td>1.28</td>
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<td>1.68</td>
<td>.08</td>
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</tr>
<tr>
<td>1953</td>
<td>.130</td>
<td>1.76</td>
<td>.04</td>
<td>5,734</td>
<td>-570</td>
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<tr>
<td>1954</td>
<td>.132</td>
<td>1.80</td>
<td>.03</td>
<td>5,164</td>
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<td>1955</td>
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<td>.18</td>
<td>5,117</td>
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<td>1960</td>
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<td>2.35</td>
<td>.16</td>
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CHART 1

TRENDS OF EMPLOYMENT AND ONE YEAR LAGGED WEIGHTED AVERAGE METAL PRICES OF BRITISH COLUMBIA'S MINING INDUSTRY
**CHART 2.**

TRENDS OF THE ABSOLUTE DIFFERENTIALS OF EMPLOYMENT AND THE ABSOLUTE DIFFERENTIALS OF ONE YEAR LAGGED WEIGHTED AVERAGE METAL PRICES OF BRITISH COLUMBIA'S MINING INDUSTRY.
amount in 1952, then the wage rate and employment results of that year would be expected. In 1953 metal prices decreased by 3.8 cents, the largest price decrease of the entire period. In 1954 productivity decreased by a much greater differential change than in 1953 and wage rates in 1954 increased by a mere 4 cents. In 1954 both determinants of the derived demand for mining labour caused the curve to shift downwards by more than the change in the curve in 1953. However, the decrease in employment in 1954 was 570—very much smaller than the decrease of 2,260 in 1953. In this case, if the supply curve of mining labour shifted by less than the assumed amount, the employment results of 1954 could be explained.

If the supply curve of mining labour varied in the same direction as lagged metal prices, then the employment results would be expected. A possible cause of such variations in the supply curve is not difficult to describe. If the demand for metals changes and metal prices change, then both the derived demand for mining labour and the upper wage bound of British Columbia's mining industry change. With changes in the upper wage bound, the number of alternative wage levels above the existing level varies. The leaders of the Mine, Mill and Smelter Workers' Union are probably aware of large changes in the alternative number of wage levels above the existing one. Moreover, the union leaders have some influence upon the wage rate level and thus upon the changes of the supply
curve of mining labour. Suppose the wage demands of union leaders are varied directly with the number of alternative wage levels above the existing wage level. If metal prices change radically, as in 1951 and 1953, then the unions' influence upon the change in the supply curve of mining labour could be sufficiently dominant to produce opposing differential movements in employment and lagged metal prices. There may be any number of forces affecting the supply curve of mining labour and only in certain conditions would union influence produce the employment results of 1952 and 1954. However, it is reasonable to assume that metal price changes will have an indirect impact upon the supply curve of mining labour, as the wage demands of union leaders depend, in part, upon lagged metal prices. In conclusion, the industry's supply curve of labour tends to shift upwards by an amount which depends upon the direction and degree of metal price changes.

The study of the trends of metal prices and employment revealed that these variables are closely related. In every year except two, prices and employment moved in the same direction. Similarly, the price and employment differentials moved in the same direction every year, with two exceptions. An examination of these last two exceptions produced the result that the changes of supply curve of mining labour in British Columbia

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14 The union leaders may not actually be aware of a change in the upper wage bound, but it is assumed that the leaders act as if they were aware of a change in the bound.
depend partially upon lagged metal price changes. This supply curve shifts upwards, but the degree of each shift depends, in part, upon lagged metal prices.

As output and employment of British Columbia's mining industry vary in the same direction as metal price changes, the wage rates of British Columbia's mining labour would also be expected to vary in the same direction as metal price changes. However, mining labour's wage rates in British Columbia have increased in every period except one, whereas metal prices have fluctuated widely. Thus the relationship between these two variables must be different from the relationship between metal prices and employment. The study of the trends of metal prices and employment showed that the supply curve of mining labour tended to shift upwards. Fortunately, the influence of metal price changes upon the variations of wage rates can be described without any information concerning the supply of mining labour of British Columbia's mining industry.

Table II lists the wage rates, metal prices, and the yearly absolute differentials of these two variables. All of the data is relevant for British Columbia's mining industry. Chart III illustrates the trends of lagged metal prices\(^{15}\) and wage

\(^{15}\)The reasons for lagged metal prices are given later in this chapter.
<table>
<thead>
<tr>
<th>Year</th>
<th>Weighted Average Prices of Lead, Zinc and Copper</th>
<th>Weighted Differentials of the Average Prices</th>
<th>Weighted Average Wage Rates of Mining Labour in British Columbia</th>
<th>Weighted Differentials of the Average Wage Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>.150</td>
<td>.003</td>
<td>1.28</td>
<td>.04</td>
</tr>
<tr>
<td>1950</td>
<td>.153</td>
<td>.044</td>
<td>1.32</td>
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</tr>
<tr>
<td>1951</td>
<td>.197</td>
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<tr>
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</tr>
<tr>
<td>1960</td>
<td>.128</td>
<td></td>
<td>2.35</td>
<td></td>
</tr>
</tbody>
</table>


CHART 3

TRENDS OF THE WEIGHTED AVERAGE WAGE RATES AND ONE YEAR LAGGED WEIGHTED AVERAGE METAL PRICES OF BRITISH COLUMBIA’S MINING INDUSTRY.
<table>
<thead>
<tr>
<th>Wage Rate Differential</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.22</td>
<td>0.044</td>
</tr>
<tr>
<td>0.20</td>
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</tr>
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<td>0.18</td>
<td>0.036</td>
</tr>
<tr>
<td>0.16</td>
<td>0.032</td>
</tr>
<tr>
<td>0.14</td>
<td>0.028</td>
</tr>
<tr>
<td>0.12</td>
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</tr>
<tr>
<td>0.10</td>
<td>0.020</td>
</tr>
<tr>
<td>0.08</td>
<td>0.016</td>
</tr>
<tr>
<td>0.06</td>
<td>0.012</td>
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<tr>
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<td>-0.004</td>
</tr>
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<td>-0.10</td>
<td>-0.020</td>
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<tr>
<td>-0.12</td>
<td>-0.024</td>
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<tr>
<td>-0.14</td>
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</tr>
<tr>
<td>-0.18</td>
<td>-0.036</td>
</tr>
<tr>
<td>-0.20</td>
<td>-0.040</td>
</tr>
</tbody>
</table>

**Chart 4**

Trends of the absolute differentials of weighted average wage rates and the absolute differentials of one year lagged weighted average metal prices of British Columbia's mining industry.
rates for the period 1949-1960. As metal prices have fluctuated and wage rates have increased in every year but one, the lack of relationship between the trends of the two variables is not surprising. A comparison of the trends of yearly absolute wage differentials and lagged yearly absolute price differentials is given in Chart IV. Except for one year, 1954, wage differentials moved in the same direction as price differentials. It seems that wage rates increase regularly, but the degree of increase depends largely upon the direction of metal price changes.

The single exception to the close correlation between the trends of wage rate and lagged metal price differentials cannot be explained in a very satisfactory manner. In 1954 metal prices increased by .2 cents and in 1953 metal prices decreased by 3.8 cents. In 1955 output-per-man increased, but in 1954 the index decreased. Therefore the derived demand curve for mining labour in 1955 increased more than the same curve in 1954. However, in 1955 wage rates increased by only 3 cents and employment decreased by 47, whereas in 1954 wage rates increased by 4 cents and employment fell by 570. The supply curve of mining labour must have shifted upwards in both years but the upward shift of 1954 must have been much greater than in 1955. The large drop of employment in 1954 may have caused union leaders to use their influence and dampen the upward shift of the supply curve of mining labour in 1955. Unfortunately the changes of the relevant variables are so small that it
is almost impossible to attribute the opposing differential movements of lagged metal prices and wage rates to any one force of supply or demand.

The study of the trends of yearly lagged absolute price differentials and yearly absolute wage rate differentials describes the influence of metal price changes upon wage rates very clearly. Metal price variations are not the cause of the regular increase in wage rates. But the degree or amount of change of wage rates in every period is partially dependent upon the changes of lagged metal prices.

The concluding topic of this chapter concerns the direction of causation between changes in metal prices and changes in wage rates. Throughout this chapter, wages have been implicitly assumed to be a dependent variable with prices as an independent variable. However, there may be some doubt as to the direction of causation or dependency.

The chart of the trends of absolute metal price differentials lagged by one year and absolute wage rate differentials was the only graphical representation which suggested a clear relationship between these two variables. Charts in which neither variable was lagged or in which absolute wage differentials were lagged by one year, were irregular and confused. It was taken as a fact that mining wage rates of British Columbia were influenced largely by changes of metal prices of the previous year. The influence of metal price changes lagged for two or more years, or not lagged at all, have been ignored. While such influences may exist, no statistical evidence of their existence could be
found. Thus, as wage rates are compared to lagged metal prices, the independent variable in the resulting relationship must be metal prices. It would be unrealistic to assume that expected future wage rate changes could influence metal prices. Moreover, as wage rates and employment were assumed to be functionally related in the same period, metal prices were lagged by one year for the study of the trends of metal prices and employment.

In summary, the objectives of this chapter were to describe the influences of changes in metal prices upon the trends of wage rates and employment of British Columbia's mining industry. However, to reach these objectives it was necessary to describe the general reactions of British Columbia's mining industry to a change of metal prices. As the demand for metals changes, the rate of output in British Columbia's mining industry varies in the same direction as the metal price change. As the rate of output varies with metal price changes, the number of mining labourers employed in the industry is expected to vary in the same direction as price changes. The close correlations between the trends of lagged metal prices and employment, and between the trends of lagged yearly absolute price differentials and yearly absolute employment differentials lead to the conclusion that the amount of employment varies in the same direction as metal price changes. The study of metal prices and employment suggested that the union influence on the supply curve of mining may vary in the same direction as metal price changes. However, this result depends upon the union leaders adjusting their wage demands to changing market conditions.
Finally, the study of the influence of lagged metal prices and lagged metal price changes upon wage rates provided the most interesting results. The trends of wage rates and lagged prices exhibit almost no relationship. However, the trends of the yearly absolute differentials of these two variables were closely related. Metal price changes are a determinant of the degree of wage rate changes, but wage rates increase regularly whether prices increase or decrease.
CHAPTER III

CONCEPTS OF PRODUCTIVITY IN THE MINING INDUSTRY

The derived demand for mining labour was defined in the Introduction as the product of the marginal physical product of mining labour times the marginal revenue received from the sale of ores. The marginal physical product of labour arises from the physical law of diminishing marginal returns defined as

This law asserts that if the quantities of all other inputs used by a firm remain constant, and one input is subjected to successive increases in quantity, eventually this input will begin (and continue) to yield diminishing (marginal) output returns.

Diminishing marginal returns may be a confusing concept at the best of times but in the mining industry the concept is even more complex. The first task is to establish whether or not diminishing marginal returns are common to mining. Although common sense suggests that this phenomenon is present in the mining industry, this is not sufficient as a proof. Following the discussion of diminishing marginal returns for a single mine, some of the conceptual and practical difficulties arising from an aggregate study of labour's productivity in British Columbia's mining industry will be described. As the thesis is concerned with the trends of aggregates, it is important to understand the shortcomings of an aggregate study of the productivity of labour.

As the concept of diminishing marginal returns is of

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fundamental importance to this thesis the following theory argues the existence of this physical law in the mining industries. Suppose two concepts of time are distinguished, one is any instant of time during which all factors are fixed; the other time period is anything longer than the first but all factors are variable. In the first time period, alternative amounts of capital and/or labour may be applied to a fixed amount of mine. This hypothesises the use of alternative combinations of factors other than the combination actually used except for mine which is fixed.

Alfred Marshall implied that the rate of recovery from a mine increases at a constant rate as more units of labour and capital are added.

The produce of mines again, . . . is said to conform to the Law of Diminishing Return, but this statement is misleading. . . . mines are as it were Nature's reservoir. The more nearly a reservoir is exhausted, the greater is the labour of pumping from it; but if one man with one pump could pump it out in ten days, ten men with ten pumps could pump it out in one day; and when once empty, it would yield no more. He acknowledges that returns decrease as the mine is depleted. However, this is of no concern as both the one man and the ten men encounter this phenomenon of diminishing returns. This phenomenon does not arise from varying factor proportions.

If Marshall's analysis were true and if the following assumptions are made; the price of ore is not appreciably affected as the supply of ore produced by one mine is increased,

\(^2\)The fixed factor, mine, will simply be called mine.

a small increase in the demand for mining capital goods would not affect the prices of these goods, capital goods used are capable of being used again after the exhaustion of a mine except in such cases as "timbering" which can be considered as depreciating in proportion to the rate extraction, a plentiful source of labour and other inputs is available at prevailing prices, then the mine owner would prefer to have a rapid exhaustion of ore because he would substitute present income for future income. Marshall thought that some combination of the above assumptions would not be true and that market conditions for both inputs and outputs would limit the rate of depletion. But as far as any one mine owner is concerned, the assumptions are not too stringent. At least some mine owners would attempt an extraordinary rate of extraction. But mining history reveals that this has not happened. Each mine owner is confronted with alternative amounts of labour and capital that he may apply to a fixed amount of mine. Most mine-owners are unconcerned with depressing the price of ore because they are unable to do so. The most suitable combination of factors is chosen through an analysis of costs with respect to alternative rates of exhaustion and the given prices of ores. The rate of output selected is not the most rapid rate because of the high costs caused by diminishing marginal returns\(^4\) -- not because of rising factor supply prices and falling output prices, all of which are given at any moment to any one mine-owner.

\(^4\)A description of the determination of the rate of output of ore is given in Chapter I.
Professor John E. Orchard stated that

The workings of rich and poor mines would indicate that it is more profitable to apply capital in the poor than to add it to the capital already applied in the richer mines. It is evident that the law of diminishing returns does apply to mines.

He suggests that a marginal mine exists in which the costs of extracting ore just equals the return to the mine-owner. However, a close examination of this definition exposes it to severe criticism. Suppose that diminishing marginal returns do not exist and that factor prices remain constant, then the marginal cost curve would be horizontal. As any one mine owner is a "price taker", the individual marginal revenue curves are horizontal. If any mine can have a marginal cost curve below the horizontal marginal revenue curve, the mine will enter production. The extensive margin of application of capital and labour limits the number of mines in the industry. But at any one point of time, the intensive margin for capital and labour is infinite. This infinite margin suggests, once again, that rapid mining would be prevalent in the industry. The existence of poor mines beside rich ones does not prove that diminishing marginal returns exist, it only indicates that some mines have higher grades of ore than others, or that some mines are more adaptable to variable inputs than others.

Donald Carlisle presents one of the best definitions of diminishing marginal returns in mining:

... it is illustrated by the decreasing effectiveness

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of more intensive applications of capital and labour in increasing the "rate" of working a deposit.

Instead of saying "more intensive applications of capital and labour . . .", he might have said "alternative intensive applications of capital and labour at any one point of time". However, if the factor mine is assumed to be constant for a period of time, then Carlisle's definition is exact. The returns to labour and capital increase at a decreasing rate as more of these factors are added to the fixed mine factor.

The conclusion that can be resolved from the preceding theory is that diminishing marginal returns exist in the mining industry because other phenomena do not exist. Although the factor mine is never constant, it would be possible to consider one of the other inputs—labour or capital—as being constant. However, this analysis is neither practical nor relevant for this thesis and it will not be presented.

The production of any mine is limited in the second time period (defined earlier in this chapter) by increasing costs as the mine factor changes. To describe this limiting effect upon production it is simpler to refer to the long run period rather than the defined "second time period". In the long run, or in the "second time period" all inputs are variable. The amount of mine employed per unit of time can only increase to a point and then it must decrease until the mine is exhausted or until the mine has become too costly to operate. As further depletion

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takes place, less time per work day will be spent upon removing ore from the untouched area of the mine. The same area of operation may be employed but the unit of operating time will diminish. The factor mine must be considered as being two-dimensional—area of operating mine per unit of time. Either or both dimensions must change over a long enough time period to cause falling output-per-unit of time. Suppose the mine-owner wishes to produce a certain amount of ore per unit of time. With a given amount of labour and capital, output-per-unit of time will decrease over a period of time as the mine factor becomes less efficient. To offset the pressures of the decreasing efficiency of the mine, the mine-owner will add units of labour and capital to maintain the given level of output. Therefore, diminishing marginal returns for labour and capital will become more acute as time passes. The net effect will be an acceleration of decreasing returns from capital and labour as more of each factor are added to a mine of decreasing efficiency.

The theoretical description of diminishing marginal returns was resolved in the conclusion that this phenomenon does exist in the mining industry. However, the productivity schedule of any factor cannot be estimated in the first time period as only one combination of factors is employed. In the second time period, the efficiency of the mine is always changing and therefore the productivity schedules of variable amounts of labour and capital combined with a fixed amount of mine cannot be
determined in this time period.

The preceding analysis has been concerned with the conceptual problems of describing and assessing diminishing marginal returns for any one mine. However, this thesis is concerned primarily with the trends of aggregates of British Columbia's mining industry. The productivity schedule of labour or capital for the industry is even more difficult to describe than a factor's productivity schedule for a single mine.

A problem becomes apparent when the differences in efficiencies between mine units are examined. If all other things were equal, then at any instant of time, the marginal physical product of labour for any two mines is never equal. That is, if the same number of labourers is employed in any two mines, then the marginal product of the labour employed in the least efficient mine will be less than the marginal product of the labour employed in the other mine. An aggregate marginal product curve for the labourers of both mines cannot be constructed because the fixed mine factor is not homogeneous. The problem is easily solved in theory by converting each mine into some sort of standard efficiency units and then aggregating the mine factor. But for a statistical study of marginal productivity such a conversion is impossible. With one important exception, this difficulty will be ignored.

A study of the trends of labour's productivity usually involves the selection of some sort of productivity index. This index provides some sort of measure of the change in labour's productivity over a period of time. The selected index is
usually some measure of output-per-worker per-unit of time. However, changes in this index and changes in labour's marginal product are not identical. The two separate changes are related but they have very different meanings.

The changing number of mines in British Columbia's mining industry introduces a fundamental problem encountered in the study of the trends of labour's productivity for the industry as a whole. If the changing efficiency of each mine in the industry is ignored, then the amount of "mine" in the industry can be considered as a fixed factor. Suppose that an aggregate marginal physical product curve for labour in British Columbia's mining industry exists at any moment of time. Both the number of mines and the amount of labour are variable in any short period of time. A change in the amount of labour employed will result in a movement along the curve. But a change in the number of mines in the industry causes a shift in the curve and a movement along the curve. The shift in the curve is caused by a change in the amount of the fixed factor employed. The movement along the curve is caused by the change in the amount of labour employed in the industry as the number of mines varies. The trends of labour's productivity for British Columbia's mining industry will include the results of both a change in the hypothetical marginal physical product curve and a movement along the curve. However, there is no reason why the trends should reveal the separate influences or results of a change in the curve and a movement along the curve.

This problem of identifying shifts and changes of labour's
marginal physical product curve is not restricted to a study of the effects of a change in the number of mines. Other influences which affect labour's marginal product may also not be identified by variations in the productivity trends. Any change in the prices or the amounts used of other factors combined with labour will cause this curve to shift. There is no hope in determining how much these changes in parameters will affect the curve—even the direction of change is difficult to ascertain. A change in employment will produce a multiple reaction on the curve. The first reaction is the change in marginal product caused by a movement on the curve. This change upsets the equilibrium of the other factors of production which, in turn, may vary and upset the stability of labour's marginal product curve. Changes in the amount of capital employed may raise or lower labour's marginal product curve, depending upon whether capital is substituted for, or complementary to, labour. In conclusion, a change in any factor whatsoever may produce movements along the curve and shifts of the curve of unknown degree and direction, but the index of labour's productivity will reveal only the net change in productivity.

In summary, diminishing marginal returns do exist in the mining industry, but theoretical problems oppose the estimation of labour's marginal product. As the amount of mine is always variable, there is no fixed factor which can be used to facilitate a statistical analysis of labour's marginal or average product in a single mine. Turning to an aggregate study of
labour's productivity in British Columbia's mining industry, two problems become evident immediately. The differing efficiencies of the industry's mines create a conceptual difficulty if an aggregate marginal physical product curve for variable proportions of labour with a fixed amount of mine is hypothesized. However, these problems of aggregation will be more or less ignored in later studies. Finally, the trends of mining labour's productivity must include every influence upon labour's marginal physical product curve. An explanation of the trends or changes of the trends is almost impossible.

It seems that the study of the productivity of mining labour is a rather discouraging task in itself. However, many of the conceptual difficulties described in this chapter can be ignored for an analysis of the influence of productivity changes upon wage rates and employment.
CHAPTER IV

THE INFLUENCE OF CHANGES IN THE PRODUCTIVITY OF BRITISH COLUMBIA'S MINING LABOUR UPON THE INDUSTRY'S WAGE RATES AND EMPLOYMENT

Changes of the productivity of mining labour of British Columbia are expected to influence the trends of wage rates and employment of British Columbia's mining industry. However, the conclusions of the last chapter indicate that a study of the aggregate trends of mining labour's productivity will have definite limitations. These limitations will restrict the analysis and descriptions provided in this chapter. Nevertheless, it is better to obtain some information of the influences of changes of mining labour's productivity than nothing at all. Therefore, many of the conceptual and practical difficulties of measuring mining labour's productivity will be ignored or assumed away, and the best possible index of mining labour's productivity of British Columbia will be selected.

Once a productivity index for mining labour has been selected, the possible effects of a change in labour's productivity will be described. This description will provide a contrast to the actual trends of productivity and wage rates, and of productivity and employment of British Columbia's mining industry.

The prime question of this chapter is, have the changes of the productivity of British Columbia's mining labour influenced the wage rates and employment trends of this industry? By answering (or attempting to answer) this question, other matters—such as the degree and the manner in which the changes
of the productivity of mining labour have influenced the trends of wage rates and employment of the industry—will be described. Finally, the limited conclusions afforded by the considerations of this chapter will be given.

Before any statistical relationships can be studied, some index of mining labour's productivity must be selected. There is no point in presenting any further proof of the futility of attempting measures of theoretical average or marginal product schedules. The actual selection of an index is simple, the lack of any worthwhile alternative makes the measure of output-per-man-per-year the logical choice.\(^1\) Perhaps some measure of "net product" should be derived from this index, that is, only a portion of the total output be attributed to the efforts of labour. However, any sort of measure of "net product" is ignored as there is no plausible method of determining each factor's contribution to the total product.

The analysis of the productivity of British Columbia's mining labour is simplified by introducing the concept of an aggregate marginal physical product curve for the labour of British Columbia's mining industry. Each mine factor is assumed to be equal in efficiency to every other unit of mine factor. Therefore, at any moment of time, the sum of the units of mine factor

\(^{1}\)The Annual Report of The Minister of Mines and Petroleum Products, British Columbia, 1960, pp. A49, A50, provides accurate data of the number of labourers employed each year in British Columbia's lode mining industry and the total tonnage produced by the lode-metal mines each year. Output-per-man-per-year is simply the ratio of the total tonnage produced each year to the number of labourers employed in that year.
of British Columbia's mining industry comprises a homogeneous fixed factor. Every labourer is assumed to be equal in efficiency to all other labourers, and the amount of capital employed in the mining industry is assumed to vary proportionately to the changes in employment of mining labour. If labour is combined in alternative amounts to the fixed mine factor at any moment of time, then an aggregate marginal net physical product curve (marginal physical product curve) for the mining labour of British Columbia can be hypothesized. The concept of an aggregate marginal physical product curve is used to describe possible or expected results of changes in variables. However, this concept is not used to prove any hypothesis, and therefore no proof will be offered that such a curve can exist. Rather, it is assumed that the curve does exist.

The supply curve of mining labour of British Columbia shifts upwards in every period. The degree of the shift in each period will depend partially upon the metal prices of the previous period.

These three concepts, the productivity index, the marginal physical product curve of mining labour, and the supply curve of mining labour, provide the necessary background information for the ensuing study of the productivity of labour of British Columbia's mining industry.

The marginal physical product of mining labour is one of the two determinants of the defined derived demand for British Columbia mining labour. If there is a change in the marginal physical product curve for mining labour of British Columbia, then the amount of employment and the level of marginal product
change, assuming the industry's supply curve remains constant. An upward shift of the marginal product curve results in an increase in employment and an increase in the level of marginal product. A downward shift of the curve has the opposite effects. If the supply curve of British Columbia mining labour shifts upwards but the derived demand for labour remains constant, then the amount of employment increases and the level of marginal product decreases. Therefore, both a shift in the marginal physical product curve and a movement along the curve will result in a change of employment and a change in the level of marginal product.

If the marginal physical product curve for mining labour of British Columbia shifts, then the change in the amount of employment of the industry is dependent upon the force which caused the curve to shift. In this case, the amount of employment of the industry becomes a dependent variable. However, if the marginal physical product curve remains fixed and the supply curve of mining labour changes, then the level of marginal product is dependent upon the changes of employment. Therefore, the level of employment is sometimes dependent upon forces changing the marginal product of labour and at other times the level of the marginal product is dependent upon the changes of employment.

It was suggested in the last chapter that the identification of the major forces, which have influenced the trends of productivity, will be a difficult task. The productivity trends of British Columbia mining labour do not distinguish between
the results of a movement along the marginal physical product curve for mining labour and the results of a shift of the curve. However, the objectives of this chapter are to describe and to analyse the influences of changes of mining labour's productivity upon the wage rates and employment of mining labour of British Columbia. Thus the study should be focused primarily upon the forces which cause shifts of mining labour's marginal physical product curve. Movements along the curve imply that the level of marginal product is determined by changes of employment—the level of employment is not influenced by changes in labour's productivity.

Only two forces which cause a shift of the marginal physical product curve of mining labour of British Columbia will be analysed in this chapter. The first of these forces is a change in the amount of capital or techniques used in British Columbia's mining industry, and the second force is a change in the number of mines in the mining industry of British Columbia. These two forces are studied because they have probably had the greatest influence upon labour's marginal physical product curve. The conclusion will be tendered at the end of the study that changes in the marginal physical product curve of mining labour have probably had little influence upon the level of employment and wage rates of British Columbia's mining industry. Therefore, it seems pointless to analyse all of the forces which may have influenced this curve.

According to Mr. C. Mitchell, Secretary of the Mining
Association of British Columbia\(^2\), there have been considerable changes in mining techniques, the forms of capital, and the amount of capital-per-labour used in British Columbia's mining industry in the period 1949-1960. The effect of these changes upon labour's marginal physical product curve are more or less indeterminate. Some of the changes of capital and technique have been complementary to labour and others have been substituted for labour. Mr. Mitchell suggested that the numbers of mining labour employed in British Columbia have been reduced by the changes of capital and techniques. However, he added that the reduction in employment from this cause has been small.

For any change in the amount of capital or techniques used in British Columbia's mining industry, output-per-man-per-year will increase or remain approximately the same as it was before the change. If complementary capital is added to the industry, employment will increase, assuming that the supply curve of labour remains constant. As the marginal physical product curve for mining labour shifts upwards, the level of marginal and average product will be at least as high after the shift as before the shift. Therefore, as output-per-man-per-year is a crude measure of average product, this index should be at least as high after the shift of the curve as it was before the shift of the curve. If capital is substituted for labour, then,

\(^2\) The writer refers to a personal interview with Mr. Mitchell, November, 1961.
assuming the level of output to remain the same\(^3\), fewer labourers will be employed to produce the same output. Output-per-man-per-year for the remaining employed labourers will increase. Therefore if changes in capital or technique have been a dominant force determining changes of employment, output-per-man-per-year would be expected to increase regularly.\(^3\)

Table IV shows that output-per-man-per-year has increased in seven out of the eleven years of the period 1949-1960. Suppose these seven changes of output-per-man-per-year were caused by varying the proportions of capital and labour employed in British Columbia's mining industry. In three years—1950, 1952, and 1960—out of these seven years, employment increased. But in 1951 and 1959\(^4\) metal prices increased. The increases of employment and wage rates in 1952 and 1960 imply that the derived demand for British Columbia mining labour shifted upwards in these years. But the marginal physical product curve for mining labour could have shifted upwards or downwards in 1952 and 1960. If metal prices were the dominant forces of the derived demand curve for British Columbia mining labour, then

\(^3\)This assumption is not necessary but the argument is simpler with the assumption. Assuming that each mine-owner maximizes profits, then a change of the proportions of capital and labour—capital being substituted for labour—less labour will be required per-unit of output. Therefore, output-per-man-per-year will increase.\(^3\)

\(^4\)It is not known whether metal prices increased or decreased in 1949. However, knowledge of the 1948 metal price is not very important for this analysis.
### TABLE III

<table>
<thead>
<tr>
<th>Year (Tons)</th>
<th>Output-per-man-per-year in British Columbia's mining industry (Tons)</th>
<th>Differentials of output-per-man-per year</th>
<th>Numbers employed in the lode mining industry of British Columbia (Units)</th>
<th>Differentials of the numbers employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949 1,063.8</td>
<td>5,758</td>
<td>1062.2</td>
<td>5,758</td>
<td>56</td>
</tr>
<tr>
<td>1950 1,170.0</td>
<td>5,814</td>
<td>-237.9</td>
<td>7,480</td>
<td>1,566</td>
</tr>
<tr>
<td>1951 932.1</td>
<td>8,094</td>
<td>201.4</td>
<td>7,480</td>
<td>614</td>
</tr>
<tr>
<td>1952 1,133.5</td>
<td>5,734</td>
<td>551.2</td>
<td>8,094</td>
<td>-2,260</td>
</tr>
<tr>
<td>1953 1,684.7</td>
<td>5,164</td>
<td>-36.0</td>
<td>5,734</td>
<td>-570</td>
</tr>
<tr>
<td>1954 1,648.7</td>
<td>5,117</td>
<td>134.9</td>
<td>5,164</td>
<td>-47</td>
</tr>
<tr>
<td>1955 1,783.6</td>
<td>5,464</td>
<td>-128.1</td>
<td>5,117</td>
<td>347</td>
</tr>
<tr>
<td>1956 1,615.5</td>
<td>4,840</td>
<td>-110.9</td>
<td>5,464</td>
<td>-624</td>
</tr>
<tr>
<td>1957 1,504.6</td>
<td>3,728</td>
<td>212.7</td>
<td>4,840</td>
<td>-1,112</td>
</tr>
<tr>
<td>1958 1,717.3</td>
<td>3,695</td>
<td>173.2</td>
<td>3,728</td>
<td>-30</td>
</tr>
<tr>
<td>1959 1,890.5</td>
<td>3,741</td>
<td>312.8</td>
<td>3,695</td>
<td>43</td>
</tr>
</tbody>
</table>

the changes of metal prices in 1951 and 1959 could have more than nullified the employment effects caused by a downward shift of the marginal physical curve in 1952 and 1960. Therefore, in 1952 and 1960 complementary capital could have been combined with labour or capital could have been substituted for labour. Furthermore, it is possible that there was no change in the amount of capital employed in the industry in 1952 and 1960.

In four years—1953, 1955, 1958 and 1959—out of the seven years in which output-per-man-per-year increased, employment decreased. However, in 1952, 1957 and 1958, metal prices decreased. Both the marginal physical product curve and the marginal revenues of metals could have shifted downwards to produce the employment and wage results of 1953, 1958 and 1959. However, it is also possible that the decreases of metal prices in 1952, 1957 and 1958 reversed the employment effects caused by an upward shift of the marginal physical product curve for mining labour in British Columbia in 1953, 1958 and 1959. Therefore in these three years the amount or form of capital employed in the industry might not have changed at all.

In 1954 metal prices increased, but in 1955 employment decreased and output-per-man-per-year and wage rates increased. However, the assumed shift of the supply curve of British Columbia's mining labour precludes a determination of the direction of change of the marginal physical product curve for

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5The supply curve of mining labour is assumed to shift upwards in every sub-period. The degree of every upwards shift depends, in part, upon one year lagged metal prices.
mining labour of British Columbia in 1955.

It is impossible to determine whether the amount or form of capital employed in British Columbia's mining industry has changed in any of the seven years. Moreover, in the four years in which output-per-man-per-year decreased, the amount or form of capital employed in the industry may have changed. These changes may have been completely hidden by variations in other variables.

The failure to find a statistical relationship between the changes of the amount and form of capital and the changes of wage rates and employment does not mean that such a relationship does not exist. The changes of other variables may have distorted the trends of labour's productivity, employment and wage rates in British Columbia's mining industry. Nevertheless, it seems reasonable to conclude that changes in the amount and form of capital employed in British Columbia's mining industry have not been a dominant force upon the trends of wage rates and employment of the industry.

A change in the number of mines in British Columbia's mining industry also causes a shift in mining labour's marginal physical product curve. A mine entering or leaving the industry is usually marginal. Suppose a marginal mine is eliminated from the industry by a small decrease in the price of metals. If the price decrease is small enough that the production plans of all other mine owners remain unchanged, then the industry's employment is reduced by the number of labourers who were employed at the eliminated mine. If the industry's marginal physical
product curve for labour did not change, then the reduction in employment would cause a movement on the curve and a new level of marginal product would be determined. But by eliminating a mine the fixed factor for the aggregate marginal product curve for labour changes and therefore the curve changes.

To describe the change of the aggregate marginal physical product curve when the fixed factor changes, it is helpful to begin the analysis by considering individual mines. Suppose every mine is converted to some sort of standard efficiency units, and then a marginal physical product curve is hypothesized for each mine at any moment of time. If all mines are approximately the same size, then the amount of the fixed factor in standard efficiency units for any mine will be in proportion to the mine's efficiency.\(^6\) It is assumed that the marginal physical product curve of every mine has a unique height which varies directly with the amount of fixed factor of each mine. The lowest curve is the marginal physical productivity curve of the marginal mine.\(^7\)

If the individual marginal product curves are aggregated,\(^7\) then the level of marginal product and the amount of employment in the industry can be determined. When the marginal physical product curves of the individual mines are aggregated, the

\(^6\)The differing efficiencies of the mines at any one moment of time must be recognized for this analysis.

\(^7\)The aggregate marginal physical product curve for the mining labour of British Columbia is assumed to be a regular and continuous curve.
marginal physical product curve of the marginal mine will be included in the lower portion of the aggregate curve. If the marginal mine is eliminated from the industry, only this lower portion of the aggregate marginal physical product curve changes. The aggregate curve will pivot downwards for all levels of marginal product which are common to both the aggregate marginal physical product curve and the marginal physical product curve of the marginal mine. Employment will be reduced by the amount of employment of the marginal mine. The new level of marginal product will be given by a point on the new portion of the aggregate marginal physical product curve.\footnote{If the level of marginal product of the marginal mine were a maximum of that mine's marginal physical product curve, then the new level of marginal product and employment for the industry would be determined by a point on the original aggregate marginal physical product curve. This point would be the point at which the new section of the aggregate marginal physical product curve pivots downwards.}

The new amount of employment is, by definition, equal to the old amount of employment less the number of labourers employed in the marginal mine. If the aggregate curve had not shifted downwards, the new level of marginal product would have been determined by a movement along the aggregate curve. However, the downward shift of the aggregate curve tends to lower the level of marginal product. The new level of marginal product cannot be higher than the level which would be determined by a movement along the curve caused by a reduction of employment equal to the employment of the marginal mine. But it is possible for the new level of marginal product to be lower than
the original level of marginal product.

It is suggested that the aggregate curve will change very little with the elimination of an inefficient mine. If there is a large number (50-100) of mines in the industry, then the exit of the least efficient mine from the industry will not significantly change the aggregate marginal physical product curve. Therefore, the predominant effect of the elimination of a marginal mine will be similar to a movement along the aggregate marginal physical product curve.  

If more than one mine are eliminated or added to the industry, then the shift of the aggregate marginal physical product curve may be significant. However, the influence of the change of the number of mines would be greatest on the lowest portion of the aggregate curve and least on the highest portion of the curve. It is doubtful whether the shift of the curve would yield a new level of marginal product very much different from the level which would result from a movement on the aggregate curve.  

If this is the case, then a change of the number of mines in British Columbia's mining industry has not had a significant influence upon the aggregate marginal physical product curve.

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9 An addition of a marginal mine to the industry will also influence labour's aggregate marginal physical product curve. This influence will be similar to a downwards movement along the aggregate curve.

10 If the mines are of different sizes or if the heights of the marginal physical product curves do not vary with the amount of fixed factor (in standard efficiency units) of each mine, then the results of the model will be slightly different. The shifts of the aggregate marginal physical product curve may be greater. The new level of marginal product may be lower than it would be if the assumptions were true. The possible results of this effect are described later in this chapter.
curve of mining labour of British Columbia.

Therefore, a change in the number of mines has not significantly influenced the trends of wage rates and employment through changes of labour's marginal physical product curve of British Columbia's mining industry. However, changes in the number of mines have influenced wage rates and employment which have influenced the level of mining labour's marginal product. The changes in the level of marginal product have influenced the trends of the productivity of British Columbia's mining labour.

In summary, the study of the influences of changes of the productivity of mining labour upon employment and wage rates of British Columbia's mining industry considered two forces—changes in the amount and form of capital or techniques used in the mining industry, and changes in the number of mines in the industry. No statistical evidence was found of the influences of changes of the amount of capital employed in British Columbia's mining industry upon the industry's wage rates or employment. It was concluded that if such an influence existed, its force was likely to be small.

The study of the influences of a change in the number of mines in the industry upon the industry's wage rates and employment led to the conclusion that the predominant effect of this force was similar to the effect of a movement along mining labour's aggregate marginal physical product curve.

The preceding analysis suggests that the changes of mining
labour's productivity, caused by shifts in the marginal physical product curve of mining labour, have not significantly influenced the wage rates and employment of British Columbia's mining industry. However, if a change in the number of mines does cause a significant shift in the aggregate marginal physical product curve for mining labour, then the wage rates of mining labour may be influenced by the shift of the aggregate curve. Wage rates may be affected because the marginal physical product of mining labour is one of the two determinants of the derived demand for mining labour.

The simplest explanation of the impact upon wages as the number of mines changes, follows when the effects are treated as statistical phenomena. There are two mining-plant extremes in the industry—the marginal mine, which is just able to cover costs, and the high rent mine, which yields the highest economic rent per unit of output. As each mine is different from all others, the employed resources have different productivities in each mine. Various demands exist for the desired resources and, in the case of labour, wages vary between mines. Because a mine is marginal, the efficiency of labour is probably lower in this mine than in others. Incentive bonuses will be relatively low. Therefore it is reasonable to assume that marginal mines pay lower average wages than inframarginal mines.

The aggregate average wage is derived from the weighted sum of the average wages of the individual mines divided by the number of mines in the industry. If low wage earning labourers employed in a marginal mine are eliminated from the industry,
then the aggregate average wage will increase. The increase in aggregate average wages follows from an arithmetic manipulation. The wages of the remaining employed mining labour have not increased.

Table IV lists the wages, prices, number of mines and wage, price and number of mines differentials for the period 1949-1960. A comparison of the changes in the number of shipping lode mines and changes of average wages suggests almost no relationship between these two variables. If this statistical wage phenomena is prevalent, then a decrease in the number of shipping lode mines should increase aggregate average wages. An increase in the number of shipping lode mines would have the opposite effect. A probable reason for the lack of correlation between these variables is indicated by the strong relationship between wages and prices.

As metal prices change, the demand for labour and wage rates change in the same direction. Similarly the number of mines entering or leaving the industry seems to be related directly to price changes. The price changes influence wage rates in one direction while the changing number of mines influences wage rates in the other direction. The impact of price changes upon wage rates more than nullifies the arithmetic change in aggregate average wage rates caused by a change in the number of mines. Nevertheless the influence of the changing number of mines probably distorts the real effect upon wage rates as metal prices change, but this distortion cannot be recognized in the given data.
TABLE IV

<table>
<thead>
<tr>
<th>Number of Shipping Mines in British Columbia</th>
<th>Differentials of Number of Shipping Mines</th>
<th>Weighted Average Wage Rates of Mining Labour in British Columbia (Dollars)</th>
<th>Differentials of Weighted Average Wage Rates</th>
<th>Weighted Average Prices of Lead, Zinc, Copper (Dollars)</th>
<th>Differentials of Weighted Average Prices of Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>118</td>
<td>1.28</td>
<td>.04</td>
<td>.150</td>
<td>.003</td>
</tr>
<tr>
<td>1950</td>
<td>112</td>
<td>1.32</td>
<td>.14</td>
<td>.153</td>
<td>.044</td>
</tr>
<tr>
<td>1951</td>
<td>119</td>
<td>1.46</td>
<td>.22</td>
<td>.197</td>
<td>-.029</td>
</tr>
<tr>
<td>1952</td>
<td>95</td>
<td>1.68</td>
<td>.08</td>
<td>.168</td>
<td>-.038</td>
</tr>
<tr>
<td>1953</td>
<td>80</td>
<td>1.76</td>
<td>.08</td>
<td>.130</td>
<td>-.038</td>
</tr>
<tr>
<td>1954</td>
<td>63</td>
<td>1.80</td>
<td>.04</td>
<td>.132</td>
<td>.002</td>
</tr>
<tr>
<td>1955</td>
<td>53</td>
<td>1.83</td>
<td>.03</td>
<td>.147</td>
<td>.015</td>
</tr>
<tr>
<td>1956</td>
<td>70</td>
<td>2.01</td>
<td>.18</td>
<td>.156</td>
<td>.009</td>
</tr>
<tr>
<td>1957</td>
<td>59</td>
<td>2.07</td>
<td>.06</td>
<td>.128</td>
<td>-.028</td>
</tr>
<tr>
<td>1958</td>
<td>57</td>
<td>2.06</td>
<td>-.01</td>
<td>.128</td>
<td>-.017</td>
</tr>
<tr>
<td>1959</td>
<td>60</td>
<td>2.19</td>
<td>.13</td>
<td>.109</td>
<td>.007</td>
</tr>
<tr>
<td>1960</td>
<td>67</td>
<td>2.35</td>
<td>.16</td>
<td>.116</td>
<td>.012</td>
</tr>
</tbody>
</table>

Therefore, a decrease in the number of mines in the industry probably increases wage rates. Although the aggregate marginal physical product curve may be lower after a decrease in the number of mines, this has no impact upon wage rates. The level of marginal product of each of the remaining mines would have remained constant if metal prices or costs had not changed.

If the labourers of the eliminated mine received higher wages than labourers of some other mine, then aggregate average wages could increase or decrease. However, it seems likely that the labourers of the least efficient mine will receive the lowest wages. Therefore, a reduction in the number of mines will increase wages.

In summary, the study of the influences of changes of the productivity of mining labour upon employment and wage rates of British Columbia's mining industry considered two forces—changes in the amount and form of capital or techniques used in the mining industry, and changes in the number of mines in the industry. No statistical evidence was found of the influence of changes of the amount of capital employed in British Columbia's mining industry upon the industry's wage rates or employment. It was concluded that if such an influence existed, its force was likely to be small.

The study of the influences of a change in the number of mines in the industry upon the industry's wage rates and employment led to the conclusion that the predominant effect of
this force was similar to the effect of a movement along mining labour's aggregate marginal physical product curve.

The preceding analysis suggests that the changes of mining labour's productivity, caused by shifts in the marginal physical product curve of mining labour, have not significantly influenced the wage rates and employment of British Columbia's mining industry. However, there are other relationships which may exist between the productivity, employment and wage rates of mining labour of British Columbia.

The trends of the yearly absolute differentials of output-per-man-per-year and the yearly absolute differentials of employment in British Columbia's mining industry are given in Chart V; the relevant data is given in Table III. For every year except two—1954 and 1960—the two variables changed in opposite directions. This result suggests that the dominant relationship between output-per-man-per-year and employment is similar to movements on an aggregate average physical product curve for labour of British Columbia's mining industry.

The average product curve will shift with changes in the amount of capital employed or changes in the number of mines in the industry (or with changes in other parameters).
However, it has been suggested that the shifts of the aggregate marginal physical product curve for British Columbia mining labour are insignificant. Therefore, the changes of the aggregate average product curve for the industry would not be significant. Thus, the conclusion is tendered that the trends given in Chart V are related in a manner which is similar to the measures of average products and employment given by several points on a theoretical average product curve for mining labour of British Columbia.

An appreciation of the methods of wage payments is necessary for an understanding of the relationships between the trends of changes of labour's productivity and the changes of wage rates of mining labour in British Columbia.

The wages paid to mining labour are a combination of time rates and incentive bonuses. Most underground workers receive a basic wage and then some form of incentive bonus. Incentive bonuses are additional payments for production exceeding some minimum quota per unit of time. If the degree or amount of incentive bonuses are given, then the more efficient labour and capital are the higher will be labour's returns. The methods of
<table>
<thead>
<tr>
<th>EMPLOYMENT DIFFERENTIALS</th>
<th>OUTPUT PER MAN PER YEAR DIFFERENTIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2200</td>
<td>550</td>
</tr>
<tr>
<td>2000</td>
<td>500</td>
</tr>
<tr>
<td>1800</td>
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<td>-550</td>
</tr>
<tr>
<td>-2400</td>
<td>-600</td>
</tr>
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</table>

**Chart 5**

Trends of the yearly absolute differentials of output per man per year and the yearly absolute differentials of employment of British Columbia's mining industry.
wage payments have some influence upon the average level of wages primarily because of incentive bonuses. The changing efficiencies of factors of production have an immediate effect upon wage rates as each worker's output per unit of time is changed. Above ground workers usually receive straight time earnings.

In the following section, the analysis turns to the study of the relationship between changes in productivity and wage rates of mining labour in British Columbia.

In an article entitled "A Theory of Interindustry Wage Structure Variation", Professor Garberino develops an interesting model explaining secular differential wage movements. He states that

Permissive factors are those which make a change in wages possible, which open up a range of alternatives. Positive factors are those which determine which of the alternatives actually materialize in a specific case.

Productivity changes are considered as both permissive and positive factors. They are permissive factors because an increase in productivity lowers costs-per-unit of output. A decrease in costs-per-unit of output increases the residual revenues accruing to the firm, other things remaining equal, and labour may

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12Ibid., p. 294.
13If labour's productivity is increased by adding factors to the production process or by substituting other factors for labour in the production process, it is assumed that costs-per-unit of output will decrease.
procure some of the increase in profits. Productivity changes for labour are positive factors if a part of the increase in labour's efficiency is immediately returned to labour in the form of incentive bonuses. If labour uses existing capital and techniques more effectively, their increased revenue from incentive bonuses is probably permanent. However, if labour's productivity increases by combining new capital with labour, the structure of wage rates and bonuses may be altered to reduce the increase in wages.\textsuperscript{14} Therefore, a change of mining labour's productivity has a similar effect as a change in the upper wage bound. A change of either of these variables changes the possibility of a wage increase.\textsuperscript{15}

If the possibility of a change of wage rates varies when the productivity of labour changes, then the trends of wage rates might be related to productivity trends. As the change in mining labour's productivity in British Columbia is a positive factor as well as a permissive factor, then the trends of productivity and wage rates of British Columbia's mining labour would be expected to be related, if all other things remained equal.

A comparison of the trends of the yearly absolute differentials of wage rates and the trends in the yearly absolute differentials of wage rates and the trends in the yearly absolute differentials of wage rates and the trends in the yearly absolute


\textsuperscript{15}A decrease of mining labour's productivity can also be described as a permissive and a positive variable for a decrease in wage rates.
differentials of output-per-man-per-year---both variables being considered for British Columbia's mining industry---is given in Chart VI. The resulting trends of the changes of wage rates and the changes of output-per-man-per-year seem unassociated. But this lack of association between these two variables is not very surprising as "other things" have not remained equal.

Suppose changes in mining wage rates vary directly with changes in the possibilities of wage rate increases in British Columbia's mining industry. If metal prices had remained constant over the period 1949-1960, then the profits of British Columbia's mining industry would have varied directly with changes of costs-per-unit of output for the industry. If mining labour's productivity in British Columbia changes, then the level of profits in the industry changes and the possibilities of an increase in mining wage rates are altered. However, if the returns of other factors of production can be altered, then both the costs-per-unit of output and the possibilities of an increase in wage rates are changed. Thus, if labour's productivity and the return to other factors of production are changed at the same time, costs-per-unit of output and the change in labour's productivity may not vary in the same direction. The level of profits for the industry, and the possibilities of a wage rate increase for British Columbia mining labour will vary directly with changes in costs-per-unit of output. Therefore, if mining labour's productivity and the returns to other factors of production in British Columbia's mining industry are altered
at the same time, then changes in wage rate may not be closely related to changes in mining labour's productivity.

The effects of changes in the returns of other factors of production in British Columbia's mining industry have probably influenced the trends given in Chart V, but the impact of this influence upon the given trends cannot be determined. The description of the effects of changes in the returns of other mining factors of production assumed that metal prices remained constant. However, the trends given in Chart V would be very different if metal prices had remained constant.

If the possibilities of a wage increase depend, in part, upon the level of profits of British Columbia's mining industry, then the possibilities of a wage increase depend upon metal prices as well as costs-per-unit of output. Suppose labour's productivity changes, then the possibilities of an increase in wage rates may be completely altered by a change in metal prices. Therefore, the permissive nature of a change in mining labour's productivity in British Columbia may be dominated by changes in metal prices.

The positive nature of changes in mining labour's productivity, while not dominated by changes of metal prices, may be hidden or distorted in the trends of wage rates by changes in metal prices. The influences of changes in metal prices upon changes in wage rates was described in Chapter II. The close relationship between the trends of the differentials of metal prices and the differentials of wage rates of British Columbia's mining labour suggests that changes of metal prices may be a dominant
Chart 6

Trends of the yearly absolute differentials of output per man per year and the yearly absolute differentials of wage rates of British Columbia's mining industry.
### TABLE V

<table>
<thead>
<tr>
<th>Year</th>
<th>Productivity</th>
<th>Wage Rates</th>
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<tbody>
<tr>
<td>1949</td>
<td>1,063.8</td>
<td>1.28</td>
</tr>
<tr>
<td>1950</td>
<td>1,170.0</td>
<td>1.32</td>
</tr>
<tr>
<td>1951</td>
<td>932.1</td>
<td>1.46</td>
</tr>
<tr>
<td>1952</td>
<td>1,133.5</td>
<td>1.68</td>
</tr>
<tr>
<td>1953</td>
<td>1,684.7</td>
<td>1.76</td>
</tr>
<tr>
<td>1954</td>
<td>1,648.7</td>
<td>1.80</td>
</tr>
<tr>
<td>1955</td>
<td>1,783.6</td>
<td>1.83</td>
</tr>
<tr>
<td>1956</td>
<td>1,615.5</td>
<td>2.01</td>
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<tr>
<td>1957</td>
<td>1,504.6</td>
<td>2.07</td>
</tr>
<tr>
<td>1958</td>
<td>1,717.3</td>
<td>2.06</td>
</tr>
<tr>
<td>1959</td>
<td>1,890.5</td>
<td>2.19</td>
</tr>
<tr>
<td>1960</td>
<td>2,203.3</td>
<td>2.35</td>
</tr>
</tbody>
</table>

**Sources:**
force of the changes of wage rates. The wage rates of mining labour in British Columbia may increase with an increase in labour's productivity. Nevertheless, the trends of the differentials of wage rates and productivity of labour need not be associated. The increase of wage rates may be caused by a change in labour's productivity, but the degree of the change in wage rates may be dominated by metal price changes.

For example, in 1952, output-per-man-per-year increased by more than the increase in output-per-man-per-year in 1951. While wage rates increased in 1952, the wage rate differential of this year was lower than the wage rate differential of 1951. Metal prices decreased in 1951. If the productivity increase caused the wage increase, the influence of the change in labour's productivity was not great enough to cause the trends of the differentials of wage rates and the differentials of labour's productivity to move in the same direction. While changes in labour's productivity influenced wage rates, this influence is not revealed in Chart VI.

The impact of a change of metal prices is not confined to the trends of changes in wage rates. Metal price changes probably have a major influence on the changing number of mines in British Columbia's mining industry. The effect of a change in the number of mines upon the marginal product and the productivity of mining labour in British Columbia was described earlier in this chapter. If metal prices change and the number of mines changes in the same direction, then labour's productivity tends
to change in the opposite direction. Therefore a change in metal prices influences a change in labour's productivity in one direction, and a change in wage rates in the other direction.

The influence of variable metal prices and variable returns to other factors of production are only two reasons for the lack of association between the trends of the differentials of productivity and the differentials of wage rates of mining labour in British Columbia. There are other forces—such as the forces of the supply of mining labour in British Columbia—which distort the actual relationships of the trends between the productivity and wage rates of British Columbia's mining labour. However, these other forces will not be described as the objectives of this part of the thesis are to describe the relationships between the changes of labour's productivity and the changes of wage rates.

The analysis of the relationships between the trends of the differentials of wage rates and the differentials of productivity of British Columbia mining labour assumed that increases in wage rates should vary directly with changes in the possibilities of a wage rate increase. This assumption may be true, but a change in the possibilities of an increase in wage rates in one year may lead to an increase in wage rates in the same year, in some other year, or in a number of years. Thus, the impact of a change in labour's productivity of British Columbia's mining industry upon the wage rates of the industry
may be released immediately, it may be lagged for one or more periods, or it may be diffused over a number of periods.

Chart VII shows the trends of wage rates and productivity for mining labour in British Columbia for the period 1949-1960. In general, both variables move in the same direction. When the trends of wage rates and productivity of mining labour were studied for a longer period (25 years), the resultant relationship between the variables was similar to the trends shown in Chart VII. The influence of changes of mining labour's productivity in British Columbia upon the wage rates of the industry might be revealed as a force underlying long run wage movements. However, the impact of changes of the productivity of mining labour upon the wage rates of British Columbia's mining industry for the period 1949-1960 cannot be determined. The positive nature of mining labour's productivity changes may cause some changes in wage rates. But the permissive nature of mining labour's productivity changes are probably dominated by metal price changes or other variables.

In conclusion, productivity and productivity changes of British Columbia's mining labour is an interesting but restricted subject for analysis. Little evidence can be found of any influence of changes in the aggregate marginal physical product curve upon the wage rates and employment of mining labour in British Columbia. No relationships can be found between the trends of the changes of mining labour's productivity and the changes of wage rates for the period 1949-1960. While the trends of
Chart 7
Trends of output per man per year and average wage rates of British Columbia's mining industry.
wage rates and productivity of mining labour in British Columbia moved in the same general direction in a long run period, this observation does not provide any conclusions for the period 1949-1960. The only positive conclusion which was based on a statistical association concerned employment. The trends of the changes of employment and changes of productivity of British Columbia mining labour were shown to be similar to movements on an aggregate average product curve for mining labour.
CONCLUSION

The objectives of this thesis were to describe and to analyse the influences of the determinants of the derived demand for mining labour upon the trends of wage rates and employment of British Columbia's mining industry.

The concept of an upper wage bound for a mine and for the industry as a whole was given in the Introduction. This concept was used for a description of the possible influences of two aspects of the market structure of British Columbia's mining industry upon the wage rates and employment of the industry. The competitive determination of metal prices probably restricts the profits of the industry more than other methods of price determination. Furthermore, the number of alternative wage levels above the existing wage level varies with the amount of profits in the industry. If the profits of British Columbia's mining industry have been restricted by the competitive determination of metal prices, then the industry's upper wage bound will be lower than it would be if metal prices had been determined in some other fashion. If the upper wage bound of British Columbia's mining industry has tended to be low, wage rate increases will depend largely upon changes of the industry's upper wage bound.

The basing point system of prices was the other aspect of market structure studied in Chapter I. The influence of base prices upon the upper wage bound of the industry could not be determined. However, if the system of base prices has encouraged a greater output in British Columbia's mining industry
than any other system of pricing, the amount of employment in
the industry will probably be larger. There are other elements
of market structure which influence the position of the mining
industry's upper wage bound. However, the influences of the
other elements of market structure were not considered as im­
portant as the competitive determination of metal prices and
the basing point system of prices.

The brief analysis of the competitive determination of
prices implied that changes in the wage rates of British Colum­
bia mining labour would be related to changes in the industry's
upper wage bound.

Metal prices and the marginal product of mining labour
were defined as determinants of both the upper wage bound and
the derived demand for mining. If the derived demand for mining
labour changes, then the upper wage bound must also change.
The concept of the derived demand for mining labour was employed
for much of the descriptive analysis of the thesis.

The trends of wage rates and metal prices were not associ­
ated—wage rates increased in every sub-period except one and
metal prices fluctuated over the entire period. Therefore, if
metal prices and wage rates were related, other wage forces
causeds the discrepancies between the trends. A theory was de­
veloped to show that the supply curve of British Columbia's min­
ing labour must shift upwards over the period 1949-1960.

The close association between the trends of yearly abso­
lute wage differentials and one year lagged absolute metal
price differentials permitted the conclusion that metal prices and wage rates of British Columbia's mining industry are related. The degree of wage rate increases of British Columbia's mining industry is dependent upon the degree and direction of lagged metal price changes.

A change in the number of mines probably changes the average aggregate wage rates of British Columbia's mining labour. If the labourers of a marginal mine receive the lowest wage rates of all mining labourers in the industry, then the reduction (addition) of a marginal mine will raise (lower) average aggregate wage rates of British Columbia mining labour. Unfortunately this influence on wage rates could not be identified in the available statistics.

A change in the number of mines in the industry changes the amount of employment of British Columbia's mining labour. However, the theoretical marginal physical product curve for mining labour shifts with a change in the number of mines. The shift of the curve dampens the change of labour's marginal product which would result from a movement along the aggregate curve if employment had changed, but the fixed factor remained constant. If there were a single wage rate for all mining labour of British Columbia, then the shift of the aggregate curve could influence wage rates through a change in the level of mining labour's marginal product. However, the varying wage rates between mines allow the wage effect of a change in the number of mines to be interpreted as a statistical phenomenon.
The study of the influences of changes of labour's productivity upon wage rates did not provide any positive conclusions. It was suggested that the possible influence upon a theoretical single wage rate for the industry by a change in the number of mines would be small. A reduction or addition of a small number of mines would not appreciably affect the theoretical average marginal product curve for British Columbia's mining labour. Changes in the amount or form of capital may have affected wage rates of the industry's mining labour, but no evidence of these influences could be found in the given statistics. The trends of yearly absolute wage rate differentials and yearly absolute output-per-man-per-year differentials provided no information of the relationship between these variables. However, long run trends of wage rates and output-per-man-per-year suggested that the productivity and wage rates of British Columbia's mining labour tended to move in the same direction. Therefore, it is possible that productivity changes are broad, long run forces underlying the industry's wage rates. Nevertheless, it was concluded that if the changes of labour's productivity in British Columbia's mining industry have had an influence upon the industry's wage rates, this influence was dominated by other wage rate determining variables.

The rate of output of British Columbia's mining industry was shown to be sensitive to changes of metal prices. If the rate of output of British Columbia's mining industry varied, employment would be expected to vary in the same direction, if other factors were not substituted for mining labour. Very
little evidence could be found to suggest that capital has been substituted for labour in British Columbia's mining industry. A lack of statistical evidence does not disprove the hypothesis that capital has been substituted for labour. Nevertheless, the given analysis plus the information supplied by Mr. C. Mitchell permits the conclusion that, if capital has been substituted for mining labour, this effect has had little influence upon employment. Therefore, it is fairly safe to conclude that employment does vary directly with changes in the rate of the mining industry's output.

If the rate of industry output varies with metal price changes, then the amount of employment would be expected to vary with metal price changes. The statistical analysis of the trends of metal prices and employment of British Columbia's mining labour suggested these variables have varied in the expected manner. Moreover, it was considered as a fact that employment of British Columbia's mining labour was a variable dependent upon metal prices and metal price changes. Wage rates of British Columbia's mining labour are closely related to lagged metal prices, and as employment and wage rates are functionally related in the same period, employment must be related to lagged metal prices. The close relationship between the yearly absolute differentials of employment of British Columbia's mining labour and the yearly absolute metal prices enforces the conclusion that changes of metal prices have been an important influence upon the trends of employment in British Columbia's mining industry for the period 1949-1960.
Finally, little statistical evidence could be found of any influences of changes in the amount or form of capital upon British Columbia's mining labour. The industry's trends of the yearly absolute employment differentials and the yearly absolute differentials of productivity did seem to be related. The relationship was similar to the expected relationship given by a number of points on a theoretical average product curve for British Columbia mining labour. The varying number of mines has an employment effect which is similar to a movement along an aggregate marginal physical product curve for British Columbia's mining labour. Therefore, the relationship between output-per-man-per-year and employment is to be expected.

In summary, the forces of the demand for mining labour have had a considerable impact upon the wage rates and employment of British Columbia's mining industry for the period 1949-1960. Wage rates and employment are both related to metal price changes. Employment varies directly with metal prices but wage rates do not seem to vary at all with metal prices. Both employment and wage differentials vary directly with lagged metal price differentials. The degree and direction of metal price changes influence the degree of wage rate changes.

Productivity changes of labour vary inversely with employment changes but little evidence can be found that changes of labour's productivity influence either wage rates or employment. There may be a long run relationship between labour's productivity and wage rates, but this relationship is not pertinent to the period 1949-1960.
BIBLIOGRAPHY


_____ Review of Man-Hours and Hourly Earnings, 1956.

_____ Review of Man-Hours and Hourly Earnings, 1957.

_____ Review of Man-Hours and Hourly Earnings, 1958.

_____ Review of Man-Hours and Hourly Earnings, 1959.

_____ Review of Man-Hours and Hourly Earnings, 1960.


