UNIVERSITÉ D'OTTAWA ÉCOLE DES GRADUÉS

# CANADA'S FACTOR ENDOWMENT

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# CURRICULUM STUDIORUM

Roma Dauphin was born November 13, 1942, in Huntingdon, Province of Quebec. He received the Bachelor es Arts with specialization in Economics from College Sainte Marie, Montreal, in 1964.

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# INTRODUCTION

This thesis constitutes an attempt to determine the relative abundance of natural resources, capital and labour in Canada. The Canadian literature dealing with that subject is scanty and seems to be inconsistent. The Economic Council[1] has argued that Canada is a capital-intensive country while others[2] suggest that Canada has a comparative advantage in natural resources implying that this factor is the most abundant in the Canadian economy if the factor-proportion theory of international trade explains the structure of Canadian foreign trade. No single study has measured in a comparative and systematic way Canada's factor endowment. The purpose of this study is to fill--with the help of J. Vanek and D.F. Wahl--such a gap. Our approach will be to infer the factor endowment from the factor requirements of Canadian foreign trade, assuming that the conditions that ensure the logical truth of the factor-proportions theory are encountered in the real world. The capital and labour requirements of Canadian foreign trade have already been calculated by D.F. Wahl[3] and

1 Economic Council of Canada, Second Annual Review, Towards Sustained and Balanced Economic Growth, Ottawa, 1965, p. 59.

2 G.W. Wilson, S. Gordon, S. Judek, Canada: An Appraisal of its Needs and Resources, The Twentieth Century Fund, University of Toronto Press, 1965, p. 161.

3 D.F. Wahl, "Capital and Labour Requirements for Canada's Foreign Trade", The Canadian Journal of Economics and Political Science, Vol. XXVII, No. 4, August, 1961.

J. Vanek's Ph.D. thesis[4] will provide us with the necessary theory to measure the natural resource requirements.

The first economist who inferred a country's factor endowment from the factor requirements of its foreign trade was W.W. Leontief[5]. Using an input-output table, he reached the conclusion that United States exports were labour-intensive and imports capital-intensive, implying that the United States is a labour-abundant and a capital-scarce country.[6] These findings caused a great deal of puzzlement because nobody doubted that compared with the rest of the world the United States is a capital-rich country. The "Leontief scarce factor paradox" has drawn a stream of discussions which have resulted in the specification of the conditions under which the factor-proportions theory necessarily hold. It is now obvious that the astonishing findings of Leontief have emerged from the limitations of his two-factor model. In addition to labour and capital, there exists a variety of natural resources which are so difficult to identify and measure that Leontief has found it impossible as yet to include them in the

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4 J. Vanek, The Natural Resource Content of United States Foreign Trade, 1870-1955, The M.I.T. Press, Cambridge, Mass. 1963, pp. 1-142.

5 W.W. Leontief, "Domestic Production and Foreign Trade: The American Capital Position Reexamined", Proceedings of the American Philosophical Society, 97, September 1955, pp. 332-349.

6 W.W. Leontief, op. cit., p. 343.

statistical measurement of factor requirements. Since that time, J. Vanek has found a way to measure natural resources. He and others[7] restated the factor proportion theorem in a three-factor model. Since the capital and labour requirements have already been calculated, the major task of this study is to compute the natural resource requirements of Canadian foreign trade.

Thus, it is the purpose of the first chapter of this study to present the concepts of measurement of the natural resources developed by J. Vanek. The pioneer study of J. Vanek will be introduced and his method of measuring the natural resource content of foreign trade will be applied to the Canadian case. First, two alternative theoretical possibilities of measuring the natural resource content of exports will be examined. Owing to a lack of statistical information, these two theoretical measures will be rejected as workable devices. Instead, the "content of natural resource products in a given bill of exports, expressed either in constant or current price", will be adopted. Finally, the accuracy of the substituted measure will be tested by changing the economic parameters. Next, an ideal index of natural resource product requirements of Canada's foreign trade will be examined. Two indexes are then suggested to serve as substitutes of this

7 J. Vanek, op. cit., pp. 31-34 and P.A. Samuelson, "Prices of Factors and Goods in General Equilibrium" Review of Economics Studies, Vol. 21, 1953-54, pp. 1-20.

ideal index. These are: first, the ratio of the value of the natural resource products directly and indirectly exported to the value of the natural resource products directly and indirectly imported and second, the ratio of the value of the natural resource products directly traded only. It will be demonstrated that the two substituted indexes are good approximations of the ideal index.

Chapters II and III will be devoted to the empirical study of the natural resources, capital and labour requirements of Canadian foreign trade. In Chapter II, we shall show and discuss the direct natural resource product content of Canadian foreign trade between 1870-1960. Then, the total (direct and indirect) natural resource requirements are presented for three selected years on an industry basis. Chapter III examines the natural resources, capital and labour total requirements of Canada's foreign trade for the years 1949 and 1970. The method used by D.F. Wahl to compute the labour and capital requirements is also briefly explained.

The factor-proportions theory of foreign trade and Canada's factor endowment will be discussed in Chapter IV. The factor-proportions theory will be first adjusted to the case of three factors and many commodities. The following conclusion will be reached: "The relative factor endowment of a country engaging in foreign trade is reflected in

the relative factor requirements of its exports and imports."[8] With this theoretical justification, we shall then infer Canada's relative abundance in natural resources, capital and labour from the relative natural resources, capital and labour requirements of Canadian foreign trade. Finally, we shall try to know how the disparities between the real world and the assumptions of the factor-proportions theory affect our findings.

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8 J. Vanek, op. cit., p. 3.

# CHAPTER I

## MEASURING THE NATURAL RESOURCE CONTENT OF CANADA'S FOREIGN TRADE

The purpose of this chapter is to design a measure of the natural resource content of Canadian imports or exports. Professor Vanek's Ph.D. thesis consisted in providing such a measure for the United States. He confronted a "number of theoretical and practical problems" in developing a "workable and meaningful concept of natural resource content".[1] Accordingly, this chapter based on J. Vanek's study falls into two parts, one theoretical, one empirical. On the one hand, tools of measurement, conceptual difficulties and the validity of the measures proposed are discussed. On the other hand, Vanek's workable devices of measuring the natural resource content of exports or imports are applied to the Canadian case. To simplify the first part of this chapter, only Canadian exports will be considered.

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1 J. Vanek, op. cit., p. 6.

## 1. IDEAL MEASURE

In the first place, it is possible to measure theoretically the quantity of natural resources necessary to produce a given volume of exports. In mathematical terms, this measure can be expressed in the following ways

$$(1) \qquad C_1 = \sum_{i=1}^{n} r_i L_i^x$$

where $C_1$ stands for the first measure of natural resource content,

$r_i$ represents the unit rent of the ith natural resource, and

$L_i^x$ stands for the physical quantity of the ith natural resource required to provide a given bill of exports. Since more than one type of natural resource is used in producing export, even this physical measure required some valuation; thus in comparing the quantity of natural resources used over time, $C_1$ would have to be deflated by a weighted index of unit rent changes.

Second, we can measure the productive contribution of natural resources in producing a given volume of exports, given the relative scarcities of productive factors in the economy.

Let $X = f(K,N,L_i) \qquad i = (1 \ldots n)$

be the export production function, where $X$ stands for a given physical volume of exports, K, for capital inputs, N, for labour inputs and $L_i$, for natural resource inputs. The second measure ($C_2$) then can be represented by the

following formula:

$$(2) \qquad C_2 = \sum_{i=1}^{n} \left( \frac{\partial X}{\partial L_i} p \right) L_i^x$$

where $p$ represents the unit price of exports, and

$\frac{\partial X}{\partial L_i}$ the marginal product of the ith natural resource.

If comparisons over time are sought, the marginal revenue product of the natural resources would have to be deflated by the export price index, in order to eliminate the effect of possible changes attributable to purely monetary phenomena.

At a given point in time, $C_1$ and $C_2$ should be equal. Under the assumption of perfect competition in both the product and factor markets, we can derive from the general equilibrium model that the marginal revenue products of the natural resource factors in each period will be equal to unit land rents, that is

$$\frac{\partial X}{\partial L_i} p = r_i \qquad (i=1, \ldots n)$$

Thus, our two theoretical measures of natural resource content are equivalent when both are used in the same period of time. However, for comparisons at different periods of time, $C_1$ and $C_2$ can no longer be considered equivalent. As noted before, the rent element contained in the total value of exports has to be deflated by an index of changes in unit rents of land if we want to use

our first measure, and by a price index of exports if we want to use our second theoretical measure. Thus, depending on the movement of unit rents and the export price level over time, the two measures will yield different results.

There are a number of difficulties in using both measures. Even if the assumption of perfect competition was encountered and rents were recorded, there would still be the problem of separating capital improvements from original land. Second, the lack of statistical data concerning rents of land and land-input technical coefficients make it impossible to use these two theoretical measures. They have been suggested here only to enable us to assess the validity of a substituted measure.

## 2. A WORKABLE MEASURE

The impossibility to use the above two theoretical measures as a workable statistical device for our empirical investigation compels us to find a substitute. The substitute which Professor J. Vanek has suggested is the value of natural resource products traded. The substitute may be represented symbolically as follows:

$$(3) \qquad C_3 = \sum_{i=1}^{n} P_i^x \; R_i^x$$

for exports (x), and for imports (m),

$$C_3 = \sum_{i=1}^{n} P_i^m \; R_i^m$$

$R_i$ stands for the physical volume of the ith natural

resource product and $P_i^m$ and $P_i^x$ for the unit price of the ith natural resource product imported and exported respectively.

J. Vanek defined as natural resource products "all commodities which are nearest to the initial stages of the productive process".[2] In such commodities, land or natural resources are used as "active" inputs, that is, "the productive contribution of land is more than just the supplying of space for production".[3] Thus, agriculture, forestry and mining will be defined as natural resource industries, but not housing, manufacturing and transportation. Obviously, the actual definition of these sectors in the Canadian economy will be somewhat arbitrary; it is difficult to draw an exact line between active and non-active uses of natural resources in certain types of industries.

In practice, the definition is consistent with two statistical classifications of Canadian trade recorded by The Dominion Bureau of Statistics[4] which presents data on Canadian foreign trade for the entire period 1900-1960, divided into three commodities classes: raw materials,

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2 J. Vanek, op. cit., p. 37.

3 Ibid., p. 37.

4 Dominion Bureau of Statistics, Trade of Canada, Vol. I. Summary and Analytical Tables, Catalogue No. 65-201 issue of 1959-60, Ottawa, 1960, p. 134.

partially manufactured, and fully manufactured. The first group, according to Vanek's definition, consists essentially of natural resource products. The Canadian inter-industry flow table[5] for the year 1949 used an industrial classification containing forty-two industries. We consider that the industries Nos. 1 through 8 are essentially natural resource industries.

They are:
1. Agriculture,
2. Forestry,
3. Fishing, hunting and trapping,
4. Metal mining and smelting and refining,
5. Coal mining, crude petroleum and natural gas,
6. Non-metal mining, quarrying and prospecting,
7. Meat products,
8. Dairy products.

## 3. THE VALIDITY OF THE WORKABLE MEASURE

A last step needs to be made. We have to demonstrate the validity of our substituted measure and to show its relationship with $C_1$ and $C_2$. The substitution of natural resource products for natural resources entering Canadian foreign trade can be justified only if we can be reasonably sure that there exists a strong positive

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5 Dominion Bureau of Statistics, Supplement to the Inter-Industry Flow of Goods and Services Canada 1949, Catalogue No. 13-513, Ottawa, 1960, p. 22.

correlation between $C_3$ and the two theoretical measures. Only then is it possible to make inferences from changes in the size of $C_3$ to changes in the actual natural resource content of exports or imports. It will be first demonstrated that the volume of natural resources entering into foreign trade varies in the same direction as the volume of natural resource products traded and second that both may be expected to vary in the same proportion when expressed in value terms. The rest of this section will be devoted to the discussion of these propositions.

Let us first discuss the precise meaning of $C_3$ and $C_1$. If $C_1$ was used directly as a measure of the natural resource content of Canadian foreign trade, we would measure the physical quantity of land or natural resources necessary to produce a given volume of exports and to do so we would evaluate all rents of land paid in producing all exported goods. On the other hand, $C_3$ expresses the volume of natural resource products in total exports. If natural resource products were produced from land alone, the other products from other factors of production alone, obviously $C_3$ would reflect exactly the natural resource content of Canadian foreign trade. Since this is not the case, $C_3$ will be subject to some bias. However, in J. Vanek's words, "the fundamental fact that allows us to substitute natural resource products for rent of land is that the resource content of natural resource products is on the

average considerable higher than that of more highly fabricated commodities".[6]

Actually, calculations[7] based on the input-output table for 1949 show that the total natural resource requirements of natural resource products exported from Canada were 5.23 times higher than those of non-natural resource products exported. A similar computation for imports, shows that the gross natural resource requirements of competitive imports of natural resource products were 5.37 times higher than those of non-natural resource products imported. Then, changes in the volume of natural resource products exported and imported are likely to be a reflection of similar changes in the natural resource content of Canadian foreign trade.

In justifying the substitution of $C_3$ for $C_2$, it will be argued that the aggregate value of the natural resource products exported has varied proportionally with aggregate value of natural resources in the past, even if some important variables would have been able to disturb that proportionality. Let us elaborate what the following

6 J. Vanek, op. cit., p. 11.

7 The requirements of the natural resource product industries (1 to 8) have simply been divided by the requirements of the other industries (9 to 42) which are presented in Table V on page 50. A similar computation made by J. Vanek for the United States reveals less satisfactory results. The respective ratios were 5.5, for exports and only 3.73 for imports. Industries no. 7 and 8 have been included in the statistical measurement even if a priori they do not seem to be resource product industries as defined on p.5 simply because they have significantly increased the above ratios, the input from the agricultural industry in these industries being very important. J. Vanek, op. cit., p. 122.

section will try to demonstrate.

If $C_2$ was used, we would measure the productive contribution of natural resources in producing Canadian exports; for instance, we would measure the natural resource content in producing the natural resource products exported ($C_2^{R^x}$) in the following way:

$$C_2^{R^x} = \left( \frac{\partial R^x}{\partial L} p \right) L$$

where $p$ is the price index of the aggregate natural resource products exported,

$$R^x = \sum_{i=1}^{8} R_i^x \quad \text{for the second definition of } R_i^x$$

and $$R^x = \sum_{i=1}^{n} R_i^x \quad \text{for the first definition of } R_i^x$$

and $$L = \sum_{i=1}^{n} L_i$$

The substitute suggested will measure the aggregate value of the natural resource products exported, namely, $C_3 = p\, R^x$.

Under what condition $C_2^{R^x}$ may be expected to vary proportionally to $C_3$ over time? Clearly, the only condition is that the quotient of $C_2^{R^x}$ divided by $C_3$ be left unchanged over time:

$$\frac{\frac{\partial R^x}{\partial L} L}{R^x}$$

Let us call this ratio the natural resource content of a

dollar's worth of the natural resource products exported. In this section, we will study what changes in the economic environment may have affected this ratio and under what conditions the impact of these changes may be expected to have neutral effect. It will be demonstrated that these conditions have been encountered and that the natural resource content of a dollar's worth of the natural resource products exported has remained unchanged over time.

First, let us indicate the most probable disturbances or shifts in parameter which are likely to alter the natural resource content of a dollar's worth of exports. A simplified model will be constructed based on the Edgeworth box diagram.

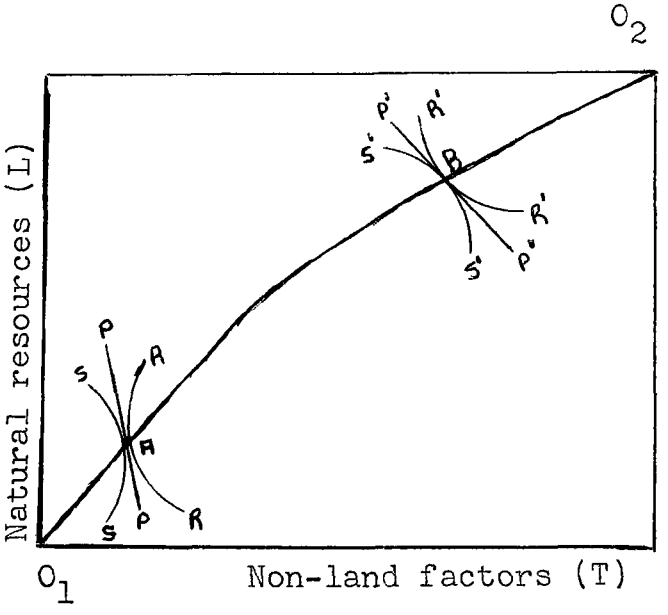


Figure 1. Efficient Allocation of Productive Services

The two dimensions of the box represent the amounts of natural resources (L) and non-land factors (T) in a country at a given point in time. From the origin $O_1$, the isoquants of natural resource products are drawn, RR, R'R', similarly from $O_2$ the isoquants of non-natural resource products are indicated, SS, S'S'. Two pairs of isoquants are drawn in the diagram at points A and B. The line connecting $O_1$ and $O_2$ is the contract curve at which the isoquants of the two industries touch but do not intersect. Besides assuming competitive conditions, we assume that the production functions of the two industries are homogeneous of the first order, that is, production is subject to constant returns to scale.

The relative prices of natural resources and non-land factors at points A and B is represented by the slope of the tangents: PP, P'P'. At point B the relative price of the natural resource factors in terms of the non-land factors is higher than at A because the natural resources are used in a smaller proportion in both industries, and consequently the marginal product of L has increased relatively to T.

What may happen over time? J. Vanek suggested that "the long-run changes in the structure and volume of exports can be caused basically by three different factors".[8]

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8 J. Vanek, op. cit., p. 123.

Domestic or foreign tastes may vary. Such variations affect the indifference and trade-indifference may and will shift the offer curve. The latter change affects the terms of trade. If there is a change in tastes away from the natural resource products, the deterioration in the factorial terms of trade may be represented by a movement from B to A along the contract curve; where, the relative price of natural resources in term of the non-land factors is lower. Secondly, factor endowment may change. These long-run changes may be represented in this model by changing the dimensions of the Edgeworth box, a new contract curve with new equilibrium points such as A and B are then derived. Finally, technology in either industry may change. This will result in a different shape and position for the isoquants, and in a different contract curve with new equilibrium points.

All these long-run shifts of parameters may have altered the price, the marginal product and the proportion of land used in both industries. Clearly, such changes may have altered the natural resource content of a dollar's worth of exports of natural resource products and of non-natural resource products. However, the natural resource content of a dollar's worth of export has remained unchanged. We intend now to substantiate this last assertion, to discuss its necessary conditions and to use the available statistical data to

demonstrate that the conditions ensuring that the land content of a dollar's worth of natural resource products or non-natural resource products has remained unchanged have been encountered in the past of Canada.

J.R. Hicks in his "Theory of Wages"[9] has defined the elasticity of substitution as a measure of the ease with which some factors can be substituted for others. In more technical terms, this elasticity is the absolute ratio between the percentage change of factor proportions and the percentage change of relative factor prices. In the case where its coefficient is unity, "the increase in one factor raises the marginal product of all factors taken together in the same proportions as the total product is raised",[10] implying that the value share of each factor in the total value remains the same under the assumption of homogeneous production function of degree one. Hence, granted the constant returns assumption, the effect of a change in tastes and factor supplies on the value share of land will depend on the elasticity of substitution between the two factors of production. Depending on whether this elasticity is greater, equal to or less than unity, the natural resource content of a dollar's worth of the export commodity will increase, remain unchanged or fall. The restrictive form

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9 J.R. Hicks, The Theory of Wages, New York, Peter Smith, 1948, p. 117.

10 Ibid., p. 117.

of the Cobb-Douglas production function has an elasticity of substitution of unity.[11] Hence, if the production function of the natural resource products was of the Cobb-Douglas type,[12] the natural resource content of a dollar's worth of natural resource products exported would have remained unchanged as tastes or factor supplies changed.

Let us now examine the third case where technology has changed. Under what condition will an improvement in technology not change the natural resource content of a dollar's worth of natural resource products. If the technological change was neutral with respect to land and the other factors, that is, saving neither land nor the other factors, the shape of the isoquants in the Edgeworth box will not change, the whole map will move in the direction of their respective origin in a systematic way, the same contract curve will apply as before, but its points A and B will now correspond to different outputs of the natural resources products. Consequently, the proportion of each factor used in each industry does not change and the natural resource requirements per dollar of output at each point of the contract curve remain the same. The natural resource content would change only to the extent

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11 R.G.D. Allen, Mathematical Analysis for Economists, London, Macmillan and Co. Ltd., 1938, p. 343.

12 That is, $R = AL^{\alpha}T^{1-\alpha}$, where R stands for physical output, L for the natural resource factor, T for the non-land factors, and where A and $\alpha$ are constant.

that the improved technology altered the form of the contract curve. Again, if the production function of natural resource products was of the Cobb-Douglas type, since neutral innovation is assumed in these production functions, the natural resource content of a dollar's worth of natural resource products exported would have remained unchanged.

Under the conditions of neutral technological changes and unit elasticity of substitution, changes in factor supplies, in demand or in technology leave unaffected the productive contribution of natural resources per dollar of natural resource products exported. Have these conditions been encountered in the past history of Canada? It seems so, some empirical support for this contention is found in the estimates of the aggregate Cobb-Douglas production function. In Canadian manufacturing, the coefficient ($\alpha$) of the Cobb-Douglas production function was found to be between .47 and .53 in three different years,[13] and Phelps Brown has concluded that "there is a considerable agreement among the numerical values of the exponents obtained for different years in one sector, and for different sectors".[14] The stability of these coefficients ($\alpha, 1-\alpha$) over time, precisely implies the stability of the natural resource content per dollar's worth of natural resource

13 E.H. Phelps Brown, "The Meaning of the Fitted Cobb-Douglas Function", Quarterly Journal of Economics, 71, November, 1957, pp. 546-650.

14 Ibid., p. 547.

products exported over time since in the case when the aggregate production function of the natural resource products exported is of the following form:

$$R^x = A\ L^{\alpha} T^{1-\alpha}$$

it may be deduced that[15] $\alpha = \dfrac{L \dfrac{\partial R^x}{\partial L}}{R^x}$

In practice, the production function of any single natural resource product does not have unit elasticity of substitution and neutral technological changes. The explanation of this stability, as J. Vanek pointed out, is found in the cancelling effects of elasticities of substitution higher and lower than unity and in different types of innovation in individual industries:

> "with a large number of natural resource products entering international trade, some products can have elasticities greater, and others smaller, than unity; some products may be subject to a land-saving innovation, others to a land-absorbing one. If such different properties of various products do not balance exactly in their effects, at least they can be expected to offset one another to a large degree and preserve approximately the postulated proportionality between the value of resource products traded and the value of land input of trade in a world of changing economic conditions."[16]

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15 This is proved as follows: The marginal product of L is $\dfrac{\partial R^x}{\partial L} = \alpha\ AL^{\alpha-1}T^{1-\alpha} = \dfrac{\alpha}{L}\ AL^{\alpha}T^{1-\alpha} = \dfrac{\alpha}{L}\ R^x$, then

$$\alpha = \frac{\partial R^x}{\partial L}\ \frac{L}{R} = \frac{L \dfrac{\partial R^x}{\partial L}}{R^x}$$

16 J. Vanek, op. cit., p. 12.

Thus, there is some evidence that the natural resource content per dollar of natural resource products exported has remained unchanged over time. We would be able to deduce also that the natural resource content of a dollar's worth of the non-natural resource products exported has been stable even if such a content in these commodities is likely to be small. Thus, $C_3$ seems to be a very good approximation of $C_2$, since the natural resource content of Canadian exports might be expected to change in proportion only with the changing value of exports.

## 4. THE IDEAL INDEX

So far, we have examined our measure of natural resource content in a given bill of exports or imports. We shall now develop an index of such a content in Canadian foreign trade.

According to the previous classification of products and factors implied in Graph I, the aggregate value of natural resource products $\dot{R} = \sum_{i=1}^{n} P_i R_i$ and the aggregate value of non-natural resource products $\dot{S} = \sum_{i=1}^{n} P_i S_i$ can be divided into two parts: the part imputable to the productive services of land $\dot{L} = \sum_{i=1}^{n} r_i L_i$ and that imputable to the productive services of other factors $\dot{T} = \sum_{i=1}^{n} r_i T_i$, that is, using

the corresponding subscripts,

$$\dot{R} = \dot{L}_r + \dot{T}_r$$

$$\dot{S} = \dot{L}_s + \dot{T}_s$$

Since Canada is importing and exporting both products, an index of the natural resource content embodied in her foreign trade may be expressed as follows, where the superscripts m and x represent imports and exports respectively.

$$I = \frac{\dot{L}^x_r + \dot{L}^x_s}{\dot{L}^m_r + \dot{L}^m_s}$$

This index, suggested by J. Vanek,[17] records the rate at which domestic natural resources embodied in the natural and non-natural resource products ($\dot{L}_r$,$\dot{L}_s$) exchange for foreign natural resources.

It has been mentioned already that satisfactory information concerning natural resource requirements is not available. This lack of information has compelled us to approximate the natural resource content by the value of natural resource products traded. In the rest of the section, two substituted indexes based on natural resource products will be suggested and discussed with reference to the above ideal index I.

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17 Ibid., p. 121.

## 5. FIRST WORKABLE INDEX[18]

The first substitute suggested which we may call $I_I$ will record the rate at which domestic natural resource products are exchanged directly and indirectly for foreign natural resource products through Canadian exports and imports. Using $\dot{R}_d$ to represent the value of natural resource products (industries Nos. 1 through 8) directly traded and $\dot{R}_s$ to represent the value of natural resource products indirectly traded through industries Nos. 9 to 42 this substituted index takes the following form:

$$I_I = \frac{\dot{R}^x_d + \dot{R}^x_s}{\dot{R}^m_d + \dot{R}^m_s}$$

Decomposing the elements of the above equation into their respective components, using the corresponding subscripts, namely

$$\dot{R}_d = \dot{L}_{rd} + \dot{T}_{rd}$$

$$\dot{R}_s = \dot{L}_{rs} + \dot{T}_{rs}$$

$I_I$ becomes in a more complex form as follows:

$$I_I = \frac{\dot{L}^x_{rd} + \dot{L}^x_{rs} + \dot{T}^x_{rd} + \dot{T}^x_{rs}}{\dot{L}^m_{rd} + \dot{L}^m_{rs} + \dot{T}^m_{rd} + \dot{T}^m_{rs}}$$

Since natural resources can "enter the production of non-resource commodities only indirectly, through the inputs

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18 J. Vanek neglected to elaborate on this substituted index. op. cit., p. 125.

of materials which use these resources directly"[19] then $\dot{L}_{rs} = \dot{L}_{s}$. The same thing is true for resource products so that $\dot{L}_{rd} = \dot{L}_{r}$, hence $I_I$ is the better approximation of I,

1) the smaller the value of the non-land factors entering in the value of natural resource products indirectly exported and imported ($\dot{T}^{x}_{rs}$ and $\dot{T}^{m}_{rs}$).

2) the smaller the value of the non-land factors entering in the value of the natural resource products directly exported and imported ($\dot{T}^{x}_{rd}$ and $\dot{T}^{m}_{rd}$).

We have touched these conditions in the first part of this chapter; in trying to justify the replacement of our first theoretical measure, it was indicated that the natural resource content of the natural resource products is considerably higher than for the more fully fabricated products. In other words, it was shown, that the value of the non-land factors entering in the value of the natural resource products is very low. Calculations based on the input-output scheme for 1949 have been presented, showing that the non-land requirements of natural resource products exported from Canada were 5.23 times lower than those of non-natural resource products exported. For competitive Canadian imports, the respective ratio was 5.37. Thus, there is a strong presumption that $I_I$ would be a very good

19 J. Vanek, op. cit., p. 122.

approximation of I.

All the information necessary to compute $I_I$ are contained in the structural-flow matrix prepared by the Dominion Bureau of Statistics for the year 1949. In this matrix, the Canadian economy is subdivided into forty-two industries, and for each industry, the inputs required per dollar of output of any other industry are recorded. It is then possible to compute $I_I$ from these data.

The aggregate value of the natural resource products directly and indirectly traded through Canadian exports and competitive imports are calculated from the Canadian input-output table[20] in the following way: let $C_{ij}$ be the elements of $(1-A)^{-1}$ where I is the identity matrix of the 42nd order and A the 42- by -42 structural-flow matrix; $b^x_{ik}$ and $b^m_{kj}$, the export and competitive import vectors respectively. Then the gross output in value term (including the flows within the sector) of a particular natural resource product required for all natural resource products directly exported ($\dot{R}_d$) are obtained as the inner product of the ith row of $C_{ij}$ and $b^x_{ik}$, namely

$$\dot{R}^x_i = C_{ij} \cdot b^x_{ik} \qquad i = 1 \ldots 8; \quad j = 1 \ldots 8$$

and the gross output in value term of the same industry required for all competitive natural resource products

20 Dominion Bureau of Statistics, Supplement to the Inter-Industry Flow of Goods and Services Canada, 1949, Catalogue No. 13-513, Ottawa, 1960.

imported are obtained as the inner product of the jth column of $C_{ij}$ and $b^{m}_{kj}$, namely

$$R'^{m}_{j} = C_{ij} \cdot b^{m}_{kj} \quad i = 1 \ldots 8; \quad j = 1 \ldots 8$$

Then, the total natural resource product requirements are

$$\sum_{i=1}^{8} R'^{x}_{i} = \sum C_{ij} \cdot b^{x}_{ik} \quad i = 1 \ldots 8; \; j = 1 \ldots 8$$

for exports of natural resource products and

$$\sum_{j=1}^{8} R'^{m}_{j} = \sum C_{ij} \cdot b^{m}_{kj} \quad i = 1 \ldots 8; \; j = 1 \ldots 8$$

for competitive import replacements of natural resource products. Similarly, we evaluate the natural resource products traded indirectly through the non-natural resource products ($R'_{s}$) as

$$\sum_{i=9}^{42} R'^{x}_{i} = \sum C_{ij} \cdot b^{x}_{ik} \quad i = 9 \ldots 42; \; j = 1 \ldots 8$$

for exports and

$$\sum_{j=9}^{42} R'^{m}_{j} = \sum C_{ij} \cdot b^{m}_{kj} \quad i = 1 \ldots 8; \; j = 9 \ldots 42$$

for competitive import replacements. Consequently, the total or gross export requirements of natural resource products are:

$$R'^{x}_{d} + R'^{x}_{s} = C_{ij} \cdot b^{x}_{ik} \quad i = 1 \ldots 42; \; j = 1 \ldots 8$$

and the total or gross import requirements of natural resource products are:

$$R'^{m}_{d} + R'^{m}_{s} = C_{ij} \cdot b^{m}_{kj} \quad i = 1 \ldots 8; \; j = 1 \ldots 42$$

Thus, in terms of the Canadian input-output table, the first approximation of I becomes:

$$I_I = \frac{C_{ij} \cdot b^x_{ik}}{C_{ij} \cdot b^m_{kj}} \qquad \begin{matrix} i = 1 \ldots 42; & j = 1 \ldots 8 \\ i = 1 \ldots 8; & j = 1 \ldots 42 \end{matrix}$$

A number of limitations contained in this method of estimating $I_I$ are obvious. The calculations described in the preceding section pertain to the competitive component of Canadian imports only. Moreover, even for competitive imports, this method assumed that the direct and indirect requirements of natural resource commodities, obtainable from the Canadian input-output table reflect the actual factor inputs in other countries. This would be true "only if factor prices and technology were comparable throughout the world".[21]

The first limitation is not a significant one. No serious error will be committed by imputing the natural resource product requirements of competitive import replacements of natural resource products to all natural resource imports. This is because the bulk of natural resource requirements embodied in a natural resource product is the particular product itself, whether produced in Canada or elsewhere. On the other hand, the bias which may arise from imputing natural resource product requirements of competitive import replacements on non-natural resource

21 J. Vanek, op. cit., p. 127.

products to all non-natural resource imports, is only of a minor importance. This is so because the bulk of Canadian non-competitive imports consists of natural resource products (mainly foodstuff), while only a negligible part of non-competitive imports falls into the group of more highly fabricated commodities. Almost eighty percent of all non-competitive imports comes from foreign agriculture and mining industries.[22] Thus, $I_I$ is expected to reflect the values of competitive import replacements together with the value of non-competitive imports of natural resource products. Moreover, D.F. Wahl has handled the calculation of the capital and labour requirements in two ways. First, he excluded non-competitive imports, second, he included all imports and the two calculations produced the same results. The same is expected in the case of natural resource products.[23]

In addition to these limitations, some general criticisms can be made about the input-output method used. This method assumes constant returns in the production of exports and competitive imports; also, the "inverse matrix provides only the original requirements plus the first-generation of indirect requirements". Another problem is that an input-output model is static and assumed fixed production coefficients. "This problem is very important

22 Dominion Bureau of Statistics, Supplement to the Inter-Industry Flow of Goods and Services, Canada, 1949, Catalogue No. 13-513, Ottawa, 1960, p. 25.

23 D.F. Wahl, op. cit., p. 352.

for a country whose rate of internal capital formation is high, as is Canada's".[24]

Satisfactory information concerning competitive imports and the flows from the natural resource product industries into other industries are available only for the years 1949, 1956, and 1970. Estimates of $I_I$ will then be presented for these years only. The estimates of natural resource content derived from $I_I$ will be presented in the following chapter.

## 6. SECOND WORKABLE INDEX

Our index which will enable us to compare the relative abundance of natural resource products over a long period of time is still not found. The ratio of the value of natural resource products directly exported to the value of natural resources directly imported over time will serve as the second substituted index. Let us call this index $I_2$, it can be represented symbolically in the following form, namely,

$$I_2 = \frac{R'^{x}_{d}}{R'^{m}_{d}}$$

Decomposing the elements of the above equation in its components as defined on page 19, $I_2$ becomes a more complex form as follows:

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24 D.F. Wahl, "Capital and Labour Requirements for Canada's Foreign Trade", The Canadian Journal of Economics And Political Science, Vol. XXVII, No. 4, issue of August, 1961, p. 350.

$$I_2 = \frac{{}^{!x}L_{rd} + {}^{!x}T_{rd}}{{}^{!m}L_{rd} + {}^{!m}T_{rd}}$$

Even though this index is influenced by the value of the non-land factors entering in the value of the resource products exported or imported and it does not take into account the indirect requirements or natural resources, it nevertheless approximates adequately the relative natural resource content of Canadian foreign trade. Let us demonstrate this proposition; J. Vanek pointed out that $I_2$ will be the better approximation of I,[25]

i) the smaller the value of the indirect natural resource products entering in the value of the non-natural resource products exported and imported ($^{!x}L_s$ and $^{!m}L_s$ in I)

ii) the more stable the ratio of the value of the natural resource factors entering in the value of the direct natural resource products over time

(ratio $\frac{L_{rd}}{R_d}$ )

Let us see how these conditions are, or can be expected to be approximated in real life. We will examine the two conditions in turn.

i) We have discussed this condition in trying to justify the replacement of our first theoretical

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25 J. Vanek, op. cit., p. 122.

measure for the actual measure used in determining the natural resource content of exports. Instead of the land rent measure, we decided to use the natural resource product measure. Thus, following the new measure, natural resource products enter the production of non-natural resource products only indirectly, through the inputs of materials which use these natural resource products directly. Consequently, there is a strong presumption that a large aggregate of exports and imports of non-natural resource products will contain considerable less indirect natural resources than will an aggregate of direct natural resource products.

ii) We discussed this condition in justifying the substitution of $C_3$ for $C_2$. Using a simplified model, with unit elasticities of substitution and neutral innovation, it was demonstrated that the condition of a stable ratio

between the value of natural resources and the total value of natural resource products was satisfied. It was further argued that, since in the real world, we can expect an elasticity of substitution greater than one to be as likely as an elasticity less than one, and innovation to be either land-saving or capital-labour-saving, there are good reasons to believe that these deviations will tend to cancel out in a large aggregate of exports or imports. Thus, we may expect that the changes in the ratio

$\frac{L'_{rd}}{R'_d}$ will not be considerable over time.

In Chapter II, we shall use $I_2$, to approximate the natural resource content of Canada's foreign trade. It remains for us to modify it a little in order to overcome some statistical difficulties. $I_2$ records the ratio of the value of natural resource products directly exported to the value of natural resource products directly imported, expressing these values into their respective elements, $I_2$ becomes:

$$I_2 = \sum_{i=1}^{n} \frac{P_i^x R_{di}^x}{P_i^m R_{di}^m}$$

where $P_i^x$ and $P_i^m$ represent the price of the ith natural resource product exported and imported respectively,

$R^x_{di}$ and $R^m_{di}$ the volume of the ith natural resource product directly exported and imported respectively, and where i stands for the large number of raw materials in the classification by the degree of manufacture recorded by the Dominion Bureau of Statistics. $I_2$ will be recorded for the entire period 1870-1960.

As mentioned earlier, it is necessary to deflate $P^x_i$ and $P^m_i$ to obtain an approximation of the changing natural resource content in physical quantities. Such deflators being unavailable over the period of time surveyed, we shall record the ratio of the direct natural resource product content per dollar of exports to the value of direct natural resource product content per dollar of imports, namely,

$$I_2' = \sum \frac{\frac{P^x_i R^x_{di}}{p^x X}}{\frac{P^m_i R^m_{di}}{p^m M}}$$

where $p^x$ stands for the price level of total exports and $p^m$ for the price level of total imports. As Vanek suggested, this procedure can be justified on the grounds that the aggregate value of exports and imports "is likely to involve price changes similar to those of the resource products".[26] Some statistics will be presented in

26 J. Vanek, op. cit., p. 12.

Chapter II to see to what extent Vanek's assertion is true.

## CONCLUSION

In this Chapter, we have discussed the theoretical problems of measuring the natural resource content of Canadian foreign trade. First, two ideal measures of such a content in a given bill of exports or imports were suggested. Owing to a lack of statistical information, both were rejected as workable devices.

Second, the content of natural resource products in a given bill of exports or imports was adopted to approximate the natural resource content, and natural resource products were defined in terms of the Canadian statistics.

Third, we examined under the conditions of changing demand, factors supply and technology, the relation between the workable measure and the theoretical measures. There was a strong presumption that natural resource product content varies proportionally to the natural resource content of Canadian exports or imports.

Fourth, an ideal index expressing the ratio of the productive services of domestic natural resources to the productive services of foreign natural resources exchanged

through Canadian exports and imports, was constructed in order to be used in testing the validity of two workable indexes.

Fifth, the ratio of the indirect and direct natural resource product content of exports to that of Canadian imports was adopted as the first workable index. Its validity has been discussed and the method of recording it from the Canadian input-output table has been indicated.

Sixth, the ratio of the natural resource product directly exported to those directly imported was suggested as the second workable index. Its validity has also been discussed. Finally, this index was slightly modified to overcome some statistical difficulties.

The next step will be to present the empirical results. This will be the matter of the next chapter.

# CHAPTER II

## THE CONTENT OF NATURAL RESOURCES IN CANADIAN FOREIGN TRADE

This chapter is entirely empirical. Using the statistical information at hand or data derived from it, estimates of $I_1$, $I_2$ and $I_2'$ are presented.

### 1. THE DIRECT NATURAL RESOURCE PRODUCT CONTENT OF CANADIAN MERCHANDISE TRADE

First, the estimates of $I_2$ and $I_2'$ concerning the direct natural resource product content only are shown. They have been recorded by using the traditional breakdown in which Canadian visible trade data are classified: namely, raw materials (natural resource products), partially manufactured and chiefly or fully manufactured products. The bulk of the information used to record our series has been compiled from TRADE OF CANADA[1]; only two estimates are taken from another source.[2] We shall record our series for the years 1870-1960. From 1870 to 1920 we recorded seven

1 Dominion Bureau of Statistics, Trade of Canada, Vol. I, Summary and Analytical Tables. Catalogue No. 65-201, issue of 1959-60, Ottawa, 1960, p. 330.

2 O.J. Firestone, Canada's Economic Development, 1867-1953, Bowes and Bowes, London, 1958, p. 156.

selected years; from 1920 to 1960 our indexes reflect five years average which are plotted at the end of the intervals considered. These averages over long periods of time aim at eliminating cyclical fluctuations.[3]

First, let us give attention to exports. Table II presents the distribution in millions and the percentage shares of raw materials, partially manufactured and chiefly manufactured goods in Canadian exports since 1870. The figure illustrating the percentage shares is shown on page 35.

At the beginning of the period studied, the exports of natural resource products (R) counted for 33% and exports of partially manufactured goods which usually require inputs of R represented another important part, 38.5% of Canadian exports. It is in these groups that we find the comparative advantage of this country. Natural resources were the dominant factor of production determining this advantage vis-a-vis Canada's principal customers during this period. From 1870 to 1915, R gained much in relative importance while the other two classes fell significantly, indicating a greater comparative advantage in R.

From 1915 to the present days, an opposite trend

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3 The trade data concern exports of Canada produce and imports for Canada consumption; both are valued f.o.b. In 1939, the trade statistics switched from fiscal to calendar years. Since, we deal mostly with five years averages, we believe that no important bias can have arisen from this change of definition.

TABLE I

Canadian Merchandise Trade, Distribution in Percentage (%) and in Millions of Dollars (000') of Exports 1870-1960

| Year | Raw Materials 000' | % | Partly Manufactured 000' | % | Fully or Chiefly Manufactured 000' | % | Total 000' | % |
|---|---|---|---|---|---|---|---|---|
| 1870 | 19 | 32.9 | 21 | 38.5 | 17 | 28.6 | 57 | 100.0 |
| 1890 | 35 | 41.4 | 22 | 26.4 | 27 | 32.2 | 84 | 100.0 |
| 1900 | 70 | 41.5 | 30 | 17.7 | 69 | 40.8 | 169 | 100.0 |
| 1905 | 79 | 41.6 | 35 | 18.2 | 77 | 40.1 | 191 | 100.0 |
| 1910 | 143 | 51.2 | 45 | 16.1 | 91 | 32.7 | 279 | 100.0 |
| 1914 | 273 | 63.1 | 44 | 10.1 | 115 | 26.7 | 432 | 100.0 |
| 1920 | 441 | 34.1 | 185 | 14.3 | 614 | 52.6 | 1,230 | 100.0 |
| 1921-25 | 440 | 45.1 | 158 | 15.9 | 397 | 40.0 | 995 | 100.0 |
| 26-30 | 556 | 42.6 | 197 | 17.0 | 488 | 40.4 | 1,241 | 100.0 |
| 31-35 | 230 | 34.3 | 162 | 24.1 | 269 | 42.6 | 661 | 100.0 |
| 36-40 | 279 | 28.0 | 299 | 30.0 | 423 | 42.0 | 1,001 | 100.0 |
| 41-45 | 552 | 19.8 | 487 | 18.4 | 1,617 | 61.8 | 2,656 | 100.0 |
| 46-50 | 781 | 27.7 | 752 | 26.5 | 1,297 | 45.8 | 2,830 | 100.0 |
| 51-55 | 1,222 | 29.7 | 1,296 | 31.7 | 1,561 | 38.4 | 4,079 | 100.0 |
| 56-60 | 1,628 | 33.2 | 1,486 | 30.1 | 1,808 | 36.7 | 4,928 | 100.0 |

Source: data for the years 1870 and 1890 are taken from O.J. Firestone, op. cit., p. 156; all data in millions of dollars have been taken from Trade of Canada, op. cit., p. 330, data in percentage are derived from it.

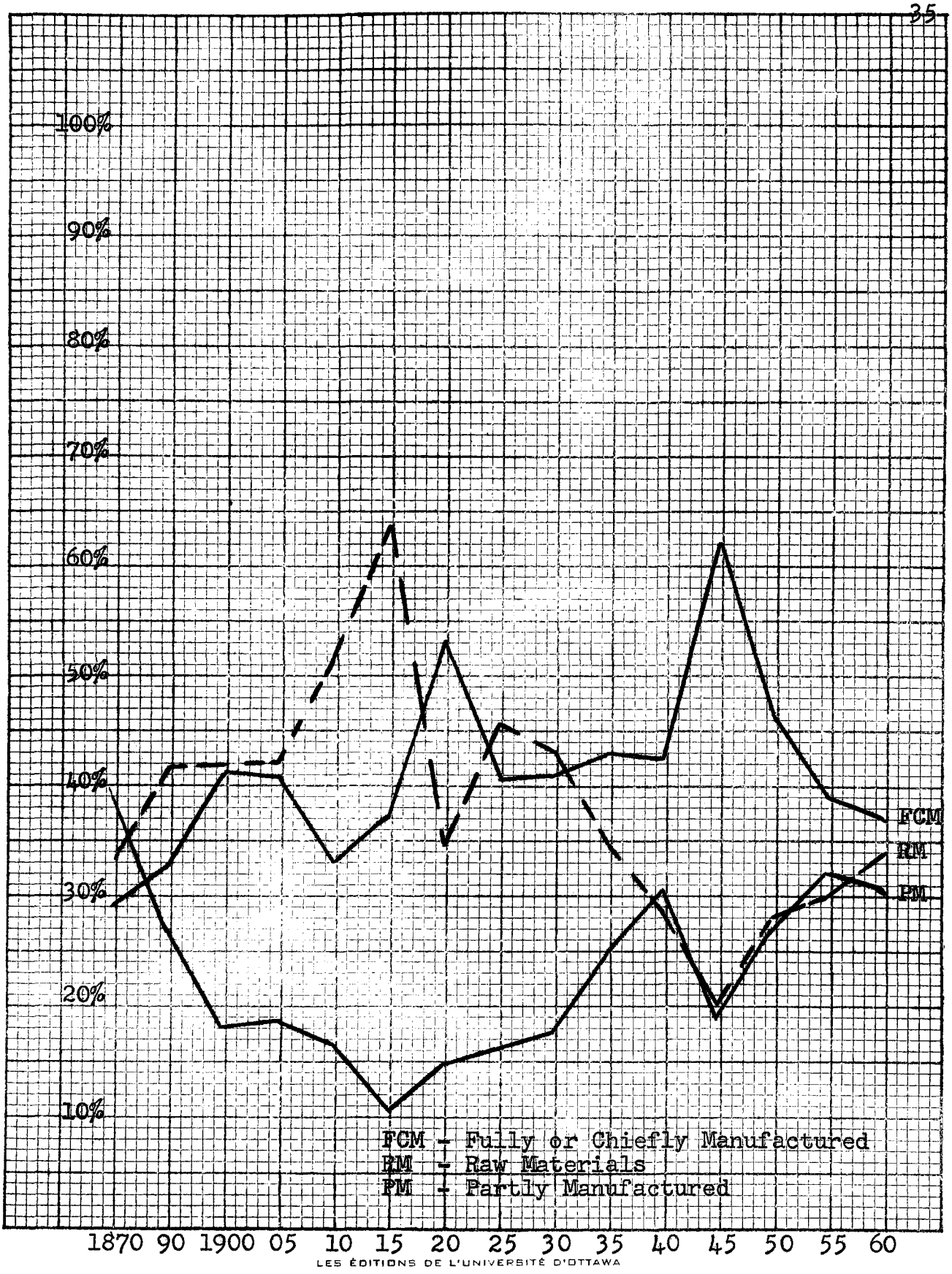




Figure 2. Index of Total Value of Canadian Exports and Percentage Shares by Economic Classes, 1870-1960.
Source: Derived from Table I.

persisted: the share of R decreased while the share of non-natural resource products (S) gained in importance. Canadian industrial development has brought a relative increase in the manufactured content of Canadian exports. Professor D.W. Slater pointed out that:

> "two kinds of forces have operated on the aggregate distribution, namely, changes in the degree of manufacture of particular items, for example, exporting refined copper rather than concentrates; and changes in the importance of items of widely different degrees of manufactures."[4]

To provide a long view of the ninety-five years period, a regression line for R and S has been computed with the least square method.

$$R^x = 37.9 - 1.24\ t$$

$$S^x = 62.1 + 1.24\ t$$

The slope of $R^x$ (-1.24) is negative, indicating a relative decreasing share of R, while that of $S^x$ (+1.24) is positive, indicating a relative increasing share of S exported. A student t-test indicates that the slope is significant at a 99 per cent level of confidence (1 per cent level of error). These findings show that Canada's comparative advantage in R has become less important over time.

Let us now give attention to imports. Table II presents the distribution in millions and the percentage

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4 D.W. Slater, "Change in the Structure of Canada's International Trade", The Canadian Journal of Economics and Political Science, Vol. XXI, No. 1, February, 1955, p. 4.

TABLE II

Canadian Merchandise Trade. Distribution in Percentage (%) and in Millions of Dollars (000') of Imports, 1870-1960

| Year | Raw Materials 000' | % | Partly Manufactured 000' | % | Fully or Chiefly Manufactured 000' | % | Total 000' | % |
|---|---|---|---|---|---|---|---|---|
| 1870 | 12 | 17.6 | 5 | 7.5 | 50 | 74.9 | 67 | 100.0 |
| 1890 | 31 | 21.7 | 9 | 8.8 | 78 | 69.5 | 118 | 100.0 |
| 1900 | 43 | 24.9 | 18 | 10.6 | 111 | 64.5 | 172 | 100.0 |
| 1905 | 64 | 25.4 | 24 | 9.4 | 164 | 65.1 | 252 | 100.0 |
| 1910 | 91 | 24.6 | 37 | 10.1 | 242 | 65.3 | 370 | 100.0 |
| 1914 | 135 | 21.8 | 58 | 9.3 | 426 | 68.8 | 619 | 100.0 |
| 1920 | 295 | 25.0 | 144 | 12.2 | 626 | 62.8 | 1,065 | 100.0 |
| 1921-25 | 246 | 29.7 | 97 | 10.0 | 553 | 60.3 | 846 | 100.0 |
| 1926-30 | 276 | 24.2 | 100 | 8.9 | 739 | 66.9 | 1,115 | 100.0 |
| 1931-35 | 154 | 27.1 | 47 | 8.2 | 368 | 64.7 | 569 | 100.0 |
| 1936-40 | 204 | 27.2 | 72 | 9.3 | 477 | 60.8 | 753 | 100.0 |
| 1941-45 | 380 | 24.7 | 90 | 5.8 | 1,072 | 69.5 | 1,542 | 100.0 |
| 1946-50 | 682 | 26.3 | 185 | 7.2 | 1,701 | 66.6 | 2,568 | 100.0 |
| 1951-55 | 867 | 20.5 | 241 | 5.8 | 3,033 | 73.7 | 4,141 | 100.0 |
| 1956-60 | 964 | 17.8 | 290 | 5.4 | 4,158 | 76.8 | 5,412 | 100.0 |

Source: data for the years 1870 and 1890 are taken from O.J. Firestone, op. cit., p. 125; all data in millions of dollars have been taken from Trade of Canada, op. cit., p. 330, data in percentage are derived from it.

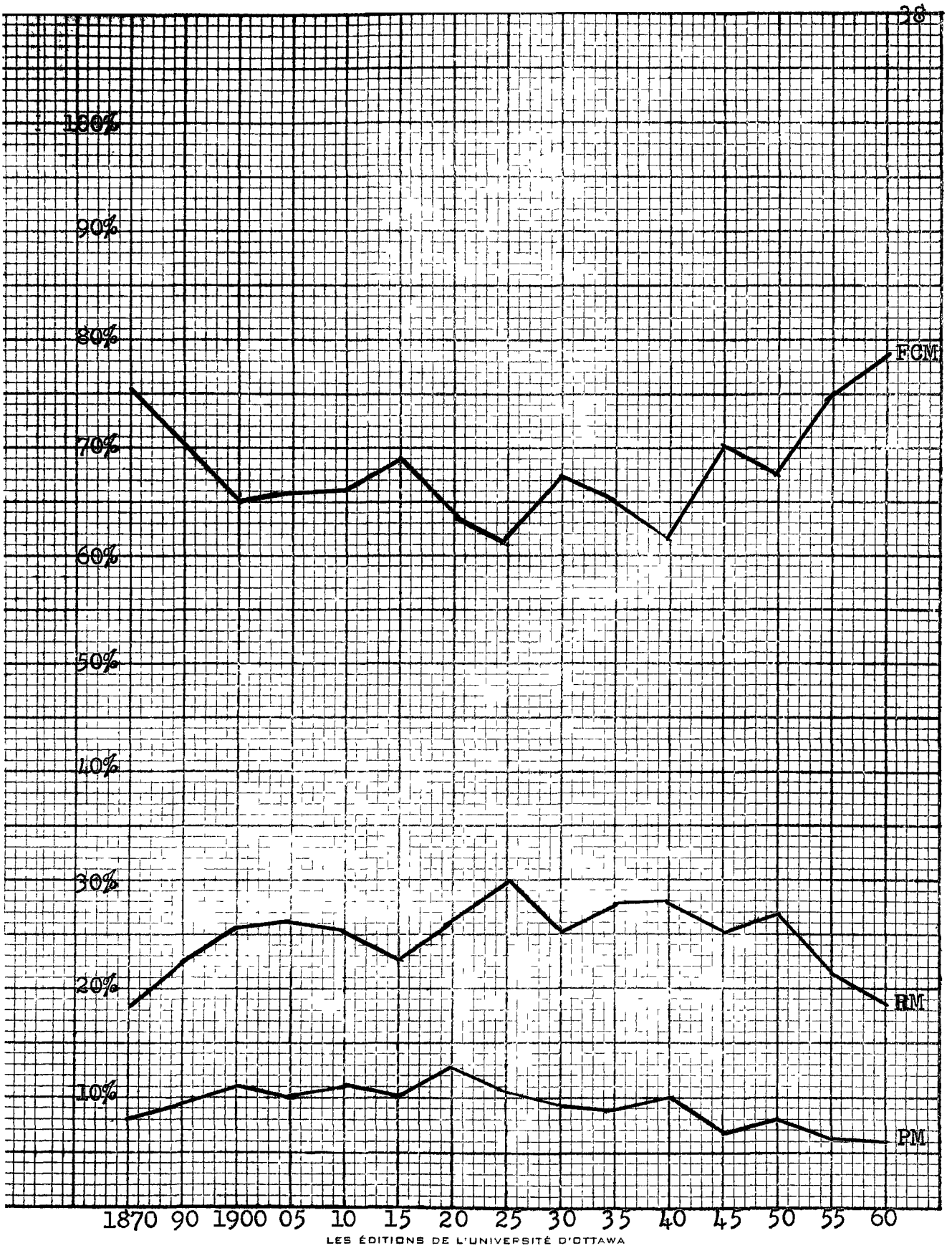




Figure 3. Index of Total Value of Canadian Imports and Percentage Shares by Economic Classes, 1870-1960

Source: Derived from Table II.

shares of raw materials, partially manufactured and chiefly manufactured goods in Canadian imports since 1870. The figure illustrating the percentage shares is shown on page 38. Because of the relative declining comparative advantage in natural resources, an increase in the percentage share of R and a decrease in that of S imported may be expected. On first examination of figure 3, it is impossible to observe these trends. Only by computing the regression lines, can we see that it was so. The regression line of the natural resource products imported is:

$$R^m = 23.9 + 0.05\ t$$

while that of the non-natural resource product is:

$$S^m = 76.1 - 0.05\ t$$

Thus, the slope of $R^m$ is positive, indicating that the relative share of natural resource products is increasing and that of S imported is diminishing, as it was expected. Here, however, a student t-test does not corroborate the last conclusions.

Before presenting the estimates of $I_2'$, we have to examine to what extent these changes were due to changing prices and to changing physical volume. It will be remembered that $I_2'$ would be a good approximation of the natural resource content only if the value of natural resource products is not significantly affected by price changes. To verify this, we constructed a price index for R since none was available for the years before 1946. The

price index for exports and imports of R is estimated from those of two sub-groups of the raw materials class of Canadian foreign trade statistics namely, agricultural and animal products, and non-metallic minerals and products.[5] All these indexes are presented for the period following 1926 to 1960 as shown in Table III and are taken from the Review of Foreign Trade.[6] All indexes are based on 1948 = 100.

Total Canadian export and import as well as R-export and import prices show similar long-range patterns. After a peak in the period 1926-30, they first declined during the Great Depression and then increased again in a long swing covering almost twenty-five years. Through these long-range movements import prices gained more than those

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5 The motive which justified this procedure is that the price indexes of these groups contain a very high raw materials weight. On the exports side, the raw materials percentage weight of the total weight account for almost 70% for the first group and more than 85% in the non-metallic minerals group. Only wheat counts for 30% in the exported agricultural and animal products. On the imports side, the same phenomena exists since raw materials in the first class and in the second covered well over 60% and 80% of their respective totals. Only crude petroleum counts for 40% in the imported non-metallic minerals groups. On the other hand, the coverage of our estimates for exports and imports of raw materials is quite satisfactory (80%). Percentage values of these two groups to total value of raw materials traded during 1948 were used as weights. For reference, see: Dominion Bureau of Statistics, Reference Papers 1950, Export and Import Prices Indexes by months: Ottawa, Canada.

6 Dominion Bureau of Statistics, Review of Foreign Trade, issues of 1954, 1957 and 1960, Catalogue No. 65-204 and 65-205, Ottawa, p. 85.

of exports. Canada's terms of trade for total foreign trade and trade in natural resources deteriorated over the period as shown in figure 4.

Taking the trend of total import and export prices as standards of comparison, we have calculated the relative price index of natural resource products. This index was obtained by deflating the price index of R by its respective index of total export and import for each period. Considering this relative price index, we observe that the R-exports were comparatively expensive when R-imports were relatively cheap from 1926 to 1945. From that period to 1960, the relative price index of natural resource products exported declined to the level of the relative price of those imported. This trend brought a slight worsening of the relative terms of trade for natural resource products as shown in figure 4.

On the whole, it may be concluded that variations in the price of R relative to the price level of total exports and imports were not very important. This means that if we took as a measure of the natural resource content valuations at constant prices, we would obtain similar results as those derived from $I_2'$ which are now presented.

We finally come to the presentation of our first estimates of the natural resource requirements of Canadian foreign trade. Both

TABLE III

Canadian Foreign Trade, Price Indexes and Terms of Trade of Total Trade and of Natural Resource Products Traded, 1926-1960, Five Years Averages, Base Year = 1948

| Price Indexes | Total Trade | | Raw Materials | | Relative Index of Raw Materials | |
|---|---|---|---|---|---|---|
| Year | Exports (i) | Imports (ii) | Exports (iii) | Imports (iv) | Exports (iii)÷(i) | Imports (iv)÷(ii) |
| 1926-30 | 64.8 | 63.9 | 69.2 | 62.3 | 106.8 | 97.5 |
| 31-35 | 42.7 | 46.0 | 44.0 | 42.6 | 103.1 | 92.7 |
| 36-40 | 48.7 | 49.4 | 52.1 | 43.7 | 107.0 | 88.5 |
| 41-45 | 61.7 | 67.8 | 66.1 | 62.0 | 107.2 | 91.5 |
| 46-50 | 97.1 | 93.9 | 99.3 | 94.1 | 102.3 | 99.8 |
| 51-55 | 119.6 | 113.7 | 110.2 | 111.4 | 92.2 | 98.0 |
| 56-60 | 122.3 | 115.8 | 106.8 | 101.1 | 87.4 | 87.5 |

| Terms of Trade | Total Trade | Raw Materials | Relative Terms of Trade of |
|---|---|---|---|
| Year | (i) ÷ (ii) | (iii) ÷ (iv) | Raw Materials |
| 1926-30 | 101.7 | 111.1 | 109.6 |
| 31-35 | 93.1 | 103.3 | 111.3 |
| 36-40 | 99.2 | 119.3 | 121.0 |
| 41-45 | 91.2 | 106.7 | 117.2 |
| 46-50 | 101.9 | 105.6 | 102.6 |
| 51-55 | 106.0 | 99.0 | 94.1 |
| 56-60 | 106.2 | 105.7 | 100.0 |

Source: the price indexes and the terms of trade of total exports and imports have been taken from the Review of Foreign Trade, op. cit., p. 85; all other data have been derived from it.

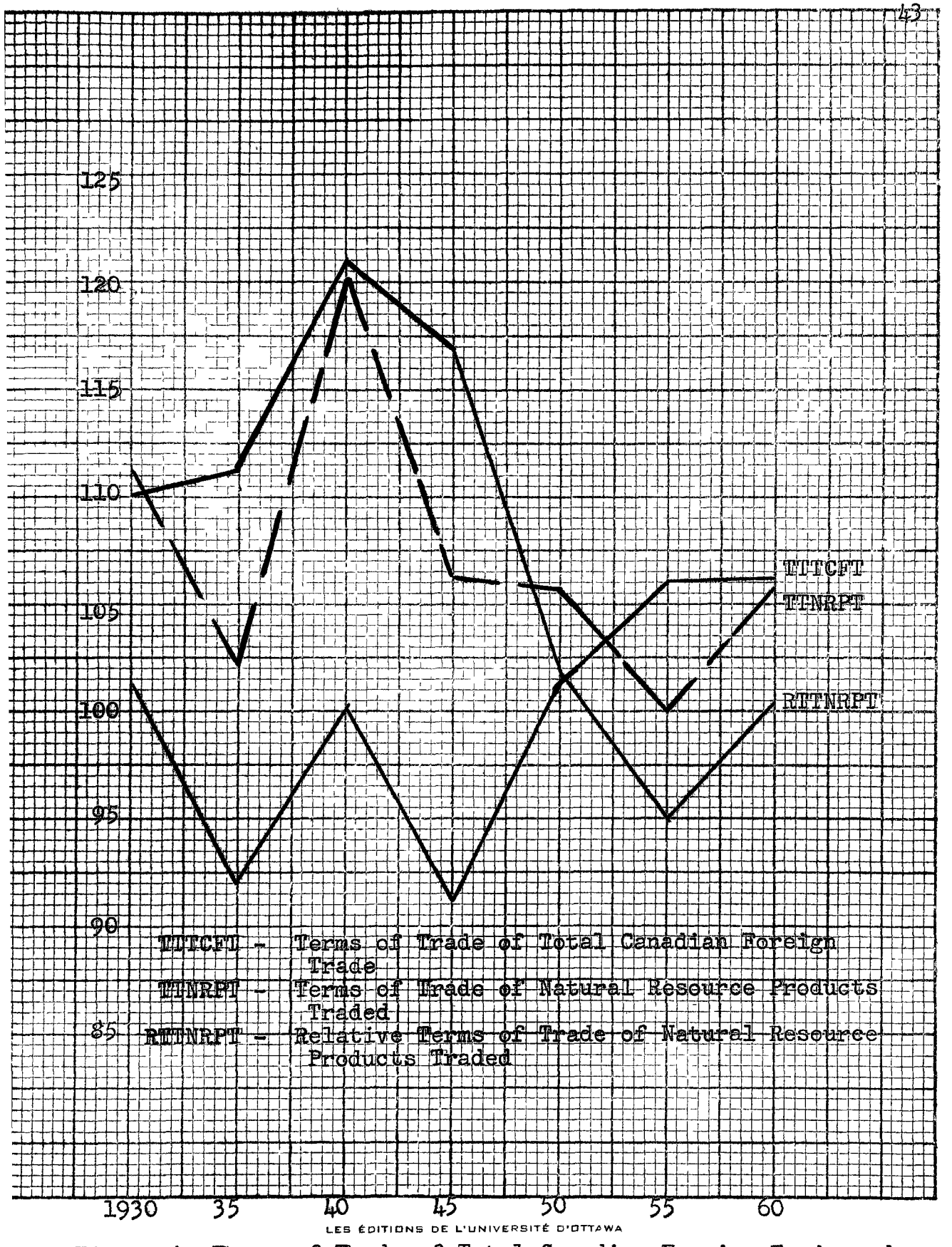




Figure 4. Terms of Trade of Total Canadian Foreign Trade and of Foreign Trade in Natural Resource Products, 1930-60

Source: Derived from Table III.

i) the ratio of the value of natural resource products exported to the value of natural resource products imported ($I_2$) and

ii) a similar ratio comparing natural resource product requirements per dollar of exports and imports ($I_2'$) are presented in Table IV and figure 5.

A declining trend is apparent in the second series while a stationary trend predominates in the first. In fact, the respective regression equations are as follows:

$$I_2 = 152.0 - 0.11\ t$$

$$I_2' = 161.0 - 5.5\ t$$

The slope of $I_2'$ is significant at a 99 per cent confidence level while that of $I_2$ is not. The virtual stability of $I_2$ is not really an indication of the unchanged relative natural resource content of Canadian foreign trade because its level is affected by the net commercial balance of Canadian foreign trade. The stability of $I_2$ may be explained by an alternative shift of surpluses and deficits in the net commercial balance, a deficit or a surplus lowering or increasing respectively the level of $I_2$. The surplus of 1920 to 1952 in the Canadian net balance of commercial trade is the key explanation of that stability. The relevant series is $I_2'$. Its declining trend indicates clearly a relative lower natural resource product content or a relative loss in comparative advantage of Canadian

TABLE IV

The Relative Natural Resource Product Direct Content of Canadian Foreign Trade, 1870-1960

| Year | Trade in Natural Resource Products | | | | Relative Natural Resource Product Direct Content | |
|---|---|---|---|---|---|---|
| | Millions of Dollars | | Percentage | | | |
| | Exports (i) | Imports (ii) | Exports (iii) | Imports (iv) | 100x(i)/(ii) $I_2$ | 100x(iii)/(iv) $I'_2$ |
| 1870 | 19 | 12 | 32.9 | 17.6 | 158 | 187 |
| 1890 | 35 | 31 | 41.4 | 21.7 | 112 | 191 |
| 1900 | 70 | 43 | 41.5 | 24.9 | 162 | 167 |
| 1905 | 79 | 64 | 41.6 | 25.4 | 123 | 164 |
| 1910 | 143 | 91 | 51.2 | 24.6 | 157 | 208 |
| 1914 | 273 | 135 | 63.1 | 21.8 | 202 | 289 |
| 1920 | 441 | 295 | 34.1 | 25.0 | 149 | 136 |
| 1921-25 | 440 | 246 | 45.1 | 29.7 | 178 | 153 |
| 1926-30 | 556 | 276 | 42.6 | 24.2 | 201 | 176 |
| 1931-35 | 230 | 154 | 34.3 | 27.1 | 149 | 126 |
| 1936-40 | 279 | 204 | 28.0 | 27.2 | 136 | 105 |
| 1941-45 | 552 | 380 | 19.8 | 24.7 | 145 | 81 |
| 1946-50 | 781 | 682 | 27.7 | 26.3 | 114 | 104 |
| 1951-55 | 1,222 | 867 | 29.7 | 20.5 | 140 | 145 |
| 1956-60 | 1,628 | 964 | 33.2 | 17.8 | 168 | 186 |

Source: Columns (i) and (iii) are taken from Table I while columns (ii) and (iv) have been borrowed from Table II.

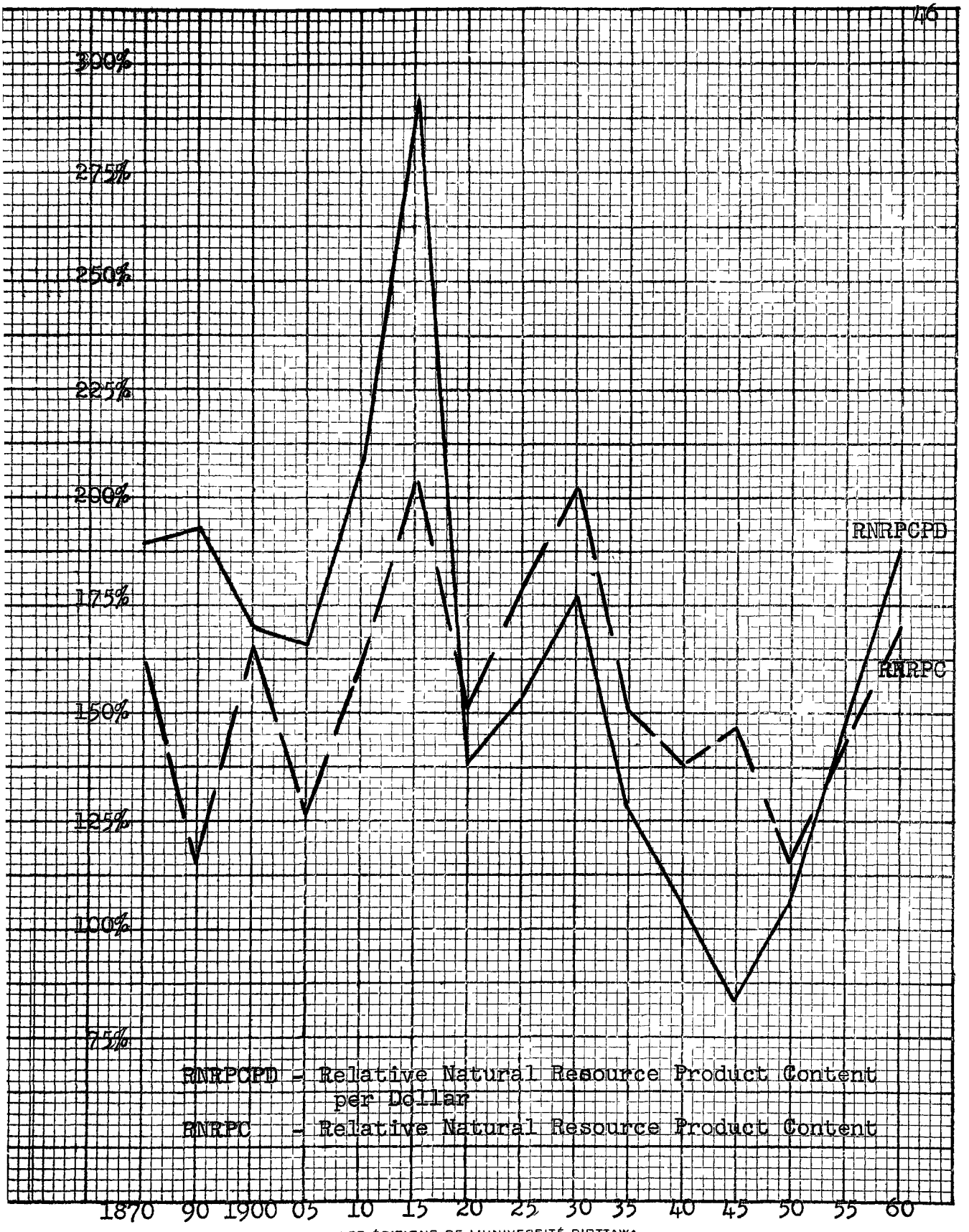




Figure 5. Canada's Natural Resource Product Direct Content of Foreign Trade, Exports Divided by Imports, 1870-1960.
Source: Derived from Table IV.

natural resource products. But since both series are well over 100, Canada's comparative advantage is still in natural resource products.

## 2. THE TOTAL NATURAL RESOURCE PRODUCT CONTENT OF CANADIAN FOREIGN TRADE

The preceding section dealt only with the direct content of natural resources in Canadian foreign trade. Although $I_2$ and $I_2'$ provided good information concerning the natural resource requirements of our foreign transactions, they do not tell the whole story. Many natural resources flow into and out of Canada as inputs of non-natural resource commodities or services. Using the index $I_1$, we will now evaluate the direct and indirect natural resource requirements of exports and imports in the current account. The results will not be significantly different from the above.

The forty-two domestic industries defined in the Canadian input-output table are first shown; each one corresponds to a number by which it is identified in Table V. Table V shows the total exports and competitive imports of natural resource products for the years 1949 to 1956 as well as the gross coefficients of each industry.

In 1949, Canada's total exports of natural resource products amounted to 2,570 millions of dollars while the respective imports were only 579 millions. In 1956, the

surplus increases to 2,872 millions of dollars. Thus, Canada was a net supplier of natural resource products either directly traded or contained in manufactured goods for these two years.

The indirect requirements of natural resource products account for a minor part of natural resource products traded through what we call the non-natural resource product industries (9 to 42), since the gross coefficients are very small in most of the cases; only industry no. 38 (transportation, storage and trade) has a high coefficient, 0.706. On the import side, it is industry 11 (grain mill products) which has the highest gross coefficient. But, the coefficients are high for the natural resource product industries. On the export side, the gross coefficients of industries 1 and 5 (agriculture and coal mining, petroleum and natural gas) amount to 2.35 and 2.07 respectively. These coefficients are well over one because they are gross, i.e. they include the requirement flows from these respective industries into the other natural resource product industries. On the import side, industries 7 and 8 (meat products and dairy products) have also high coefficients for that reason.

The Forty-two Industries

| Industry No. | Industry |
|---|---|
| 1 | Agriculture |
| 2 | Forestry |
| 3 | Fishing, hunting and trapping |
| 4 | Metal mining and smelting and refining |
| 5 | Coal mining, crude petroleum and natural gas |
| 6 | Non-metal mining, quarrying and prospecting |
| 7 | Meat products |
| 8 | Dairy products |
| 9 | Fish processing |
| 10 | Fruit and vegetable preparations |
| 11 | Grain mill products |
| 12 | Bakery products |
| 13 | Carbonated beverages |
| 14 | Alcoholic beverages |
| 15 | Confectionery and sugar refining |
| 16 | Miscellaneous food preparations |
| 17 | Tobacco and tobacco products |
| 18 | Rubber products |
| 19 | Leather products |
| 20 | Textile products |
| 21 | Clothing |
| 22 | Furniture |
| 23 | Wood products |
| 24 | Paper products |
| 25 | Printing, publishing, and allied industries |
| 26 | Primary iron and steel |
| 27 | Agricultural implements |
| 28 | Iron and steel products, n.e.s. |
| 29 | Transportation equipment |
| 30 | Jewellery and silverware |
| 31 | Non-ferrous metal products, n.e.s. |
| 32 | Electrical apparatus and supplies |
| 33 | Non-metallic mineral products |
| 34 | Products of petroleum and coal |
| 35 | Chemicals and allied products |
| 36 | Miscellaneous manufacturing industries |
| 37 | Construction |
| 38 | Transportation, storage and trade |
| 39 | Communication |
| 40 | Electric power, gas and water utilities |
| 41 | Finance, insurance and real estate |
| 42 | Service industries |

Source: taken from Table 1 of the Canadian Inter-Industry flow table. op. cit.

TABLE V

Total Requirements of Canadian Natural Resource Products Traded in 1949 and 1956 by Industries

| Industry No. | Exports | | | Competitive Imports | | |
|---|---|---|---|---|---|---|
| | Gross Coefficients | Millions of $ 1949 | 1956 | Gross Coefficients | Millions of $ 1949 | 1956 |
| 1 | 2.35 | 1367.5 | 1513.0 | 1.05 | 80.3 | 166.6 |
| 2 | 1.03 | 52.7 | 65.3 | 1.02 | 3.3 | 11.2 |
| 3 | 1.00 | 45.1 | 42.4 | 1.01 | 3.0 | 4.0 |
| 4 | 1.01 | 549.3 | 1213.0 | 1.02 | 18.1 | 47.0 |
| 5 | 2.07 | 6.2 | 224.3 | 1.01 | 284.5 | 400.0 |
| 6 | 1.01 | 42.3 | 121.0 | 1.03 | 52.7 | 27.9 |
| 7 | 1.01 | 87.5 | 57.5 | 1.66 | 42.8 | 70.2 |
| 8 | 1.00 | 30.0 | 15.6 | 1.67 | 4.2 | 8.1 |
| 9 | 0.004 | 0.3 | 0.4 | 0.463 | 1.8 | 6.5 |
| 10 | - | - | - | 0.266 | 2.6 | 12.5 |
| 11 | 0.186 | 19.7 | 16.0 | 0.550 | 0.4 | 0.9 |
| 12 | - | - | - | 0.237 | 0.3 | 1.2 |
| 13 | - | - | - | 0.043 | - | - |
| 14 | - | - | - | 0.056 | 0.9 | 1.2 |
| 15 | 0.008 | - | - | 0.113 | 0.6 | 1.6 |
| 16 | 0.004 | - | - | 0.152 | 0.7 | 2.7 |
| 17 | - | - | - | 0.425 | 0.4 | 0.8 |
| 18 | 0.033 | 0.4 | 0.3 | 0.016 | 0.2 | 0.8 |
| 19 | 0.001 | - | - | 0.119 | 1.3 | 2.4 |
| 20 | 0.058 | 1.0 | 1.0 | 0.015 | 3.2 | 4.0 |
| 21 | 0.001 | - | - | 0.019 | 0.3 | 1.0 |
| 22 | 0.003 | - | - | 0.043 | 0.1 | 0.7 |
| 23 | 0.063 | 12.4 | 25.2 | 0.341 | 5.6 | 18.1 |
| 24 | 0.057 | 36.1 | 60.0 | 0.266 | 6.3 | 18.4 |
| 25 | 0.023 | 0.1 | - | 0.058 | 1.8 | 3.8 |
| 26 | 0.035 | 1.4 | 2.5 | 0.064 | 6.8 | 15.5 |
| 27 | 0.005 | 0.4 | 0.5 | 0.023 | 3.8 | 5.1 |

(continued)

TABLE V (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| 28 | 0.171 | 8.2 | 12.0 | 0.029 | 8.6 | 25.8 |
| 29 | 0.174 | 26.9 | 23.6 | 0.019 | 3.9 | 12.6 |
| 30 | - | - | - | 0.169 | 3.1 | 7.8 |
| 31 | 0.015 | 0.3 | 0.5 | 0.275 | 5.7 | 19.0 |
| 32 | 0.031 | 0.5 | 1.2 | 0.042 | 3.2 | 12.5 |
| 33 | 0.024 | 0.6 | 1.1 | 0.073 | 4.9 | 8.7 |
| 34 | 0.279 | 2.2 | 4.0 | 0.129 | 13.2 | 22.0 |
| 35 | 0.114 | 10.9 | 23.8 | 0.105 | 9.0 | 20.4 |
| 36 | 0.025 | 0.2 | - | 0.027 | 1.4 | 3.2 |
| 37 | 0.193 | - | - | 0.070 | 0.1 | - |
| 38 | 0.706 | 267.5 | 420.6 | 0.020 | - | 10.2 |
| 39 | 0.030 | - | - | 0.011 | - | - |
| 40 | 0.118 | 0.6 | 1.8 | 0.042 | - | - |
| 41 | 0.196 | - | - | 0.018 | - | - |
| 42 | 0.076 | 0.1 | - | 0.035 | 0.1 | - |
| Total | | 2570.0 | 3846.6 | | 579.2 | 974.4 |

Source: the gross coefficients have been derived from Table 3A of the Canadian Inter-Industry Flow Table, op. cit., The data on competitive imports and exports for the year 1949 are taken from the same source on page 24 and Table 1 respectively. For the year 1956, they have been derived from T.I. Matuszewski, P.R. Pitts and J.A. Sawyer, "The Impact of Foreign Trade on Canadian Industries 1956" The Canadian Journal of Economics and Political Science, Vol. XXXI, No. 2, May 1965. Table V, p. 209, and p. 217. For the technique of the derivation of the exports and competitive imports as shown in this table, see Chapter I, pp. 21-23.

To bring our research up-to-date, we have consulted forecasts regarding the composition of Canadian foreign trade; the Caves-Holton's forecast for the year 1970 appears to be more relevant for this study. Cavesused the same classification as ours and it was possible to derive from it the R- requirements for 1970.[7] Caves explains his method of forecasting commodity groups as follows:

> "In general, specific export classes were projected by looking at the following things: i) prospective rate of growth of income and demand in the countries which are the best customers of each export; ii) trends in Canadian exportable supply - that is, the excess of Canadian productive capacity over probable domestic consumption; and iii) potential output of producers competing with Canada in the export of each commodity. The material above indicated how the first of these was handled. For each export, or group of exports, the growth of Canada's major overseas markets has been estimated from the economic growth rates of the relevant areas and rough estimates of the income elasticity of demand where such an estimate was feasible".[8]

Caves has condensed the 42- by -42 table of 1949 into sixteen sectors. The aggregation of the forty-two sectors given by the Bureau of Statistics into the sixteen sectors listed in Table VI is fairly straightforward; the first three industries have the same definition as previously, industries nos. 4 and 6 are condensed in industry no. 5 in the Caves classification, and industry

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7 R.E. Caves and R.H. Holton, The Canadian Economy: Prospect and Retrospect, Cambridge, Mass., 1959, p. 399.

8 Ibid., p. 400.

TABLE VI

Total Requirements of Canadian Natural Resource Products Trade by 1970 by Industries

| Industry | Exports Gross Coefficients | Exports Millions of $ | Competitive Imports Gross Coefficients | Competitive Imports Millions of $ |
|---|---|---|---|---|
| 1 Agriculture | 1.465 | 981.3 | 1.139 | 423.8 |
| 2 Forestry | 1.035 | 49.7 | 1.061 | 35.0 |
| 3 Fishing, hunting, trapping | 1.029 | 99.8 | 1.042 | 10.4 |
| 4 Coal, crude petroleum, gas | 1.057 | 307.6 | 1.033 | 322.3 |
| 5 Other mining, quarrying | 1.037 | 2,592.2 | 1.059 | 231.9 |
| 6 Food, beverage, tobacco | 1.241 | 620.4 | 1.529 | 764.4 |
| 7 Clothing, household goods | 0.139 | 2.1 | 0.054 | 24.8 |
| 8 Forest products | 0.164 | 322.5 | 0.305 | 34.2 |
| 9 Metal products | 0.404 | 224.0 | 0.072 | 211.4 |
| 10 Electrical apparatus, supplies | 0.037 | 2.0 | 0.052 | 28.9 |
| 11 Mineral products | 0.391 | 125.2 | 0.122 | 76.2 |
| 12 Miscellaneous manufacturing | 0.105 | 37.0 | 0.068 | 67.0 |
| 13 Construction | 0.165 | - | 0.099 | - |
| 14 Transport, storage, trade | 1.459 | 722.2 | 0.047 | 19.0 |
| 15 Communication, etc. | 0.351 | 3.5 | 0.047 | 5.5 |
| 16 Other service industries | 0.090 | 37.5 | 0.169 | 100.5 |
| Total | | 6,127.0 | | 2,355.0 |

Source: The gross coefficients are derived from R.E. Caves "The Inter-industry Structure of the Canadian Economy". The Canadian Journal of Economics and Political Science, Vol. XXIII, 1957, p. 330; the gross coefficient of a particular industry as shown here is the sum of the coefficient of an inverse matrix indicating the requirements flows from that industry to industries 1 to 6. The exports and imports data are from R.E. Caves and R.H. Holton, op. cit., p. 399.

no. 6 includes meat and dairy products. Thus, following our definition, we consider sectors 1 to 6 as natural resource product industries although industry no. 6 may contain some non-natural resource products. Finally the inverse matrix[9] of this 16- by -16 table was used to forecast the natural resource requirements for 1970. The results are shown in Table VI.

As in 1949 and 1956, Canada's exports of natural resource products will exceed her respective imports of 1970. In that year, Canada's exports of natural resource products will amount to 6,127 millions of dollars while her imports will be only 2,355 indicating a net surplus of 3,772 millions. It is surprising to see how important the natural resource product content will be in the output of the transportation and trade industry (no. 14) in 1970, since the gross coefficient is well over one.

We now have all the relevant information to estimate $I_I$, that is, the ratio of the direct and indirect requirements of exports, to total import requirements of natural resource products. The following table presents the results.

9 This inverse matrix is shown in an article of R.E. Caves "The Inter-Industry Structure of the Canadian Economy". Canadian Journal of Economics and Political Science, 1957, p. 330.

Table VII

Relative Natural Resource Product Requirements of Canadian Foreign Trade in 1949, 1956 and 1970, Exports divided by Imports.

| | |
|---|---|
| 1949 | 4.2 |
| 1956 | 3.9 |
| 1970 | 2.6 |

Source: derived from Tables V and VI.

Similar to the results derived with $I_2'$, an over-all decline of the net exports of natural resource products over time is found with $I_1$. Thus, it appears that Canada's comparative advantage in natural resource products is decreasing, but, since the level of $I_1$ is well over unity, here comparative advantage in natural resources is still very important. The magnitude of $I_1$ depends on the absolute - not the relative - value of natural resource products. Thus, it may be influenced by a change in the level of prices of natural resource products exported and imported. However, during the period covered, the price indexes of natural resource products exported and imported shown in Table III indicate similar movements for the two indexes and they are almost in the same proportions. Consequently, the magnitude of this index may be interpreted

as recording the volume of natural resources used per unit of Canadian exports and imports.

Before concluding this chapter, let us make a digression. We will divide the aggregate of natural resource products into two parts: renewable and non-renewable natural resource products. This distinction has been made by Resources for Tomorrow.[10] Agriculture, forestry, fishing and trapping are considered as renewable resources. In Table VIII, we present the total requirements of both categories.

Table VIII

Relative Renewable and Non-renewable Natural Resource Product Requirements in 1949, 1956 and 1970, Exports divided by Imports

| Year | Renewable Resources | | | Non-Renewable Resources | | |
|---|---|---|---|---|---|---|
| | Exports | Imports | Exports / Imports | Exports | Imports | Exports / Imports |
| | Millions of dollars | | | | | |
| 1949 | 1,635.2 | 156.8 | 10.43 | 640.2 | 394.2 | 1.62 |
| 1956 | 2,114.7 | 357.7 | 5.91 | 1,702.9 | 576.6 | 2.95 |
| 1957 | 2,565.3 | 1,479.5 | 1.73 | 3,380.2 | 761.7 | 4.43 |

Source: derived from Tables V and VI.

In relative terms, considering the ratio of export requirements to import requirements for the two categories, the

10 Proceedings of the Resources for Tomorrow Conference in Montreal, October 23-28, incl. Queen's Printer, Ottawa, 1962.

decline of renewable natural resource products and the rise of the non-renewable are easily apparent. We may therefore state that Canada's comparative advantage in renewable natural resource products is decreasing at a very rapid rate while Canada has gained a greater comparative advantage in non-renewable natural resource products since 1949.

## CONCLUSION

The first chapter was concerned with the methods of measuring the natural resource content in a given bill of exports and imports. Its conclusion was that the volume of Canadian natural resource products traded approximates the natural resource content of Canadian foreign trade. In this chapter, the natural resource product content of Canadian foreign trade has been calculated. It is now possible to infer the natural resource requirements of Canadian foreign trade from the natural resource product content.

The essential conclusion of the present chapter is that Canada enjoys a comparative advantage in natural resource products. This comparative advantage was greater in the past but is still important today. Disaggregating natural resource products, it was found that Canada enjoys a much smaller comparative advantage in renewable natural

resource products today than in the past. Although her comparative advantage in non-renewable natural resource products has gained recently, From these conclusions, it is perfectly legitimate to derive the following more important conclusions.

The natural resource content of Canadian exports has always exceeded that of Canadian imports. Although the difference has been reduced over the one hundred years studied, the natural resource content of exports will outweigh that of imports by almost two hundred percent in 1970. Canada is a net exporter of renewable natural resources, but this export surplus will decrease very much from 1949 to 1970. Finally, Canada is also a net exporter of non-renewable natural resources and this export surplus is increasing.

# CHAPTER III

## CAPITAL, LABOUR AND NATURAL RESOURCE REQUIREMENTS OF CANADIAN FOREIGN TRADE

Our calculation of the total natural resource product requirements was done specifically to be integrated in D.F. Wahl's[1] computation of capital and labour requirements. In this chapter, we will explain briefly the way D.F. Wahl estimated the capital and labour requirements. Finally, the empirical results are presented along with those of the natural resources derived in the preceding chapter.

To calculate the total labour requirements of Canadian foreign trade, D.F. Wahl has used the wages and salaries row of the Canadian input-output table; however "he has overlooked the point that some labour income is also contained in the net income of unincorporated business".[2] In order to solve the capital requirements

1 D.F. Wahl, "Capital and Labour Requirements for Canada's Foreign Trade", The Canadian Journal of Economics and Political Science, Vol. XXVII, No. 4, August, 1961, p.353.

2 T.I. Matuszewski, P.R. Pitts and J.A. Sawyer, "The Impact of Foreign Trade on Canadian Industries, 1956". The Canadian Journal of Economics and Political Science, Vol. XXXI, No. 2, May, 1965, p. 213.

problem, D.F. Wahl has relied on the Gordon Commission which has published estimates of the capital stock; he derived the capital coefficient from A. Scott's gross capital estimates, computed according to the "perpetual inventory" method.

Table IX presents the capital, labour and natural resource product content of Canadian foreign trade in 1949 and 1970. It indicates that an average millions dollars' worth of Canadian total exports in 1949 and 1970 contained more natural resources and capital and less labour than would have been required to replace an average millions dollars' worth of total Canadian competitive imports with domestic production. In other words, under the assumption that Canada's production function is identical with that of the rest of the world, Canada is a net exporter of natural resources and capital but is a net importer of labour. However, the capital "surplus" and labour "deficit" is small while the natural resource "surplus" is pretty large.

Over the twenty years studied, two important tendencies are easily apparent. First, there is an increasing content of labour and a decreasing content of natural resources in Canadian exports. Second, the natural resource content of Canadian imports will increase from 1949 to 1970 due to the relative loss in comparative advantage of Canadian natural resource products.

TABLE IX

Domestic Capital, Labour, and Natural Resource Product Requirements per Millions of Dollars of Canadian Exports and of Competitive Imports in 1949 and 1970

| | 1949 Requirements | | 1970 Requirements | |
|---|---|---|---|---|
| | Import Millions | Export of $ | Import Millions | Export of $ |
| Capital | 1,634 | 1,773 | 1,630 | 1,744 |
| Labour | 430 | 387 | 429 | 426 |
| Natural Resource Products | 210 | 832 | 281 | 739 |

Source: capital and labour requirements are taken from D.F. Wahl, op. cit., p. 353, and the natural resource requirements are derived from Tables V and VI, in the following way:

$$1{,}000 \times \frac{\text{requirements of natural resources in total export}}{\text{total exports}}$$

Following our way of measuring the natural resource content, let us compute the ratios of export requirements to import requirements of capital and labour. Table X presents the results.

TABLE X

Relative Natural Resources, Capital and Labour Requirements in 1949 and 1970, Exports divided by Imports

| | 1949 | 1970 |
|---|---|---|
| Capital | 1.08 | 1.07 |
| Labour | 0.90 | 1.01 |
| Natural Resources | 4.2 | 2.6 |

Source: derived from Table IX.

Table X is another way of expressing Table IX and contains nothing new. But it will constitute a basis of the following chapter.

One technical matter should be treated before leaving this chapter. The capital and labour requirements for 1970 are in 1949 dollars while the natural resource produce requirements have not been deflated. The extent to which this may have affected the results is likely to be small since similar price changes may be expected for the Canadian import and export of natural resource products.

# CHAPTER IV

## CANADA'S FACTOR ENDOWMENT

In this section, we shall infer from the empirical findings of the last chapter the relative abundance of the productive factors in Canada and in the rest of the world. Before doing so, a theoretical matter should be treated; it concerns the factor-proportions theory of international trade which states that a country tends to export the products using relatively more of its abundant factor.

The development of the present chapter runs as follows: first, the factor-proportions theory is stated in a two-factor, two-commodity model, then it is extended to the case of three factors and many commodities. Secondly, Canada's factor endowment is inferred from the factor requirements of Canadian foreign trade. Finally, the assumptions of the factor-proportions theory are fully discussed. We then try to know how the non-fulfillment of these assumptions may affect our results.

## 1. THE FACTOR-PROPORTIONS THEORY

Rigorous treatments[1] of the factor-proportions theory were based on a two-factor or multi-commodity model. In these models, the conditions which ensure the "logical truth" of the theory have been summarized by J. Bhagwati.[2] Here, we propose to state them only; they will be more fully discussed further. They are

i) international identity of production functions;

ii) non-reversibility of factor-intensities;

iii) homogeneous production functions of degree one and diminishing returns along isoquants;

iv) identity of the consumption pattern between countries at each relevant commodity price ratio;

v) perfect competition in both product and factor markets, no tariff and zero-transportation cost.

Then the proof of the theory runs as follows; under perfect competition, condition three will generate a convex transformation curve, where, at each point, there is a unique relationship between factor and commodity price

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1 P.A. Samuelson, "International Trade and Equalization of Factor Prices", The Economic Journal, Vol. 58, June, 1948, pp. 163-184, R. Jones, "Factor-Proportions and the Heckscher-Chlin Model". The Review of Economic Studies Vol. 24, 1956-57, pp. 1-10.

2 J. Bhagwati, "The Pure Theory of International Trade: a survey", The Economic Journal, Vol. 74, March 1964, pp. 1-84.

ratios. It is then possible to demonstrate that if a country (I) in a two-country model, both satisfying conditions one and two, has a higher capital (K) - labour (N) ratio in the aggregate than the other country (II) i.e.,

$$(1) \qquad \left(\frac{K}{N}\right)^{I} > \left(\frac{K}{N}\right)^{II}$$

the capital-abundant country (country I) will have a higher ratio of capital-intensive (Kg) to labour-intensive (Ng) goods at each commodity price ratio, i.e.

$$(2) \qquad \left(\frac{Kg}{Ng}\right)^{I} > \left(\frac{Kg}{Ng}\right)^{II}$$

When condition four is added, "it follows that the pre-trade commodity price ratios will be such that the capital-intensive commodity will be cheaper in the capital-abundant country".[3] It then results that the capital-abundant country (I) will be a net exporter of capital and a net importer of labour embodied in her competitive imports. One way to represent symbolically this pattern of foreign trade is as follows:

$$(3) \qquad \frac{K^{x}_{I}}{K^{m}_{II}} > \frac{N^{x}_{I}}{N^{m}_{II}}$$

where the superscripts x and m stand for export and competitive import respectively and the subscript II represents the labour-abundant country.

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3 J. Bhagwati, op. cit., p. 19.

To fit into our analysis, the factor-proportions theory has to be extended to the case of three factors of production. This extension has already been made by J. Vanek.[4] He has ordered the relative abundance of natural resources (L), capital (K), labour (N) of the two trading countries, say, Canada (I) and the rest of the world (II), according to the relative abundance, starting, say, with $L_I$ being the relatively most abundant factor of country (I); i.e.

$$(4) \qquad \frac{L_I}{L_{II}} > \frac{K_I}{K_{II}} > \frac{N_I}{N_{II}}$$

Then, under the set of assumptions previously stated, J. Vanek assesses that the following may be expected: "The relative value contents of exports (x) and imports (m) will approximate the order of the relative factor endowment" stated by the preceding inequalities, i.e.

$$(5) \qquad \frac{L^x_I}{L^m_{II}} > \frac{K^x_I}{K^m_{II}} > \frac{N^x_I}{N^m_{II}}$$

if factor-output ratios are independent from one another.

## 2. CANADA'S FACTOR ENDOWMENT

Let us now integrate our theoretical and empirical study. If our estimators $I_1$, $I_2$ and $I_2'$ provide a good measure of the relative natural resource requirements, and

4 J. Vanek, International Trade Theory and Economic Policy, R.D. Irwin, Homewood, Ill., 1962, p. 194.

if we were living in a world in which the assumptions of the factor-proportions theory were rigorously fulfilled our conclusions would be quite straightforward.

Over the hundred years studied, Canada has become steadily poorer in natural resources relative to the rest of the world but this factor of production is still and by a large margin the most abundant one. Labour is the scarce factor but its scarcity has been declining since 1949. Capital, which occupies the intermediate position, is relatively abundant. Let us derive more systematically these conclusions.

In Table X, we presented the ratios between export and competitive import requirements of natural resources, capital and labour in total Canadian foreign trade. In fact, Table X represents equation (5). Using the same symbols as before and ordering them from the highest to the lowest, they are, for 1949 and 1970, as follows:

$$1949: \quad \frac{L^x_I}{L^m_{II}} = 4.2 > \frac{K^x_I}{K^m_{II}} = 1.08 > \frac{N^x_I}{N^m_{II}} = 0.90$$

$$1970: \quad \frac{L^x_I}{L^m_{II}} = 2.6 > \frac{K^x_I}{K^m_{II}} = 1.07 > \frac{N^x_I}{N^m_{II}} = 1.01$$

Thus, assuming the fulfillment of certain conditions in Canada and abroad, we may deduce inequality (4) from inequality (5), that is, we may infer Canada's factor endowment from the factor requirements of Canadian foreign trade.

The relative Canada's factor endowment appears then as follows:

1949: $\frac{L_I}{L_{II}} \simeq 4.2 > \frac{K_I}{K_{II}} \simeq 1.08 > \frac{N_I}{N_{II}} \simeq 0.90$

1970: $\frac{L_I}{L_{II}} \simeq 2.6 > \frac{K_I}{K_{II}} \simeq 1.07 > \frac{N_I}{N_{II}} \simeq 1.01$

Taking the factor endowment of the rest of the world as a standard of comparison,[5] we may argue that natural resources in 1949 were 3.9 and 4.6 times more abundant than capital and labour respectively and that the corresponding ratio will be 2.4 and 2.6 in 1970.

## 3. LIMITATIONS OF THE APPROACH

Many serious limitations accompany the approach taken in this thesis. They concern mainly the factor-proportions theory. The theory is valid only if very special assumptions are made, none of which may actually correspond to the conditions of the real world. We propose here to discuss the disparities between the real world and the conditions that ensure the logical truth of the factor-proportions theory. We will try to indicate, if possible, in what way they affect our conclusions about Canada's factor endowment.

We may start with the condition of international

5 We have simply divided the ratio of exports to imports of natural resources by the corresponding ratio of capital and labour respectively.

identity of the production functions. This condition implies that the factor inputs must be qualitatively identical and that technologies be the same in Canada and in the rest of the world. Since Canada's foreign trade is mainly with the United States, we will consider the United States as a good approximation of "the rest of the world". The lesser skill of Canadian workers and management as compared to the United States has been greatly emphasised by the Economic Council.[6] Not only are Canadian workers less educated but technology is different between Canada and the United States. Canada's technology is certainly less advanced than that of the United States, because in the present dynamic world, technological progress spreads more quickly in the United States than in Canada. The non-fulfillment of the first condition affects our results. The factor-abundance calculation would have certainly revealed a greater scarcity of labour than our results indicate if the human capital element had been imputed to labour. Also a greater abundance of natural resources would have appeared if allowances for different technologies would have been made.

The non-reversibility of factor-intensities was the second condition. Although the different factor-output

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6 Economic Council of Canada, Towards Sustained and Balanced Economic Growth, Second Annual Review, 1965, Ottawa, p. 64.

ratios are not likely to be completely independent from one another, since the model developed in this thesis deals with only three factors only three reversals of factor-intensity may happen. But in his review of Minhas' study, we believe that Leontief[7] has provided a very convincing explanation as to why such factor-reversals are not likely to happen.

The condition of homogeneous production functions of degree one and diminishing returns along isoquants implies constant returns to scale and the fulfillment of the law of variable proportions. The latter holds certainly both in Canada and in the rest of the world, but it is hard to judge to what extent constant returns to scale are present in the real world. Increasing costs are perhaps an important driving force in the natural resource product industries. They might, of course, explain the slow but gradually decreasing comparative advantage of Canada in natural resource products. Whether this could explain the entire decline of our indicators over the past ninety-five years surveyed is extremely doubtful.

The condition that the consumption patterns of the two countries at each relevant commodity price ratio be identical implies identity of tastes and unit income elasticity for all goods. Conditioned by the same institutional environment, tastes in Canada and United

7 W. Leontief, "An International Comparison of Factor Costs and Factor Use" American Economic Review, 1964, pp. 335-345. and B.S. Minhas, An International Comparison of Factor Costs and Factor Use, North Holland, 1963.

States are quite similar. Natural resource products may be expected to have lower income elasticities of demand than the remainder of traded commodities. But, since the rates of increase of income in Canada and in the United States have always been similar, the effect of different income elasticities have been reduced.

Perfect competition, the absence of tariff and transportation cost are the last assumptions. Perfect competition is possibly the most unrealistic assumption of the whole study. At best, we can expect that its non-fulfillment has played on both sides and has neutralized effects. Non-zero transportation costs can generally be expected to bias trade against bulky natural resource products. The increasing efficiency in sea and freight transportation have nevertheless reduced such bias. Moreover, this bias is likely to operate equally strong on exports and imports. The presence of tariff barriers has certainly played an important role. High tariff barriers in the United States and Canada have reduced trade in manufactured products. In this case, the bias is against capital- and labour-intensive products. Even if this bias plays on the imports and the exports side, it may be responsible for a smaller abundance of capital and labour than the real or potential abundance of these factors in the Canadian economy.

## CONCLUSION

With the present chapter, we have reached the purpose of this thesis, Canada's factor endowment is now known. However, the approach taken embodies serious difficulties. We have mentioned in this chapter those accompanying the derivation of the factor-endowment from the factor-requirements of Canadian foreign trade. Unfortunately other imperfections arise in our way of measuring factor requirements. The capital requirements have been calculated with the perpetual inventory method and the labour requirements were simply derived from the wages and salaries row of the Canadian input-output table, The natural resource requirements have been approximated by the natural resource product requirements of Canadian foreign trade. These above limitations affect also the precision of the findings. The empirical results of this thesis convey two types of information; firstly, the direction and the rate of change of the trends; secondly, the absolute level of the series at each point of time. Although we can be quite confident with respect to the adequacy of the results as indications of the direction of change, we would be cautious in trusting the second type of information.

# CONCLUSIONS

In conclusion, let us summarize our empirical findings, give some recommendations in testing the factor-proportions theory and finally draw some policy implications.

Canada is a net exporter of natural resources and capital while the country is a net importer of labour. This was true for the year 1949 and the same pattern is forecast for the year 1970. Over the one hundred years surveyed, Canada has lost some comparative advantage in the natural resource products as compared to the labour and capital-intensive products. Since 1949, the major gain of comparative advantage is enjoyed by the labour-intensive commodities. The aggregate of the natural resource-intensive commodities hides two offsetting tendencies. On the one hand, the comparative advantage of the renewable natural resources will decrease significantly from 1949 to 1970. On the other hand, non-renewable natural resources will gain a higher comparative advantage during this period.

A complete chapter of this study is concerned with the factor-proportions theory. This was a crucial step in the logical development of this thesis since we were then able to infer Canada's factor endowment from her factor requirements of foreign trade. It was found that natural

resources are the most abundant and labour the scarcest of all the factors of production in the Canadian economy. Since these results were popularly accepted on an intuitive basis,[1] our study is a successful verification of the factor-proportions theory. D.F. Wahl's computation of the capital and labour requirements suggest an unsuccessful test.[2] The integration of natural resources changes the picture to quite an extent and re-establishes the validity of the factor-proportions theory in explaining the structure of Canadian foreign trade.

The Leontief "scarce factor paradox" has been explained when J. Vanek has found that a high natural resources-output ratio usually required a high capital-output in the United States. The relative capital abundance of the United States then is not reflected exactly in the factor requirements of its international trade, the abundance of capital being disguised by a strong scarcity of natural resources.[3] In the case of Canada and the United States, empirical testing of the factor-proportions theory has given successful results only when natural resources have been integrated. Either the relative inelastic supply or the non-negligible productive contribution of natural resources are certainly two important elements which have

1 Economic Council of Canada, op. cit., p. 59. G.W. Wilson, S. Gordon, S. Judek, op. cit., p. 161

2 J. Bhagwati, op. cit., p. 25.

3 J. Vanek, op. cit., p. 135.

biased the recent test of the factor-proportions theory in Japan and India.[4]

The economic policy suggested by our results constitutes an interesting subject for a conclusion of this thesis. Since labour is the scarcest of all the factors of production in the Canadian economy, policies encouraging a quantitative increase or qualitative improvement of the Canadian labour force are advisable. Natural resources are the most abundant factor of production and Canada is a net exporter of this factor. Recently, the exports of non-renewable resources to the United States have increased significantly. Although this may be desirable from the balance of payments standpoint, this new development may be judged good or bad depending on the attitude one takes on the conservation of natural resources. On the one hand, it may be argued that Canada should encourage the rate of use of her non-renewable resources because she still has large unexploited reserves and more may be discovered. On the other hand, the view expressing concern at the growing rate of use of Canadian non-renewable resources provides a strong case since the supply of these resources is limited from a long-run point of view.

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4 R. Bharadway, "Factor Proportion and the Structure of Indo-U.S. Trade". Indian Economic Journal, Vol. 10, Oct. 1962 and M. Tatemoto and S. Ichimura, "Factor-Proportions and Foreign Trade: the case of Japan", Review of Economics and Statistics, Vol. 41, Nov. 1959.

At a time where economists in Canada and the United States are speaking of a free trade area between the two countries, no outstanding study has been made in Canada to know the impact of a bilateral or unilateral tariff reduction on the possible changes of factor endowment in this country. C.L. Barber[5] and J.H. Young[6] have both written on the subject. With a limited amount of information, they made important contributions towards greater knowledge of this impact. But the result was quite unsatisfactory. It is implied in Barber's analysis and may be derived from the model used in this thesis that the impact on the abundance of capital and labour in Canada will depend mainly on whether the proportion of the total protective effect on natural resource products is greater or smaller than on manufactured products. The only way to know this extremely important impact is to measure with an input-output table the effective rate of protection by industries, the task of a Ph.D. thesis.

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5 C.L. Barber, "Canadian Tariff Policy", The Canadian Journal of Economics and Political Science, Nov. 1955, pp. 513-530.

6 J.H. Young, Canadian Commercial Policy, Royal Commission on Canada's Economic Prospects, Queen's Printer, Ottawa, 1957, Chap. 7.

## Books and Periodicals

Leontief, W.W., "Domestic Production and Foreign Trade: The American Capital Position Reexamined", Proceedings of the American Philosophical Society, 97, September, 1955, pp. 332-349.

This was the first study which attempted to test empirically the factor-proportions theory.

Samuelson, P.A., "International Trade and Equalization of Factor Prices", in Economic Journal, No. 58, June, 1948, pp. 163-184.

This article presents a systematic exposition of the factor-proportions theory in a two-factor, two-commodity model.

Vanek, J., The Natural Resource Content of United States Foreign Trade 1870-1955, The M.I.T. Press, Cambridge, Massachusetts, 1963, xvi-140 p.

This book discusses the most important theoretical concepts and tools of measurement used in our inquiry and adapts the factor-proportions theory to the case where three factors of production are used in producing large numbers of commodities. In an empirical study, J. Vanek considers the direct and indirect natural resource product requirements of American foreign trade.

-------- "The Natural Resource Content of United States Foreign Trade, 1870-1955, and the Relative Abundance of Natural Resources in the United States", Review of Economics and Statistics, May, 1959,

This article is a summary of the author's Ph.D. thesis.

Wahl, D.F., "Capital and Labour Requirements for Canada's Foreign Trade", in The Canadian Journal of Economics and Political Science, Vol. 27, No. 4, August, 1961, pp. 349-358.

D.F. Wahl used the input-output method to evaluate capital and labour requirements of Canadian exports and competitive imports.

## Government Publications

Dominion Bureau of Statistics, Trade of Canada, Vol. 1, Summary and Analytical Tables, Catalogue No. 65-201, issue of 1959-60, Ottawa, 1960.

This publication records Canadian foreign trade statistics using the degree of manufacture classification.

Dominion Bureau of Statistics, Review of Foreign Trade, issues of 1954, 1957 and 1960, Catalogue No. 65-204 and 65-205, Ottawa.

This review records price and volume indexes of Canadian foreign trade.

Dominion Bureau of Statistics, Supplement to the Inter-Industry Flow of Goods and Services Canada 1949, Catalogue No. 13-513, Ottawa, 1960, 60 p.

This publication provided all the necessary information to compute the indirect natural resource product requirements of Canadian foreign trade.

# GLOSSARY OF MOST FREQUENTLY USED SYMBOLS

| Symbol | | Introduced on Page |
|---|---|---|
| $C_1$ | the first theoretical measure of natural resource content | 2 |
| $C_2$ | the second theoretical measure of natural resource content | 3 |
| $C_3$ | the workable measure of natural resource content | 4 |
| I | the ideal index of natural resource content in a country foreign trade | 18 |
| $I_1$ | the index of natural resource content including both the direct and indirect requirements | 19 |
| $I_2$ | the index of natural resource content excluding the indirect requirements | 26 |
| $I_2'$ | the relative natural resource content per dollar | 29 |
| K | volume of capital inputs | 2 |
| Kg | volume of capital-intensive goods | 65 |
| L | volume of natural resource inputs | 2 |
| $L_r$ | volume of natural resources embodied in the natural resource products | 16 |
| $L_s$ | volume of natural resources embodied in the non-natural resource products | 16 |
| $L_{rd}$ | volume of natural resources entering in the volume of natural resource products directly traded | 20 |
| $L_{rs}$ | volume of natural resources entering in the volume of natural resource products indirectly traded | 20 |
| M | volume of import | 2 |
| N | volume of labour inputs | 2 |
| Ng | volume of labour intensive goods | 65 |
| p | unit price or price index of export or import | 3 |
| P | unit price or price index of natural resource products | 4 |
| r | unit rent or an index of unit rent changes | 2 |

# GLOSSARY OF MOST FREQUENTLY USED SYMBOLS

| Symbol | | Introduced on Page |
|---|---|---|
| R | volume of natural resource products | 4 |
| $R_d$ | volume of natural resource products directly traded | 18 |
| $R_s$ | volume of natural resource products indirectly traded | 19 |
| S | volume of non-natural resource products | 11 |
| T | volume of non-land factors | 11 |
| $T_{rd}$ | volume of non-land factors entering in the volume of natural resource products directly traded | 20 |
| $T_{rs}$ | volume of non-land factors entering in the volume of natural resource products indirectly traded | 20 |
| X | volume of exports | 2 |

The subscript i run across industries and

The superscript ' stands for the value instead of

the volume of the particular variable.

# The Abstract of
# Canada's Factor Endowment

This thesis inferred Canada's factor endowment from the net trade of natural resources, labour and capital between Canada and the rest of the world.

The main task has been to measure the natural resource requirements of Canadian foreign trade since the labour and capital requirements had already been computed by others. It has been demonstrated that natural resource products may be used as a very good proxy for natural resource content of Canadian foreign trade.

The conditions which make valid the inference of the factor abundance from the factor requirements of foreign trade are then discussed. It has been argued that even if the conditions were not fully encountered in the real world, the validity of the inference was not affected. Canada was found to be a labour-poor and a natural resource-rich country.