1982

Canadian Import Demand, And The Effects Of Tariffs On The Prices Of Domestic Factors

Brendan Murphy

CANADIAN IMPORT DEMAND, AND THE EFFECTS OF TARIFFS ON THE PRICES OF DOMESTIC FACTORS

by

Brendan Murphy

Department of Economics

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Faculty of Graduate Studies

The University of Western Ontario

London, Ontario

July, 1982

ABSTRACT

Canada's demand for imports is examined using an econometric model derived from production theory. The production theory approach provides a useful framework for examining two important issues: the effects of Canada's tariff policies on wage and rental rates, and the effects of changes in the price of imports on the demand for imports.

Three important problems that arise in moving from the theoretical model of the production sector to the econometric model are examined in the empirical work: choosing a method of analysing the technology of the production sector; specifying a functional form for the technology; and specifying the speed with which the production sector adjusts following any change in exogenous variables.

The empirical results provide strong evidence that Canada's tariff policies redistribute income from owners of labour to owners of capital. In fact, higher import prices - caused by (increases in) tariffs, for example - lead to an increase in the rental rate and a decrease in the wage rate. The empirical results also indicate that Canadian import demand is quite responsive ("elastic") to changes in the price of imports.

The gradual adjustment of the production sector in

response to an increase in the price of imports is analysed in the theoretical work. The analysis focuses on how domestic factor prices change during the various stages of the adjustment. One interesting result is that the short-run changes in the prices of some or all of the domestic factors could be reversed in the long run. Thus, there could be a conflict between the short-run and long-run interests of the owners of domestic factors.

ACKNOWLEDGEMENTS

I am indebted to Professor David Burgess, my chief advisor. He encouraged me to undertake this research and his guidance and assistance have been very important at every stage. I am grateful, also, to Professors Elie Appelbaum, Robin Carter, Jim Markusen and Chin Lim for their advice and encouragement. Finally, I want to thank Laurie Bildfell who encouraged and helped me to finish.

This thesis is dedicated to my mother and to the memory of my father.

TABLE OF CONTENTS

LIST OF TABLES

Table	Description	Page
5.11	The Own Price (Partial) Elasticity of Demand for Imports	105
5.12	The Effect on Wage and Rental Rates of a One Percent Increase in the Price of Imports	106
5.13	Translog Cost Function With Disaggregated Imports: R^2, D.W. Statistics and Value of Log of Likelihood Function	108
5.14	Tests of the Null Hypotheses	109
5.15	Parameter Estimates - The Disaggregated Imports Case	110
6.1	Choosing the Value of the Adjustment Parameter (λ)	126
6.2	Comparison of the Planning Price and Actual Price of Imports	127
6.3	Parameter Estimates - The Model With the Planning Price of Imports	128
6.4	Adjustment of the Planning Price of Imports	129
6.5	Point Estimates of Elasticities	130
6.6	The Own Price (Partial) Elasticity of Demand for Imports	131
6.7	The Effect on Wage and Rental Rates of a One Percent Increase in the Planning Price of Imports	132
6.8	The Cumulative Percent Change in the Wage Rate Following a One Percent Increase in the Price of Imports: Points Along the Adjustment Path	133
7.1	The Variety of Short-Run Equilibria and Conflicts Between Short Run and Long Run: The Case of a Tariff on Intermediate Goods	159

CHAPTER I

INTRODUCTION AND OVERVIEW

In this thesis I re-examine two issues that have long interested economic researchers and policy-makers: how Canada's tariff policies affect the real incomes of the owners of domestic factors of production, and how Canada's demand for imports responds to changes in the price of imports. Although these issues have been examined in many empirical studies, most of these studies have been criticized for using ad-hoc econometric models, and for neglecting the insights provided by the theory of international trade.

Accordingly, one major aim of this thesis is to bring theoretical and empirical work closer together by deriving the econometric model used in the empirical work directly from a theoretical model. This approach has many advantages. It improves the specification of the econometric model and thus improves the quality of the empirical work. It permits an empirical examination of the theoretical model, which is useful for guiding future theoretical work. And finally, the approach ensures that the close connection between the two issues examined in this thesis is carried over into the econometric specification of the model. In the past, empirical studies have usually examined one or the other, but not both, of these issues, despite the fact that theoretical studies have shown the close connection between them. The econometric model used here provides a single framework for empirically examining both of these issues.

I use a theoretical model that is based on the behavioural assumption that domestic profit maximizing (or cost minimizing) firms use combinations of imported goods and domestic factors of production to produce final goods. All imports are treated as inputs in the process of producing final goods, and no distinction is made between (for example) imports of raw materials and imports of end products. One reason for treating all imports as inputs is that all imports are purchased by domestic firms, and thus all imports require some processing by domestic firms before they are sold to final users. More fundamentally, the treatment of all imports as inputs recognizes that all final goods sold by the production sector must ultimately have been produced using domestic primary factors and/or imported goods.

This theoretical model was used as a framework in two recent studies of Canada's imports.[1] These studies demonstrated the usefulness of this framework, and they also provided some important empirical evidence on both the elasticity of demand for Canada's imports, and the effects of tariffs on the prices of domestic factors.[2] However, these studies did not examine the practical problems that arise in setting up and estimating the econometric model. Since the manner in which these practical problems are resolved can affect the empirical results, it is important to examine these problems in order to improve the quality of the empirical work. A major part of this thesis is devoted to explaining three important practical problems, and exploring how each of these problems affects the empirical results.

The first problem arises in choosing a functional form to represent the technology of the production sector. It is important that the functional form used imposes the minimum number of undesirable restrictions on the empirical work. Now, in this thesis I assume that firms use at least three inputs - capital services, labour services, and imported goods - in the production process. There is no a priori reason for believing that the extent to which imports can be substituted for capital services is identical to the extent to which imports can be substituted for labour services. Thus it is important that this belief should not be maintained a priori in the empirical work, the moreso because the theoretical model highlights the importance of these substitution possibilities in determining both the elasticity of demand for imports, and the effects of tariffs on domestic factor prices. This consideration suggests that some of the more familiar functional forms used to describe the technology, such as the Cobb-Douglas function, or the Constant-Elasticity-of-Substitution (C.E.S.) function, should not be used in the empirical work, since these functions do impose this belief a priori.

Fortunately, in recent years, a large number of functional forms - called flexible functional forms - which impose no a priori restrictions on the extent to which inputs can be substituted for one another in the production process have been developed. The Translog, the Square-Root Quadratic, and the Generalized Leontief are examples of flexible functional forms[3], and these are well suited for my empirical work. There remains, however, the problem of choosing a particular flexible functional form from amongst the many forms that are available. This is an important step, since the empirical results will be affected by the type of flexible functional form used. I compare the empirical results derived from three different functional forms to see how sensitive my results are to changes in the specification of the functional form.

The second problem arises in choosing a method of analyzing the questions I am interested in. The analysis can be performed using a production function or a cost function or a restricted profit function. However, the empirical results will differ depending upon which method of analysis is chosen, particularly when flexible functional forms are used. Since I use flexible functional forms in my empirical work, it is important to examine how sensitive the empirical results are to changes in the method of analysis. I estimate both a cost function and a restricted profit function and I compare the results derived from these two empirically different methods of analysis.

The third problem arises in modelling how firms react to changes in exogenous variables. In empirical work, it is often assumed that firms adjust effortlessly to changes in exogenous variables, to ensure that they always use the least-cost techniques of production. A useful modification of this assumption recognizes that, since these are adjustment costs, firms may adjust slowly to any changes in exogenous variables. Thus, for example, whenever the price of imports changes, firms may adjust slowly to this change. If it is assumed, on the contrary, that firms adjust instantaneously to the change in import prices, the own price elasticity of demand for imports may be underestimated. I specify an econometric model that allows firms to adjust slowly to any changes in import prices. The assumption of instantaneous adjustment is a special case of this more general model, and thus it is possible to test how quickly Canada's production sector reacts to any changes in import prices.

In addition to examining the practical problems that arise in moving from the theoretical model to the empirical work, I use the theoretical model to examine in some detail how tariffs on imports affect the prices of domestic factors. The theoretical model used in this thesis differs from the more familiar theoretical models used in trade theory. As I mentioned above, all imports are treated as inputs. Thus the initial impact of tariffs on imports is to increase the cost of an input used in the production process. In the more familiar models, on the other hand, imports are often treated as final demand goods, and the initial impact of tariffs on imports is to change the relative prices of final goods. The analysis of the effects of tariffs provided here thus provides an interesting comparison to the more familiar analyses.

One important insight provided by the theoretical model is that the ability of firms to substitute between domestic factors and imported goods often plays an important role in determining how tariffs on imports affects the prices of domestic factors. The exact nature of these theoretical results depends upon the constraints faced by the firms in the economy. Following the tradition of theoretical studies of international trade, and in order to provide a more complete understanding of how tariffs on imported inputs (or, imported intermediate goods) affect the prices of domestic factors, I provide a theoretical examination of the effects of such tariffs under two different assumptions concerning the mobility of the domestic factors of production. The first assumption is that the domestic factors are freely mobile between all firms in all sectors of the economy. The second assumption is that one of the domestic factors is immobile between the different sectors of the economy. While the analysis using the former assumption - the "long-run" case - is well known, an explicit analysis using the latter assumption - the "short-run" case - has not been presented in the literature on the theory of trade. A comparison of the long-run and short-run results is quite revealing. For example, tariffs on imported intermediate goods can benefit the owners of a domestic factor in the short run, but harm them in the long run.

* * * * *

The presentation of the thesis is organized as follows:

In Chapter II I outline the theoretical model used in the thesis. I show how the econometric specifications used in the empirical work are derived from the theoretical model, and I outline the practical problems that arise in moving from the theoretical model to the empirical work.

In Chapter III I review some empirical studies of Canada's demand for imports, and some empirical evidence on the general equilibrium effects of Canada's tariff policies on the wage and rental rates in Canada.

In Chapters IV, V and VI I present the results of my empirical work. Chapter IV deals with the problem of choosing a flexible functional form. Chapter V contains a comparison of the empirical results derived from estimating a cost function and a restricted profit function. Chapter VI deals with the problem of specifying an econometric model that incorporates the assumption that firms adjust slowly to any changes in the price of imports.

In Chapter VII I use the theoretical model introduced in Chapter II to examine how tariffs on imports affect the prices of domestic factors in the short run. I also compare the short-run changes with the long-run changes in factor prices.

Finally, in Chapter VIII I present a summary of the results of my research.

FOOTNOTES - CHAPTER I

1. See Kohli [1978] and Appelbaum and Kohli [1979].

2. Throughout this thesis the expression "the price of labour (capital)" is used interchangeably with "the wage rate (rental rate)".

3. The Translog Functional Form is discussed in Christensen, Jorgensen and Lau (1971); the Square-Root Quadratic in Lau (1974); and the Generalized Leontief in Diewert (1971).

CHAPTER II

AN OUTLINE OF THE THEORETICAL MODEL AND THE DERIVATION OF THE ECONOMETRIC MODEL

In this chapter I outline the theoretical model which forms the basis for my empirical work[1], and I derive the theoretical results which I (later) examine empirically.[2] I also indicate how the econometric specifications used in the empirical work are derived from the theoretical model, and I explain some practical problems that arise in setting up the econometric model.

THE MODEL

I assume that one final demand output is produced by a large number of profit maximizing firms.[3] All firms use three inputs: capital services, labour services and imported goods, and there are constant returns to scale in production. The production process can be represented by a production function:

$$Y = F(K, L, M) \tag{1}$$

where Y, K, L and M are the quantities of output, capital services, labour services and imports, respectively; and where F(.) is linearly homogeneous (given the assumption that there are constant returns to scale in production).

Assume, now, that the economy faces exogenous prices for the final demand output (P_Y) and for the imports (P_M), and assume that the supply of the domestic factors (K and L) is fixed. Given perfect competition (and constant returns to scale), the economy behaves as if it maximizes value added.[4] Thus the equilibrium for the economy can be found by solving the following problem:

$$\max_{\{Y,M\}} P_Y Y - P_M M: \quad \begin{aligned} Y &\le F(K,L,M) \\ K &\le \bar{K} \\ L &\le \bar{L} \end{aligned} \qquad (2)$$

There are a number of ways in which we can now proceed:

A. The Production Function

We can solve the optimization problem (2). The solution to this problem, assuming full employment of domestic factors, is given by:

$$\begin{aligned} P_Y F_K &= r \\ P_Y F_L &= w \\ P_Y F_M &= P_M \\ F(K,L,M) &= Y , \end{aligned} \qquad (3)$$

where $F_K = \frac{\delta F}{\delta K}$, and similarly for F_L, F_M, and

$r(w)$ is the price of capital services (labour services).

The equations (3) are the inverse demand functions for the three inputs used in the production process, and the supply of final demand output function. It is clear from these equations how the demand for imports is determined: Firms decide what quantity of all inputs to use in the production process, and these decisions determine the demand for all inputs, including imports. The equation of the demand for imports is one equation within a system of demand equations.

The expression for the (inverse) own price (partial) elasticity of demand for imports can be found by differentiating the first order condition

$$P_Y F_M = P_M$$

holding P_Y, K and L constant. The general equilibrium effects of a change in the price of imports on the prices of the domestic factors can be examined by totally differentiating the equations (3), holding P_Y, K and L constant.[5]

The results of these exercises are in the form of derivatives of the production function. Thus, in order to find empirical estimates of these results we must specify a functional form of the production function (1), and then estimate the parameters of this production function. (This procedure is used by Appelbaum and Kohli (1980), for example, whose work is discussed in Chapter III, below.) But while the theoretical model directs us to estimate the parameters of a three-input production function, it does not indicate what particular (flexible) functional form should be used in the empirical work. Thus if we choose to analyse the demand for imports using a production function, one practical problem that arises in moving from the theoretical model to empirical work is the problem of choosing a functional form of the production function.

B. The Restricted Profit Function

Rather than explicitly solving the optimization problem (2), we note that the solution will be in the form of a restricted profit function

$$\pi(P_Y,\ P_M;\ K,\ L) \tag{4}$$

That is, given that the economy behaves as if domestic value added is maximized, the production sector of the economy can be represented by a restricted profit function defined as[6]:

$$\pi(P_Y,\ P_M;\ K,\ L) \equiv \underset{\{Y,M\}}{\text{MAX}}\ P_Y Y - P_M M: \quad \begin{array}{l} Y \leq F(K,L,M) \\ K \leq \overline{K} \\ L \leq \overline{L}, \end{array}$$

Using Hotelling's (1932) lemma, we can differentiate the restricted profit function (4) to find the equations for the supply of output, the demand for imports, and the (inverse) demand for capital services and labour services:

$$\pi_{P_Y} = Y$$

$$\pi_{P_M} = -M$$

$$\pi_K = r$$

$$\pi_L = w, \qquad (5)$$

where $\pi_{P_Y} = \frac{\delta\pi}{\delta P_Y}$, and similarly for π_{P_M}, π_K, and π_L.

Expressions for the own price (partial) elasticity of demand for imports, and for the general equilibrium effect of a change in the price of imports on the prices of domestic factors can be found by (totally) differentiating the equations (5). In this case, the results are in the form of derivatives of the restricted profit function: The own price (partial) elasticity of demand for imports is derived by differentiating the first order condition

$$\pi_{P_M} = -M$$

holding P_Y, K and L fixed. The result is:

$$\left(\frac{\delta M}{\delta P_M}\right)\left(\frac{M}{P_M}\right) = -\left(\pi_{P_M P_M}\right)\left(\frac{P_M}{M}\right), \qquad (6)$$

where $\pi_{P_M P_M} \equiv \frac{\delta^2 \pi}{\delta P_M \delta P_M}$.

The proportional change in domestic factor prices caused by a one percent increase in the price of imports is derived by differentiating the first order conditions

$$\pi_K = r$$
$$\pi_L = w$$

holding P_Y, K and L fixed. The results are:

$$\hat{r} = (\pi_{KP_M}) \left(\frac{P_M}{\pi_K}\right)$$
$$\hat{w} = (\pi_{LP_M}) \left(\frac{P_M}{\pi_L}\right) \qquad (7)$$

where $\pi_{KP_M} = \frac{\delta^2 \pi}{\delta K \delta P_M}$, and similarly for π_{LP_M}, and where $\hat{w}(\hat{r})$ is the proportional change in the wage rate, $\frac{dw}{w}$ (rental rate, $\frac{dr}{r}$).

These results can be rewritten in the following manner:

$$\hat{r} = H_{KM}\theta_M$$
$$\hat{w} = H_{LM}\theta_M \qquad (8)$$

where $H_{KM} = \frac{\pi\pi_{KP_M}}{\pi_K \pi_{P_M}}$, the elasticity of intensity[7] between capital and imports,

$H_{LM} = \frac{\pi\pi_{LP_M}}{\pi_L \pi_{P_M}}$, the elasticity of intensity between labour and imports, and

$\theta_M = \frac{P_M M}{\pi}$, the share of imports in restricted profits.

Finally, in order to find empirical estimates of these results we must specify a functional form of the restricted profit function (4) and then estimate the parameters of this function - and, again, the problem of choosing a particular functional form arises. This procedure is used by Kohli (1978), for example, whose work is discussed in Chapter III, below. I use this procedure in Chapters V and VI.

C. The Cost Function

Rather than solving the optimization problem (2), we can solve the dual of this problem. The dual problem is

$$\underset{\{r,w,P_M\}}{\text{MINIMIZE}}\ wL + rK: \quad C(r,w,P_M) \geq P_Y$$
$$r,w,P_M \geq 0 \tag{9}$$

where $C(r,w,P_M)$ is the unit cost function, defined as the minimum cost of producing a unit of final demand output when the input prices are r, w and P_M.[8] Using Shephard's lemma, we can differentiate the unit cost function to find:

$$YC_r = K$$
$$YC_w = L$$
$$YC_{P_M} = M$$
$$C(r,w,P_M) = P_Y \tag{10}$$

where $C_r = \frac{\delta C}{\delta r}$, and similarly for C_w, C_{P_M}.

Once again, expressions for the own price (partial) elasticity of demand for imports, and for the general equilibrium effect of a change in the price of imports on the rewards of domestic factors can be found by (totally) differentiating the equations (10). In this case, the results are in the form of derivatives of the unit cost function: The own price (partial) elasticity of demand for imports is derived by differentiating the first order condition

$$YC_{P_M} = M$$

holding Y, r and w fixed.[9] The result is:

$$\left(\frac{\delta M}{\delta P_M}\right)\left(\frac{M}{P_M}\right) = (C_{P_M P_M})\left(\frac{P_M \cdot Y}{M}\right) \tag{11}$$

where $C_{P_M P_M} = \delta^2 C/\delta P_M \delta P_M$.

The proportional change in domestic factor prices caused by a one percent increase in the price of imports is derived by differentiating the first order conditions (10), holding P_Y, K and L fixed. The results are[10]:

$$\hat{r} = \frac{\theta_L \theta_M}{\Delta}\{S_{KM} - S_{LM} + S_{LL} - S_{LK}\}$$

$$\hat{w} = \frac{\theta_K \theta_M}{\Delta}\{S_{LM} - S_{KM} + S_{KK} - S_{LK}\} \tag{12}$$

where $S_{ij} \equiv \frac{CC_{ij}}{C_i C_j}$, $i,j = K,L,M$

$\theta_K \equiv \frac{rC_r}{C}$, and similarly for θ_L, θ_M, and

$\Delta = \theta_K \theta_L (2S_{KL} - S_{KK} - S_{LL})$

≥ 0, since the unit cost function is linear homogeneous and concave in (w, r, P_M).

The θ_i's are the shares of the inputs in unit costs, while the S_{ij}'s are the Allen (1938)/Uzawa (1962) partial elasticities of substitution between the inputs in the production process, where S_{ij} measures the (normalized) change in the demand for input i following a change in the price of input j, holding the quantity of output and the prices of all other inputs constant.[11] Two factors are said to be (Allen/Uzawa) substitutes if $S_{ij} = S_{ji} > 0$, and complements if $S_{ij} = S_{ji} < 0$. Note that $S_{ii} < 0$.

The results indicate that the (real) price of <u>at most</u> one of the domestic factors could increase following an increase in the price of imports. For example, if we assume that capital and labour are substitutes in production, so that $S_{LK} > 0$, then the expressions $(S_{KK}-S_{LK})$ and $(S_{LL}-S_{LK})$ are both negative. In this case, the rental rate will increase if the expression $(S_{KM}-S_{LM})$ is positive and sufficiently large. (Note that if $(S_{KM}-S_{LM})$ is positive, the wage rate will decrease.) Thus, the likelihood that the owners of capital will be better off following the imposition of a tariff is greater, the greater the degree of substitutability between capital and the imports, and the greater the degree of complementarity between labour and imports.

If tariffs raise the price of capital in Canada then capital formation will be encouraged.[12] How will an increase in the endowment of capital affect the demand for imports? In fact, the proportional change in the demand for imports caused by a one percent increase in the endowment of capital is the dual of the proportional change in the price of capital caused by a one percent increase in the price of imports. Differentiating the first order conditions (10), holding P_Y, P_M and L fixed, we find:

$$\hat{M} = \frac{-\theta_L\theta_K}{\Delta}\,[S_{KM} - S_{LM} + S_{LL} - S_{LK}]\hat{K} \qquad (13)$$

where $\hat{M} = \frac{dM}{M}$, and similarly for $\hat{K}$.

It is possible, of course, that the prices of both domestic factors would fall following an increase in the price of imports. If the prices of both domestic factors fall, it is interesting to consider which factor suffers the larger proportional decline in price. The answer to this factoral income distribution question depends on the elasticities of substitution between the inputs in the production process. In particular,

$$\hat{w} - \hat{r} > 0 \text{ iff } (S_{LM} - S_{KM}) > 0$$

Thus (for example) labour gains relative to capital whenever $S_{LM} > S_{KM}$, that is, whenever labour is more substitutable for imports than is capital.

It is worth pointing out that the increase in the price of imports examined here can be interpreted (more generally) as a worsening of Canada's terms of trade. The (tariff-distorted) terms of trade are given by (P_Y/P_M); an increase in P_M, holding P_Y fixed, clearly represents a decline in the terms of trade. (Note that if $\hat{P}_M = \hat{P}_Y = 1\%$, $\hat{w} = \hat{r} = 1\%$. That is, the (real) prices of domestic factors change only if the terms of trade change.) Thus the results derived here also indicate how factor prices are affected by a change in Canada's terms of trade.

Finally, in order to find empirical estimates of these results we must specify a functional form of the unit cost function, and then estimate the parameters of this function - and, again, the problem of choosing a particular functional form arises. I use this procedure in Chapters IV and V.

CONCLUSION

In this chapter I have outlined the theoretical model which forms the basis of the empirical work performed in this thesis. I have also used this model to examine both the determinants of the demand for imports, and the effects of changes in import prices on the (real) prices of domestic primary factors. One important result is that the demand for imports is determined simultaneously with the demand for all other inputs, and that the demand-for-imports equation is one equation within a system of equations. A second important result is that the effects of a change in the price of imports on factoral income distribution depend crucially on the degree of substitutability (or "intensity") between imports and the domestic factors.

I have also shown that I can choose one (or more) of three methods - the production function, the restricted profit function, and the cost function - to analyse the issues I am interested in. While the theoretical results are not affected by the choice of analysis, the empirical results will be affected by the choice. Again, once a method of analysis has been chosen, a particular flexible functional must be chosen in order to undertake empirical work, and the empirical results will be affected by the choice of a functional form. Thus it is important to examine how these two choices affect the empirical results. Before proceeding to these tasks, I present a brief review of some empirical studies of Canada's demand for imports, and I review some empirical evidence on the effects of a change in import prices on the prices of Canada's domestic primary factors.

FOOTNOTES - CHAPTER II

1. The model described here is sometimes called the Production Theory approach.

2. Further theoretical results are presented in Chapter VII, below.

3. The analysis presented here is applicable for an economy that produces many final demand goods, so long as the production process is separable between outputs and inputs. This form of separability implies that changes in the composition of output have no effect on the profit maximizing demand for inputs. See Hall (1973). Alternatively, the analysis is applicable for a multi-output economy if the ratios of the prices of the outputs do not change. See Diewert (1978).

4. See Debreu (1959), pp. 39-45.

5. See below, pp. 16-20, for a derivation and a discussion of the general equilibrium effects of a change in the price of imports on the prices of the domestic factors.

6. See Diewert (1973) for a discussion of the relationship between restricted profit and production functions.

7. See Diewert (1973).

8. See McFadden (1978) for a discussion of the relationship between cost and production functions.

9. Notice that the own price partial elasticity of demand for imports calculated in this manner using the cost function is not directly comparable to the (partial) elasticity calculated using the restricted profit function (see (6)). In calculating the elasticity using the cost function, Y, r and w are held fixed; in calculating the elasticity using the restricted profit function, Y, r and w are allowed to vary. An elasticity comparable to (6) can be calculated using the cost function by totally differentiating the first order conditions (10), allowing Y, r and w to vary.

10. These results are well known. See Burgess (1976).

11. See Allen (1938), pp. 505-509, and Uzawa (1962). These elasticities of substitution are not directly comparable to the elasticities of intensity calculated using the restricted profit function (see footnote 9).

12. The economy's endowment of capital (at the beginning of each time period) is exogenous in the model described in this chapter. An obvious extension would be to endogenise the capital formation process.

A higher rate of capital formation is achieved by diverting more of the economy's (single) output into the investment sector, thus lowering the amount of output available for the consumption and export sectors. Note that if exports now fall short of imports, so that there is a balance of trade deficit, an inflow of foreign funds ("financial capital") is needed to finance the trade deficit. In this sense, we may speak of the tariff causing an inflow of foreign funds.

CHAPTER III

LITERATURE REVIEW

This literature review is divided into three sections. In the first section I outline the approach used in many empirical studies of Canada's demand for imports. My main objective here is to point out some of the shortcomings of the approach used in these studies. The empirical work undertaken in this thesis does not suffer from these same faults.

In sections two and three I review some empirical evidence on the question of how Canada's tariff policies affect the prices of domestic primary factors. The studies reviewed in section two are not chiefly concerned with the question of how tariffs affect factor prices. Nevertheless, these studies do provide some, often indirect, evidence on the question. In the third section I review two recent empirical studies that use the production theory approach outlined in Chapter II, above, to examine both the determinants of Canada's demand for imports, and the general equilibrium effects of changes in the prices of imports (caused by tariffs, for example) on domestic factor prices.

1. SOME SHORTCOMINGS OF TRADITIONAL STUDIES OF CANADA'S DEMAND FOR IMPORTS

There have been many empirical studies of Canada's demand for imports, including those of Slater (1957), Kemp (1962), Shearer (1962), and Gray (1966). Typically, these studies pay scant attention to the microeconomic foundations of the demand for imports, and instead use an *ad hoc* econometric specification.[1] The demand for imports is written as a linear or loglinear function of domestic value added, and of the price of imports relative to the price of domestic goods. This estimating equation is consistent with the conventional theory of firm and/or household behaviour only when we make restrictive assumptions about the technology of the production sector and/or the utility function of the household sector. Since the theoretical results of international trade models depend upon the characteristics of the domestic economy's technology, it is important to test these restrictions empirically rather than impose them *a priori*.[2] In addition, the fact that the import demand equations are part of a complete system of demand equations is usually ignored, and in the estimation no use is made of the properties of complete demand systems.

This crude treatment of imports is also to be found in conventional macro-economic models, such as Rhomberg (1964), and Candide Model 1.2 (1975). One exception is RDX2 (1977), where close attention is paid to the micro-foundations of the demand for imports. The demand for imports is explicitly derived from the utility maximizing behaviour of households.

However, because the level of disaggregation makes the number of parameters in an unrestricted model very large, in practice a large number of restrictions are imposed in the econometric work. Moreover, because of a lack of data, an incomplete system of demand equations is estimated, and thus little use can be made of the properties of complete demand systems.

2. SOME EVIDENCE ON THE EFFECTS OF CANADA'S TARIFF POLICIES ON DOMESTIC FACTOR PRICES

The effects of Canada's tariff policies on the development of the Canadian economy have been examined in many empirical studies, including those of Mackintosh (1939), Young (1957), and Dales (1966). These studies show that Canada's tariff policies protected industries in the secondary manufacturing sector. Dales, for example, examined the development of the Canadian economy during the period 1926-1955. He found that Canada's tariff policies encouraged the growth of the secondary manufacturing sector. He also pointed out that the expansion of job opportunities in the protected sector led to an increased immigration of labour from Europe. Barber (1955) interpreted the results of these studies using the Stolper-Samuelson (1941) theorem. He reasoned that Canada's tariff policies increased the prices of final outputs of the secondary manufacturing sector, and since this sector was relatively labour intensive, the tariff policies raised real wages and lowered the real rental rate.

The Stolper-Samuelson (1941) theorem can also be used to derive evidence on the factoral income distribution question from studies of the labour and capital content of Canada's imports and exports. Wahl (1961) examined Canada's imports and exports to determine whether imports were relatively labour intensive or relatively capital intensive. He found that "Canadian exports in 1949 were capital intensive while imports were labour intensive" (p. 357) and that "the abundant factor [labour] is used in the import-competing sector" (p. 358). Wurzburger (1978), using input-output data presented in Postner (1975), calculated that in 1970 "in the export sector, each dollar input of labour flow (direct and indirect) requires $3.33 of fixed capital stock, while in the aggregate economy each dollar input of labour flow requires $2.70 of fixed capital stock as an input. The export sector is indeed more capital intensive." Thus, using the Stolper-Samuelson theorem, these results suggest that tariff policies, to the extent that these policies raise the prices of final demand imports, cause an increase in the real wage rate and a reduction in the real rental rate in Canada.

It is worth pointing out, however, that the Stolper-Samuelson result shows the effects of tariffs in an economy that uses two inputs to produce two outputs, and where the production process is nonjoint in inputs. Jones and Scheinkman (1977) present a generalization of the Stolper-Samuelson result. The generalization may be stated as follows: for an economy that produces two or more outputs using two or more inputs (and where the production process is nonjoint in inputs), an increase in the price of an output unambiguously raises the real reward of at least one factor and unambiguously lowers the real reward of at least one (other) factor. However, to determine which factor prices rise and which factor prices fall, we need information on the "technology for each and every commodity-factor share and (in cases in which the number of factors exceeds the number of commodities) the elasticities of substitution between factors" (p. 915). This result of Jones and Scheinkman warns against placing two much confidence in the distributional implications I have derived above from the studies of Wahl (1961) and Wurzburger (1978).

Finally, it has been suggested that studies of effective protection provide some evidence on the question of how a country's tariff policies affect the rewards of its domestic primary factors.[3] The effective rate of protection measures, for each industry, the extent to which the existing tariff structure has increased the value added per unit of output, where value added in any industry is the total reward of the domestic primary factors used in that industry.[4] Thus, a ranking of industries according to the effective rates of protection in each industry could be used to provide an indication of which factors would lose most immediately following the removal of the tariff structure (and before the inevitable reallocation of resources between sectors. Thus studies of effective protection do not provide evidence on the general equilibrium effects of tariffs.) Alternatively, if those industries which are relatively labour (capital) intensive have higher effective rates of protection, then there is some evidence that the tariff structure raises the price of labour (capital) relative to the price of capital (labour).[5]

Wilkinson and Norrie (1975) calculated the effective rates of protection for 103 Canadian industries in 1966. They found that industries in the manufacturing sector had positive effective rates of protection while all other industries had negative effective rates. The manufacturing industries with the highest effective rates were "clothing and textiles, leather products, furniture, electrical assemblies, food and beverages, copper processing, chemical products and petroleum and coal products" (p. 68). Some of these highly protected industries, such as clothing and textiles, and leather products, are known to be relatively labour intensive industries.[6] These results may indicate, therefore, that Canada's tariff policies protect labour, and that owners of labour would be more adversely affected than owners of capital by a reduction in tariffs.

Overall, the empirical evidence reviewed in this section suggests that Canada's tariff policies benefit labour owners and harm owners of capital. Of course, the evidence is not overwhelming, particularly since the studies reviewed here do not explicitly examine the factoral income distribution question in a general equilibrium framework.

3. TWO EMPIRICAL APPLICATIONS OF THE PRODUCTION THEORY APPROACH

In recent years there have been a number of empirical studies, including those of Burgess (1974A,B, 1975, 1976) for the U.S. economy, and Kohli (1978), and Appelbaum and Kohli (1979) for the Canadian economy, which have provided some direct evidence on the general equilibrium effects of tariffs on the prices of domestic factors. At the same time, these studies have corrected some of the shortcomings of the traditional approach to estimating the demand for imports. There are a number of features common to all of these studies, and it is useful to outline these common features before proceeding to a discussion of the results of Kohli (1978) and of Appelbaum and Kohli (1979).

In the studies, imports are treated as inputs into the domestic production process. The econometric models used in the empirical work are derived explicitly from production theory, in the manner outlined in Chapter II, above. The production process is represented by a flexible functional form of a production, cost or restricted profit function. These functions are not estimated directly[7]; instead, a complete system of supply (of outputs) and demand (for inputs) equations is derived, and this system of equations is estimated. Thus, the demand for imports is estimated within a system of demand equations. Finally, the parameter estimates are used to calculate the general equilibrium effect of a change in the price of imports on the prices of the domestic factors.

Kohli (1978) assumed that the Canadian production sector produced three outputs - consumption, investment, and exports - using three inputs - capital services, labour services and an aggregate imported input. He represented the production process by a Translog restricted profit function. Using annual data for the years 1949-1972 inclusive, he estimated the complete system of supply and demand equations for the production sector. He found that "the own partial price elasticity of the demand for imports fluctuates between -0.9 and -1 during the sample period, and that the own partial price elasticity of the supply of exports varies between 1.5 and 2.2" (p. 176). Turning to the effects of tariffs on domestic factor rewards, Kohli found that an increase in the price of the aggregate imported input (or a decrease in the price of the export good), redistributed income from labour to capital: in fact, the rental rate rose and the wage rate fell. He also found that a simultaneous increase in the price of imports and exports increased the rental rate and reduced the wage rate.

Appelbaum and Kohli (1979) studied Canada-U.S. trade with a view to determining whether or not Canadian firms buying inputs from the U.S. exercised monopsony power, and whether or not Canadian firms exporting goods to the U.S. exercised monopoly power. To examine the former question, the authors assumed that the Canadian production sector used three inputs - capital, labour, and "imports from the U.S."- to produce an aggregate output, and that the U.S. production sector used two inputs - capital and labour - to produce two outputs, exports to Canada and "all other" output. Both production sectors were represented by a Generalized Leontief production function. The authors derived a function representing the U.S. supply of exports to Canada from the U.S. production function. The maintained hypothesis was that Canadian importers behave monopsonistically (given the U.S. supply of exports to Canada function), and the authors tested the null hypothesis of price-taking behaviour on the part of Canadian importers.

The authors estimated their model using annual data for the years 1951-1972. They found that they were unable to reject the hypothesis that when Canadian firms bought imports from the U.S., the firms behaved as price-takers. Also, using a model very similar to the model outlined in the preceding paragraph, the authors rejected the hypothesis that Canadian firms exporting to the U.S. behaved as price-takers. Turning to the effects of import tariffs on Canadian wage and rental rates, their results indicated that an increase in the price of U.S. imports increased the rental rate and reduced the wage rate in the Canadian economy.

In summary, the results of Kohli (1978) suggest that an increase in the price of aggregate Canadian imports increases the real rental rate and reduces the real wage rate in Canada. The results of Appelbaum and Kohli (1979) suggest that an increase in the price of "imports from the U.S." has the same qualitative effect. This evidence suggests that Canada's tariff policies protect capital owners and harm labour owners.

* * * * * * * * *

How accurate are these results? In this thesis, I examine this question, and I extend the work begun in these two studies by examining a number of important issues that are not discussed in either of them. First, I examine how the choice of flexible functional form influences the empirical results. Second, I examine how the empirical results derived from estimating a cost function differ from the results derived from estimating a restricted profit function. Third, I disaggregate Canada's imports into two categories - imports from the U.S., and "all other" imports - and I examine Canada's demand for "all other" imports. Finally, I discuss how firms adjust to changes in exogenous prices, and I re-estimate the effects of changes in import prices in a model where firms adjust slowly to any changes in exogenous prices.

FOOTNOTES -- CHAPTER III

1. The criticisms made in this paragraph are well known. See Leamer and Stern (1970), Burgess (1974, 1976) and Kohli (1978).

2. Burgess (1974) makes this point.

3. See, for example, Burgess (1976). However, many students of effective protection have stressed that effective protection studies should not be used as a basis for examining the general equilibrium effects of (changes in) tariffs. See, for example, Melvin and Wilkinson (1968).

4. An alternative method of measuring the effective rate of protection is to calculate the percentage decrease in value added per unit of output following the removal of tariffs. This method was used by Wilkinson and Norrie (1975).

5. Burgess (1976) discusses these two interpretations of effective rates of protection. See also Balassa (1965), Bavesi (1966) and Travis (1968).

6. See Wilkinson and Norrie (1975), p. 60.

7. For an exception, see Burgess (1975).

CHAPTER IV

CHOOSING A FLEXIBLE FUNCTIONAL FORM

1. INTRODUCTION

A variety of flexible functional forms is available for use in empirical work. There is no *a priori* reason for choosing any particular flexible form for the empirical work in this thesis.[1] Some flexible form must be used, however, and choosing a particular flexible form is an important step since the empirical results will be affected by the choice.

In a recent paper, Appelbaum (1979) demonstrated a technique which provides some guidance in choosing which flexible functional form to use in any particular empirical study. In this paper, Appelbaum introduced a generalized functional form which can be restricted to yield three commonly used flexible functional forms - the Translog, the Square-Root Quadratic, and the Generalized Leontief.[2] It is thus possible to begin any empirical study by performing parametric tests to determine whether any of these functional forms should not be used. Appelbaum applied this technique using data from the U.S. manufacturing sector. He represented the U.S. manufacturing sector by a generalized functional form of the production function, and he tested and rejected all three functional forms.[3]

In this chapter, I use the technique introduced by Appelbaum (1979) to explore the problem of choosing a functional form for the technology of the Canadian production sector. I assume that the production sector produces one output, using three inputs.[4] I represent the technology by a cost function, and I compare three different flexible functional forms of the cost function.

I find that I cannot reject any of the three functional forms. For all three functional forms, an increase in the price of imports reduces both the price of capital and the price of labour. However, there is no unanimity concerning the factoral income distribution effects of a change in the price of imports.

This chapter is organized as follows: In Section 2 a generalized functional form for the unit cost function is presented, and three commonly used flexible functional forms are derived as special cases of this generalized form. In Section 3, I discuss briefly the method of estimation. In Section 4, I present and discuss the results of the estimation.

2. THREE FLEXIBLE FUNCTIONAL FORMS OF THE UNIT COST FUNCTION

Suppose the unit cost function is given by[5]

$$C(\lambda) = \sum_i \alpha'_i \, w_i(\lambda) + \frac{1}{2} \sum_i \sum_j \beta_{ij} \, w_i(\lambda) w_j(\lambda) \qquad (1)$$

where C is the unit cost function,

w_i are the input prices,

$\beta_{ij} = \beta_{ji}$ (symmetry), and

$C(\lambda)$ and $w_i(\lambda)$ are the Box-Cox (1964) transformations given by:

$C(\lambda) = (C^{2\lambda}-1)/2\lambda,$

$w_i(\lambda) = (w_i^{\lambda}-1)/\lambda \;, \quad \forall \; w_i.$

By restricting the parameter λ in equation (1), it is possible to get three commonly used flexible functional forms as special cases.

Case 1:

Let $\lambda = 0$.

Then $w_i(\lambda) = \ell n w_i$ and $C(\lambda) = \ell n C$, and we have the Translog functional form:

$$\ell n C = \sum_i \alpha_i \, \ell n w_i + \frac{1}{2} \sum_i \sum_j \beta_{ij} \, \ell n \, w_i \, \ell n \, w_j \qquad (2)$$

This function is linear homogeneous when

$\sum \alpha_i = 1$

$\sum_j \beta_{ij} = 0.$

Case 2:

Let $\lambda = 1$.

Then $w_i(\lambda) = w_i - 1$ and $C(\lambda) = (C^2-1)/2$, and we have the Square-Root Quadratic functional form:

$$C = [\sum_i \sum_j \beta_{ij} w_i w_j + 2 \sum_i (\alpha_i - \sum_j \beta_{ij}) w_i$$

$$+ 2\sum_i (\sum_j \frac{\beta_{ij}}{2} - \alpha_i) + 1]^{1/2} \qquad (3)$$

This function is linear homogeneous when

$\sum_i \alpha_i = 1$, and $\alpha_i = \sum_j \beta_{ij}, \forall i$.

Case 3:

Let $\lambda = 1/2$.

Then $w_i(\lambda) = (w_i^{1/2} - 1)/2$, and $C(\lambda) = C-1$, and we have the Generalized Leontief functional form:

$$C = 2 \sum_{ij}\sum \beta_{ij} w_i^{1/2} w_j^{1/2} + 2\sum_i (\alpha_i - 2\sum_j \beta_{ij}) w_i^{1/2}$$

$$+ 2\sum_i (\sum_j \beta_{ij} - \alpha_i) + 1 \qquad (4)$$

This function is linear homogeneous when

$\sum_i \alpha_i = 1$, and $\alpha_i = 2\sum_j \beta_{ij}, \forall i$

It is convenient to estimate the parameters of these cost functions by estimating the equations representing the share of each input in total cost. These share equations are given, in general, by

$$\frac{\delta C}{\delta w_i} \frac{w_i}{C} = \frac{w_i X_i}{C} = \frac{\alpha_i w_i^\lambda + \sum_j \beta_{ij} w_i^\lambda (w_j^\lambda - 1)/\lambda}{\sum_i \alpha_i w_i^\lambda + \sum_{ij}\sum \beta_{ij} w_i^\lambda (w_j^\lambda - 1)/\lambda} \qquad (5)$$

where X_i is the per unit output demand for factor i.

By imposing the restrictions $\lambda = 0, 1/2$, and 1, we can generate the input share equations corresponding to the Translog, Generalized Leontief, and Square-Root Quadratic functional forms respectively.

3. THE METHOD OF ESTIMATION

Assuming that each cost function provides an exact representation of the technology in the relevant range, the parameters of each cost function can be estimated indirectly by estimating the share equations (5). I adopt a stochastic specification that reflects the fact that errors occur in cost minimization. Let U_{it} be the additive error term for the ith share equation at time t, and let U_t be the vector of error terms for all share equations at time t. I assume that the vectors of error terms are normally distributed, with $E(U_t) = 0$ for all t, $E(U_t U_s') = \Omega$, $t = s$, and $E(U_t U_s') = 0$, $t \neq s$. The share equations are estimated using the non-linear maximum likelihood procedure of Berndt, Hall, Hall and Hausman (1974b)).[6]

Since the share equations contain parameters in common (because of symmetry restrictions, $\beta_{ij} = \beta_{ji}$), the individual equations must be stacked and then estimated as a single equation, in order to obtain consistent estimates (that is to say, in order that we will get one estimate of $\beta_{ij} = \beta_{ji}$). In addition, since the cost shares sum to one, the overall variance-covariance matrix of the stacked equations is singular. I therefore drop one of the input share equations and stack the remaining (n-1) equations. The estimation technique yields estimates which are invariant to the choice of the omitted equation. (In the estimation I omit the equation representing the share of imported inputs in total cost.) The model contains six free parameters in the case where λ is unrestricted, and five free parameters in the case of the three alternate functional forms.

In order to estimate the factor share equations I require time-series data on factor prices and factor quantities. (Note that data on output are not required.) The data on all the variables were supplied by the Bank of Canada. The sample period covers the years 1948-1972, inclusive. (This data is a slightly modified version of the data presented in Kohli (1975), and used by Kohli (1978) and by Appelbaum and Kohli (1979).) Finally, I assume neutral disembodied (or, Hicks-neutral) technical progress during the sample period, which implies that the factor shares are not affected by the technical progress.

4. PARAMETER ESTIMATES, PARAMETRIC TESTS, AND DISCUSSION OF RESULTS

Parameter Estimates

The parameter estimates for the four models, along with the value of the log of the Likelihood function (L) and the Durbin-Watson (D.W.) statistics for the two input share equations estimated in each case, are given in Table 4.I.

The unit cost function must be nondecreasing and concave in factor prices. The unit cost function will have these properties provided

$$\text{(i)} \quad C_{w_i} \geq 0 \ , \ \forall i$$

and

$$\text{(ii)} \quad [C_{w_i w_j}] \text{ is negative semi-definite.}$$

We can check (i) by checking that the predicted cost shares are all positive; and we can check (ii) by checking that the matrix of Allen/Uzawa partial elasticities of substitution, $[\frac{C\, C_{w_i w_j}}{C_{w_i} C_{w_j}}]$, is negative semi-definite.

All three functional forms estimated here (and, indeed, the more general functional form), satisfy conditions (i) and (ii) over the entire sample period.

Parametric Tests

In order to test whether any of the three functional forms are rejected by the data, I test the validity of the corresponding restriction on λ. The test for each functional form thus involves one linear restriction. I use the Likelihood Ratio test, described as follows: if L is the maximum of the Likelihood function of a structural model

TABLE 4.1* Parameter Estimates of the Cost Functions

PARAMETER	UNRESTRICTED	QUADRATIC	LEONTIEF	TRANSLOG
λ	1.1 (0.013)	1	0.5	0
α_L	0.567 (0.002)	0.567 (0.002)	0.57 (0.002)	0.571 (0.002)
α_K	0.26 (0.003)	0.26 (0.003)	0.26 (0.003)	0.26 (0.003)
α_M	0.17 (0.14)	0.17 (0.003)	0.17 (0.003)	0.17 (0.0033)
β_{LL}	0.105 (0.013)	0.096 (0.006)	0.055 (0.005)	0.017 (0.005)
β_{LK}	0.265 (0.042)	0.236 (0.007)	0.096 (0.007)	-0.05 (0.0074)
β_{LM}	0.256 (0.037)	0.236 (0.01)	0.133 (0.01)	0.033 (0.009)
β_{LK}	-0.081 (0.012)	-0.081 (0.012)	-0.058 (0.016)	-0.009 (0.019)
β_{KM}	0.102 (0.019)	0.103 (0.019)	0.092 (0.021)	0.058 (0.024)
β_{MM}	-0.165 (0.032)	-0.166 (0.008)	-0.14 (0.017)	-0.091 (0.026)

*Standard errors in brackets.

For the Unrestricted, Quadratic and Leontief forms, point estimates of the parameters α_L, α_K, α_M, β_{MM} were estimated indirectly; for the Translog form point estimates of the parameters α_M, β_{LM}, β_{KM}, β_{MM} were estimated indirectly.

The interpretation of the D.W. statistics (see next page) is not clearcut, since the estimation method is <u>not</u> OLS. The problem of autocorrelation of the error terms is discussed in some detail in Chapter V, below.

TABLE 4.1 (cont'd)

	UNRESTRICTED		QUADRATIC		LEONTIEF		TRANSLOG	
	R^2	DW	R^2	DW	R^2	DW	R^2	DW
Equation:								
Labour	0.64	1.3	0.64	1.3	0.61	1.11	0.60	1.06
Capital	0.77	1.46	0.75	1.36	0.67	0.93	0.66	0.84
Log L	168.160		168.065		166.723		167.5	

which is nested in a larger structural model with maximized likelihood L*, then the statistic

$$-2(\log L - \log L^*)$$

is distributed asymptotically as χ^2, with degrees of freedom equal to the difference in the number of parameters in the two models.[7]

The test statistics are:

$\lambda = 1$, Quadratic: 0.19

$\lambda = 0.5$, Leontief: 2.87

$\lambda = 0$, Translog: 1.22

The critical value of the χ^2 statistic with one degree of freedom, and at the 1% (2.5%) significance level, is 6.63 (5.02). Thus none of the three functional forms are rejected.

Discussion of Results

Point estimates of the Allen/Uzawa partial elasticities of substitution (S_{ij}) between all pairs of inputs are given in Table 4.2 at the end of this chapter.[8] For all four values of λ, the signs of the estimated S_{ij} are the same. In all cases, all three inputs are Allen/Uzawa substitutes for one another. For the Translog functional form the values of all S_{ij} show little variation throughout the sample period. For the Square-Root Quadratic and (to a lesser extent) the Generalized Leontief functional forms the value of S_{KM} falls dramatically during the sample period. This change in the value of S_{KM} is perhaps surprising in view of the fact that the data (on factor prices and quantities and on actual factor shares) do not show a great deal of variation over the sample period.[9]

Point estimates of the own price elasticity of demand for imports (holding the wage rate, the rental rate and the quantity of output fixed) for selected years in the sample period are given in Table 4.3. These estimates are calculated from the point estimates of the substitution elasticities in the following manner:

$$E_M = \theta_M S_{MM} = - \theta_L S_{ML} - \theta_K S_{MK}$$

where E_M is the own price elasticity of demand for imports.

TABLE 4.3 The Own Price (Partial) Elasticity of Demand for Imports

λ =	λ →	1	1/2	0
1948	-1.7	-1.7	-1.55	-1.37
1958	-1.14	-1.2	-1.34	-1.33
1961*	-1.05	-1.12	-1.33	-1.37
1972	-0.56	-0.65	-1.03	-1.28

(* 1961 is used as the base year in the estimation.)

Note that for the Square-Root Quadratic (and, to a lesser extent, the Generalized Leontief) functional form the value of E_M falls dramatically during the sample period; for the Translog form the value of E_M shows little variation throughout the sample period.

The impact of a change in the price of imports on the rewards of domestic factors depends upon the relative sizes (as well as the signs) of the S_{ij}. As noted in Chapter II, an increase in the price of imports will

(a) increase (reduce) the rental rate if

$$RHAT \equiv (S_{KM}-S_{LM}) + (S_{LL}-S_{KL}) > 0 \quad (<0)$$

(b) increase (reduce) the wage rate if

$$WHAT \equiv (S_{LM}-S_{KM}) + (S_{KK}-S_{KL}) > 0 \quad (<0)$$

The values of RHAT and WHAT in the base year (1961) of the sample period are given in Table 4.4.

TABLE 4.4 The Change in Domestic Factor Prices

λ =	λ	1	1/2	0
RHAT =	-1.63 (0.72)*	-1.39 (0.008)	-0.64 (0.017)	-0.37 (0.46)
WHAT =	-2.29 (0.4)	-2.72 (0.1)	-4.17 (0.067)	-4.64 (0.59)

(* Standard errors in brackets)

Thus all four functions give that same (qualitative) result: an increase in the price of imports reduces both the real wage rate and the real rental rate.[10] (This result conflicts with Kohli's (1978) result. Kohli found that an increase in the price of imports reduced the wage rate and increased the rental rate.)

Consider now <u>the question of factoral income distribution</u>. As shown in Chapter II, labour gains relative to capital, following an increase in the price of imports, whenever $(S_{LM}-S_{KM}) > 0$.[1] The values of $(S_{LM}-S_{KM})$ for selected years in the sample period are given in Table 4.5.

TABLE 4.5 Factoral Income Distribution

λ =	λ	1	1/2	0
1948	-2.5	-2.4	-1.4	-0.86
1961	0.33 (0.32)*	0.09 (0.002)	-0.7 (0.014)	-1 (0.5)
1972	0.86	0.63	-0.4	-1

(* Standard errors have been computed for the base year, and are given in brackets.)

For the Square-Root Quadratic form the factoral income distribution result is not clear-cut: For the first 13 years, and again in the sixteenth year, capital gains relative to labour, while for all other years labour gains relative to capital. On the other hand, both the Generalized Leontief and the Translog functional forms indicate that capital gains relative to labour throughout the entire sample period. Since I have no <u>a priori</u> reason to expect the factoral income distribution result to change in mid-sample, I am tempted to accept the results of the Generalized Leontief and the Translog functional forms. However, the indecisive result of the Square-Root Quadratic form suggests that it would be useful to test the null hypothesis that a change in the price of imports has no effect on factoral income distribution.

Testing the Validity of a Cost Function With Two Inputs

It may be that the use of a three input cost function unnecessarily complicates the analysis, and that I can examine all the issues I am interested in using a two input cost function, where the two inputs are domestic value added and imports. This two input cost function is appropriate if the technology of the production sector exhibits weak homothetic separability between the domestic factors, on the one hand, and imports on the other.[12] In this case, firms behave as if they treat the domestic factors as a single input - called domestic value added - and choose cost minimizing combinations of domestic value added and imports to produce final outputs. Furthermore, if the technology is separable in this way, a change in the price of imports has no effect on the wage-rental ratio in the economy.

Assuming that the linear homogeneous unit cost function provides an exact representation of the production process, testing for weak homothetic separability between the domestic factors and imports involves testing the validity of the following restrictions on the parameters of the unit cost function:

$$\frac{\alpha_L}{\alpha_K} = \frac{\beta_{KL}}{\beta_{KK}} = \frac{\beta_{LL}}{\beta_{KL}} \tag{6}$$

(or, equivalently, $\frac{\beta_{LM}}{\beta_{KM}} = \frac{\beta_{KL}}{\beta_{KK}} = \frac{\beta_{LL}}{\beta_{KL}}$). These restrictions imply $S_{LM} = S_{KM}$[13] (which in turn implies that a change in the price of imports has no effect on the wage-rental ratio.)

In estimation the restrictions (6) imply two non-linear restrictions on the parameters:

$$\beta_{LL} = \beta_{KL} \cdot \frac{\beta_{KL}}{\beta_{KK}}, \text{ and}$$

$$\alpha_L = \alpha_K \cdot \frac{\beta_{KL}}{\beta_{KK}}$$

I test the validity of these restrictions for all three functional forms using the Likelihood ratio test. The results are given in Table 4.6.

TABLE 4.6 Tests of the Null Hypothesis

	Value of Log L in Unrestricted Case (L*)	Value of Log L in Restricted Case (L)	Test Statistic: -2(L-L*)	Critical $\chi^2_{0.01}$ With Two Degrees of Freedom
Square-Root Quadratic	168	110	116	9.21
Generalized Leontief	166.7	139	55.4	9.21
Translog	167.5	150	35	9.21

The separability hypothesis is rejected using all three flexible functional forms. Thus it would be inappropriate to represent the technology by a two input cost function (of the Square-Root Quadratic, Generalized Leontief, or Translog forms). Furthermore, the fact that the separability hypothesis is rejected implies that the hypothesis that a change in the price of imports has no effect on the wage-rental ratio is also rejected.

5. CONCLUSION

The results of the parametric tests indicate that all three flexible functional forms of the unit cost function examined in this chapter are NOT rejected by the data. In addition, all three forms yield fairly similar empirical results. These two facts suggest that the empirical work in this thesis will not be unduly influenced by the particular flexible functional form of the unit cost function used in the empirical work.[14]

I use the Translog functional form in the empirical work in the next two chapters. The Translog form is a convenient form for exploring the issues addressed in these chapters. In particular, in Chapter V I compare cost and restricted profit function specifications of the technology of Canada's production sector, and I also perform tests for separability between inputs using a four input cost function.

As I have pointed out (see footnote 13), the Square-Root Quadratic functional form is not a useful form for testing separability restrictions; while the Generalized Leontief form is not a useful form for comparing cost and restricted profit function specifications, since the Generalized Leontief restricted profit function does not exist. The Translog form, on the other hand, is useful both for testing separability restrictions and for comparing cost and restricted profit function specifications of the technology.

FOOTNOTES - CHAPTER IV

1. See Appelbaum (1979). All flexible functional forms are second order local approximations to an arbitrary twice differentiable function.

2. The Translog functional form is discussed in Christensen, Jorgensen and Lau (1971); the Square-Root Quadratic in Lau (1974); and the Generalized Leontief in Diewert (1971).

3. Appelbaum used the same data and the same technique to test the three functional forms of the indirect production function (which is a dual of the production function). He rejected both the Translog and the Generalized Leontief forms, but he was unable to reject the Square-Root Quadratic form.

In the event that all three functional forms are rejected, or that more than one is not rejected, when we perform the parametric tests, Appelbaum suggested that we rank the test statistics used in these tests, and choose the functional form with the lowest value for the test statistic. Berndt, Darrough and Diewert (1976) provide a Bayesian rationale for using this approach, along with any available prior information, in making the choice.

4. Implicit here is the assumption that we can aggregate consumption, investment and exports without biasing the empirical results.

5. The presentation in this section follows Appelbaum (1979).

6. The procedure reduces to Zellner's (1962) seemingly-unrelated-equations estimator if the equations are linear in the parameters.

7. See Berndt, et al. (1974b).

8. These elasticities can be calculated from the formula

$$S_{ij} = 1-[illegible] + \frac{\beta_{ij}\ w_i w_j}{\theta_i \theta_j [1/\lambda\ \Sigma\Sigma\beta_{ij} w_i^{\lambda} w_j^{\lambda}]}\ ,\ i \neq j$$

The elasticities S_{ij}, $i = j$ can now be calculated using the fact that

$$\sum_i \theta_i S_{ij} = 0.$$

For the Translog functional form the formula for calculating S_{ij} becomes

$$S_{ij} = \frac{\beta_{ij} + \theta_i \theta_j}{\theta_i \theta_j}\ ,\ i \neq j.$$

9. From footnote 8, note that S_{ij} varies during the sample period as $[\beta_{ij}\ w_i^{\lambda} w_j^{\lambda}]/[\theta_i \theta_j (1/\lambda\ \Sigma\Sigma\beta_{ij}\ w_i^{\lambda} w_j^{\lambda})]$ varies. During the sample period, the price of labour relative

to the prices of capital and imports rises quite considerably (while the share of labour does not show any trend). Because of this, the value of the denominator in the expression above tends to rise during the sample period. In calculating S_{KM}, the price of labour does not appear in the numerator; therefore the value of S_{KM} declines during the sample period.

10. For both $\lambda = 1/2, 0$, RHAT < 0 throughout the sample period. For $\lambda = 1$ and λ unrestricted, RHAT > 0 for the first five years of the sample; thereafter, RHAT < 0.

11. "Labour gains relative to capital" whenever $\hat{w} - \hat{r} > 0$.

12. See Green (1964), pp. 17-24.

13. For the Square-Root Quadratic functional form, the restrictions also imply $S_{KL} = S_{LL} = S_{KK}$ ($\neq S_{KM}$), that is, that capital and labour are complements (since $S_{ii} < 0$). Thus the Square-Root Quadratic form is not as useful as either the Translog or the Generalized Leontief functional forms for testing the separability hypothesis.

14. However, since the functional forms examined in this chapter are not self-dual (see Chapter V), there is no reason to expect that any (or all three) of these

functional forms of a (for example) production function would not be rejected by the data.

TABLE 4.2 Point Estimates of the Allen/Uzawa Partial Elasticities of Substitution

A. Unrestricted

	S_{LK}	S_{LM}	S_{KM}
1	.951127	1.21390	3.76256
2	.919847	1.23453	3.49447
3	.876908	1.31470	3.53424
4	.802945	1.47179	3.63434
5	1.08458	.905716	2.73281
6	.932435	1.06090	2.32080
7	.764499	1.29145	2.01443
8	.865406	1.12003	2.02915
9	.871927	1.08633	1.88942
10	.735902	1.27010	1.64422
11	.675817	1.34797	1.49121
12	.700433	1.26493	1.34035
13	.651597	1.31728	1.19646
14	.598265	1.38366	1.07756
15	.610162	1.38980	1.17301
16	.639569	1.31625	1.11406
17	.665327	1.24586	1.03320
18	.668223	1.19235	.871511
19	.676148	1.12356	.698508
20	.609673	1.15064	.479695
21	.604623	1.11293	.371623
22	.606426	1.06793	.278312
23	.584833	1.04648	.168639
24	.607296	.980263	.104741
25	.632157	.927974	.729055E-01

TABLE 4.2 (cont'd)

B. Quadratic

	S_{LK}	S_{LM}	S_{KM}
1	.885072	1.25600	3.64174
2	.862318	1.27059	3.41682
3	.827086	1.34111	3.45643
4	.766097	1.47896	3.55194
5	1.00628	.970102	2.74083
6	.884997	1.10237	2.39543
7	.744986	1.30592	2.14103
8	.831380	1.15187	2.14349
9	.838563	1.12006	2.01805
10	.723167	1.28478	1.81115
11	.671763	1.35604	1.67887
12	.694540	1.27964	1.53813
13	.652450	1.32881	1.41109
14	.605818	1.39242	1.30703
15	.615827	1.39699	1.39423
16	.642364	1.32848	1.33616
17	.665993	1.26302	1.25826
18	.670158	1.21383	1.10703
19	.679363	1.15016	.943493
20	.621545	1.17985	.741211
21	.618468	1.14580	.637592
22	.621738	1.10430	.547003
23	.603756	1.08689	.441606
24	.626387	1.02334	.377142
25	.650808	.972436	.344012

TABLE 4.2 (cont'd)

C. Leontief

	S_{LK}	S_{LM}	S_{KM}
1	.687155	1.37182	2.80888
2	.685938	1.36896	2.74869
3	.678381	1.39509	2.77395
4	.664947	1.44528	2.82619
5	.728096	1.22886	2.47975
6	.708556	1.26755	2.40211
7	.678428	1.34252	2.36354
8	.700655	1.27860	2.33001
9	.705218	1.26084	2.27997
10	.678034	1.32633	2.24576
11	.665448	1.35664	2.21569
12	.674599	1.31997	2.14647
13	.663930	1.34310	2.11174
14	.650767	1.37628	2.08958
15	.652690	1.37705	2.12300
16	.662021	1.34334	2.08367
17	.671062	1.31068	2.03704
18	.675714	1.28583	1.96478
19	.683106	1.25263	1.88093
20	.667664	1.27438	1.80384
21	.669590	1.25812	1.74849
22	.674021	1.23647	1.69520
23	.670701	1.23189	1.64125
24	.683387	1.19313	1.59051
25	.696061	1.16047	1.55859

TABLE 4.2 (cont'd)

D. Translog

	S_{LK}	S_{LM}	S_{KM}
1	.680476	1.35460	2.21853
2	.679106	1.35255	2.22273
3	.680455	1.35544	2.23212
4	.682935	1.36092	2.24953
5	.666705	1.33112	2.18245
6	.666484	1.33243	2.21002
7	.669173	1.33919	2.25545
8	.665051	1.33136	2.22492
9	.662626	1.32790	2.22193
10	.665364	1.33442	2.26493
11	.666261	1.33735	2.28900
12	.662383	1.33133	2.27917
13	.662899	1.33361	2.30162
14	.664396	1.33773	2.32985
15	.665212	1.33830	2.32229
16	.662208	1.33315	2.30810
17	.658823	1.32785	2.29613
18	.654968	1.32298	2.29550
19	.649665	1.31644	2.29193
20	.649257	1.31868	2.33096
21	.646010	1.31529	2.33505
22	.642020	1.31088	2.33421
23	.639738	1.30956	2.34976
24	.633055	1.30167	2.33272
25	.627179	1.29496	2.31436

CHAPTER V

CHOICE OF ANALYSIS

1. INTRODUCTION

The Translog functional form, like most flexible functional forms, is not self dual.[1] Thus, choosing the Translog cost function to represent the technology of Canada's production sector implies a rejection of the Translog form of the economy's restricted profit, and production, functions. In other words, the maintained hypothesis that the Translog cost function provides an exact representation of the technology is quite different from the maintained hypothesis that the Translog restricted profit function (or Translog production function) provides an exact representation of the technology. If the empirical results are sensitive to which of these maintained hypotheses is imposed in the empirical work, great care must be taken in choosing a method of analysis.

There is some evidence that empirical results can be drastically different depending upon what type of function - cost, restricted profit, or production - is estimated. Burgess (1975) studied the effect of changes in the price of imports on factoral income distribution in the U.S. He estimated both a Translog cost function and a Translog production function. Using the Translog cost function, he found "that higher import prices will distribute a diminished total factor income from capital to labour" (p. 119). Using the Translog production function, however, he found "that higher import prices will distribute a diminished total factor income from labour to capital (p. 117).[2]

Is the Translog cost function a better maintained hypothesis than the Translog restricted profit, or production, function? There is no a priori answer to this question, nor is there any statistical test which could be used to indicate which of the three Translog functions is the best maintained hypothesis in this empirical study. If we cannot choose one, it would be best to estimate more than one of the Translog functions, and compare the results of the estimations. If the empirical results are (qualitatively) the same, then we can be more confident that we have found the "true" results.

In this chapter I estimate a Translog unit cost function and a Translog restricted profit function, and I compare the results of the two estimations.[3] In making this comparison, I maintain the assumption used in Chapter IV that the Canadian economy produces one output using three inputs. I find no conflict between the empirical results of the two estimations.[4]

The empirical work in this chapter refines the work performed in Chapter IV by, first, allowing for non-Hicks-neutral technical change, and, second, by testing the null hypothesis of zero autocorrelation of the error terms in the estimating equations.[5] The addition of these refinements affects some of the empirical results. In particular, the effect of changes in the price of imports on the price of capital is sensitive to changes in the specification of technical change.

A useful extension of the empirical work in this chapter involves disaggregating imports into a number of subcategories. In the last section of this chapter, I disaggregate imports into two types, imports from the U.S., and "all other" imports. I find that tariffs on imports from the U.S. may have a different effect on the price of capital than tariffs on "all other" imports.

This chapter is organized as follows: In Section two I discuss the results derived from estimating a Translog unit cost function. In Section three I discuss the results of a Translog restricted profit function, and I compare the two sets of results. Finally, in Section four I compare the effects of tariffs on imports from the U.S. with the effects of tariffs on "all other" imports.

presented in Table 5.12.

In all four models an increase in the price of imports reduces (real) wages, and redistributes income from labour owners to capital owners. In models one and two, the (real) rental rate rises, while in models three and four the rental rate falls.

A Note on Model Four

Model four yields estimates of the shares of output and imports (but not of labour and capital) that are quite different from the actual shares: the estimated share of output varies between 5.37 and 5.15 (-4.37 and -4.15 for imports), while the actual share of output varies between 1.18 and 1.23 (-.18 and -.23 for imports). The estimated share of imports is used to calculate the point estimates of E_{MM}, and the (point) estimates of the effect of a change in the price of imports on wage and rental rates, and thus all these estimates are extremely large for model four. Once again I am inclined to disregard the results of model four.

CONCLUSION

The Translog cost and restricted profit functions yield (qualitatively) similar factoral income distribution results. Higher import prices lower the (real) wage rate and redistribute correlation in the error terms, I assume

$$U_{it} = \rho_i U_{i,t-1} + \varepsilon_{it} \tag{3}$$

where ρ_i is the autocorrelation coefficient, and where (by assumption) the vectors $\varepsilon_t \equiv [\varepsilon_{1t} \ldots \varepsilon_{nt}]$ are normally distributed with $E(\varepsilon_t) = 0$, and $E(\varepsilon_t \varepsilon_s') = \begin{cases} \Omega, t=s \\ 0, t \neq s. \end{cases}$ The first order autocorrelation assumption in (3) implies that the error term of the ith share equation is not serially correlated with the error terms of the other share equations. Berndt and Savin (1975) have shown that in this case the autocorrelation coefficients of all share equations are identical.[6]

Thus, the share (equation) of factor i, i = K,L,M, at time t, is given by:

$$\theta_{it} = \alpha_i + \sum_j \beta_{ij} \ln w_{jt} + \gamma_i t + \rho\theta_{i,t-1} - \rho\alpha_i - \rho \sum_j \beta_{ij} \ln w_{j,t-1} - \rho\gamma_i (t-1) + \varepsilon_{it} \tag{4}$$

The special case of no autocorrelation -$\rho = 0$-is nested in the general model (4). Thus, we can test the null hypothesis of no autocorrelation using the Likelihood Ratio test. We can also test the null hypothesis of Hicks-neutral (or zero) technical change-$\gamma_i = 0$, for all i -, using the Likelihood Ratio test. Finally, by setting $\rho = \gamma_i = 0$ we have the specification used in Chapter IV, and thus that specification can be tested using the Likelihood Ratio test.

The data and the estimation procedure are described in Chapter IV. Because there are lagged variables in the estimated share equations, the sample period covers the years 1949-1972. In the estimation, I omit the equation of the share of imports.

RESULTS

The results are presented in Tables 5.1 to 5.6 at the end of this chapter. I estimate four "models" of the Translog cost function. The models are:

<u>Model 1</u>: Non-zero autocorrelation coefficient ($\rho \neq 0$) and non-Hicks-neutral technical change ($\gamma_L, \gamma_K \neq 0$).

<u>Model 2</u>: $\rho = 0$; $\gamma_L, \gamma_K \neq 0$.

<u>Model 3</u>: $\rho = \gamma_L = \gamma_K = 0$.

<u>Model 4</u>: $\rho \neq 0$; $\gamma_L = \gamma_K = 0$.

In all four models the estimated cost function satisfies the regularity conditions over the entire sample period (except model 4, over the first four sample points).

<u>Tests of the Null Hypothesis</u>

At the one percent significance level, the null hypothesis of zero autocorrelation (model 2) is strongly rejected, while the null hypothesis of Hicks-neutral technical change (model 4) is not rejected (see Table 5.3)[7]. (Model 4 is rejected at the 2.5 percent significance level.) The Translog form estimated in Chapter III (model 3) is strongly rejected.

Allen-Uzawa Partial Elasticities of Substitution

For all four models, both capital and labour are Allen-Uzawa substitutes for imports (see Table 5.4). The point estimates of these substitution elasticities -- used to examine factoral income distribution questions -- vary from model to model.

The sign of S_{LK} is sensitive to the specification of the model. For models two and three, S_{LK} is positive. For model one S_{LK} is positive for the first eighteen years of the sample, and negative for the final six years; while for model four S_{LK} is negative for the first 16 years and positive for the final eight years. Furthermore, the size of the point estimates of S_{LK} is quite small for all models except model three.

The Own Price (Partial) Elasticity of Demand for Imports

The own price partial elasticity of demand for imports (E_M) derived from the cost function measures the effect of a change in the price of imports on the demand for imports, holding output fixed. It is related to the own partial elasticity of substitution by the formula

$$E_M = S_{MM}\theta_M$$

The values of E_M for the four models are given in Table 5.5. The values of the point estimates of E_M vary from model to model.

The Changes in Domestic Factor Prices

In all four models an increase in the price of imports reduces real wages and redistributes factor income from labour owners to capital owners (see Table 5.6). In models one and two, the real rental rate rises; in model three the real rental rate falls; and in model four the real rental rate rises in the first seventeen years of the sample, and falls in the final seven years of the sample.

A Note on Model Four

The estimates of the cost shares calculated in model four (and used in the calculation of the S_{ij}) are quite different from the actual cost shares. For example, in the first ten years of the sample, the estimated cost share of labour varies between 0.2 and 0.3, while the actual cost share of labour varies between 0.55 and 0.53; again, in these years the estimated cost share of capital far exceeds the actual cost share of capital. (In the other three models, actual and estimated cost shares are quite close to one another.) For this reason, I am inclined to disregard the results of model four.

3. THE TRANSLOG RESTRICTED PROFIT FUNCTION

The Translog restricted profit function is given by:

$$\ln\pi = \sum_i \alpha_i \ln(P_i e^{\lambda_i t}) + \sum \phi_j \ln(X_j e^{\lambda_j t})$$
$$+ \frac{1}{2}\sum_{ik}\sum z_{ik}\ln(P_i e^{\lambda_i t})\ln(P_k e^{\lambda_k t}) + \sum_{ij}\sum \beta_{ij}\ln(P_i e^{\lambda_i t})\ln(X_j e^{\lambda_j t})$$
$$+ \frac{1}{2}\sum_{jh}\sum \tau_{jh}\ln(X_j e^{\lambda_j t})\ln(X_h e^{\lambda_h t}) \qquad (5)$$

where $z_{ik} = z_{ki}$ and $\tau_{jh} = \tau_{hj}$ (symmetry), where P_i are the prices of the variable quantities (output (Y) and imports (M)), and X_j are the quantities of the fixed factors (capital (K) and labour (L)), and where I have assumed disembodied, exponential technical change in inputs and output. The Translog restricted profit function satisfies the following regularity conditions: (1) monotonically increasing and concave in L and K, and (2) convex in the prices of Y and M, and monotonically increasing (decreasing) in the price of Y (M). The function is linear homogeneous in the prices of Y and M and in the quantities of K and L if

$$\sum_i \alpha_i = 1 \ , \ \sum_j \phi_j = 1$$
$$\sum_i z_{ik} = \sum_i \beta_{ij} = \sum_j \beta_{ij} = \sum_j \tau_{jh} = 0$$

I estimate the parameters of the linear homogeneous Translog restricted profit function by estimating the equations representing the shares (with respect to restricted profit) of the variable quantities, Y and M (where the share of M is negative), and of the fixed factors, K and L. These share equations are given by:

$$V_i \equiv \frac{\delta \ln \pi}{\delta \ln P_i} = \alpha_i + \sum_k z_{ik} \ln P_k + \sum_j \beta_{ij} \ln X_j + \gamma_i t$$

$$\theta_j \equiv \frac{\delta \ln \pi}{\delta \ln X_j} = \phi_j + \sum_h \tau_{jh} \ln X_h + \sum_i \beta_{ij} \ln P_i + \gamma_j t \quad (6)$$

where the V_i are the shares of output and the imported input, and

the θ_j are the shares of capital and labour, and where

$$\gamma_i = \sum_k z_{ik}\lambda_k + \sum_j \beta_{ij}\lambda_j$$

$$\gamma_j = \sum_h \tau_{jh}\lambda_h + \sum_i \beta_{ij}\lambda_i$$

The share equations are stacked in order to find consistent estimates of the common parameters. Since the V_i shares sum to one, and the θ_j shares sum to one, the overall covariance matrix is singular, and one each of the V_i and θ_j share equations must be omitted.

The error term specification includes the assumption that there is first order autocorrelation. This implies that the autocorrelation coefficients for all the V_i equations are identical, and that the autocorrelation coefficients for all the θ_j equations are identical.[8]

The data and the estimation procedure are described in Chapter IV. The sample period covers the years 1949-1972. In the estimation, I omit the equations of the shares of imports and of capital.

RESULTS

The results are presented in Tables 5.7 to 5.12 at the end of this chapter. I estimate four "models" of the Translog restricted profit function. The models are:

<u>Model 1</u>: Non-zero autocorrelation coefficients ($\rho_Y, \rho_L \neq 0$) and non-Hicks neutral technical change ($\gamma_Y, \gamma_L \neq 0$).

<u>Model 2</u>: $\rho_Y = \rho_L = 0;\ \gamma_Y, \gamma_L \neq 0$.

<u>Model 3</u>: $\rho_Y = \rho_L = \gamma_Y = \gamma_L = 0$.

<u>Model 4</u>: $\rho_Y, \rho_L \neq 0;\ \gamma_Y, \gamma_L = 0$.

In all four models, the estimated restricted profit function satisfies the regularity conditions over the entire sample period.

<u>Tests of the Null Hypothesis</u>

The null hypothesis of zero autocorrelation is just rejected at the one percent level of significance. The null hypothesis of Hicks-neutral technical change (model 4) is not rejected at this significance level (nor is model 4 rejected at the 2.5 percent significance level). The null hypothesis that both the autocorrelation and the technical progress coefficients are zero (model 3) is strongly rejected (see Table 5.9).

The Partial Elasticities

The partial elasticities in Table 5.10 are defined in the following way:

T_{YM} is the partial elasticity of transformation between Y and M, where

$$T_{YM} \equiv \frac{\pi\pi_{P_Y P_M}}{\pi_{P_Y}\pi_{P_M}}$$

J_{KL} is the inverse partial elasticity of substitution between K and L, where

$$J_{KL} \equiv \frac{\pi\pi_{KL}}{\pi_K \pi_L}$$

H_{YK}, H_{YL}, H_{ML}, and H_{MK} are the "elasticities of intensity" where (for example)

$$H_{YK} \equiv \frac{\pi\pi_{P_Y K}}{\pi_{P_Y}\pi_K}$$

(These elasticities are not directly comparable to the Allen-Uzawa elasticities calculated from the cost function. See footnotes 9 and 11 in Chapter II.) Once again, the size and the sign of the point estimates of these elasticities vary from model to model.

The Own Price (Partial) Elasticity of Demand for Imports

The own price (partial) elasticity of demand for imports (E_{MM}), derived from the restricted profit function, measures the effect of a change in the price of imports on the demand for imports, allowing output (and domestic factor prices) to change. It is related to the own partial elasticity of transformation by the formula

$$E_{MM} = T_{MM} V_M$$

Point estimates of E_{MM} for all four models are presented in Table 5.11.

The Changes in Domestic Factor Prices

The effects of a one percent increase in the price of imports are calculated using the formulas:

$$\hat{w} = H_{LM} V_M$$

$$\hat{r} = H_{KM} V_M$$

where $\hat{w}$ ($\hat{r}$) is the proportional change in the wage (rental) rate, and H_{LM} (H_{KM}) is the elasticity of intensity between imports and labour (capital). The values of w and r are presented in Table 5.12.

In all four models an increase in the price of imports reduces (real) wages, and redistributes income from labour owners to capital owners. In models one and two, the (real) rental rate rises, while in models three and four the rental rate falls.

A Note on Model Four

Model four yields estimates of the shares of output and imports (but not of labour and capital) that are quite different from the actual shares: the estimated share of output varies between 5.37 and 5.15 (-4.37 and -4.15 for imports), while the actual share of output varies between 1.18 and 1.23 (-.18 and -.23 for imports). The estimated share of imports is used to calculate the point estimates of E_{MM}, and the (point) estimates of the effect of a change in the price of imports on wage and rental rates, and thus all these estimates are extremely large for model four. Once again I am inclined to disregard the results of model four.

CONCLUSION

The Translog cost and restricted profit functions yield (qualitatively) similar factoral income distribution results. Higher import prices lower the (real) wage rate and redistribute income from owners of labour to owners of capital.

The effect of higher import prices on the real rental rate is quite sensitive to changes in the specification of the nature of technical change. If non-Hicks-neutral technical change is assumed then both the cost function and the profit function indicate that higher import prices increase the real rental rate. On the other hand, if Hicks-neutral technical change is imposed -- and this specification of technical change is often imposed in empirical studies -- the profit function indicates that the rental rate falls, while the cost function indicates that the rental rate rises in the early years of the sample and falls in the later years. Although the null hypothesis of Hicks-neutral technical change is not rejected (where the maintained hypothesis is non-zero autocorrelation and non-Hicks-neutral technical change), I find that the imposition of this null hypothesis leads to estimates of "shares" (dependent variables) that are quite different from the actual values of the shares. Since these estimated shares are used to calculate the effects of higher import prices on domestic factor prices, it is clear that the imposition of Hicks-neutral technical change leads to unreliable estimates of the changes in domestic factor prices. Therefore, I use the results derived from the model(s) with non-Hicks-neutral technical change, and I conclude that higher import prices increase the rental rate in Canada.[9]

The point estimates of the own price elasticity of demand for imports (holding output and factor prices fixed) derived from the cost function are quite sensitive to the specification of autocorrelation: when zero (first order) autocorrelation is assumed, this elasticity is greater than one (ignoring the negative sign), while when non-zero autocorrelation is assumed the elasticity is less than one. Similarly, the point estimate of the own price elasticity of demand for imports (allowing output and factor prices to vary) derived from the profit function is greater than one when zero autocorrelation is assumed, and less than one when non-zero autocorrelation is assumed (ignoring model four of the profit function). Since zero autocorrelation is rejected by the data, the evidence of this chapter suggests that both own price elasticities of demand for imports are less than one.[10]

4. A DISAGGREGATION OF IMPORTS

The results of Appelbaum and Kohli (1980) suggest that an increase in the price of "imports from the U.S." increases the rental rate and reduces the wage rate in the Canadian economy. What happens to domestic factor prices when the prices of imports from all other countries ("all other" imports) rise? The results of Sections two and three of this chapter, which indicate the effects of a change in the price of aggregate imports, could be used to make inferences about the effects of a change in the price of some sub-category of imports only if either (a) the technology is separable between all types of imports on one hand, and each of the domestic factors on the other[11], or (b) the prices of all imports vary in strict proportion.[12] If the production process is separable between imports and each of the domestic factors, firms choose their optimal input combinations in two separate steps. First, firms allocate expenditures among capital, labour and the aggregate of imports. Second, firms decide how much of the overall expenditure on aggregate imports should be spent on each type of import. Thus, in this case, if an increase in the price of aggregate imports causes (for example) a decrease in the wage rate, then an increase in the price of each and every sub-category of imports also causes a decrease in the wage rate.

When we disaggregate imports into "imports from the U.S.", and "all other" imports, there is reason to believe that there has been some divergence between the movements of the price indices for these two types of imports. These divergences may have arisen, for example, because Canada reduced tariffs on imports from the U.S. without changing tariffs on imports from other countries. In this section, I examine the separability question. I assume that the Canadian production sector produces one output using four inputs: capital services, labour services, "imports from the U.S.", and "all other" imports. I examine the effect of a change in the price of each type of import on domestic factor rewards, and I test the null hypothesis that the Canadian production process is separable between the two imported inputs, on the one hand, and each of the domestic factors, on the other.

The Translog Cost Function With Four Inputs

The econometric model is the same as that described in Section two of this chapter, extended to the case of four inputs. I estimate the equations representing three (of the four) inputs in total unit cost. I assume disembodied exponential technical change in inputs, and first order autocorrelation of the error terms of the share equations.

RESULTS

The results are presented in Tables 5.13 to 5.15 at the end of this chapter. I estimate four "models" of the cost function in order to test the null hypotheses of zero autocorrelation and Hicks-neutral technical change. The null hypothesis of zero autocorrelation is strongly rejected while the null hypothesis of Hicks-neutral technical change is also rejected (see Tables 5.13 and 5.14). For this reason, I present the results of model 1 (maintained hypothesis of non-zero autocorrelation and non-Hicks-neutral technical change). The estimated cost function satisfies the regularity conditions for all except the first five years of the sample period.

The parameter estimates for model one are given in Table 5.15. Using these (point) estimates I find that capital and labour are (Allen/Uzawa) substitutes; "imports from the U.S." are substitutes for both capital and labour, while "all other" imports are complements of both capital and labour. The two imported inputs are substitutes for one another. Turning to the own price elasticity of demand for imports (holding output and domestic factor prices constant), I find that the own price elasticity of demand for "imports from the U.S." is approximately 1.1 throughout the sample period, while the own price elasticity of demand for "all other" imports varies between 0.05 and 0.26 throughout the sample period (not including three early sample points when this elasticity is positive). Finally, using the point estimates of the substitution elasticities I find the following factor price changes:

(i) an increase in the price of "imports from the U.S." causes a fall in the wage rate and an increase in the rental rate[13], and

(ii) an increase in the price of "all other" imports causes a decrease in both the wage rate and the rental rate; furthermore $\hat{w} - \hat{r} < 0$.[14]

Test of the Separability Hypothesis

The null hypothesis is that the Translog cost function (model 1) is separable between the two imported inputs, on the one hand, and each of the domestic inputs, on the other. (This does not imply that the two domestic inputs form a separable sub-group.) This separability restriction implies

$$\theta_N \beta_{ML} = \theta_M \beta_{NL}$$

$$\theta_N \beta_{MK} = \theta_M \beta_{NK} \qquad (7)$$

where θ_N (θ_M) is the share of U.S. imports (all other imports), and the β_{ij} are parameters of the Translog cost function.

The conditions (7) hold throughout the sample period iff

$$\frac{\alpha_M}{\alpha_N} = \frac{\beta_{ML}}{\beta_{NL}} = \frac{\beta_{MK}}{\beta_{NK}} = \frac{\beta_{MM}}{\beta_{NM}} = \frac{\gamma_M}{\gamma_N} \qquad (8)$$

where $\gamma_i = \Sigma \beta_{ij}\lambda_j$, $i = M, N$, $j = L,K,M,N$, and where λ_j are the technical progress terms (see (1) in Section two of this chapter).

Note that the conditions (8) imply that for each year in the sample period $S_{LN} = S_{LM} \neq S_{KN} = S_{KM}$. In estimation, the conditions (8) imply four non-linear restrictions on the parameters.

Without the separability restrictions the value of the log of the Likelihood Function (L) is 304.98. With the restrictions imposed the value of L is 298.87. The value of the test statistic is thus 12.22. The critical value of $\chi^2_{0.01}$ ($\chi^2_{0.025}$) with four degrees of freedom is 13.28 (11.14). Thus the separability hypothesis is not rejected at the one percent significance level, while it is rejected at the 2.5 percent significance level.[15]

The cost function with the separability conditions imposed satisfies the regularity conditions throughout the sample period. All four inputs are Allen-Uzawa substitutes. Turning to the factoral income distribution results, an increase in the price of either import causes a decrease in the wage rate and an increase in the rental rate. Finally, the point estimates of the own price elasticity of demand for U.S. imports varies between -1.1 and -1.2, while that for all other imports varies between -0.88 and -0.86.[16]

CONCLUSION

The results of this section suggest that additional information is gained by disaggregating imports into two categories, "imports from the U.S." and "all other" imports.

An increase in the price of "all other" imports reduces both the rental rate and the wage rate, and redistributes income from owners of labour to owners of capital. The fact that an increase in the price of this category of imports actually reduces the rental rate is the first indication that tariffs on some imports harm the owners of capital. The results of this section also confirm that an increase in the price of "imports from the U.S." raises the rental rate and reduces the wage rate.

FOOTNOTES - CHAPTER V

1. See McFadden (1978) for a discussion of the concept of self-duality.

2. Similar results are reported in Geary and McDonnell (1980), using data for the Irish economy.

3. In practice, the two estimations differ not only because of the difference in the maintained hypothesis but also because of differences in the stochastic specifications of the two models.

4. I have also estimated a Translog production function. The factoral income distribution results derived from the production function are similar to the results derived from the cost and restricted profit functions. See footnote 9, below.

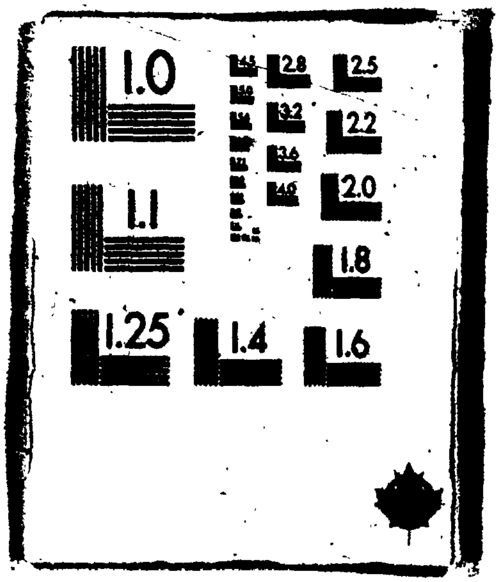
5. Kohli (1978) includes these two refinements in his work.

6. See Berndt and Savin (1975). The authors examine the problem of serial correlation when the covariance matrix is singular.

7. The procedure used in Table A.3 follows the procedure outlined in Kohli (1978).

8. See Berndt and Savin (1975).

2



9. I have also estimated a Translog Production Function. Using this production function I was unable to reject both the null hypothesis of Hicks-neutral technical change and the null hypothesis of zero autocorrelation coefficients. With both of these hypotheses imposed (which gives the production function equivalent of model three), the Translog production function confirms my results: higher import prices cause a fall in the wage rate and an increase in the rental rate in Canada.

10. But see the discussion in Chapter VI, below. The problem of serial correlation of the error terms does not exist when the model is modified to allow for slow adjustment in the production sector.

11. More correctly, if the technology exhibits (at least) weak homothetic separability. See Green (1964), pp. 17-24.

12. In this case the conditions for Hicks' (1946) aggregation are satisfied. See Diewert (1978).

13. For a change in the price of some imported good (M), the price of the other imported good (N) remaining constant, we have:

$$\hat{w} \gtrless 0 \text{ as } (S_{LM}-S_{KM}) + (S_{KK}-S_{LK}) \gtrless 0$$

$$\hat{r} \gtrless 0 \text{ as } (S_{KM}-S_{LM}) + (S_{LL}-S_{LK}) \gtrless 0$$

$$\hat{w}-\hat{r} \gtrless 0 \text{ as } (1-\theta_M)(S_{LM}-S_{KM}) + \theta_N(S_{LM}-S_{KM}) \gtrless 0$$

14. The model four version of the cost function (which satisfies the regularity conditions) yields similar factoral income distribution results. It is noteworthy that here, in contrast to the results of sections A and B, the factoral income distribution results are not sensitive to changes in the specification of technical change.

The models two and three versions of the cost function do not satisfy the regularity conditions. For both of these versions the estimated own price elasticity of demand for "all other" imports is positive. I attempted to estimate these models with the regularity conditions imposed (see Lau (1978)), but the estimation procedure did not converge.

15. An alternative approach is to test the null hypothesis that the underlying (unknown) cost function is (weakly) separable between the two imported inputs and each of the domestic inputs. In this case the Translog cost function is treated as a second order approximation to the underlying cost function. By imposing two non-linear restrictions on the Translog cost function it

is possible to generate a Translog cost function that is a second order approximation to underlying separable cost function. Essentially, this null hypothesis implies that in the base year $S_{LN} = S_{LM} \neq S_{KN} = S_{KM}$, while in all other years $S_{LN} \neq S_{LM} \neq S_{KN} \neq S_{KM}$. (See Denny and Fuss (1977).) I tested and rejected this null hypothesis (again, using model one).

16. I estimated a Translog restricted profit function with disaggregated imports. The estimated functions did not satisfy the regularity conditions. I attempted to estimate the restricted profit function with the regularity conditions imposed (see Lau (1978)), but the estimation procedure did not converge.

TABLE 5.1 PARAMETER ESTIMATES OF THE TRANSLOG COST FUNCTION

	Model 1	Model 2	Model 3	Model 4
α_L	.57 (.005)	.58 (.003)	.57 (.002)	.34 (.09)
α_K	.25 (.007)	.25 (.004)	.26 (.003)	.40 (.06)
β_{LL}	.18 (.006)	.11 (.003)	.02 (.005)	.18 (.002)
β_{LK}	-.14 (.013)	-.12 (.019)	-.053 (.007)	-.14 (.013)
β_{KK}	.13 (.017)	.053 (.030)	-.005 (.019)	.14 (.016)
γ_L	-.008 (.001)	-.005 (.001)	- -	- -
γ_K	.0045 (.001)	.004 (.001)	- -	- -
ρ	.79 (.065)	- -	- -	.96 (.011)

Note: Standard errors in brackets.
All other parameter estimates can be calculated using the restrictions on the parameters.

TABLE 5.2 R^2, D.W. STATISTICS AND VALUE OF LOG OF LIKELIHOOD FUNCTION

	Model 1		Model 2		Model 3		Model 4	
Equation	R^2	D.W.	R^2	D.W.	R^2	D.W.	R^2	D.W.
Labour	.92	1.67	.8	0.96	.66	1.35	.9	1.56
Capital	.92	2.41	.7	0.75	.63	0.96	.89	2.59
Log L	192		170.2		163.5		188.3	

TABLE 5.3 TESTS OF THE NULL HYPOTHESIS

	Number of Restrictions	Test Statistic	Critical $\chi^2_{0.01}$	Critical $\chi^2_{0.025}$
A. Maintained Hypothesis: $\gamma_1, \gamma_2 \neq 0$ and $\rho \neq 0$ (Model 1)				
Null Hypothesis $\rho = 0$ (Model 2)	1	44	6.63	5.02
B. Maintained Hypothesis: $\gamma_1, \gamma_2 \neq 0$ and $\rho \neq 0$ (Model 1)				
Null Hypothesis $\gamma_1 = \gamma_2 = 0$ (Model 4)	2	7.4	9.21	7.38
C. Maintained Hypothesis: $\gamma_1, \gamma_2 \neq 0$ and $\rho = 0$ (Model 2)				
Null Hypothesis $\gamma_1 = \gamma_2 = 0$ (Model 3)	2	13.6	9.21	7.38
D. Maintained Hypothesis: $\gamma_1 = \gamma_2 = 0$ and $\rho \neq 0$ (Model 4)				
Null Hypothesis $\rho = 0$ (Model 3)	1	50	6.63	5.02

TABLE 5.4 POINT ESTIMATES OF THE ALLEN/UZAWA PARTIAL ELASTICITIES OF SUBSTITUTION

Model 1

	S_{LL}	S_{KK}	S_{MM}	S_{LK}	S_{LM}	S_{KM}
2	-.24	-.84	-3.92	.14	.53	1.13
3	-.24	-.83	-3.85	.13	.53	1.12
4	-.25	-.83	-3.77	.13	.54	1.12
5	-.24	-.83	-3.85	.14	.53	1.12
6	-.23	-.85	-3.85	.12	.54	1.13
7	-.21	-.86	-3.83	.092	.56	1.14
8	-.22	-.86	-3.77	.10	.55	1.13
9	-.23	-.86	-3.73	.10	.56	1.13
10	-.21	-.87	-3.71	.078	.57	1.13
11	-.20	-.87	-3.68	.061	.58	1.14
12	-.20	-.87	-3.66	.060	.58	1.14
13	-.20	-.86	-3.63	.042	.59	1.14
14	-.19	-.86	-3.59	.022	.60	1.14
15	-.21	-.86	-3.50	.038	.60	1.13
16	-.22	-.87	-3.46	.044	.60	1.13
17	-.22	-.87	-3.43	.046	.60	1.12
18	-.22	-.87	-3.42	.038	.60	1.13
19	-.21	-.86	-3.41	.028	.60	1.13
20	-.19	-.84	-3.42	-.012	.62	1.14
21	-.19	-.83	-3.41	-.025	.62	1.14
22	-.18	-.83	-3.39	-.033	.62	1.14
23	-.17	-.80	-3.38	-.058	.63	1.15
24	-.18	-.81	-3.37	-.052	.63	1.15
25	-.19	-.83	-3.34	-.040	.63	1.14

TABLE 5.4 (cont'd)

Model 2

	S_{LL}	S_{KK}	S_{MM}	S_{LK}	S_{LM}	S_{KM}
2	-.44	-1.85	-7.77	.20	1.11	2.46
3	-.45	-1.82	-7.81	.20	1.11	2.45
4	-.46	-1.79	-7.96	.21	1.12	2.45
5	-.46	-1.88	-6.97	.18	1.11	2.38
6	-.44	-1.95	-7.19	.17	1.11	2.45
7	-.41	-2.02	-7.63	.17	1.11	2.55
8	-.44	-1.96	-7.19	.17	1.11	2.46
9	-.44	-1.96	-7.06	.16	1.10	2.44
10	-.41	-2.02	-7.46	.16	1.11	2.54
11	-.40	-2.05	-7.65	.16	1.11	2.58
12	-.[illegible]	-2.06	-7.42	.15	1.10	2.56
13	-.40	-2.09	-7.59	.15	1.11	2.60
14	-.39	-2.11	-7.83	.15	1.11	2.65
15	-.41	-2.03	-7.68	.16	1.11	2.57
16	-.42	-2.01	-7.42	.16	1.11	2.53
17	-.43	-2.01	-7.19	.16	1.10	2.49
18	-.42	-2.04	-7.07	.15	1.10	2.49
19	-.42	-2.08	-6.90	.13	1.10	2.50
20	-.39	-2.18	-7.18	.12	1.10	2.61
21	-.39	-2.21	-7.10	.11	1.10	2.62
22	-.38	-2.24	-6.97	.10	1.10	2.62
23	-.37	-2.29	-7.01	.096	1.10	2.66
24	-.38	-2.30	-6.70	.084	1.10	2.62
25	-.39	-2.29	-6.40	.078	1.09	2.56

TABLE 5.4 (cont'd)

Model 3

	S_{LL}	S_{KK}	S_{MM}	S_{LK}	S_{LM}	S_{KM}
2	-.76	-2.55	-8.11	.65	1.35	2.20
3	-.76	-2.54	-8.23	.65	1.35	2.21
4	-.75	-2.52	-8.47	.66	1.36	2.23
5	-.77	-2.67	-7.32	.64	1.33	2.16
6	-.75	-2.72	-7.47	.64	1.33	2.19
7	-.73	-2.74	-7.85	.64	1.34	2.24
8	-.74	-2.76	-7.50	.64	1.33	2.21
9	-.74	-2.79	-7.38	.63	1.33	2.20
10	-.72	-2.81	-7.74	.64	1.33	2.25
11	-.71	-2.83	-7.92	.64	1.33	2.27
12	-.71	-2.87	-7.70	.63	1.33	2.26
13	-.70	-2.90	-7.85	.63	1.33	2.29
14	-.68	-2.91	-8.08	.63	1.33	2.32
15	-.69	-2.89	-8.07	.64	1.34	2.31
16	-.69	-2.92	-7.85	.63	1.33	2.30
17	-.69	-2.95	-7.65	.63	1.32	2.28
18	-.69	-3.01	-7.49	.62	1.32	2.28
19	-.69	-3.08	-7.28	.62	1.31	2.28
20	-.67	-3.14	-7.48	.62	1.31	2.32
21	-.67	-3.19	-7.38	.61	1.31	2.33
22	-.66	-3.25	-7.24	.61	1.31	2.33
23	-.65	-3.30	-7.24	.61	1.31	2.35
24	-.66	-3.38	-6.93	.60	1.30	2.33
25	-.66	-3.43	-6.66	.59	1.29	2.31

TABLE 5.4 (cont'd)

Model 4

	S_{LL}	S_{KK}	S_{MM}	S_{LK}	S_{LM}	S_{KM}
2	.17	-.41	-2.20	-.259819	.368283	1.00470
3	.15	-.41	-2.20	-.255144	.373825	1.00471
4	.11	-.42	-2.19	-.248162	.382847	1.00473
5	-.30	-.43	-2.27	-.198755	.395478	1.00489
6	-.18	-.46	-2.29	-.136711	.444633	1.00515
7	-.30	-.51	-2.31	-.872425E-01	.491163	1.00545
8	-.27	-.49	-2.32	-.999853E-01	.473832	1.00535
9	-.29	-.50	-2.33	-.870919E-01	.481867	1.00543
10	-.35	-.54	-2.35	-.524547E-01	.518839	1.00573
11	-.38	-.56	-2.36	-.354335E-01	.538314	1.00593
12	-.39	-.57	-2.38	-.257573E-01	.543321	1.00603
13	-.40	-.59	-2.40	-.130329E-01	.560173	1.00625
14	-.40	-.62	-2.41	-.392772E-01	.576374	1.00648
15	-.40	-.61	-2.40	-.993354E-01	.568651	1.00635
16	-.40	-.60	-2.41	-.720727E-01	.567155	1.00636
17	-.40	-.61	-2.42	-.265978E-01	.567776	1.00641
18	-.40	-.62	-2.45	.753943E-01	.577145	1.00662
19	-.40	-.64	-2.49	.178568E-01	.586412	1.00686
20	-.39	-.68	-2.52	.247205E-01	.610402	1.00740
21	-.38	-.70	-2.55	.275239E-01	.617721	1.00766
22	-.37	-.71	-2.58	.298372E-01	.622956	1.00789
23	-.36	-.73	-2.60	.277959E-01	.633025	1.00828
24	-.36	-.73	-2.63	.319905E-01	.632776	1.00841
25	-.36	-.73	-2.66	.367972E-01	.630192	1.00843

TABLE 5.5 THE OWN PRICE (PARTIAL) ELASTICITY OF DEMAND FOR IMPORTS (E_M)

MODEL 1	MODEL 2	MODEL 3	MODEL 4
-.631992	-1.31205	-1.37030	-.595947
-.632897	-1.31448	-1.37740	-.595782
-.633674	-1.32248	-1.39066	-.595453
-.632914	-1.26580	-1.32358	-.598960
-.632902	-1.27861	-1.33252	-.600163
-.633037	-1.30438	-1.35501	-.600966
-.633681	-1.27852	-1.33409	-.601208
-.633971	-1.27084	-1.32713	-.601866
-.634110	-1.29461	-1.34861	-.602532
-.634328	-1.30543	-1.35912	-.603049
-.634478	-1.29242	-1.34611	-.603897
-.634632	-1.30180	-1.35504	-.604443
-.634782	-1.31514	-1.36839	-.604844
-.635002	-1.30703	-1.36787	-.604389
-.635027	-1.29242	-1.35554	-.604833
-.635006	-1.27892	-1.34328	-.605411
-.634991	-1.27147	-1.33401	-.606393
-.634990	-1.26113	-1.32077	-.607566
-.635004	-1.27827	-1.33288	-.608664
-.634982	-1.27367	-1.32705	-.609447
-.634951	-1.26572	-1.31816	-.610214
-.634927	-1.26805	-1.31843	-.610975
-.634881	-1.24904	-1.29916	-.611760
-.634775	-1.23029	-1.28169	-.612301

TABLE 5.6 THE EFFECT ON WAGE AND RENTAL RATES OF A ONE PERCENT INCREASE IN THE PRICE OF IMPORTS

	Model 1		Model 2	
	$\hat{r}$*	$\hat{w}$	$\hat{r}$	$\hat{w}$
2	.833777E-01	-.347609	.152854	-.387430
3	.793982E-01	-.356130	.144658	-.385410
4	.768172E-01	-.365244	.137903	-.380535
5	.778383E-01	-.356568	.147959	-.414449
6	.970797E-01	-.354523	.172570	-.408537
7	.128479	-.356733	.200895	-.395755
8	.103858	-.363150	.176700	-.408944
9	.103321	-.367170	.175697	-.413629
10	.134503	-.370839	.200296	-.401355
11	.154627	-.376857	.211427	-.396112
12	.153541	-.379717	.211976	-.403652
13	.177365	-.386725	.223495	-.399223
14	.208569	-.396411	.234602	-.392728
15	.169538	-.401291	.207346	-.394858
16	.154511	-.405051	.197474	-.402393
17	.145610	-.408866	.191443	-.409970
18	.157241	-.411832	.200471	-.415379
19	.172691	-.414106	.213502	-.423127
20	.256449	-.428240	.262093	-.415697
21	.284399	-.436453	.263206	-.419542
22	.304308	-.443247	.271877	-.425356
23	.378015	-.462118	.292212	-.425695
24	.355353	-.459136	.293207	-.438295
25	.309614	-.452977	.283811	-.450564

TABLE 5.6 (cont'd)

	Model 3 $\hat{r}$	Model 3 $\hat{w}$	Model 4** $\hat{r}$	Model 4** $\hat{w}$
2	-.731718E-01	-.271525	-2.12207	3.77865
3	-.713404E-01	-.268797	-2.38529	4.34479
4	-.680750E-01	-.263829	-2.99780	5.65966
5	-.806877E-01	-.291673	8.07614	-18.6817
6	-.738137E-01	-.288345	.693716	-2.33640
7	-.636422E-01	-.279454	.253139	-1.33848
8	-.699451E-01	-.288118	.340139	-1.53830
9	-.701969E-01	-.291359	.272955	-1.38306
10	-.605838E-01	-.282666	.126461	-1.03603
11	-.553693E-01	-.278675	.781126E-01	-.914402
12	-.565873E-01	-.284251	.615377E-01	-.868394
13	-.516576E-01	-.280874	.342589E-01	-.792174
14	-.459342E-01	-.275804	.154970E-01	-.734498
15	-.477992E-01	-.275818	.252569E-01	-.766256
16	-.500246E-01	-.280835	.242051E-01	-.761400
17	-.517833E-01	-.286059	.203301E-01	-.747384
18	-.508934E-01	-.290369	.759819E-01	-.702478
19	-.503282E-01	-.296620	-.275349E-01	-.659488
20	-.411007E-01	-.291868	-.130447E-01	-.597154
21	-.391775E-01	-.294744	-.142660E-01	-.574670
22	-.381593E-01	-.299024	-.141808E-01	-.556751
23	-.338195E-01	-.299277	-.108304E-01	-.534674
24	-.358110E-01	-.308514	-.106189E-01	-.524306
25	-.386839E-01	-.317254	-.116189E-01	-.519382

* These results are calculated using the point estimates of the substitution elasticities (see Table 5.4). See equation in Chapter II for the formulas for $\hat{w}$ and $\hat{r}$.

Notice that $(\hat{w} - \hat{r})$ is negative throughout the sample period for all four models.

The effect of a one percent increase in P_Y (holding P_M constant) can be calculated from this table by using the fact that the percentage change in the wage (rental) rate caused by a one percent increase in P_Y equals one minus the percentage change in the wage (rental) rate caused by a one percent increase in P_M.

**The values of w and $\hat{r}$ for the first four sample points in this model are distorted by the fact that the estimated cost function does not satisfy the regularity conditions for these four years.

TABLE 5.7 PARAMETER ESTIMATES OF THE TRANSLOG RESTRICTED PROFIT FUNCTION

	MODEL 1	MODEL 2	MODEL 3	MODEL 4
α_Y	1.18 (.007)	1.18 (.004)	1.2 (.004)	5.2 (.09)
ϕ_L	.69 (.009)	.68 (.005)	.69 (.003)	.68 (.004)
z_{YY}	-.10 (.078)	.045 (.057)	.102 (.076)	-.21 (.07)
β_{YL}	.16 (.050)	.17 (.035)	.022 (.020)	.15 (.05)
τ_{LL}	-.11 (.078)	.05 (.04)	-.043 (.003)	-.027 (.018)
γ_Y	.009 (.0025)	.008 (.002)	- -	- -
γ_L	-.0038 (.0034)	.003 (.002)	- -	- -
ρ_Y	.56 (.2)	- -	- -	1.0 (.037)
ρ_L	.61 (.13)	- -	- -	.51 (.14)

*Standard errors in brackets. All other parameter estimates can be calculated using the restrictions on the parameters.

TABLE 5.8 R^2, D.W. STATISTICS AND VALUE OF LOG OF THE LIKELIHOOD FUNCTION

	MODEL 1		MODEL 2		MODEL 3		MODEL 4	
	R^2	D.W.	R^2	D.W.	R^2	D.W.	R^2	D.W.
EQUATION:								
OUTPUT	.56	1.9	.71	1.6	.09	1.2	.8	2.0
LABOUR	.78	2.4	.52	1.3	.64	.77	.27	2.2
LOG L	152.7		147.7		138.7		150.5	

TABLE 5.9 TESTS OF THE NULL HYPOTHESES

	Number of Restriction	Test Statistic	$\chi^2_{0.01}$	$\chi^2_{0.025}$
A. Maintained Hypothesis: $\gamma_Y, \gamma_L \neq 0$ and $\rho_Y, \rho_L \neq 0$ (Model 1)				
Null Hypothesis $\rho_Y = \rho_L = 0$ (Model 2)	2	10	9.21	7.38
B. Maintained Hypothesis: $\gamma_Y, \gamma_L \neq 0$ and $\rho_Y, \rho_L \neq 0$ (Model 1)				
Null Hypothesis $\gamma_Y = \gamma_L = 0$ (Model 4)	2	4.4	9.21	7.38
C. Maintained Hypothesis: $\gamma_Y, \gamma_L \neq 0$ and $\rho_Y = \rho_L = 0$ (Model 2)				
Null Hypothesis $\gamma_Y = \gamma_L = 0$ (Model 3)	2	18	9.21	7.38
D. Maintained Hypothesis: $\gamma_Y = \gamma_L = 0$ and $\rho_Y, \rho_L \neq 0$ (Model 4)				
Null Hypothesis $\rho_Y = \rho_L = 0$ (Model 3)	2	24	9.21	7.38

TABLE 5.10 POINT ESTIMATES OF ELASTICITIES

Model 1

	T_{YM}	J_{KL}	H_{YL}	H_{YK}	H_{ML}	H_{MK}
2	.58	1.51	1.19	.59	2.17	-1.37
3	.57	1.50	1.20	.61	2.20	-1.31
4	.60	1.50	1.20	.62	2.16	-1.16
5	.59	1.52	1.19	.59	2.14	-1.39
6	.56	1.50	1.20	.60	2.24	-1.40
7	.55	1.52	1.19	.58	2.22	-1.54
8	.54	1.52	1.19	.57	2.24	-1.65
9	.57	1.50	1.20	.60	2.19	-1.35
10	.58	1.51	1.19	.59	2.16	-1.35
11	.54	1.52	1.19	.57	2.23	-1.68
12	.52	1.52	1.19	.57	2.28	-1.76
13	.53	1.52	1.19	.57	2.26	-1.73
14	.52	1.52	1.19	.56	2.28	-1.80
15	.55	1.52	1.19	.57	2.20	-1.59
16	.56	1.52	1.19	.58	2.19	-1.53
17	.56	1.51	1.19	.59	2.20	-1.48
18	.56	1.52	1.19	.58	2.19	-1.53
19	.57	1.53	1.19	.57	2.15	-1.57
20	.57	1.53	1.19	.56	2.15	-1.63
21	.58	1.55	1.18	.54	2.09	-1.69
22	.60	1.55	1.18	.54	2.05	-1.56
23	.61	1.56	1.18	.53	2.01	-1.57
24	.59	1.56	1.18	.52	2.05	-1.74
25	.61	1.56	1.18	.53	2.02	-1.61

TABLE 5.10 (cont'd)

Model 2

	T_{YM}	J_{KL}	H_{YL}	H_{YK}	H_{ML}	H_{MK}
2	1.18	.77	1.21	.58	2.27	-1.43
3	1.18	.77	1.22	.58	2.32	-1.46
4	1.18	.77	1.22	.58	2.31	-1.45
5	1.18	.76	1.21	.55	2.23	-1.59
6	1.18	.76	1.21	.55	2.24	-1.63
7	1.19	.76	1.21	.55	2.30	-1.74
8	1.19	.76	1.21	.55	2.32	-1.75
9	1.19	.76	1.21	.55	2.28	-1.70
10	1.19	.76	1.21	.55	2.32	-1.77
11	1.20	.76	1.21	.54	2.39	-1.90
12	1.20	.76	1.21	.54	2.35	-1.88
13	1.20	.76	1.21	.54	2.37	-1.92
14	1.21	.76	1.21	.54	2.40	-1.96
15	1.20	.76	1.21	.55	2.37	-1.85
16	1.19	.76	1.21	.54	2.34	-1.81
17	1.19	.76	1.21	.54	2.28	-1.74
18	1.18	.76	1.20	.53	2.22	-1.73
19	1.18	.75	1.20	.52	2.19	-1.76
20	1.18	.75	1.20	.51	2.19	-1.81
21	1.18	.75	1.20	.51	2.20	-1.87
22	1.17	.75	1.20	.50	2.17	-1.84
23	1.17	.75	1.20	.50	2.16	-1.87
24	1.17	.74	1.19	.49	2.13	-1.86
25	1.17	.74	1.19	.49	2.10	-1.83

TABLE 5.10 (cont'd)

Model 3

	T_{YM}	J_{KL}	H_{YL}	H_{YK}	H_{ML}	H_{MK}
2	1.43	1.19	1.02	.94	1.17	.67
3	1.44	1.19	1.02	.94	1.17	.66
4	1.44	1.19	1.02	.94	1.17	.66
5	1.41	1.19	1.02	.94	1.16	.67
6	1.41	1.19	1.02	.94	1.16	.67
7	1.41	1.19	1.02	.94	1.16	.66
8	1.42	1.19	1.02	.94	1.16	.66
9	1.42	1.19	1.02	.94	1.16	.66
10	1.42	1.19	1.02	.94	1.16	.65
11	1.43	1.19	1.02	.94	1.16	.64
12	1.42	1.19	1.02	.94	1.16	.64
13	1.43	1.20	1.02	.94	1.16	.64
14	1.43	1.20	1.02	.94	1.16	.63
15	1.44	1.20	1.02	.93	1.16	.62
16	1.44	1.20	1.02	.93	1.16	.62
17	1.44	1.20	1.02	.93	1.16	.62
18	1.43	1.20	1.02	.93	1.16	.63
19	1.42	1.20	1.02	.93	1.16	.63
20	1.42	1.20	1.02	.93	1.15	.63
21	1.42	1.20	1.02	.93	1.15	.62
22	1.42	1.20	1.02	.93	1.15	.62
23	1.42	1.20	1.02	.93	1.15	.62
24	1.41	1.20	1.02	.93	1.15	.62
25	1.41	1.20	1.02	.93	1.15	.62

TABLE 5.10 (cont'd)

Model 4

	T_{YM}	J_{KL}	H_{YL}	H_{YK}	H_{ML}	H_{MK}
2	.990935	1.11844	1.04205	.923900	1.05168	.906476
3	.990921	1.11807	1.04225	.924383	1.05193	.907056
4	.990900	1.11820	1.04223	.924118	1.05192	.906709
5	.990741	1.12211	1.04104	.918066	1.05055	.899087
6	.990699	1.12270	1.04093	.917107	1.05043	.897858
7	.990640	1.12323	1.04087	.916174	1.05040	.896641
8	.990617	1.12321	1.04092	.916099	1.05047	.896521
9	.990604	1.12341	1.04089	.915784	1.05044	.896117
10	.990562	1.12371	1.04087	.915211	1.05044	.895362
11	.990498	1.12442	1.04079	.914026	1.05037	.893824
12	.990459	1.12536	1.04059	.912640	1.05015	.892066
13	.990422	1.12572	1.04056	.912018	1.05013	.891253
14	.990396	1.12562	1.04063	.912040	1.05024	.891250
15	.990416	1.12476	1.04084	.913246	1.05048	.892764
16	.990398	1.12504	1.04079	.912805	1.05044	.892197
17	.990385	1.12543	1.04071	.912241	1.05034	.891484
18	.990338	1.12677	1.04043	.910306	1.05002	.889035
19	.990281	1.12833	1.04015	.908078	1.04970	.886206
20	.990222	1.12957	1.03996	.906250	1.04950	.883869
21	.990171	1.13045	1.03986	.904932	1.04940	.882172
22	.990148	1.13101	1.03978	.904125	1.04931	.881142
23	.990098	1.13224	1.03961	.902379	1.04913	.878910
24	.990064	1.13311	1.03949	.901146	1.04901	.877337
25	.990043	1.13361	1.03943	.900440	1.04894	.876432

TABLE 5.11 THE OWN PRICE (PARTIAL) ELASTICITY OF DEMAND FOR IMPORTS (E_{MM})

MODEL 1	MODEL 2	MODEL 3	MODEL 4
-.717394	-1.42658	-1.71658	-5.31906
-.721022	-1.42708	-1.72445	-5.31527
-.731746	-1.42691	-1.72608	-5.30991
-.673922	-1.42660	-1.70376	-5.26777
-.670070	-1.42668	-1.70389	-5.25697
-.642862	-1.42793	-1.70718	-5.24191
-.647877	-1.42837	-1.71074	-5.23596
-.669981	-1.42746	-1.71082	-5.23248
-.659324	-1.42849	-1.71411	-5.22184
-.629931	-1.43109	-1.71685	-5.20577
-.637997	-1.42971	-1.71363	-5.19606
-.634559	-1.43057	-1.71587	-5.18681
-.636309	-1.43190	-1.72077	-5.18057
-.676721	-1.43019	-1.72648	-5.18554
-.694129	-1.42903	-1.72656	-5.18098
-.718773	-1.42747	-1.72462	-5.17772
-.724899	-1.42675	-1.71872	-5.16632
-.721857	-1.42653	-1.71363	-5.15230
-.711618	-1.42661	-1.71195	-5.13815
-.703454	-1.42682	-1.71233	-5.12607
-.719275	-1.42649	-1.71132	-5.12057
-.716496	-1.42646	-1.70944	-5.10862
-.725659	-1.42640	-1.70796	-5.10074
-.741834	-1.42651	-1.70741	-5.09587

TABLE 5.12 THE EFFECT ON WAGE AND RENTAL RATES OF A ONE PERCENT INCREASE IN THE PRICE OF IMPORTS

	Model 1		Model 2	
	$\hat{w}$	$\hat{r}$	$\hat{w}$	$\hat{r}$
2	-.44	.27	-.47	.29
3	-.44	.26	-.46	.29
4	-.45	.24	-.46	.29
5	-.44	.28	-.46	.33
6	-.43	.27	-.46	.33
7	-.43	.29	-.45	.34
8	-.42	.31	-.45	.34
9	-.44	.27	-.45	.33
10	-.44	.27	-.44	.34
11	-.42	.31	-.44	.34
12	-.41	.32	-.44	.35
13	-.41	.32	-.44	.35
14	-.41	.32	-.43	.35
15	-.42	.30	-.44	.34
16	-.43	.30	-.44	.34
17	-.43	.29	-.45	.34
18	-.43	.30	-.45	.35
19	-.43	.31	-.45	.36
20	-.42	.32	-.45	.37
21	-.43	.34	-.45	.38
22	-.43	.33	-.45	.38
23	-.44	.34	-.45	.39
24	-.43	.36	-.45	.39
25	-.43	.35	-.45	.40

TABLE 5.12 (cont'd)

	Model 3		Model 4	
	$\hat{w}$	$\hat{r}$	$\hat{w}$	$\hat{r}$
2	-.23	-.13	-4.6	-3.9
3	-.22	-.12	-4.6	-3.9
4	-.22	-.12	-4.6	-3.9
5	-.24	-.14	-4.5	-3.9
6	-.24	-.14	-4.5	-3.9
7	-.23	-.13	-4.5	-3.8
8	-.23	-.13	-4.5	-3.8
9	-.23	-.13	-4.5	-3.8
10	-.23	-.13	-4.5	-3.8
11	-.23	-.12	-4.5	-3.8
12	-.23	-.12	-4.5	-3.8
13	-.23	-.12	-4.4	-3.8
14	-.22	-.12	-4.4	-3.8
15	-.22	-.12	-4.4	-3.8
16	-.22	-.12	-4.4	-3.8
17	-.22	-.12	-4.4	-3.8
18	-.22	-.12	-4.4	-3.7
19	-.23	-.12	-4.4	-3.7
20	-.23	-.12	-4.4	-3.7
21	-.23	-.12	-4.4	-3.7
22	-.23	-.12	-4.4	-3.7
23	-.23	-.12	-4.4	-3.7
24	-.23	-.12	-4.4	-3.6
25	-.23	-.12	-4.4	-3.6

*Notice that ($\hat{w}$ - $\hat{r}$) is negative throughout the sample period for all four models.

The effect of a one percent increase in P_Y (holding P_M constant) can be calculated from this table by subtracting the value for $\hat{w}$ ($\hat{r}$) given in the table from one (1).

TABLE 5.13 TRANSLOG COST FUNCTION WITH DISAGGREGATED IMPORTS: R^2, D.W. STATISTICS AND VALUE OF LOG OF LIKELIHOOD FUNCTION

	Model 1		Model 2		Model 3		Model 4	
EQUATION	R^2	D.W.	R^2	D.W.	R^2	D.W.	R^2	D.W.
LABOUR	.92	1.7	.82	0.94	.70	1.34	.89	1.58
CAPITAL	.93	2.4	.81	0.78	.75	0.95	.92	2.64
U.S. IMPORTS	.58	2.01	.34	0.94	.32	1.27	.54	2.08
LOG L	304.989		277.932		271.315		298.777	

Model 1 is the unrestricted case.

Model 2 is the case where the autocorrelation coefficient is set equal to zero.

Model 3 is the case where both the autocorrelation coefficient, and the technical progress coefficients, are set equal to zero.

Model 4 is the case where the technical progress coefficients are set equal to zero.

TABLE 5.14 TESTS OF THE NULL HYPOTHESES

	Number of Restrictions	Test Statistic	$\chi^2_{0.01}$	$\chi^2_{0.025}$
A. Maintained Hypothesis: $\gamma_L, \gamma_K, \gamma_N \neq 0$, and $\rho \neq 0$ (Model 1)				
Null Hypothesis $\rho = 0$ (Model 2)	1	54	6.63	5.02
B. Maintained Hypothesis: $\gamma_L, \gamma_K, \gamma_N \neq 0$, and $\rho \neq 0$ (Model 1)				
Null Hypothesis $\gamma_L = \gamma_K = \gamma_N = 0$ (Model 4)	3	12.4	11.3	9.35
C. Maintained Hypothesis: $\gamma_L, \gamma_K, \gamma_N \neq 0$ and $\rho = 0$ (Model 2)				
Null Hypothesis $\gamma_L = \gamma_K = \gamma_N = 0$ (Model 3)	3	13.2	11.3	9.35
D. Maintained Hypothesis: $\gamma_L = \gamma_K = \gamma_N = 0$ and $\rho \neq 0$ (Model 4)				
Null Hypothesis $\rho = 0$ (Model 3)	1	55	6.63	5.02

TABLE 5.15 PARAMETER ESTIMATES - THE DISAGGREGATED IMPORTS CASE (MODEL 1)

α_L	0.58 (0.005)	β_{NN}	-0.029 (0.069)
α_K	0.25 (0.006)	γ_L	-0.008 (0.001)
α_N	0.12 (0.007)	γ_K	0.005 (0.001)
β_{LL}	0.18 (0.021)	γ_N	0.001 (0.001)
β_{LK}	-0.14 (0.013)	ρ	0.78 (0.061)
β_{LN}	-0.003 (0.021)		
β_{KK}	0.13 (0.016)		
β_{KN}	0.023 (0.018)		

* Standard errors in brackets.
Here "N" refers to imports from the U.S. All other parameter estimates can be calculated using the restrictions of the parameters.

CHAPTER VI

ADJUSTMENT IN THE PRODUCTION SECTOR

1. INTRODUCTION

In this chapter I examine how the production sector adjusts following a change in the price of imports. I use an econometric model that allows the production sector to adjust slowly towards the long-run equilibrium. Because the model allows slow adjustment, it is possible to distinguish between short-run and long-run effects of trade policies. Many recent theoretical studies (including Chapter VII of this thesis) have drawn sharp distinctions between the short-term and long-term effects of trade policies; and while the econometric model used here does not permit the rich variety of results that can be found in the theoretical studies, it does provide some empirical distinction between long-run and short-run effects.

The econometric model used in this chapter is based on the assumption that whenever the price of imports changes, firms move along an adjustment path from one long-run equilibrium to another. Thus the data used in empirical work may reflect points along the adjustment path, and not long-run equilibrium points. It is an extremely complex problem to specify the adjustment path directly[1], and so I specify the adjustment path indirectly using the "planning price" approach introduced by Woodland (1977). I assume that firms maximize profits subject to a planning price of imports, and I specify an adjustment path along which the planning price eventually converges to the actual price of imports. As the planning price adjusts to the actual price, the production sector moves along an adjustment path towards the long-run equilibrium.

The results of this chapter suggest that the assumption of instantaneous adjustment - maintained in Chapters IV and V - is incorrect; and furthermore, that the use of that assumption leads to an underestimation of the own price elasticity of demand for imports. On the other hand, the results of this chapter indicate that tariffs lower the wage rate and raise the rental rate, which confirms the results of Chapter V.

This chapter is organized as follows: In section two I outline the econometric model. In section three I briefly discuss the method of estimation. Finally, in section four I present and discuss the empirical results.

2. THE MODEL

The model used here is the same as the model used in Chapters IV and V, with one modification. Rather than assuming that firms base their production plans on the actual or current price of imports, I assume here that firms base their plans on a planning price of imports. The technology of the production sector can be represented by a restricted profit function

$$\pi(P_Y, P_M^*, K, L) \equiv \max_{\{Y,M\}} P_Y Y - P_M^* M: \quad \begin{array}{l} Y \leq F(K,L,M) \\ K \leq \overline{K} \\ L \leq \overline{L} \end{array} \qquad (1)$$

where P_M^* is the planning price of imports, and
P_Y, K, L, Y, M are as defined before.

The use of the planning price of imports can be justified by assuming that when the actual price of imports changes, firms are uncertain whether this change is permanent, or whether there will be further changes in the price of imports. Since firms incur costs in adjusting their production plans, it may be inefficient for firms to adjust fully to the current change in the price of imports, only to find that they must again undertake adjustment when the price of imports changes again.[2] Furthermore, if the cost of adjustment rises as the speed of adjustment rises, it may be efficient to adjust slowly to any change in the current price of imports, even if no further changes in the price of imports are expected. Accordingly, I assume that at every time, t, firms use current and past prices of imports to calculate a planning price of imports, where the planning price eventually converges to the current (actual) price, and that firms optimize with respect to this planning price.

The use of the planning price can also be interpreted in the following manner[3]: When the price of imports changes, the economy moves along the transformation frontier to the new optimum point. In Figure 6.1, the production sector

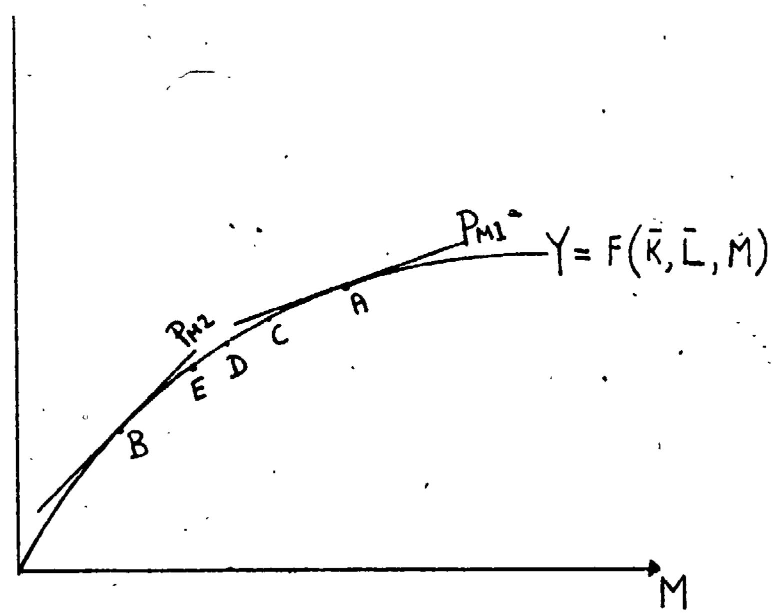


FIGURE 6.1

moves from point A, when the price of imports is P_{M1}, to the point B, when the price of imports changes to P_{M2}. This adjustment is not instantaneous, however, and along the way the economy will produce at (for example) the points C, D, E,.... If we draw lines tangent to the transformation frontier at each of these points, these lines can be interpreted as planning prices of imports. Thus, during the adjustment process, the economy is optimizing with respect to the ever-changing planning price of imports, until the economy finally reaches the long-run equilibrium at point B.

This interpretation suggests that, as an alternative to specifying a planning price for imports, I could specify a quantity adjustment path for output. The problem with using a quantity adjustment path is that a number of restrictions must be imposed on this path to ensure that the economy is always on the transformation frontier, and these restrictions are quite complex when the production sector is represented by a flexible functional form. By using the planning price approach, on the other hand, I ensure that the economy is always on the transformation frontier without having to impose any complex restrictions in the estimation.

The Planning Price

The planning price of imports at time t is calculated using the formula

$$P^*_{M,t} - P^*_{M,t-1} = \lambda(P_{M,t} - P^*_{M,t-1}) \qquad (2)$$

where λ is the adjustment parameter.[4] The planning price converges to the actual price if λ lies between 0 and 2.[5] When $\lambda = 1$, the planning price at time t equals the actual price at time t. Thus it is possible to test the hypothesis that the economy adjusts to the new long-run equilibrium immediately by testing the hypothesis that $\lambda = 1$.

3. ESTIMATION

I assume that the linear homogeneous Translog restricted profit function provides an exact representation of the technology. I estimate the parameters of the function by estimating the share equations. The two share equations used in the estimation are

$$V_Y \equiv \frac{\delta \ell n \pi}{\delta \ell n P_Y} = \alpha_Y + z_{YY} \ell n(\frac{P_Y}{P_M^*}) + \beta_{YL} \ell n(\frac{L}{K}) + \gamma_Y t$$

$$\theta_L \equiv \frac{\delta \ell n \pi}{\delta \ell n L} = \phi_L + \beta_{YL} \ell n(\frac{P_Y}{P_M^*}) + \tau_{LL} \ell n(\frac{L}{K}) + \gamma_L t \qquad (3)$$

The dependent variable V_Y is the share of output in restricted profits,

$$V_Y \equiv \frac{P_Y Y}{P_Y Y - P_M^* M}$$

V_Y is an unobserved variable. A time-series of observations on this variable must be generated by first generating a time-series of observations on P_M^*. To do this, I assume that the planning price in 1948 (which is now treated as the year before the first year of the sample period) is equal to the actual price in that year. I then generate a time-series of observations on P_M^* and V_Y for the years 1949-1972 by specifying a particular value for λ, $\lambda \in (0,2)$. I estimate the two share equations using these time-series.

of V_Y and P^*_M. I repeat this procedure for various values of λ, $\lambda \epsilon (0,2)$, and I choose the value of λ for which the log of the Likelihood function attains its highest value. (I used this procedure twice, first assuming non-zero autocorrelation of the error terms and then assuming zero autocorrelation. I report the results for the case where zero autocorrelation is imposed. See the discussion in section 4 below.)

4. RESULTS

The results are presented in eight tables at the end of the chapter.

Calculating the Value of λ

The values of the log of the Likelihood function (L) for various values of λ, $\lambda \epsilon (0,2)$, are given in Table 6.1. The value of L rises steadily until $\lambda = .4$, and thereafter the value of L falls steadily. This steady rise and fall of L suggests that L attains its maximum value somewhere in the interval $\lambda \epsilon (.3, .5)$. A search over this interval reveals that L attains its maximum value when $\lambda = 0.44$.

The value of the planning price calculated using this value of λ is given in Table 6.2. The value of the planning price is quite close to, but always lower than, the actual price in every year of the sample. Since the planning price approach is an indirect method of modelling the adjustment of the economy, the fact that the planning price is not equal to the actual price reflects the fact that the economy is somewhere along the adjustment path.

Parameter Estimates and D.W. Statistics

The parameter estimates, along with the D.W. statistic for the two estimated equations, are given in Table 6.3.

The estimated function satisfies the regularity conditions over the entire sample period.

The Adjustment of the Planning Price

Starting from a long-run equilibrium, where $P_M = P_M^* = 1$, a one percent increase in P_M causes a 0.44 percent increase in P_M^* in the first year. (See Table 6.4.) After four years, the adjustment of P_M^* to P_M is 90 percent complete.

The null hypothesis that the planning price adjusts fully within the observation period to any change in the actual price of imports can be tested using the Likelihood Ratio test. The maintained hypothesis is that $\lambda = 0.44$, while the null hypothesis is that $\lambda = 1$. The value of the log of the Likelihood function (L) under the maintained hypothesis is 161.8, while the value of L under the null hypothesis is 147.7. Thus the value of the test statistic is 28.2. The critical value of χ^2 with one degree of freedom is 9.21. Thus the null hypothesis of immediate adjustment is rejected.

The rejection of the null hypothesis suggests that the econometric models used in Chapters IV and V are misspecified, since in those models it was assumed that the production sector adjusted fully within the observation period to any change in the price of imports. Despite this, however, we shall see that the factoral income distribution results of Chapter V, which are essentially long-run results, are supported by the long-run results in this chapter.

Elasticities

Point estimates of the various elasticities are given in Tables 6.5 and 6.6. Note that all these elasticities are calculated using the planning price of imports. The values of these elasticities are very similar to the values of the elasticities calculated from the Translog restricted profit function (model 2) in Chapter V. One exception is the point estimate of the own price (partial) elasticity of demand for imports, E_{MM}. In the earlier chapter E_{MM} was estimated to be -1.4 (see model two of the restricted profit function), while in this chapter $E_{MM} = -2.4$.[6]

In Chapter V I noted that the point estimates of the own price elasticity of demand for imports were sensitive to the specification of autocorrelation: whenever non-zero autocorrelation was assumed the value of this elasticity was quite low (much less than one), while when zero autocorrelation was imposed, the value of the elasticity was high (greater than one). Furthermore, since I rejected the null hypothesis of zero autocorrelation, I concluded that the value of the elasticity was in fact quite low. Using the planning price approach, however, the inclusion of non-zero autocorrelation coefficients adds little to the explanatory power of the model. In fact, the null hypothesis of zero autocorrelation cannot be rejected. This result suggests that the presence of serial correlation in the error terms in the models estimated in Chapter V may be due to the fact that those models are misspecified, and that the problem of serial correlation can best be dealt with by respecifying those models to permit slow adjustment.

The Changes in Domestic Factor Prices

The effects of a change in the price of imports on the wage and rental rates are presented in Tables 6.7 and 6.8. The values of $\hat{w}$ and $\hat{r}$ in Table 6.7 indicate the effect of a one percent increase in the planning price of imports on the wage and rental rates. These values of $\hat{w}$ and $\hat{r}$ can be interpreted as measuring the long-run effects on wage and rental rates of a one percent increase in the actual price of imports, since in the long run a one percent increase in the actual price causes a one percent increase in the planning price. As can be seen in Table 6.7, the wage rate falls and the rental rate rises, and this confirms the (long-run) results of Chapter V.

What are the short-run effects of a change in the actual price imports? In the econometric model used here the short-run effects must be in the same direction as the long-run effects. Thus the model used here rules out the possibility, found in theoretical studies using the Ricardo-Viner model (see Chapter VII), that the short-run change in the price of a domestic factor could be reversed in the long run. However, the model used here does not rule out another possibility found in the theoretical studies, that the price of some domestic factor could fall (or rise) by a greater amount in the short run than in the long run.

Using the estimated parameter values, and starting from a long-run equilibrium at time t = 0 where P_Y, P_M^*, K and L are all set equal to 1, I have calculated the (cumulative) changes in the wage rate as the economy adjusts to the new long-run equilibrium following a one percent increase in the actual price of imports.[7] The results are given in Table 6.8 below. As can be seen from this table, the wage rate falls steadily during the adjustment process, so that the wage rate falls by a greater amount in the long run than in the short run.

The Welfare Gain From Tariff Reduction

The point estimate of E_{MM} calculated here measures the change in the demand for imports caused by a change in the price of imports, after allowing output and domestic factor prices to adjust to their new equilibrium values. Thus this value of E_{MM} can be used to calculate approximate welfare gains from tariff reductions. If Canada removes its tariff so that P_M falls (and thus the terms of trade improve), the change in welfare is the increase in producer surplus minus the loss of tariff revenue, $-\frac{1}{2}(\Delta P_M)(\Delta Q_M)$ (where ΔQ_M is the change in the quantity of imports). Expressed as a percentage of GNP, the welfare gain is $-\frac{1}{2} V_M . E_{MM}(\hat{P}_M)^2$. Assuming the removal of tariffs causes a ten percent fall in the price of imports[8], and assuming V_M is equal to twenty percent, the welfare gain is 0.54 percent of GNP. If Canada's trading partners now reduce their tariffs on Canada's exports, so that Canada's production sector enjoys a further improvement in the terms of trade (represented by a further fall in P_M), there is an additional gain of producer surplus equal to $-Q_M . (\Delta P_M) - \frac{1}{2}(\Delta Q_M)(\Delta P_M)$. Expressed as a percentage of GNP this gain in producer surplus is $-V_M . \hat{P}_M - \frac{1}{2} V_M . E_{MM} . (\hat{P}_M)^2$. Assuming the fall in P_M is (for example) ten percent, the additional gain for Canada is 2.24 percent of GNP.

5. CONCLUSION

The planning price approach allows us to examine how the production sector adjusts following a change in the price of imports. The null hypothesis that the economy adjusts immediately to any change in the price of imports is rejected. Thus the econometric models used in Chapters IV and V are misspecified insofar as those models assume full adjustment within the current observation person. But despite this, the long-run factoral income distribution results calculated in those earlier chapters are confirmed by the long-run distribution results calculated in this chapter: higher import prices harm labour owners and benefit capital owners.

The assumption of instantaneous adjustment leads to an underestimation of the size of the own price elasticity of demand for imports (E_{MM}). This in turn can cause an underestimation of the welfare gains (costs) of lower (higher) tariffs, since E_{MM} is used in the calculation of these welfare changes. Using the value of E_{MM} estimated here, I find that Canada would enjoy a welfare gain equal to three percent of GNP if all tariffs on Canada's imports and exports were removed.

FOOTNOTES - CHAPTER VI

1. See Nadiri and Rosen (1969, 1973) for discussion of the complexity of this problem. The problem is also discussed in Woodland (1977).

2. Woodland (1977) gives this rationale for using planning prices.

3. This interpretation is also given in Woodland (1977).

4. This is an ad hoc specification of the process by which the planning price is calculated. This specification is used in Woodland (1977).

5. See Woodland (1977).

6. In this chapter, E_{MM} measures the change in the demand for imports caused by a one percent change in the planning price of imports. This can be interpreted as the long-run effect of a change in the actual price of imports, since in the long run the planning price converges to the actual price.

7. This calculation is made in the following manner: The expression

$$\hat{w} = H_{ML} \cdot V_M \cdot \hat{P}^*_M$$

can be rewritten

$$\hat{w} = \left[\frac{\beta_{LM} + \theta_L(1-V_Y)}{\theta_L}\right]\hat{P}^*_M \qquad (4)$$

(where θ_L and V_Y both depend on P^*_M).

When P_M rises by one percent, P^*_M will begin to adjust as described in Table 1. But substituting the values for $\hat{P}^*_M$ into the expression (4) the cumulative values for $\hat{w}$ during the adjustment process are derived.

8. Burgess (1982) argues that an elimination of all of Canada's trade barriers would reduce import prices by 15 percent.

9. The terms of trade are P_Y/P_M. An improvement in the terms of trade can be represented either by an increase in P_Y, holding P_M constant, or by a fall in P_M, holding P_Y constant.

TABLE 6.1 CHOOSING THE VALUE OF THE ADJUSTMENT PARAMETER (λ)

λ =	L =
.1	155
.2	156.6
.3	159.3
.4	161.6
.5	161.4
.6	158.9
.7	155.6
.8	152.6
.9	149.9
1.0	147.7
1.1	141.4
1.2	137.7
1.3	136.1
1.4	134.9
1.5	133.5
1.6	131.6
1.7	128.4
1.8	121.8
1.9	110.9

TABLE 6.2 COMPARISON OF THE PLANNING PRICE AND THE ACTUAL PRICE OF IMPORTS

	P^*_M	P_M
1949	.833	.842
	.864	.904
	.934	1.024
	.926	.914
	.916	.905
	.910	.902
	.915	.922
	.930	.948
	.947	.969
	.960	.976
	.962	.964
	.967	.976
1961	.982	1.000
	1.012	1.050
	1.033	1.060
	1.048	1.066
	1.052	1.057
	1.055	1.059
	1.059	1.064
	1.070	1.085
	1.087	1.109
	1.106	1.129
	1.123	1.145
1972	1.147	1.178

TABLE 6.3 PARAMETER ESTIMATES - THE MODEL WITH THE PLANNING PRICE OF IMPORTS

α_Y	1.17 (.003)
z_{YY}	.231 (.047)
β_{YL}	.182 (.025)
ϕ_L	.675 (.005)
τ_{LL}	.048 (.041)
γ_Y	.0066 (.0014)
γ_L	.0027 (.002)

D.W. (Output Share) = 1.97

D.W. (Labour Share) = 1.26

Log L = 161.83

TABLE 6.4 ADJUSTMENT OF THE PLANNING PRICE OF IMPORTS

P_M	P^*_M
1	1
1.01	1.00440
1.01	1.00686
1.01	1.00824
1.01	1.00902
1.01	1.00945
1.01	1.00969
1.01	1.00983
1.01	1.00990
1.01	1.00995
1.01	1.00997
1.01	1.00998
1.01	1.00999
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000
1.01	1.01000

TABLE 6.5 POINT ESTIMATES OF ELASTICITIES

	T_{YM}	H_{YL}	H_{YK}	H_{MK}	H_{ML}	J_{KL}
2	1.98018	1.23165	.561100	-1.66541	2.40681	.789360
3	2.01206	1.23267	.559061	-1.74022	2.44596	.789345
4	1.95244	1.22749	.550854	-1.67223	2.35346	.786578
5	1.92120	1.22359	.541696	-1.66297	2.29915	.783874
6	1.92713	1.22311	.538349	-1.69461	2.30227	.783169
7	1.98980	1.22573	.536178	-1.83657	2.38046	.783691
8	2.00478	1.22587	.533820	-1.88201	2.39639	.783361
9	1.96493	1.22303	.529704	-1.82420	2.33936	.781720
10	2.00983	1.22481	.528214	-1.92725	2.39488	.782090
11	2.08885	1.22789	.526733	-2.10219	2.49380	.782892
12	2.06077	1.22593	.523272	-2.06561	2.45287	.781667
13	2.08505	1.22637	.520704	-2.13365	2.47998	.781397
14	2.13093	1.22804	.520062	-2.23525	2.53719	.781866
15	2.11517	1.22755	.520619	-2.19810	2.51806	.781791
16	2.10991	1.22727	.520288	-2.18915	2.51090	.781641
17	2.06477	1.22498	.518217	-2.10664	2.45073	.780503
18	2.00901	1.22125	.511868	-2.02688	2.37193	.778068
19	1.95983	1.21723	.502851	-1.97417	2.29955	.774923
20	1.95345	1.21569	.496210	-1.99961	2.28422	.773099
21	1.95623	1.21475	.490313	-2.04102	2.28131	.771630
22	1.92045	1.21211	.484735	-1.99222	2.23176	.769430
23	1.90364	1.21013	.477654	-1.99422	2.20452	.767181
24	1.88126	1.20818	.472282	-1.97232	2.17255	.765214
25	1.85198	1.20582	.466509	-1.93504	2.13233	.762908

TABLE 6.6 THE OWN PRICE (PARTIAL) ELASTICITY OF DEMAND FOR IMPORTS*

	E_{MM}
2	-2.37052
3	-2.39792
4	-2.34690
5	-2.32057
6	-2.32555
7	-2.37876
8	-2.39164
9	-2.35751
10	-2.39600
11	-2.46489
12	-2.44025
13	-2.46154
14	-2.50211
15	-2.48813
16	-2.48348
17	-2.44375
18	-2.39528
19	-2.35317
20	-2.34776
21	-2.35012
22	-2.31994
23	-2.30591
24	-2.28737
25	-2.26338

*with respect to planning price

TABLE 6.7 THE EFFECT ON WAGE AND RENTAL RATES OF A ONE PERCENT INCREASE IN THE PLANNING PRICE OF IMPORTS

	$\hat{w}$	$\hat{r}$
2	-.474442	.328294
3	-.469067	.333726
4	-.475485	.337853
5	-.477946	.345696
6	-.475981	.350351
7	-.465328	.359011
8	-.462430	.363169
9	-.467389	.364464
10	-.460145	.370296
11	-.448941	.378443
12	-.451682	.380371
13	-.447810	.385273
14	-.441944	.389350
15	-.444000	.387582
16	-.444560	.387594
17	-.449823	.386666
18	-.456057	.389714
19	-.461529	.396225
20	-.461079	.403628
21	-.459344	.410962
22	-.464258	.414429
23	-.465849	.421410
24	-.468989	.425767
25	-.473686	.429859

TABLE 6.8 THE CUMULATIVE PERCENT CHANGE IN THE WAGE RATE FOLLOWING A ONE PERCENT INCREASE IN THE ACTUAL PRICE OF IMPORTS: POINTS ALONG THE ADJUSTMENT PATH

$\hat{w}$
-.192881
-.300627
-.360882
-.394599
-.413472
-.424038
-.429955
-.433268
-.435123
-.436162
-.436743
-.437069
-.437252
-.437354
-.437411
-.437443
-.437461
-.437471
-.437477
-.437480
-.437482
-.437483
-.437483
-.437483

CHAPTER VII

FURTHER THEORETICAL RESULTS: AN EXAMINATION OF THE SHORT-RUN EFFECTS OF TARIFFS USING THE RICARDO-VINER MODEL

1. INTRODUCTION

In recent years, the Ricardo-Viner model has been used as a framework for examining the short-run effects of import tariffs on domestic wage and rental rates. In the simplest version of this model the production side of the economy consists of two sectors, each of which produces a final demand good using a mobile factor (say, labour) and a factor specific to each sector (say, capital).[1] One of the final goods is treated as a perfect substitute for imports, and so (higher) import tariffs cause an increase in the price of the import-competing final good. This in turn causes a change in the prices of the factors of production. The price of the mobile factor (the wage rate) rises, but the proportional increase in the wage rate is less than the proportional increase in the price of the protected final good. Thus it is not clear whether the tariff makes labour owners better or worse off in the short run. On the other hand, there is no uncertainty regarding the effect of the tariff on the welfare of the owners of the specific factors. The price of the specific factor in the protected sector rises by a greater proportional amount than the price of the protected final good, and so owners of this factor benefit from the tariff. The price of the other specific factor falls, and so the tariff makes the owners of this factor worse off in the short run.

A comparison of these results with the familiar Stolper-Samuelson results reveals that there are some interesting differences between the short-run and long-run changes in domestic factor prices caused by import tariffs. For the mobile factor the long-run price change may either reverse the short-run price change, so that ultimately the wage rate actually falls, or enhance the short-run price change, so that ultimately the proportional increase in the wage rate exceeds the proportional increase in the price of the protected final good. Thus the short-run and long-run interests of labour owners may conflict with one another. On the other hand, the owners of one of the specific factors - which specific factor it is depends upon technological conditions - unambiguously face a conflict between long-run and short-run interests, while the owners of the other specific factor face no such conflict.

In a recent paper, Burgess (1980) modified the simple Ricardo-Viner model by introducing inter-industry flows, and he showed that the results of the simple model did not necessarily hold. He found, for example, that it was quite possible that import tariffs unambiguously benefited the owners of the mobile factor in the short run. Furthermore, Burgess' analysis indicates that when the Ricardo-Viner model is modified to include inter-industry flows, the potential for conflict between the long-run and short-run interests of domestic factor owners is more varied than that found using the simple Ricardo-Viner model. For example, it is quite possible that the owners of all (three) domestic factors face no conflict between short-run and long-run interests.

In this chapter I introduce imported intermediate goods into the Ricardo-Viner model, and I use this framework to analyse the short-run changes in wage and rental rates that occur when tariffs are imposed on imported intermediate goods. One major aim of this analysis is to highlight the importance of the elasticities of substitution between imported and domestic inputs in determining how wage and rental rates change in the short run. These elasticities played a crucial role in the theoretical and empirical analysis of the earlier chapters; in this chapter I find that knowledge of the relative sizes of these elasticities is often sufficient to determine how factor prices are affected in the short run.

I also use a diagrammatic technique to show the potential for conflict between the long-run and short-run interests of the owners of domestic factors. A large variety of results are possible, depending upon technological conditions. For example, tariffs on imported intermediate goods may not cause any conflicts; it is also possible that there is a conflict between the long-run and short-run interests of the owners of all the domestic factors. This diagrammatic technique is also useful for illustrating the changes in domestic factor prices caused by tariffs on imported final goods.

This chapter is organized as follows: In section two I outline the basic framework for the analysis. In sections three, four and five I discuss and compare the long-run and short-run changes in domestic factor prices caused by tariffs on imported intermediate goods. Finally, in section six I examine the role of the elasticities of substitution between imported and domestic inputs in determining how tariffs on imported final goods affect domestic factor prices in the short run.

2. ANALYTICAL FRAMEWORK

The production side of the economy is divided into two sectors, and in each sector one final output is produced by a large number of profit maximizing firms operating in competitive conditions. Three factors of production are used in the production of each of the final outputs. The factors of production are the domestic factors, capital (K) and labour (L), and an imported input (M). The quantities of capital and of labour are fixed in supply for the economy, and these domestic factors are always fully employed. The price of the imported input (P_M) is exogenous, and the prices of the two final goods (P_i, i=1,2) are exogenous. The economy faces no restriction on the quantity of the imported input that can be purchased. The two final outputs are X_1 and X_2, and the production function for each output is:

$$X_i = F^i (K_i, L_i, M_i), \quad i = 1,2;$$

where F^i is linear homogenous and strictly quasi-concave in the inputs.[2]

It is useful to define for each sector a locus of wage and rental rates that the typical firm can pay per unit of the domestic factors, given the prices of the final outputs, the price of the imported input, and the assumption of zero profits for all firms. Following Mussa (1979), these loci are called isoprice curves (IC). The IC of sector "i", IC^i, (i = 1,2) is the dual of the real (unit) value added function of sector i (see Khang (1971)). IC^i is strictly convex to the origin, and the shape of IC^i depends upon the extent to which capital and labour can be substituted for one another in the production of sector i output. Figure 1 graphs the IC of the two sectors[3].

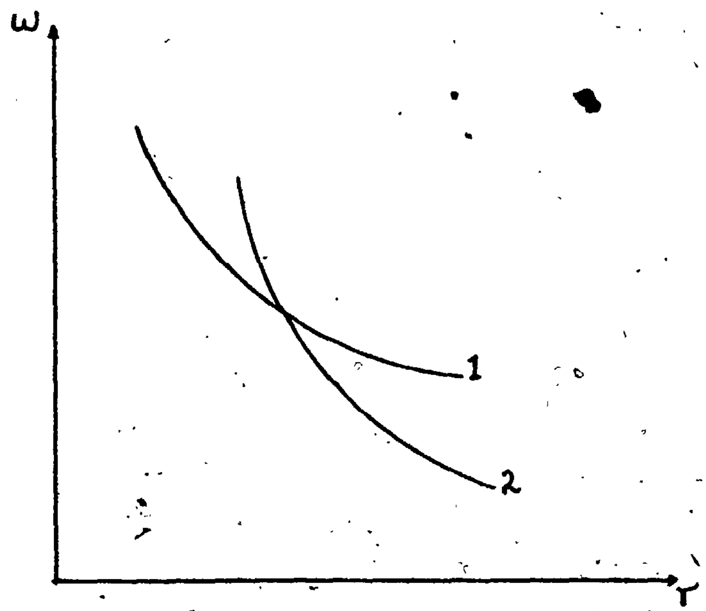


FIGURE 1

The equilibrium wage and rental rates in this economy depend upon the mobility of the domestic factors between the two sectors. The distinction between long run and short run used in this chapter (and used throughout trade theory) is based upon differences in the mobility of the domestic factors. I begin by examining the long-run equilibrium.

3. THE LONG-RUN EFFECTS OF A TARIFF ON IMPORTED INPUTS

In the long run, capital and labour are perfectly mobile between all firms in all sectors. This assumption ensures that in equilibrium the same wage (rental) rate will be paid to all units of labour (capital) by all firms in both sectors.

The long-run equilibrium can be found by solving the problem of maximizing value added given the prices of the outputs and of the imported input and given the fixed supplies of the domestic factors.[4] It is convenient to work with the dual of this problem. The dual problem is:

$$\underset{(w,r,P_M)}{\text{MINIMIZE}}\ wL + rK: \quad C^i(w,r,P_M) \geq \bar{P}_i \quad (i=1,2)$$
$$K \leq \bar{K}$$
$$L \leq \bar{L} \qquad (3.1)$$

where $C^i(w,r,P_M)$ is the minimum cost of producing a unit of X_i when the input prices are w, r and P_M.

The first order conditions for an interior minimum are given by:

$$C^1(w,r,P_M) = \bar{P}_1 \qquad (3.2)$$

$$C^2(w,r,P_M) = \bar{P}_2 \qquad (3.3)$$

$$X_1C^1_w + X_2C^2_w = \bar{L} \qquad (3.4)$$

$$X_1C^1_r + X_2C^2_r = \bar{K} \qquad (3.5)$$

$$X_1C^1_{P_M} + X_2C^2_{P_M} = M \qquad (3.6)$$

where $C^i_w = \frac{\delta C^i}{\delta w}$, and similarly for C^i_r, $C^i_{P_M}$.

This system of equations can be solved for the equilibrium values of w, r, X_1, X_2, and M (and for the equilibrium quantities of the factors employed in each sector).

The long-run effects of a small change in the price of the imported input on the prices of capital and labour (given fixed output prices), are found by totally differentiating (3.2) and (3.3) (holding output prices fixed):

$$\theta_K^1 \hat{r} + \theta_L^1 \hat{w} = -\theta_M^1 \hat{P}_M \qquad (3.7)$$

$$\theta_K^2 \hat{r} + \theta_L^2 \hat{w} = -\theta_M^2 \hat{P}_M \qquad (3.8)$$

where θ_K^i is the share of capital in total cost of producing X_i (at the initial equilibrium),

$$\theta_K^i \equiv \frac{r(K_i/X_i)}{P_i} = \frac{rC_r^i}{C^i},$$

(and similarly for θ_L^i, θ_M^i),

and where $\hat{r} = \frac{dr}{r}$ (and similarly for $\hat{w}$, $\hat{P}_M$).

By inspection of (3.7) and (3.8) it is clear that while w and r cannot both increase following an increase in P_M, an increase in either w or r is not ruled out. The solution to (3.7) and (3.8) is:

$$\hat{w} = \frac{\theta_K^1\theta_M^2 - \theta_K^2\theta_M^1}{\theta_L^1\theta_K^2 - \theta_L^2\theta_K^1} \cdot \hat{P}_M \qquad (3.9)$$

$$\hat{r} = \frac{\theta_L^2\theta_M^1 - \theta_L^1\theta_M^2}{\theta_L^1\theta_K^2 - \theta_L^2\theta_K^1} \cdot \hat{P}_M \qquad (3.10)$$

And from (3.9) and (3.10):

$$\hat{w} - \hat{r} = \frac{\theta_M^2 - \theta_M^1}{\theta_L^1\theta_K^2 - \theta_L^2\theta_K^1} \cdot \hat{P}_M \qquad (3.11)$$

Thus the effect of an increase in the price of imported inputs on the prices of the domestic factors depends only on the initial cost shares of the three factors in both sectors.[5] Using (3.9) to (3.11) we can find the conditions under which the real wage (rental) rate rises, and the conditions under which labour gains relative to capital, following an increase in the price of the imported input:

Real Wage Rate

$\hat{w} > 0$ iff $(\theta_K^1\theta_M^2 - \theta_K^2\theta_M^1)$ and $(\theta_L^1\theta_K^2 - \theta_L^2\theta_K^1)$ have the same sign. This can be rewritten as:

$$\hat{w} > 0 \text{ iff } \frac{\theta_K^1}{\theta_K^2} \text{ lies between } \frac{\theta_L^1}{\theta_L^2} \text{ and } \frac{\theta_M^1}{\theta_M^2}.$$

Real Rental Rate

$$\hat{r} > 0 \text{ iff } \frac{\theta_L^1}{\theta_L^2} \text{ lies between } \frac{\theta_K^1}{\theta_K^2} \text{ and } \frac{\theta_M^1}{\theta_M^2}.$$

Factoral Income Distribution

If sector i has a larger capital/labour ratio than sector j ($\theta_K^i/\theta_L^i > \theta_K^j/\theta_L^j$), then whenever $\theta_M^i > \theta_M^j$ ($\theta_M^i < \theta_M^j$) labour gains relative to capital (capital gains relative to labour). (Note that since w and r_i (w and r_j) cannot both rise, whenever $\theta_K^i/\theta_L^i > \theta_K^j/\theta_L^j$, and $\theta_M^i > \theta_M^j$, r must fall, while whenever $\theta_K^i/\theta_L^i > \theta_K^j/\theta_L^j$, and $\theta_M^i < \theta_M^j$, w must fall.)

Diagrammatic Illustration

The factoral income distribution result can be illustrated using the IC. The long-run equilibrium values of the factor prices are given by the unique intersection point of the two IC (E_o in Figure 2). The capital/labour ratios in equilibrium are given by the slope of the tangents to each IC at this intersection point (by Shepherd's Lemma). Thus sector 2 has a higher capital/labour ratio than sector 1, that is, $\theta_K^1/\theta_L^1 < \theta_K^2/\theta_L^2$.

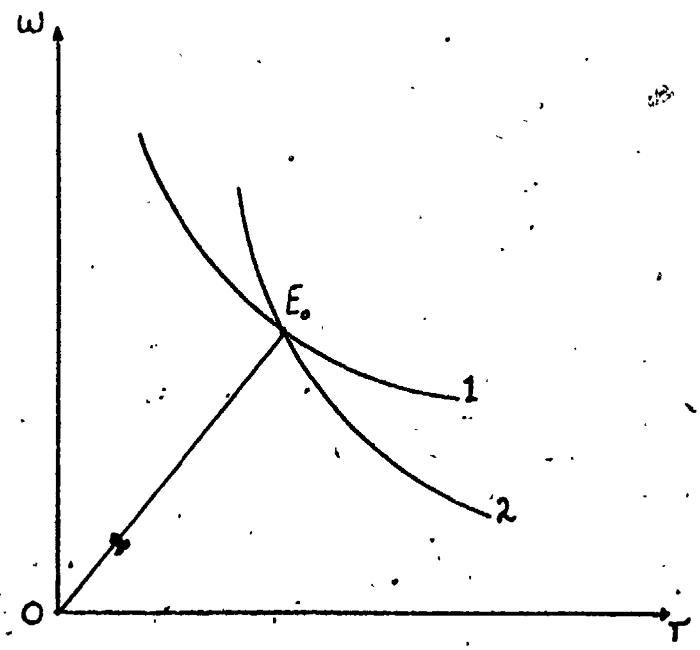


FIGURE 2

Now consider an increase in the price of the imported input. The new IC for sector 1 lies everywhere inside the old IC^1; and similarly for the second sector. The amount by which each IC shifts in along the ray OE_o (that is, at unchanged w/r ratio) depends only on the share of imports in the cost of a unit of output.[6] The new long-run equilibrium is at the intersection of the two new IC. Thus, if $\theta_M^2 > \theta_M^1$, IC^2 shifts inward along OE_o by a greater amount than IC^1, and the intersection of the two new IC must lie above the ray OE_o. In this case, an increase in the price of imports redistributes income in favour of labour. This result is confirmed by (3.11) above.

It is difficult to show diagrammatically the general conditions under which w or r increases following an increase in the price of the imported input. However, for purposes of illustration I consider, in Figure 3, the simple case where imports are used as an input in the second sector only. The initial equilibrium is at E_o. An increase in the price of imports shifts IC^2 inwards, while IC^1 is not affected. In the new equilibrium, at E_1, w has risen and r has fallen. This result is predicted by the algebra, since in this case $\theta_L^1/\theta_L^2 > \theta_K^1/\theta_K^2 > \theta_M^1/\theta_M^2$.

Finally, it is interesting to interpret the empirical results of the earlier chapters in the framework of this two sector model. We have seen that higher tariffs cause an increase in the rental rate and a fall in the wage rate in Canada. Now suppose we disaggregate the production sector

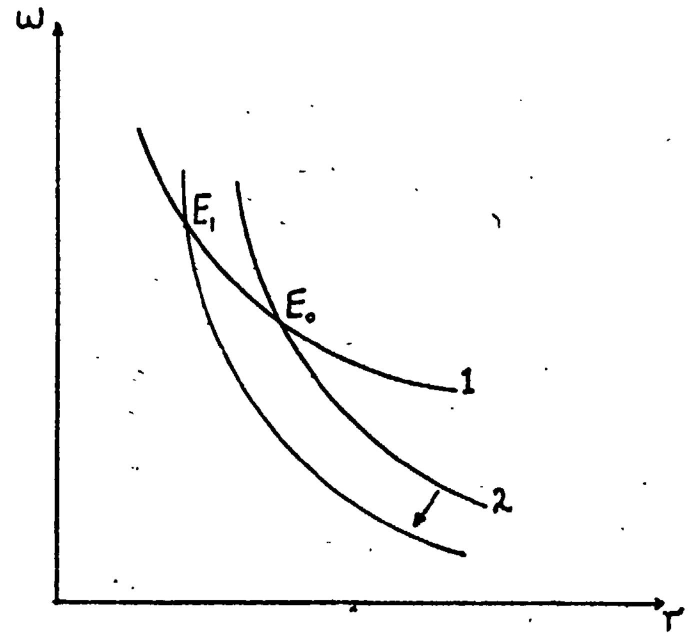


FIGURE 3

into the natural resources sector, on the one hand, and the manufacturing and services sector, on the other. The former is the more capital intensive sector; the latter buys most of Canada's imports. Thus, using Figure 3, an increase in the price of imports shifts IC^1 (representing the manufacturing and services sector) inwards, while IC^2 (representing the natural resources sector) is not affected (or shifts in only a small amount). In the new equilibrium, the rental rate has risen and the wage rate has fallen.

4. THE SHORT-RUN EFFECTS OF A TARIFF ON IMPORTED INPUTS

In the short run labour is freely mobile between all firms in both sectors, while capital is freely mobile between all firms in a particular sector, but perfectly immobile between sectors. In equilibrium all factors are fully employed: the same wage rate is paid to all units of labour by all firms in both sectors; and all firms in sector 1 (2) pay the same rental rate to all units of capital in sector 1 (2), but the rental rate can differ between sectors.

The short-run equilibrium in the production sector can be derived by solving the (dual) problem:

$$\underset{(w,r_1,r_2,P_M)}{\text{MINIMIZE}} \quad wL + r_1K_1 + r_2K_2: \quad \begin{array}{l} C^i(w,r_i,P_M) \geq P_i, \ (i=1,2) \\ L \leq \bar{L} \\ K_i \leq \bar{K}_i, \ (i=1,2) \end{array} \tag{4.1}$$

where $C^i(w,r_i,P_M)$ is the minimum cost of producing a unit of X_i when the input prices are w, r_i, and P_M, and where $\bar{K}_i$ is the fixed quantity of K in sector i.

The first order conditions for an interior minimum are given by:

$$C^1(w,r_1,P_M) = \bar{P}_1 \tag{4.2}$$

$$C^2(w,r_2,P_M) = \bar{P}_2 \tag{4.3}$$

$$X_1C^1_w + X_2C^2_w = \bar{L} \tag{4.4}$$

$$X_1C^1_{r_1} = \bar{K}_1 \tag{4.5}$$

$$X_2C^2_{r_2} = \bar{K}_2 \tag{4.6}$$

$$X_1C^1_{P_M} + X_2C^2_{P_M} = M \tag{4.7}$$

This system of equations can be solved for the equilibrium values of w, r_1, r_2, X_1, X_2, and M.

The short-run effects of a small change in the price of the imported input on w, r_1, and r_2 are found by totally differentiating (4.2) to (4.6), holding constant the prices of the outputs, the total supply of labour, and the quantity of capital in each sector. The results are:

$$\hat{w} = \frac{1}{\Delta}\{\lambda_1\theta^1_K\theta^1_M\theta^2_K[S^1_{LM}-S^1_{KM} + S^1_{KK}-S^1_{KL}] + \lambda_2\theta^1_K\theta^2_K\theta^2_M[S^2_{LM}-S^2_{KM} + S^2_{KK}-S^2_{KL}]\}\hat{P}_M \tag{4.8}$$

$$\hat{r}_1 = \frac{1}{\Delta}\{\lambda_1\theta^1_L\theta^1_M\theta^2_K[S^1_{KM}-S^1_{LM} + S^1_{LL}-S^1_{KL}] + \lambda_2\theta^1_L\theta^2_K\theta^2_M[S^2_{KM}-S^2_{LM} + S^2_{KL}-S^2_{KK}] + \lambda_2\theta^1_M\theta^2_L\theta^2_K[-2S^2_{KL} + S^2_{LL} + S^2_{KK}]\}\hat{P}_M \tag{4.9}$$

$$\hat{r}_2 = \frac{1}{\Delta}\{\lambda_1\theta_K^1\theta_M^1\theta_L^2[S_{KM}^1 - S_{LM}^1 + S_{KL}^1 - S_{KK}^1]$$

$$+ \lambda_2\theta_K^1\theta_L^2\theta_M^2[S_{KM}^2 - S_{LM}^2 + S_{LL}^2 - S_{KL}^2]$$

$$+ \lambda_1\theta_L^1\theta_K^1\theta_M^2[-2S_{KL}^1 + S_{LL}^1 + S_{KK}^1]\}\ \hat{P}_M \qquad (4.10)$$

where S_{jh}^i is the Allen/Uzawa partial elasticity of substitution between factors j and h in sector i,

$\lambda_i = L_i/L$, i = 1,2, and

$$\Delta = \{\lambda_1\theta_L^1\theta_K^1\theta_K^2[2S_{KL}^1 - S_{LL}^1 - S_{KK}^1]$$

$$+ \lambda_2\theta_K^1\theta_L^2\theta_K^2[2S_{KL}^2 - S_{LL}^2 - S_{KK}^2]\}$$

≥ 0, since each unit cost function is linear homogeneous and concave in factor prices.

Thus in the short run the effect of a change in the price of imports on the prices of the domestic factors depends (in a complicated manner) on initial cost shares and on the various partial elasticities of substitution between the inputs in each sector. In order to gain some understanding of these results I now show how the short-run equilibrium can be found using the IC, and I use the IC to examine the effects of a change in the price of the imported input.

<u>Diagrammatic Analysis</u>

Using (4.5) and (4.6), (4.4) can be rewritten

$$\bar{K}_1 \frac{C_w^1}{C_{r_1}^1} + \bar{K}_2 \frac{C_w^2}{C_{r_2}^2} = \bar{L} \quad (4.11)$$

Without loss of generality, set $\bar{K}_1 = \bar{K}_2 = \bar{L} = 1$. Now (4.11) becomes

$$\frac{1}{k_1} + \frac{1}{k_2} = 1, \quad (4.12)$$

where $k_i \equiv \frac{K_i}{L_i}$.

The IC of the two sectors are drawn in Figure 4. Short-run equilibrium is given by the (unique) wage rate - common to all firms in both sectors - where (4.12) is satisfied. Recall that the slope of the tangent to IC^1 (IC^2) gives the capital-labour ratio for sector 1 (sector 2). Draw these tangents at some common wage rate, and let the tangents intersect one another at A, and let the tangents intersect the base line at B and C. Drop a perpendicular from A to intersect the base line at some point D. Now the requirement (4.12) can be rewritten as:

$$\frac{1}{\frac{DA}{DB}} + \frac{1}{\frac{DA}{DC}} = 1 \quad (4.13)$$

which implies $DA = BC$ (4.14)

Thus the short-run equilibrium can be found (in Figure 4) by finding the unique w such that the triangle formed by the tangents to the IC at this common wage rate, and the

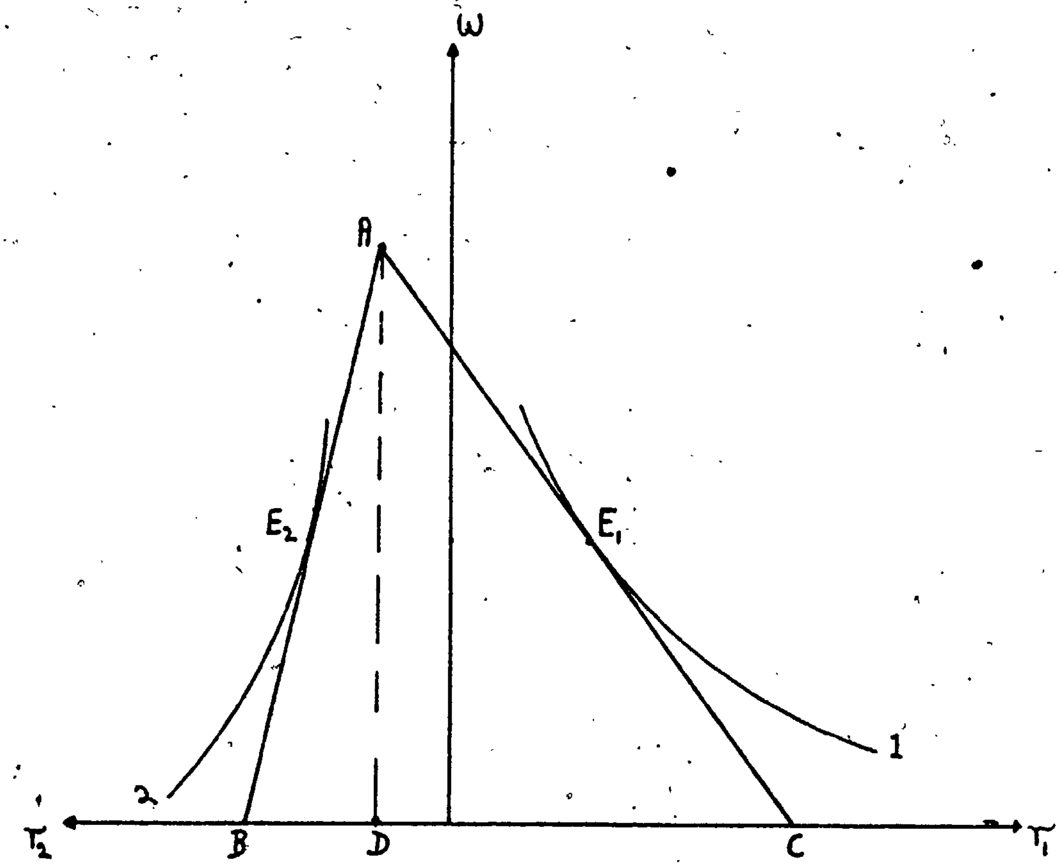


FIGURE 4

base line, has the property that the length of its base equals its vertical height. In Figure 4, the short-run equilibrium is (E_1, E_2).

Now consider the effect on domestic factor prices of a change in the price of the imported input. It is useful to divide the short-run adjustment of the economy into two stages. In the first stage, there is no movement of factors between the two sectors. The capital/labour (K/L) ratio in the two sectors does not change, and w and r in each sector adjust to ensure full employment of capital and labour in each sector. During this stage the change in w_i and r_i in sector i can be found by differentiating the equilibrium conditions for sector i:

$$C^i(w_i, r_i, P_M) = P_i \qquad (4.15)$$

$$X_i C^i_{w_i} = \bar{L}_i \qquad (4.16)$$

$$X_i C^i_{r_i} = \bar{K}_i \qquad (4.17)$$

holding P_i, L_i and K_i fixed. The results are:

$$\hat{w}_i = \frac{1}{\Delta_i}\{\theta^i_K\theta^i_M[S^i_{LM} - S^i_{KM} + S^i_{KK} - S^i_{KL}]\}\hat{P}_M \qquad (4.18)$$

$$\hat{r}_i = \frac{1}{\Delta_i}\{\theta^i_L\theta^i_M[S^i_{KM} - S^i_{LM} + S^i_{LL} - S^i_{KL}]\}\hat{P}_M \qquad (4.19)$$

$$\hat{w}_i - \hat{r}_i = \frac{1}{\Delta_i}\{\theta^i_M[S^i_{LM} - S^i_{KM}]\}\hat{P}_M \qquad (4.20)$$

where $\Delta_i \equiv \theta^i_L\theta^i_K[2S^i_{KL} - S^i_{LL} - S^i_{KK}] > 0$.

Thus whether w_i (r_i) increases or decreases during the first stage of the adjustment process depends on the relative sizes of the Allen/Uzawa elasticities of substitution; and clearly w_i or r_i (but not both) could rise. Furthermore, whether $(\hat{w}_i - \hat{r}_i)$ is positive or negative depends only on the value of $(S^i_{LM} - S^i_{KM})$.

Figure 5 shows one possible change in w_i and r_i after the economy completes the first stage of the adjustment process. An increase in P_M shifts both IC inward; IC^1 shifts in more than IC^2 because of the assumption that $\theta^1_M > \theta^2_M$. The new wage and rental rates in sector 1 (2) at the unchanged K_1/L_1 (K_2/L_2) ratio are w^G_1, r^G_1 $(w^F_2$, $r^F_2)$.

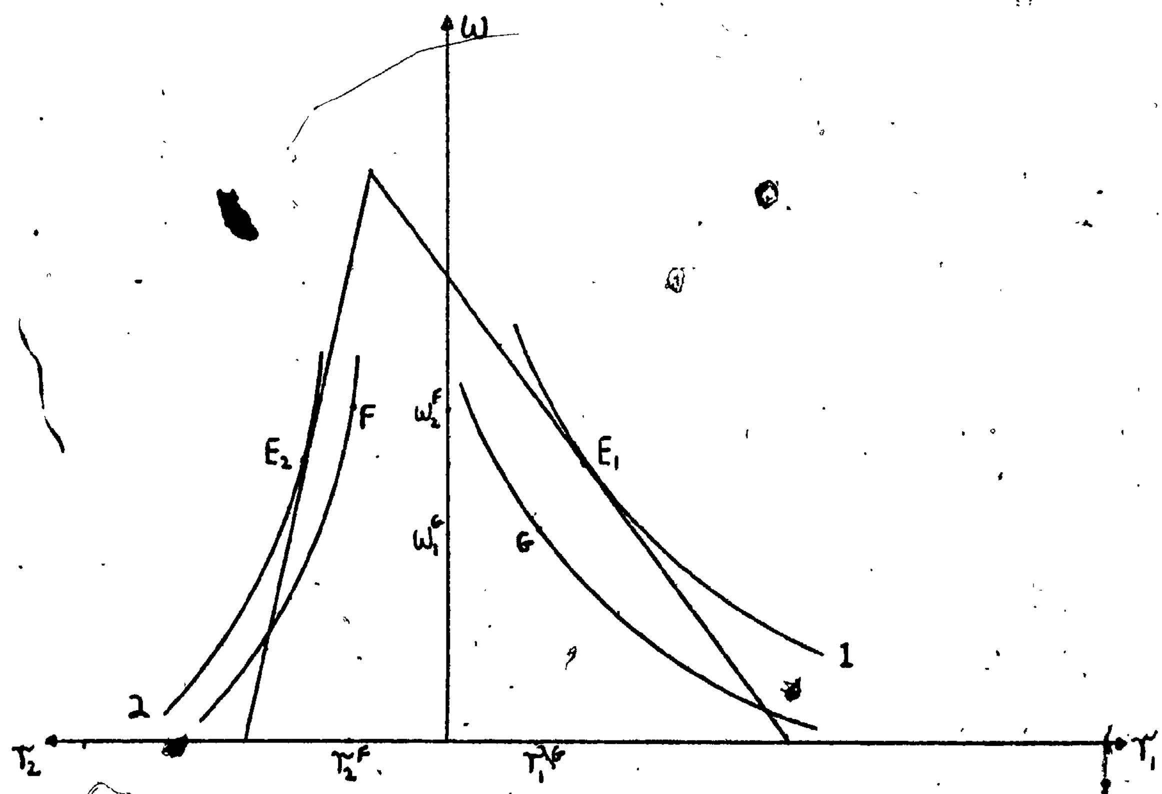


FIGURE 5

In the second stage of the short-run adjustment process labour moves in response to the difference in the wage rate between the two sectors. This adjustment continues until a common wage rate exists in the two sectors. This common wage rate cannot be w_1^G: if we draw tangents at this common wage rate the triangle formed has a base which exceeds its vertical height. Thus in order to adjust the triangle to meet (4.14) we must move to a higher wage rate. A similar reasoning indicates that the equilibrium cannot be above w_2^F. Thus the short-run equilibrium wage rate must lie between w_1^G and w_2^F. This result holds whether $w_1^G \gtrless w_2^F$, whether $(K_1/L_1) \gtrless (K_2/L_2)$ and whether $\theta_M^1 \gtrless \theta_M^2$.

The Role of the Elasticities of Substitution Between Imports and the Domestic Factors

One aim of this chapter is to examine the importance of S_{KM}^i and S_{LM}^i in determining the short-run effects of changes in the price of imported inputs on w, r_i, and factoral income distribution. In order to do this I consider, in turn, three different restrictions on S_{KM}^i and S_{LM}^i: $S_{KM}^i = S_{LM}^i$, $S_{KM}^i > S_{LM}^i$, and $S_{KM}^i < S_{LM}^i$.

(i) $S_{KM}^i = S_{LM}^i$, $i = 1,2$.

During the first stage of the short-run adjustment process (when all factors are immobile between sectors) $\hat{w}_i = \hat{r}_i$

(see (4.20)). In Figure 6, as IC^1 (IC^2) shifts in, its slope is unchanged along the ray OE_1 (OE_2). The (temporary) equilibrium in sector 1 (sector 2) is at the point where the ray OE_1 (OE_2) cuts the new IC^1 (IC^2) – point G (F) in Figure 6.

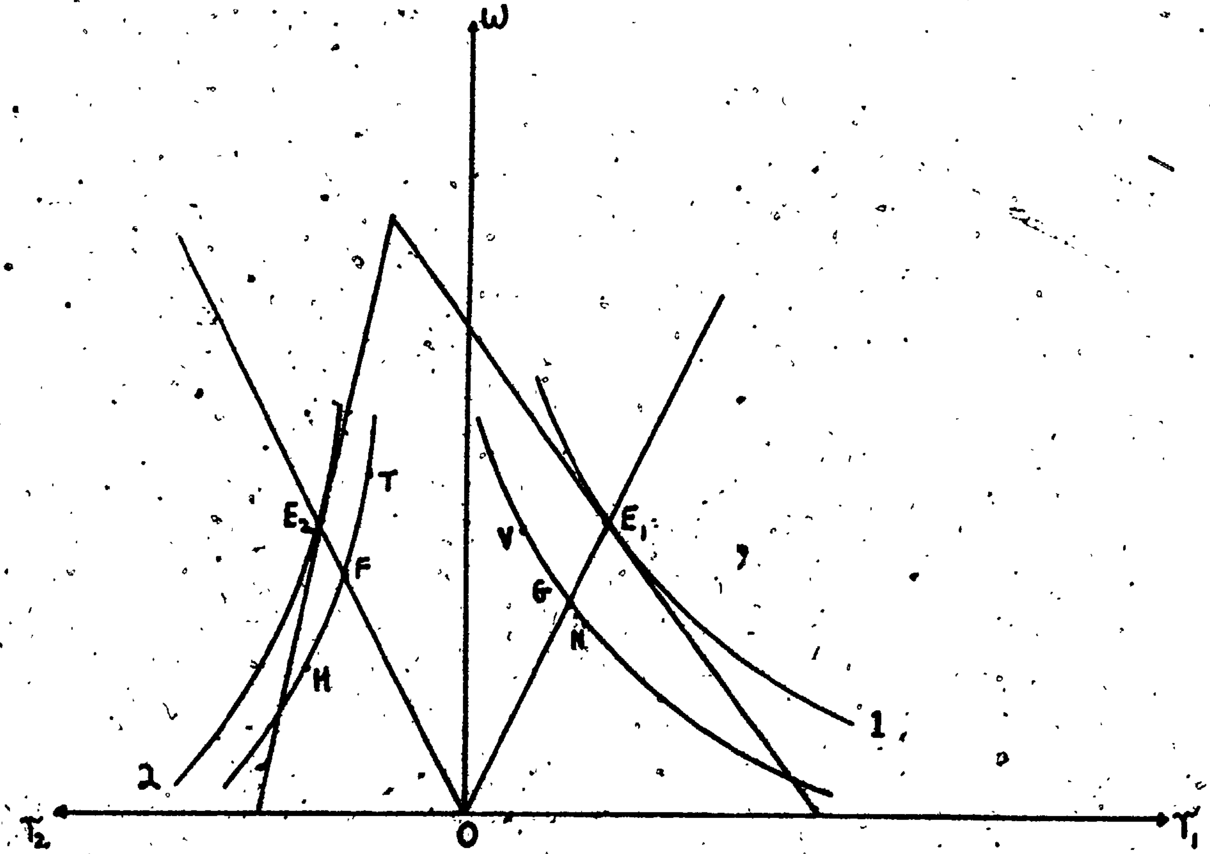


FIGURE 6

The short-run equilibrium must be at a common wage rate between the points G and F. Thus w falls in the short run. Furthermore, by inspection of Figure 6, if $\theta^i_M > \theta^j_M$, [illegible] and $\hat{r}_j \gtrless 0 > \hat{w}$. That is, if sector 1 uses more of the imported input per unit of output than sector 2, then the price of the specific factor in sector 1 must fall while the price of the specific factor in sector 2 may rise or fall. (These results are also proved in Proposition 1 in the appendix to this chapter.)

(ii) $S^i_{KM} > S^i_{LM}$, $i = 1,2$

In the first stage of the short-run adjustment process $\hat{w}_i - \hat{r}_i < 0$, $i = 1,2$ (see (4.20)). In Figure 6, as IC^1 (IC^2) shifts in, it becomes steeper along the ray OE_1 (OE_2), and the (temporary) equilibrium in sector 1 (sector 2) is at a point on the new IC^1 (IC^2) below the ray OE_1 (OE_2) - for example, point N (point H). Note that w falls in both sectors.

The short-run equilibrium must be at some common w between N and H. Thus w falls in the short run. (See Proposition 2 in the appendix.) It is striking to compare the short-run and long-run changes in w in this case. The wage rate must fall in the short run. Relative factor shares play no part in determining the direction of change of w. In the long run, on the other hand, relative factor shares alone determine the direction of change of w, and it is quite possible that w rises in the long run.

By inspection of Figure 6 it is clear that both rental rates may rise or fall in the short run. Furthermore, $\theta_M^i < \theta_M^j$ implies $\hat{w} - \hat{r}_i < 0$ and $\hat{w} - \hat{r}_j \gtrless 0$. (See Proposition 2 in the appendix.)

(iii) $S_{KM}^i < S_{LM}^i$, $i = 1,2$

In the first stage of the adjustment process $\hat{w}_i - \hat{r}_i > 0$, $i = 1,2$ (see (4.20)). In Figure 6, as IC^1 (IC^2) shifts in, it becomes flatter along the ray OE_1 (OE_2), and the (temporary) equilibrium in sector 1 (sector 2) is at a point on the new IC^1 (IC^2) above the ray OE_1 (OE_2) – for example, point V (point T). Note that w may rise in either (or both) sectors.

The short-run equilibrium must be at some common w between V and T. Thus w may rise or fall in the short run (see Proposition 3). Under what conditions would w rise in the short run? Clearly, if w_i and w_j both rise during the first stage of the adjustment process, then w must rise in the short run. Furthermore, either w_i or w_j must rise during the first stage if w is to rise in the short run. If w_i rises and w_j falls during the first stage, then w is more likely to rise in the short run when θ_M^i and λ_i are large.

The Variety of Short-Run Equilibria and Conflicts Between Short Run and Long Run

In Figure 7 and Table 7.1 I present the variety of short-run changes in w and r that are possible (in the case where $\theta_M^1 = 0$). The initial long-run equilibrium is at E_o. A rise in the price of imports shifts IC^2 inwards (while IC^1 is unaffected). The new long-run equilibrium is at E_1. Thus in the long run w rises and r falls. The short-run equilibrium will be at points like (A_1,A_2), (B_1,B_2), (C_2,E_o), (D_1,D_2) or (F_1,F_2), depending upon the cost share of imports in the production of sector 2 output, and upon the Allen/Uzawa elasticities of substitution between the inputs in the production process. Table 7.1 lists the changes in w, r_1, and r_2 that take place when the short-run equilibrium is at any of these points.

Two of these equilibria deserve some comment. First, if the short-run equilibrium is at the point (A_1,A_2) then in the short run $\hat{w} < 0$ and $\hat{r}_1,\hat{r}_2 > 0$. All domestic factor owners face a conflict between short-run and long-run interests. A necessary (but not sufficient) condition for short-run equilibrium at (A_1,A_2) is $S^2_{KM} > S^2_{LM}$.[8]

Second, if the short-run equilibrium is at (F_1,F_2) then w rises more in the short run than in the long run - and thus w must fall during the transition from short-run to long-run equilibrium, while r_1 and r_2 fall more in the short run than

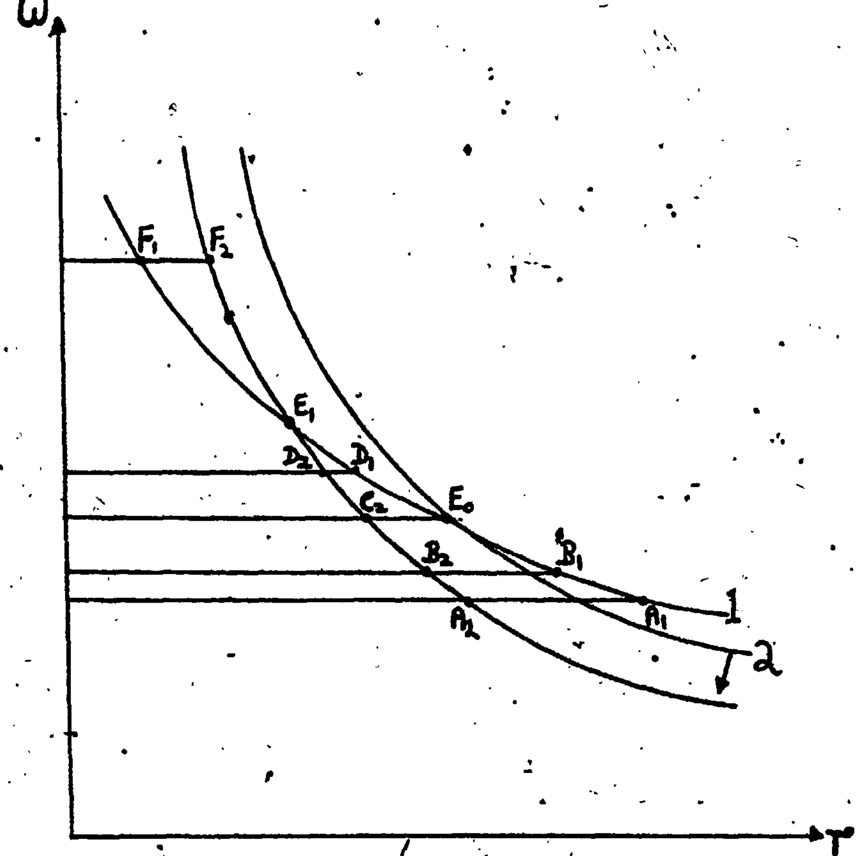


FIGURE 7

in the long run. (w falls and both r_i increase because both sectors become more labour intensive as the economy moves from (F_1, F_2) to E_1.) Since w rises in the short run, a necessary (but not sufficient) condition for short-run equilibrium at (F_1, F_2) is $S^2_{KM} < S^2_{LM}$.

TABLE 7.1. THE VARIETY OF SHORT RUN EQUILIBRIA AND CONFLICTS BETWEEN SHORT RUN AND LONG RUN: THE CASE OF A TARIFF ON INTERMEDIATE GOODS

	Short-Run Change in Factor Prices	Relative Rewards of K_i in the Short Run Equilibrium	Factors With Conflicts Between Long Run and Short Run
(A_1, A_2)	$\hat{r}_1>0, \hat{r}_2>0, \hat{w}<0$	$r_1>r_2$	L, K_1, K_2
(B_1, B_2)	$\hat{r}_1>0, \hat{r}_2<0, \hat{w}<0$	$r_1>r_2$	L_1, K_1
(C_2, E_o)	$\hat{r}_1=0, \hat{r}_2<0, \hat{w}=0$	$r_1>r_2$	NONE
(D_1, D_2)	$\hat{r}_1<0, \hat{r}_2<0, \hat{w}>0$	$r_1>r_2$	NONE
(F_1, F_2)	$\hat{r}_1<0, \hat{r}_2<0, \hat{w}>0$	$r_1<r_2$	NONE

5. FROM THE SHORT RUN TO THE LONG RUN

In this section I outline how factor prices change as the economy adjusts from a short-run to a long-run equilibrium. The adjustment occurs as capital migrates from the sector where, in the short run, the rental rate is relatively low into the sector where the rental rate is relatively high. This causes continuous adjustment of the output of each sector, of the quantity of labour employed in each sector, of the domestic factor prices, and so on, until the economy is once again in a long-run equilibrium, where the same rental rate is paid to all units of capital in both sectors.

Initially, the economy is in some long-run equilibrium, as described by equations (3.2) to (3.6). This long-run equilibrium determines some initial distribution of capital between the two sectors. An increase in the price of the imported input moves the economy towards some short-run equilibrium, as described by equations (4,2) to (4.7), given the initial distribution of capital. Once the economy arrives at this short-run equilibrium, the long-run adjustment begins, as capital is attracted from the low rental to the high rental industry.

To find the effect on domestic factor prices as capital moves from, say, sector 2 into sector 1 (this occurs whenever $r_2 < r_1$ in short-run equilibrium) totally differentiate (4.2) through (4.7), holding P_1, P_2, P_M, and L fixed, and setting $dK_1 = -dK_2$, and solve for

$$dw = \frac{1}{\Delta} \{\frac{\theta_K^1 \theta_K^2}{k_1 k_2 L} [k_2 - k_1]\} dK_1 \qquad (5.1)$$

$$\hat{r}_1 = - [\frac{\theta_L^1}{\theta_K^1}] \hat{w} \qquad (5.2)$$

$$\hat{r}_2 = - [\frac{\theta_L^2}{\theta_K^2}] \hat{w} \qquad (5.3)$$

Thus wages increase during the adjustment iff capital is moving into the sector with lower capital/labour ratio. (Note that during the adjustment, wages move in the opposite direction to both rental rates.)

This adjustment brings the economy towards a long-run equilibrium whenever

$$dr_2 - dr_1 > 0$$

(i.e., either r_2 is rising faster than r_1, or r_2 is falling slower than r_1). From (5.2) and (5.3)

$$dr_2 - dr_1 = \frac{1}{k_1 \cdot k_2} [k_2 - k_1] dw \qquad (5.4)$$

$$> 0$$

since from (5.1) dw is positive (negative) whenever $(k_2 - k_1)$ is positive (negative).

Figure 8, below, shows the initial IC and also the new IC^2 following a change in the price of the imported input (assuming, once again, that sector 1 does not use any imported input). The initial long-run equilibrium is at E_0,

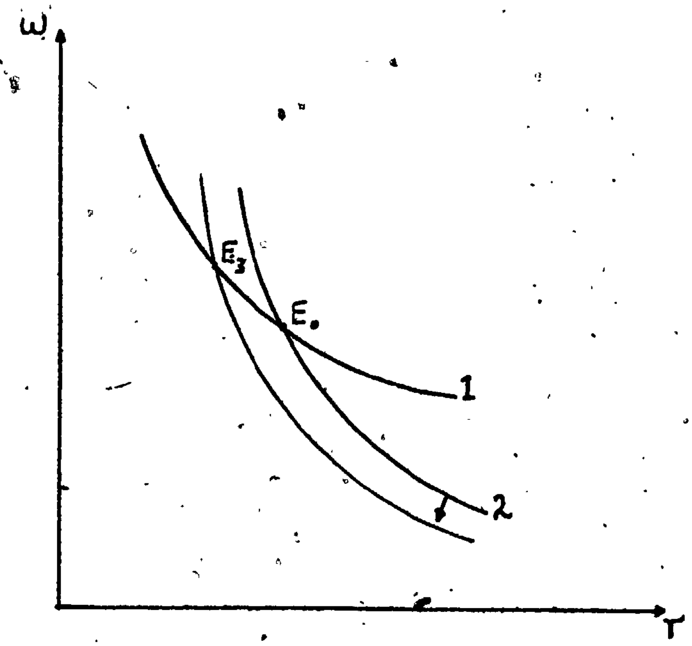


FIGURE 8

while the new long-run equilibrium is at E_3. If the short-run equilibrium is below E_3, then during the adjustment capital moves into sector 1, which has the lower capital/labour ratio, and both sectors become more capital intensive. Thus the wage rate increases while both rental rates decline. On the other hand, if the short-run equilibrium is above E_3, then both sectors become more labour intensive during the long-run adjustment process, and the wage rate falls while both rental rates rise during the adjustment process.

6. A TARIFF ON IMPORTED FINAL GOODS

In this section I use the modified Ricardo-Viner model outlined in section 2, above, to examine the short-run changes in domestic factor prices caused by a tariff on imported final goods. The analysis in this section is quite similar to the analysis in Burgess [1980], but extends the analysis performed by Burgess by (i) highlighting the importance of the elasticities of substitution between imported and domestic inputs, and (ii) using a diagrammatic technique to examine the potential for conflict between the long-run and short-run interests of domestic factor owners.

The Short Run

A tariff on imported final goods raises P_1 (assuming the output of sector one is a substitute for imported final goods). To calculate the effect of an increase in P_1 on domestic factor rewards, totally differentiate (4.2) to (4.6) (holding P_2 and P_M fixed) and solve for

$$\hat{w} = \frac{1}{\Delta}\{\theta_K^2\theta_K^1\lambda_1(S_{KL}^1 - S_{KK}^1)\}\hat{P}_1 \qquad (6.1)$$

$$\hat{r}_1 = \frac{1}{\Delta}\{\theta_K^2\theta_L^1\lambda_1(S_{KL}^1-S_{LL}^1) + \theta_K^2\theta_L^2\lambda_2(2S_{KL}^2-S_{LL}^2-S_{KK}^2)\}\hat{P}_1 \quad (6.2)$$

$$\hat{r}_2 = \frac{1}{\Delta}\{\theta_L^2\theta_K^1\lambda_1(S_{KK}^1 - S_{KL}^1)\}\hat{P}_1 \quad (6.3)$$

(The terms are as defined above.)

Labour (capital in sector i) enjoys an unambiguous increase in real income whenever $\hat{w} > \hat{P}_1$ ($\hat{r}_i > \hat{P}_1$). Before examining the circumstances under which the reward of any domestic factor unambiguously increases, it is interesting to examine the importance of the elasticity of substitution between the domestic factors and the imported input in the protected sector in determining the direction in which domestic factor prices change. To do this, note that (6.1) and (6.2) can be rewritten:

$$\hat{w} = \frac{1}{\Delta}\{\theta_K^2\lambda_1[\theta_M^1(S_{KM}^1-S_{LM}^1) + \theta_L^1(S_{KL}^1-S_{LL}^1)]\}\hat{P}_1 \quad (6.4)$$

$$\hat{r}_1 = \frac{1}{\Delta}\{\theta_K^2\lambda_1[\theta_M^1(S_{LM}^1-S_{KM}^1) + \theta_K^1(S_{KL}^1-S_{KK}^1)] + \lambda_2\theta_K^2\theta_L^2(2S_{KL}^2-S_{LL}^2-S_{KK}^2)\}\hat{P}_1 \quad (6.5)$$

In Figure 9, the initial long run equilibrium is at (E_1,E_2). An increase in P_1 shifts IC^1 out; the shift of IC^1 along the ray OE_1 is equal to $\hat{P}_1/(1-\theta_M^1)$. The slope of the IC^1 along the ray OE_1D is unchanged if $S_{KM}^1 = S_{LM}^1$, while the slope becomes flatter (steeper) whenever $S_{KM}^1 > S_{LM}^1$

$(S^1_{KM} < S^1_{LM})$.

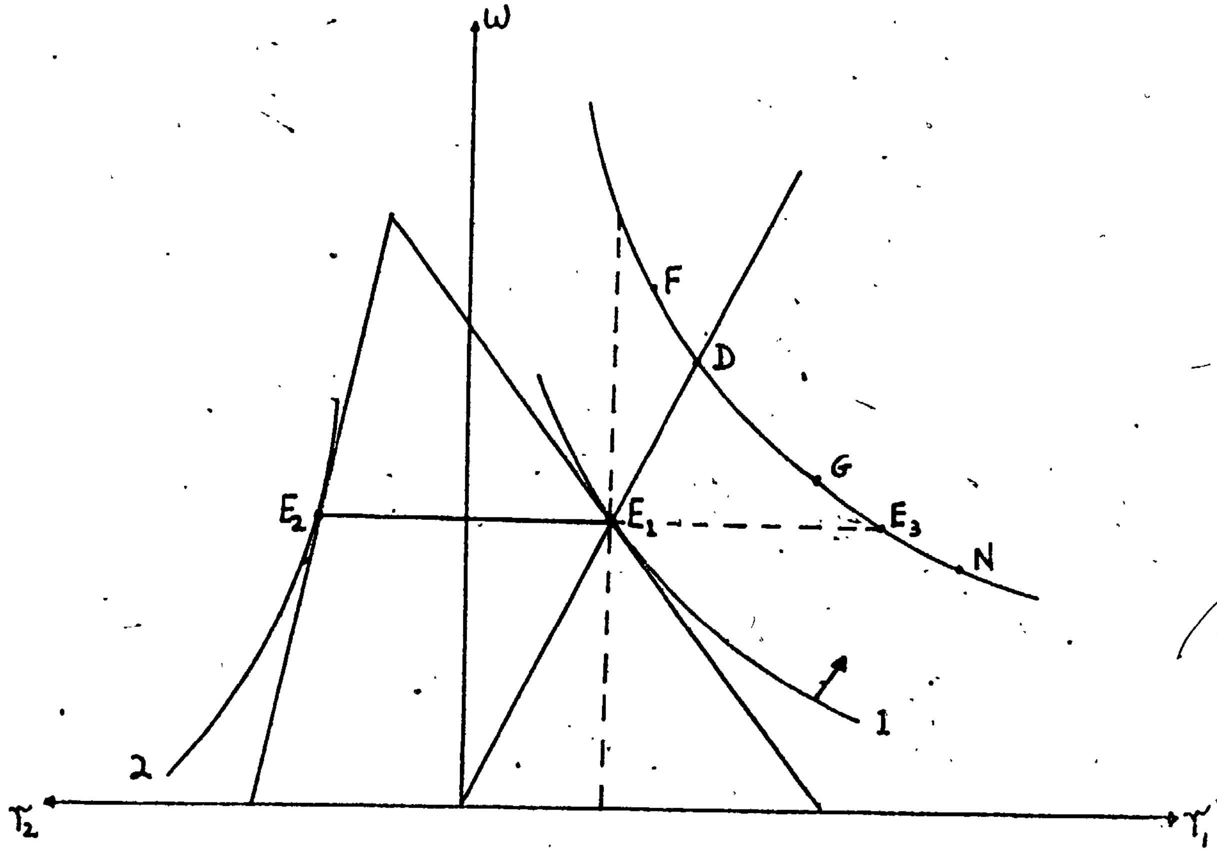


FIGURE 9

Now consider the following restrictions on S^1_{KM} and S^1_{LM}:

(i) $S^1_{KM} = S^1_{LM}$

During the first stage of the short-run adjustment process (when all factors are immobile between sectors) $\hat{w}_1 = \hat{r}_1 = \hat{P}_1/(1-\theta^1_M)$. In Figure 9, as IC^1 shifts out, its slope is unchanged along the ray OE_1. The (temporary) equilibrium in sector 1 is at the point of intersection of the ray OE_1, and the new IC^1 - point D. The equilibrium in sector 2 remains at E_2 during this stage of the adjustment process.

The short-run equilibrium must be at some common wage rate between D and E_2. Thus, w rises in the short run. Furthermore, by inspection of Figure 7, $\hat{r}_1 > \hat{P}_1/(1-\theta^1_M) > \hat{w} > 0 > \hat{r}_2$. (See Proposition 4 in the appendix.)

(ii) $S^1_{KM} > S^1_{LM}$

In the first stage of the short-run adjustment process $\hat{w} > \hat{P}_1/(1-\theta^1_M) > \hat{r}_1 \gtrless 0$. In Figure 9, as IC^1 moves out it becomes flatter along the ray OE_1D, and the (temporary) equilibrium in sector 1 is at a point along the new IC^2 above the ray OE_1D - for example, point F.

During the second stage of the adjustment process, labour moves from sector 2 into sector 1. The short-run equilibrium must be at some common wage rate between F and E_2. Thus w rises in the short run. Furthermore, $\hat{r}_1 \gtrless 0$, and $\hat{w} - \hat{r}_1 \gtrless 0$. (See Proposition 5 in the appendix.)

(iii) $S^1_{KM} < S^1_{LM}$

In the first stage of the adjustment process $\hat{r}_1 > \hat{P}_1/(1-\theta^1_M) > \hat{w}_1 \gtrless 0$. In Figure 9, as IC^1 shifts out it becomes steeper along the ray OE_1, and the (temporary) equilibrium is at some point along the new IC^1 below the ray OE_1D. The possibility that w falls in the short run arises in this case.

If the temporary equilibrium is above E_3 - at point G, for example - then $\hat{r}_1 > \hat{P}_1/(1-\theta^1_M) > \hat{w}_1 > 0$. During the second stage of the adjustment process, labour moves from sector 2 into sector 1. The short-run equilibrium must be at some common w between G and E_2 and so w rises in the short run. On the other hand, if the temporary equilibrium in sector 1 is at a point on the new IC^1 below E_3 - at point N, for example - then $\hat{r}_1 > \hat{P}_1/(1-\theta^1_M) > 0 > \hat{w}_1$. During the second stage of the adjustment process labour moves from sector 1 into sector 2.[9] The short-run equilibrium must be at some common w between N and E_2 and so w falls in the short run. Finally, note that whether $\hat{w} \gtrless 0$, $\hat{r}_1 > \hat{P}_1/(1-\theta^1_M)$ and $\hat{w} - \hat{r}_1 < 0$. (See Proposition 6 in the appendix.)

Summing up, then, whenever $S^1_{KM} > S^1_{LM}$ we can be certain that $\hat{w} > 0$ (and $\hat{r}_2 < 0$), while we need more information to determine whether r_1 rises or falls; and whenever $S^1_{KM} < S^1_{LM}$ we can be certain that $\hat{r}_1 > 0$, while we need more information to determine whether w rises or falls (r_2 falls or rises). It is striking, once again, to note that short-run changes in wage and rental rates often depend crucially on the relative values of S^1_{KM} and S^1_{LM}, while long-run changes (see below) are independent of these substitution elasticities.

Unambiguous Changes in Domestic Factor Prices[10]

(i) An Unambiguous Fall In the Real Wage Rate

Under what conditions would w fall in the short run? Clearly, a necessary condition for $\hat{w} < 0$ is $S^1_{KM} < S^1_{LM}$. Furthermore, using (6.1), a necessary and sufficient condition for $\hat{w} < 0$ is $(S^1_{KL}-S^1_{KK}) < 0$. Note that $(S^1_{KL}-S^1_{KK}) < 0$ implies $S^1_{KL} < 0 < S^1_{KM} < S^1_{LM}$.[11] Thus here again it is noteworthy that whether $\hat{w} < 0$ in the short run depends only on relative values of elasticities of substitution, while in the long run these elasticities play no part in determining whether $\hat{w} < 0$.

(ii) An Unambiguous Increase in the Real Wage Rate

From (6.1)

$$\hat{w} > \hat{P}_1 \text{ iff } \{\lambda_1(S^1_{KL}-S^1_{KK})-\Sigma\lambda_i\theta^i_L(2S^i_{KL}-S^i_{KK}-S^i_{LL})\} > 0.$$

Since $(2S^i_{KL}-S^i_{KK}-S^i_{LL}) > 0$, a necessary condition for $\hat{w} > \hat{P}_1$ is $(S^1_{KL}-S^1_{KK}) > 0$.

(iii) An Unambiguous Fall in the Real Rental Rate in the Protected Sector

A necessary condition for an unambiguous decline in the real rental rate in the protected sector, that is, for

$\hat{r}_1 < 0$, is $S^1_{KM} > S^1_{LM}$. Furthermore, using (6.2), a necessary and sufficient condition for $\hat{r}_1 < 0$ is

$$\{\lambda_1\theta^1_L(S^1_{KL}-S^1_{LL}) + \lambda_2\theta^2_L(2S^2_{KL}-S^2_{LL}-S^2_{KK})\} < 0.$$

Since $2S^2_{KL}-S^2_{LL}-S^2_{KK} > 0$, a necessary condition for $\hat{r}_1 < 0$ is $(S^1_{KL}-S^1_{LL}) < 0$. Again, $(S^1_{KL}-S^1_{LL}) < 0 \Rightarrow S^1_{KL} < 0 < S^1_{LM} < S^1_{KM}$.[12]

(iv) An Unambiguous Increase in the Real Rental Rate in the Protected Sector

From (6.2)

$$\hat{r}_1 > \hat{P}_1 \text{ iff } \{\lambda_1\theta^2_K\theta^1_L(1-\theta^1_K)(S^1_{KL}-S^1_{LL}) + \lambda_2\theta^2_K\theta^2_L(1-\theta^1_K)$$

$$(2S^2_{KL}-S^2_{LL}-S^2_{KK}) - \lambda_1\theta^2_K\theta^2_L\theta^1_K(S^1_{KL}-S^1_{KK})\} > 0.$$

<u>The Variety of Short Run Equilibria and Conflicts Between Short Run and Long Run</u>

Figure 10 and Table 7.2 show the variety of results that are possible when an imported input is included in the Ricardo-Viner model. In the diagram, the initial equilibrium is at E_o. An increase in P_1 shifts IC^1 out, and the economy moves to a new short-run equilibrium. Assume that if w rises to the point J, then $\hat{w} = \hat{P}_1$; this implies that if r_1 (r_2) rises to the point M, $\hat{r}_1 = \hat{P}_1$ ($\hat{r}_2 = \hat{P}_1$).

A wide variety of short-run results are possible. The Mayer-Mussa result ($\hat{r}_1 > \hat{P}_1 > \hat{w} > 0 > \hat{r}_2$) holds if the equilibrium lies between points M and F, but the equilibrium need not lie between these points.[13] Note that there is no ambiguity concerning the change in the real price of ANY of the domestic factors if the equilibrium lies above E_1', between E_1 and B, between C and H, or below G. Thus one of the more interesting results of the Mayer-Mussa analysis - the fact that the real change in the price of one of the domestic factors is ambiguous - does not necessarily hold in an economy that uses imported inputs.

The long-run effects of an increase in P_1 (caused by the tariff) are calculated by totally differentiating (3.2) and (3.3), holding P_2 and P_M fixed. The results are

$$\hat{w} = \frac{-\theta_K^2}{\theta_K^1\theta_L^2 - \theta_L^1\theta_K^2} \cdot \hat{P}_1 \qquad (6.6)$$

$$\hat{r} = \frac{\theta_L^2}{\theta_K^1\theta_L^2 - \theta_L^1\theta_K^2} \cdot \hat{P}_1 \qquad (6.7)$$

Thus in the long run we observe the familiar magnification results: iff good 1 is labour intensive (in the same sense that $\theta_K^1/\theta_L^1 < \theta_K^2/\theta_L^2$), then a one percent increase in P_1 causes w to rise by more than one percent, while r falls. That is, real wages rise in terms of any commodity price, while the real rental rate falls in terms of any commodity price.

In Figure 10 the new long-run equilibrium is at the point E_1. Because the protected sector is relatively labour intensive, real wages have risen and the real rental rate has declined when the economy has adjusted from the old to the new (long-run) equilibrium. The situations in which domestic factor owners have (or do not have) a conflict between short-run and long-run interests are listed in Table 7.2.

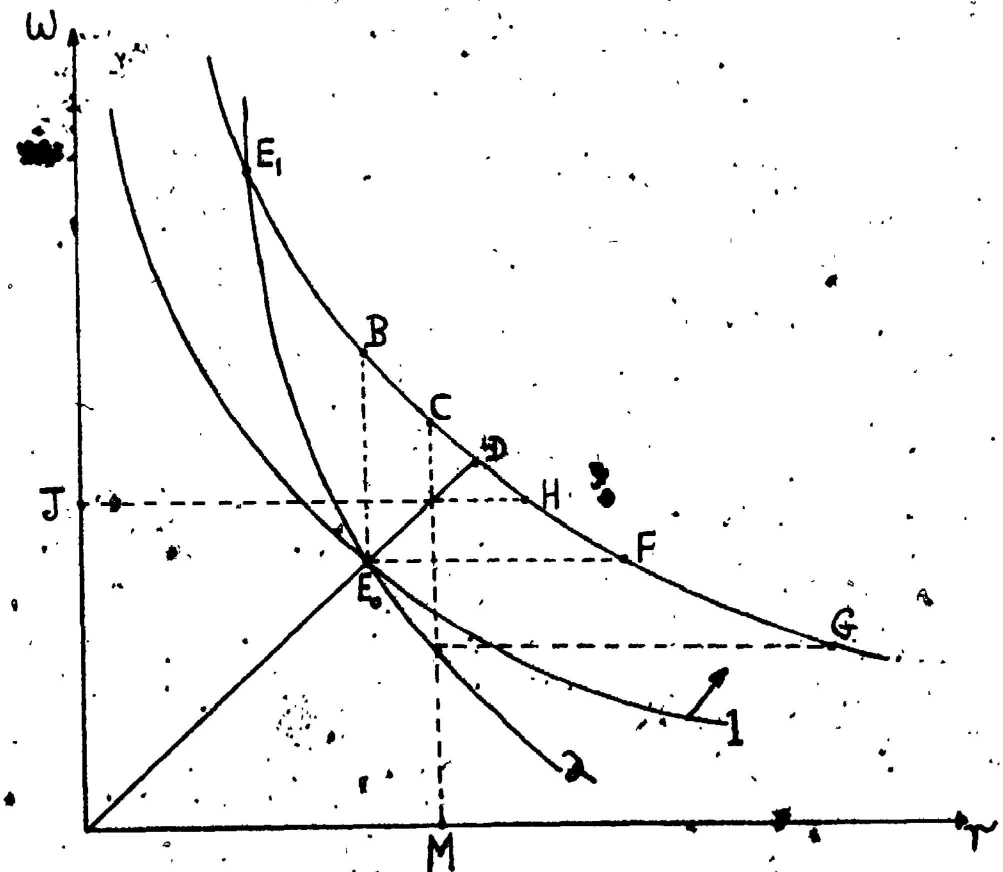


FIGURE 10

TABLE 7.2 THE VARIETY OF SHORT-RUN EQUILIBRIA AND CONFLICTS BETWEEN SHORT RUN AND LONG RUN: THE CASE OF A TARIFF ON FINAL GOODS

	Short-Run Change in Factor Prices	Relative Prices of K_1 in Short-Run Equilibrium	Factors With Conflict
Above E_1:	$\hat{w} > \hat{P}_1, \hat{r}_1 < 0, \hat{r}_2 < 0$	$r_2 > r_1$	NONE
Between E_1 and B:	$\hat{w} > \hat{P}_1, \hat{r}_1 < 0, \hat{r}_2 < 0$	$r_1 \gtrless r_2$	NONE
Between B and C:	$\hat{w} > \hat{P}_1, 0 < \hat{r}_1 < \hat{P}_1, \hat{r}_2 < 0$	$r_1 > r_2$	K_1
Between C and D:	$\hat{w} > \hat{r}_1 > \hat{P}_1 > 0 > \hat{r}_2$	$r_1 > r_2$	K_1
Between D and H:	$\hat{r}_1 > \hat{w} > \hat{P}_1 > 0 > \hat{r}_2$	$r_1 > r_2$	K_1
Between H and F:	$\hat{r}_1 > \hat{P}_1 > \hat{w} > 0 > \hat{r}_2$	$r_1 > r_2$	K_1
Between F and G:	$\hat{r}_1 > \hat{P}_1 > \hat{r}_2 > 0 > \hat{w}$	$r_1 > r_2$	K_1, K_2, L
Below G:	$\hat{r}_1 > \hat{r}_2 > \hat{P}_1 > 0 > \hat{w}$	$r_1 > r_2$	K_1, K_2, L

A Special Case: The Mayer-Mussa Result

By setting $\theta^i_M = 0$, $i = 1,2$, we have the standard Ricardo-Viner model, and (6.1) becomes (after some manipulation):

$$\hat{w} = \left\{\frac{\lambda_1 S^1_{KL}/\theta^1_K}{\lambda_1 S^1_{KL}/\theta^1_K + \lambda_2 S^2_{KL}/\theta^2_K}\right\} \hat{P}_1 \qquad (6.8)$$

This is the Mayer-Mussa result (see Mayer (1974) and Mussa (1974)). In Figure 11, the initial equilibrium is at (E_1E_2), where this equilibrium satisfies (4.14). An increase in P_1 shifts IC^1 outwards, while IC^2 is unaffected. IC^1 shifts outwards along the ray OE_1 by an amount equal to $\hat{P}_1$, and the slope of IC^1 along the ray OE_1 does not change. The new equilibrium must satisfy (4.14). Suppose we assume that w is unchanged. By drawing tangents to the IC at the unchanged w, the triangle formed has a base which exceeds its vertical height. Thus w must rise. Will the percentage increase in w be the same as the percentage increase in P_1? This occurs if the new equilibrium wage rate is w_2. By drawing tangents to the ICs at the common wage w_2, the triangle formed has a base which is less than its vertical height. Thus w cannot rise to w_2. The new equilibrium wage rate must, therefore, be somewhere between the old wage rate and w_2. For any w between these extreme values we have (by inspection)

$$\hat{r}_1 > \hat{P}_1 > \hat{w} > 0 > \hat{r}_2.$$

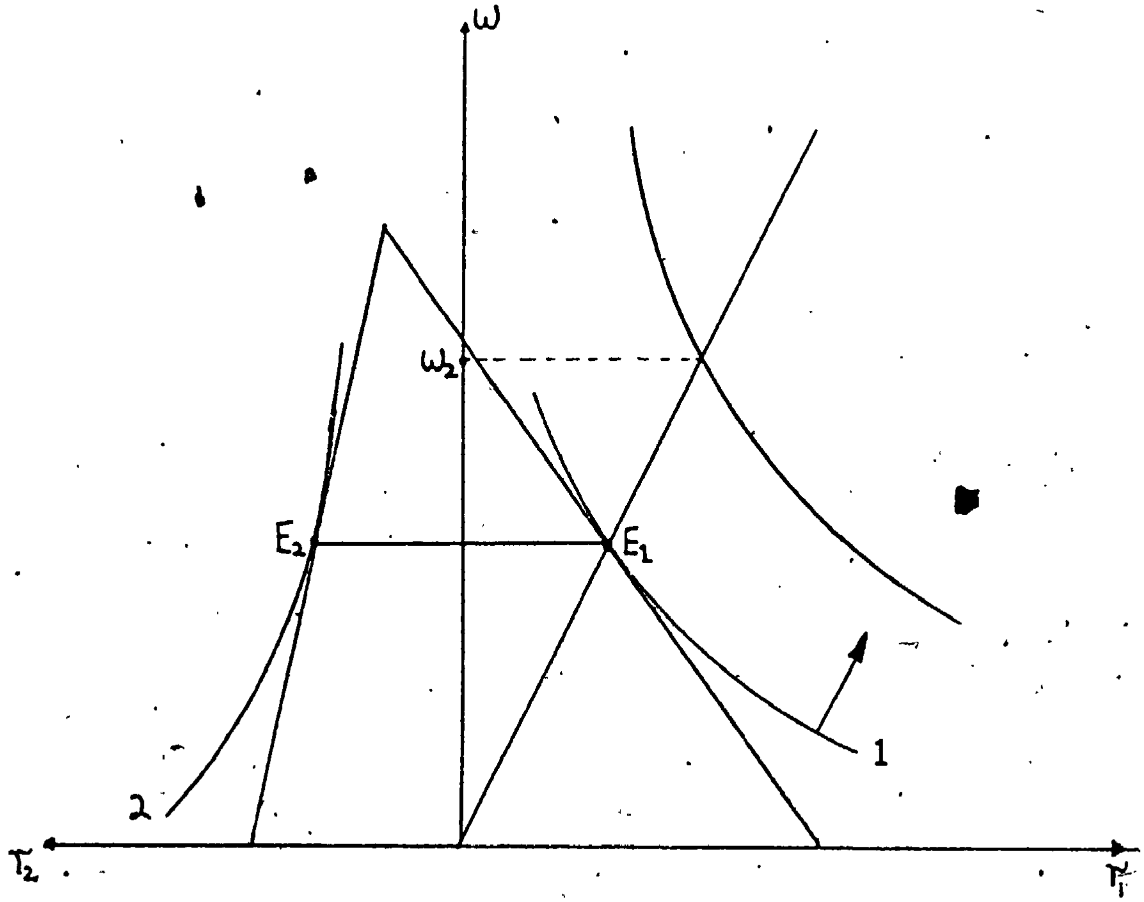


FIGURE 11

That is, the real reward of the specific factor in the protected (unprotected) industry rises (falls), while the change in the real wage rate is ambiguous.

CONCLUSION

In this chapter I extend the Ricardo-Viner model to include an imported intermediate good, and I use this model to examine the short-run changes in domestic factor prices caused by tariffs on both imported intermediate goods and imported final goods. Within the framework of this model, the changes in wage and rental rates depend (in a complicated manner) on the technology of the economy, as represented by the shares of all inputs in the cost of production, and by the (Allen/Uzawa) partial elasticities of substitution between the inputs. In general, an increase or decrease in the wage rate is quite possible, and so too is an increase or decrease in the rental rates.

Since the extension of the Ricardo-Viner model considered here is the inclusion of an imported intermediate good, it is interesting to examine the role of the partial elasticities of substitution between this input and the domestic factors in determining the changes in wage and rental rates. These elasticities often play a crucial role in determining whether the wage rate rises or falls. For example, if the elasticity of substitution between capital and imported intermediate goods is greater than the elasticity of substitution between labour and imported intermediate goods (in both sectors), then a tariff on imported intermediate goods causes a fall in the wage rate in the short run, while a tariff on imported final goods causes an increase in the wage rate. On the other hand, the relative sizes of these elasticities alone is usually not sufficient to determine how rental rates are affected (particularly by tariffs on imported intermediate goods); more detailed knowledge of the technology is required in order to determine whether any particular rental rate rises or falls in the short run.

Finally, it is quite possible that the short-run changes in wage and/or rental rates could be reversed in the long run. Thus the short-run interests of domestic factor owners could conflict with their long-run interests. Whether such conflicts actually arise depends on technological conditions; and furthermore, it is possible that all domestic factor owners face a conflict, that some face a conflict (while others do not), and that none face a conflict.

FOOTNOTES - CHAPTER VII

1. See, for example, Jones (1971), Mayer (1974) and Mussa (1974)..

2. Note that the production sector described here is non-joint in inputs. See Hall (1973).

3. If capital and labour must always be used together in fixed proportions in sector i, then IC^i is linear. If capital and labour are infinitely substitutable for one another, IC^i is right-angled. The IC^i drawn in Figure 1 represent a situation intermediate between these two extremes.

   Note that the IC^i are shown intersecting in (w,r) space. This ensures that the economy produces some of both goods. See Section three, below.

4. See Debreu (1959), pp. 39-45.

5. These results are derived by Burgess (1976). The results are similar to the Stolper-Samuelson results for the two input, two output, perfect capital mobility case. In the Stolper-Samuelson result, as θ_L^1 gets closer in value to θ_L^2, the change in factor rewards gets larger and larger. This phenomenon is not a feature of the model presented in this thesis. Note that

since output prices are unchanged, $\hat{w}$ ($\hat{r}$) measures the change in the real price of labour (capital).

6. The slope of the new IC for sector i (i = 1,2) along the ray OE_O will usually be different from the slope of the old IC^i along the ray (see Section 4, ahead). Also, the new equilibrium value of the capital/labour ratio in sector i, given by the slope of IC^i at the intersection of the new IC, will be different from the initial capital/labour ratio in sector i. However, the long-run effects of small changes in the price of imported inputs on the prices of domestic factors are fully determined by the initial capital/labour ratios, and so the changes in the slope of IC^i, and in the capital/labour ratio in sector i, are not crucially important here. See Jones (1965), and the reference in that paper to the Wong-Viner theorem.

7. Since $\theta^1_M = 0$, the expression for $\hat{r}_2$ becomes:

$$\hat{r}_2 = \frac{1}{\Delta}\{\lambda_2\theta^1_K\theta^2_L\theta^2_M[S^2_{KM}-S^2_{LM} + S^2_{LL}-S^2_{KL}]$$

$$+ \lambda_1\theta^1_L\theta^1_K\theta^2_M[-2S^1_{KL} + S^1_{LL} + S^1_{KK}]\}\ \hat{P}_M$$

Again, $S^2_{KM} < S^2_{LM} \Rightarrow (S^2_{LL}-S^2_{KL}) < 0$. And since $(-2S^1_{KL} + S^1_{LL} + S^1_{KK}) < 0$, then whenever $S^2_{KM} < S^2_{LM}$, r_2

must fall. Thus a necessary condition for $\hat{r}_2 > 0$ is $S^2_{KM} > S^2_{LM}$.

8. This is a "perverse employment effect" - employment in the protected sector falls (see Burgess (1980)). This perverse employment response is a necessary and sufficient condition for w to fall in the short run.

9. The conditions for an unambiguous fall (increase) in the wage rate, and in the rental rate in the protected sector, are examined in detail in Burgess (1980).

10. This is shown in Burgess (1980).

11. Note that $S^1_{KL} < 0$ is a necessary condition both for $\hat{w} < 0$ and for $\hat{r}_1 < 0$. However, w and r_1 cannot both fall. w must fall when $(S^1_{KL}-S^1_{KK}) < 0$; in this case r_1 must rise. r_1 may fall when $(S^1_{KL}-S^1_{LL}) < 0$; in this case w must rise.

12. The short-run equilibrium lies between points H and F whenever $S^1_{KM} = S^1_{LM}$ (sufficient but not necessary). That is, whenever the technology in sector 1 is separable between the domestic factors, on the one hand, and the imported input on the other, the Mayer-Mussa result holds.

APPENDIX

The Propositions in this Appendix are derived using the following "adding-up" constraints on the S_{ij}:

$$\theta_L^i S_{LL}^i + \theta_K^i S_{KL}^i + \theta_M^i S_{LM}^i = 0 \tag{1}$$

$$\theta_K^i S_{KK}^i + \theta_L^i S_{KL}^i + \theta_M^i S_{KM}^i = 0 \tag{2}$$

<u>Proposition 1</u>: Whenever $S_{KM}^i = S_{LM}^i$, $i = 1,2$, then $\hat{w} < 0$. Furthermore, $(\hat{w} - \hat{r}_i) > 0$ iff $\theta_M^i > \theta_M^j$.

Proof:

Subtract (2) from (1):

$$\theta_K^i(S_{KL}^i - S_{KK}^i) = \theta_L^i(S_{KL}^i - S_{LL}^i)$$

Thus either (a) $(S_{KL}^i - S_{KK}^i) > 0$ <u>and</u> $(S_{KL}^i - S_{LL}^i) > 0$

or (b) $(S_{KL}^i - S_{KK}^i) < 0$ <u>and</u> $(S_{KL}^i - S_{LL}^i) < 0$

But $(S_{KL}^i - S_{KK}^i) + (S_{KL}^i - S_{LL}^i) > 0$.

Thus (b) is not possible, and so

$$(S_{KL}^i - S_{KK}^i) > 0 \text{ and } (S_{KL}^i - S_{LL}^i) > 0.$$

By inspection of (4.8), $\hat{w} < 0$.

Consider now, $(\hat{w} - \hat{r}_2)$.

$$(\hat{w} - \hat{r}_2) = \frac{1}{\Delta}\{\lambda_1\theta_K^1\theta_M^1\theta_K^2(S_{KK}^1-S_{KL}^1) + \lambda_2\theta_K^1\theta_K^2\theta_M^2(S_{KK}^2-S_{KL}^2)$$

$$- \lambda_1\theta_K^1\theta_M^1\theta_L^2(S_{KL}^1-S_{KK}^1) - \lambda_2\theta_K^1\theta_L^2\theta_M^2(S_{LL}^2-S_{KL}^2)$$

$$- \lambda_1\theta_L^1\theta_K^1\theta_M^2(-2S_{KL}^1-S_{LL}^1-S_{KK}^1)\}$$

By substituting $\theta_K^i(S_{KL}^i-S_{KK}^i) = \theta_L^i(S_{KL}^i-S_{LL}^i)$ this can be re-written:

$$(\hat{w} - \hat{r}_2) = \frac{1}{\Delta}\{\lambda_1\theta_K^1(S_{KK}^1-S_{KL}^1)(\theta_M^1-\theta_M^2)\}$$

Similarly, $(\hat{w} - \hat{r}_1) = \frac{1}{\Delta}\{\lambda_2\theta_K^2(S_{KK}^2-S_{KL}^2)(\theta_M^2-\theta_M^1)\}$.

Thus, $(\hat{w} - \hat{r}_i) < 0$ iff $\theta_M^i < \theta_M^j$

$(\hat{w} - \hat{r}_i) > 0$ iff $\theta_M^i > \theta_M^j$

Proposition 2: Whenever $S_{KM}^i > S_{LM}^i$, $i = 1,2$, then $\hat{w} < 0$. Furthermore, $\theta_M^i > \theta_M^j \Rightarrow (\hat{w}-\hat{r}_i) < 0$, $(\hat{w}-\hat{r}_j) \gtrless 0$.

Proof:

Subtract (2) from (1):

$$\theta_K^i(S_{KL}^i-S_{KK}^i) = \theta_L^i(S_{KL}^i-S_{LL}^i) + \theta_M^i(S_{KM}^i-S_{LM}^i).$$

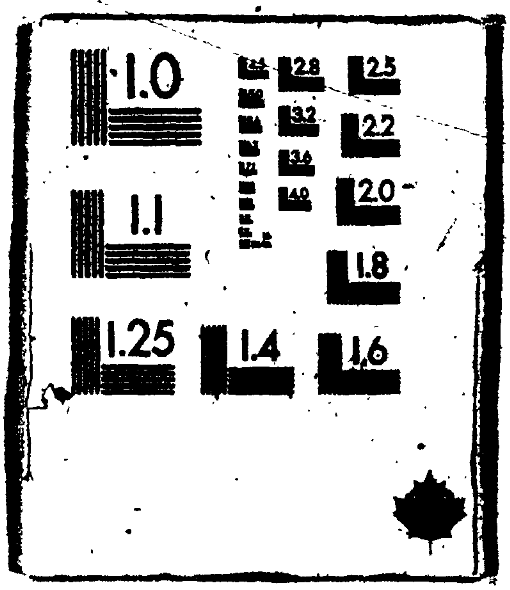
Thus $S_{KL}^i-S_{KK}^i < 0 \Rightarrow S_{KL}^i-S_{LL}^i < 0$

which is impossible.

Thus $(S_{KL}^i-S_{KK}^i) > 0$ (and $(S_{KL}^i-S_{LL}^i) \gtrless 0$).

By inspection of (4.8), $\hat{w} < 0$.

3 OF/DE 3



Denny, M., and Fuss, M., "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates", American Economic Review, LXVII (1977) 404-419.

Diewert, W.E., "An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function", Journal of Political Economy, LXXIX (1971), 481-508.

____________, "Functional Forms for Profit and Transformation Functions", Journal of Economic Theory, VI (1973), 284-316.

____________, "Annual Employment, Industry by Occupation in Canada", Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration, Ottawa (1975).

____________, "Hicks' Aggregation Theorem and the Existence of a Real Value Added Function", in Fuss, M., and McFadden, D., eds., Production Economics: A Dual Approach to Theory and Applications, Volume II, (Amsterdam: North Holland, 1978).

Geary, P.T., and McDonnell, E.J., "Implications of the Specifications of Technologies", Journal of Econometrics, XIV (1980), 247-255.

Gray, H.P., "The Demand for International Travel by the United States and Canada", International Economic Review, VII (1966), 83-93.

Hall, R.E., "The Specification of Technologies With Several Kinds of Outputs", Journal of Political Economy, LXXXI (1973), 878-892.

Hotelling, H., "Edgeworth's Taxation Paradox and the Nature of Supply and Demand Functions", Journal of Political Economy, XL (1932), 577-616.

Jones, R.W., "The Structure of Simple General Equilibrium Models", Journal of Political Economy, LXXIII (1965), 557-573.

____________, "A Three Factor Model in Theory, Trade, and History" in Bhagwati, J., ed., Trade, Balance of Payments, and Growth (Amsterdam: North-Holland, 1971).

<u>Proposition 3</u>: Whenever $S^i_{KM} < S^i_{LM}$, $i = 1,2$, then $\hat{w} \gtrless 0$.

Proof:

Subtract (2) from (1)

$$\theta^i_K(S^i_{KL}-S^i_{KK}) = \theta^i_L(S^i_{KL}-S^i_{LL}) + \theta^i_M(S^i_{KM}-S^i_{LM}).$$

Thus $(S^i_{KL}-S^i_{LL}) < 0 \Rightarrow (S^i_{KL}-S^i_{KK}) < 0$, which is impossible.

Thus $(S^i_{KL}-S^i_{LL}) > 0$ (and $(S^i_{KL}-S^i_{KK}) \gtrless 0$).

By inspection of (4.8), $\hat{w} \gtrless 0$.

<u>Proposition 4</u>: Whenever $S^1_{KM} = S^1_{LM}$, then $0 < \hat{w} < \hat{P}_1/(1-\theta^1_M)$ and $\hat{r}_1 > \hat{P}_1/(1-\theta^1_M)$, (and $\hat{r}_2 < 0$).

Proof:

(5.7) can be written in the following way:

$$\hat{w} = \frac{\hat{P}_1}{1-\theta^1_M}\left\{\frac{\theta^2_K\lambda_1[(1-\theta^1_M)(1-\theta^1_M)S^1_{KL} + \theta^1_M(1-\theta^1_M)S^1_{KM}]}{\theta^2_K\lambda_1[(1-\theta^1_M)(1-\theta^1_M)S^1_{KL}+\theta^1_M(1-\theta^1_M)S^1_{KM}+\theta^1_M\theta^1_K(S^1_{LM}-S^1_{KM})] + \theta^1_K\lambda_2[(1-\theta^2_M)(1-\theta^2_M)S^2_{KL}+\theta^2_M(1-\theta^2_M)S^2_{KM}+\theta^2_M\theta^2_K(S^2_{LM}-S^2_{KM})]}\right\}$$

where the first term in square brackets in the denominator equals $\theta^1_K\theta^1_L(2S^1_{KL}-S^1_{KK}-S^1_{LL})$ (>0), and the second term in square brackets in the denominator equals $\theta^2_K\theta^2_L(2S^2_{KL}-S^2_{KK}-S^2_{LL})$ (>0). By inspection, if $S^1_{KM} = S^1_{LM}$, $0 < \hat{w} < \hat{P}_1/(1-\theta^1_M)$.

Using

$$\theta_L^1 \hat{w} + \theta_K^1 \hat{r}_1 = \hat{P}_1$$

whenever $\hat{w} < \hat{P}_1/(1-\theta_M^1)$, then $\hat{r}_1 > \hat{P}_1/(1-\theta_M^1)$.

Proposition 5: Whenever $S_{KM}^1 > S_{LM}^1$, then $\hat{w} > 0$, $\hat{r}_1 \gtrless 0$, and $(\hat{w}-\hat{r}_1) \gtrless 0$.

Proof:

We know that

$$\theta_K^1(S_{KL}^1-S_{KK}^1) = \theta_L^1(S_{KL}^1-S_{LL}^1) + \theta_M^1(S_{KM}^1-S_{LM}^1)$$

Thus $(S_{KL}^1-S_{KK}^1) < 0 \Rightarrow (S_{KL}^1-S_{LL}^1) < 0$

which is impossible.

Thus $(S_{KL}^1-S_{KK}^1) > 0$ (and $(S_{KL}^1-S_{LL}^1) \gtrless 0$).

Thus $\hat{w} > 0$, $\hat{r}_1 \gtrless 0$, $\hat{r}_2 < 0$.

Corollary:

A necessary condition for $\hat{w} < 0$ $(\hat{r}_2 > 0)$ is $S_{KM}^1 < S_{LM}^1$.

Consider, now $(\hat{w}-\hat{r}_1)$:

$$(\hat{w}-\hat{r}_1) = \frac{1}{\Delta}\{\lambda_1\theta_K^2[\theta_K^1(S_{KL}^1-S_{KK}^1) + \theta_L^1(S_{LL}^1-S_{KL}^1)]$$

$$- \lambda_2\theta_L^2\theta_K^2(2S_{KL}^2-S_{LL}^2-S_{KK}^2)\}\hat{P}_1$$

$$= \frac{1}{\Delta}\{\lambda_1\theta_K^2\theta_M^1(S_{KM}^1-S_{LM}^1) - \lambda_2\theta_L^2\theta_K^2(2S_{KL}^2-S_{LL}^2-S_{KK}^2)\}\hat{P}_1$$

Since $(S_{KM}^1-S_{LM}^1) > 0$ and $(2S_{KL}^2-S_{LL}^2-S_{KK}^2) > 0$, $(\hat{w}-\hat{r}_1)$ may be positive or negative.

<u>Proposition 6</u>: Whenever $S^1_{KM} < S^1_{LM}$, then $\hat{w} \gtrless 0$, $\hat{r}_1 > 0$, and $(\hat{w}-\hat{r}_1) < 0$.

Proof:

We know that

$$\theta^1_K(S^1_{KL}-S^1_{KK}) = \theta^1_L(S^1_{KL}-S^1_{LL}) + \theta^1_M(S^1_{KM}-S^1_{LM}).$$

Thus $(S^1_{KL}-S^1_{LL}) < 0 \Rightarrow (S^1_{KL}-S^1_{KK}) < 0$,

which is impossible.

Thus $(S^1_{KL}-S^1_{LL}) > 0$ (and $(S^1_{KL}-S^1_{KK}) \gtrless 0$)

Thus $\hat{w} \gtrless 0$, $\hat{r}_1 > 0$, $\hat{r}_2 \gtrless 0$.

<u>Corollary</u>:

A necessary condition for $\hat{r}_1 < 0$ is $S^1_{KM} > S^1_{LM}$.

Consider, now, $(\hat{w}-\hat{r}_1)$.

$$(\hat{w}-\hat{r}_1) = \frac{1}{\Delta}\{\lambda_1\theta^2_K\theta^1_M(S^1_{KM}-S^1_{LM}) - \lambda_2\theta^2_L\theta^2_K(2S^2_{KL}-S^2_{LL}-S^2_{KK})\}\hat{P}_1$$

Since $(S^1_{KM}-S^1_{LM}) < 0$, and $(2S^2_{KL}-S^2_{LL}-S^2_{KK}) > 0$, $(\hat{w}-\hat{r}_1)$ must be negative.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

In this thesis I use production theory to examine the determinants of the demand for imports, and I empirically examine Canada's demand for imports using an econometric model derived from production theory. The production theory approach provides a useful framework for examining two important questions: how changes in the price of imports -- caused by changes in tariffs, for example -- affect the prices of domestic factors of production, and thus the incomes of the owners of domestic factors, and how the demand for imports changes as the price of imports changes.

The model of the production sector used in the theoretical and empirical work is based on the assumption that domestic firms transform inputs of labour, capital and imported goods into final outputs. In this model, firms respond to an increase in the price of imported goods by rearranging their use of inputs in the production process in order to ensure that production costs are minimized. Thus the demand for imported goods, and for domestic factors, changes; and the change in the demand for domestic factors causes changes in the prices of these factors.

The exact nature of the theoretical results, and the manner in which the theoretical results are affected by changes in the specification of the theoretical model are discussed in Chapters II and VII. In these chapters, I examine the important role of the elasticities of substitution between domestic factors and imported goods. These elasticities measure the ease with which firms can substitute domestic factors for imported goods in the production of final goods. The values of these elasticities are often crucial to determining whether a change in the price of imported goods increases or decreases the prices of labour and capital.

In Chapter VII, also, I examine how the production sector adjusts over time following a change in the price of imported goods, and how domestic factor prices change during the various stages of this adjustment process. It has often been noted that if the production sector adjusts slowly following a change in the price of imported goods, so that the ultimate changes in domestic factor prices develop slowly over time, then current owners of domestic factors would be interested in the short-run changes in factor prices as well as the ultimate (or long-run) changes. In Chapter VII I examine the short-run changes in factor prices, and compare these to the long-run changes.

The most interesting result of this comparison is the fact that the short-run changes in the prices of some or all of the domestic factors could be in the opposite direction to the long-run changes. This result confirms the potential for conflict between the long-run and short-run interests of owners of domestic factors that has been found in other studies using a theoretical framework different from the one used in this thesis. Since the production theory approach used in Chapter VII provides a convenient framework for empirical work, it may in the future be possible to estimate whether any conflict actually exists.

In the empirical work in this thesis I examine the long-run effects of changes in the price of imports on Canada's demand for imports, on the prices of domestic factors in Canada, and on the distribution of income amongst the owners of domestic factors. As I mentioned above, I use an econometric model which is derived from production theory, and which therefore incorporates the insights provided by the theoretical analysis. However, while production theory provides important guidelines for the empirical work, it does not provide all the answers; and in the empirical work there are a number of practical questions that must be decided without any guidance from theoretical work. In Chapters IV, V and VI I explore a number of these practical questions, and I examine the extent to which the empirical results are affected by these decisions.

The fact that practical questions can have an important bearing on the empirical results is demonstrated in Chapter IV. In that chapter I examine the problem of choosing a functional form for use in the empirical work. I represent the technology of the production sector by three different functional forms, all of which are commonly used in empirical work, and no single one of which is a priori preferred to the other two. I estimate the three functional forms, and I compare the empirical results from the three estimations. The results provide conflicting evidence on the question of how an increase in the price of imports affects the distribution of income amongst the owners of domestic factors. Two of the functional forms indicate that higher import prices redistribute income from owners of labour to owners of capital throughout the sample period (1948-1972). The third functional form confirms this income redistribution result during the first half of the sample period, but indicates the redistribution is in the opposite direction during the second half of the sample period.

The empirical results of Chapters V and VI provide strong evidence that higher import prices redistribute income from owners of labour to owners of capital throughout the entire sample period. In fact, the empirical evidence in these chapters suggests that higher import prices cause an increase in the (real) price (or rental rate) of capital, while the (real) price (or wage rate) of labour falls, These results are quite robust, for whether a cost or restricted profit function is estimated (see Chapter V), and whether the speed of adjustment in the production sector is imposed or estimated (see Chapter VI), the results do not change. One modification of these results is indicated by the empirical work in Chapter V: whether the price of capital rises or falls following an increase in the price of imports may depend upon the country of origin of the imports. When the price of "imports from the U.S." (about seventy percent of all imports) rises, the price of capital rises, while when the price of "all other imports" rises, the price of capital falls. However, regardless of the country of origin of the imports, higher import prices redistribute income from owners of labour to owners of capital.

Two implications of these empirical results are worth stressing. First, by raising import prices, and thus causing an increase in the rental rate in Canada, tariffs stimulate capital formation; and the higher supply of capital lowers Canada's demand for imports.

Second, since a change in the price of imports can be interpreted as a change in the terms of trade, the empirical results indicate how factor prices would be affected by any change in the terms of trade. Thus the results indicate that if (for example) the U.S. lowered its tariff on imports from Canada, thereby improving Canada's terms of trade, the wage rate in Canada would rise and the rental rate would fall.

My empirical results confirm the results of two previous studies that used production theory to examine the effect of higher import prices on the prices of Canada's domestic factors. Thus studies based on production theory indicate that Canada's tariffs benefit owners of capital and harm owners of labour. Many earlier studies emphasized the role of tariffs in increasing the unit price received by domestic producers of import-competing final goods, and the (limited) evidence from these studies suggested that Canada's tariffs, to the extent that these tariffs raised the selling price of import-competing final goods, benefitted owners of labour and harmed owners of capital. The difference between the results of these earlier studies and the results derived using the production theory approach is quite striking. However, I am inclined to reject the results of the earlier studies -- particularly since the econometric methods used in those studies were quite crude - in favour of the results derived using the production theory approach. I conclude that the best empirical evidence currently available indicates that the burden of Canada's tariffs falls on owners of labour.

In examining how a change in the price of imports affects the demand for imports I emphasize the overall adjustment of the production sector caused by a change in the price of imports. The change in the demand for imports is one aspect of this adjustment. Whether the change in the demand for imports is large or small depends on the degree to which firms can substitute domestic factors for imported goods in the production process. The empirical evidence (of Chapter VI particularly) indicates that there is a high degree of substitutibility between imports and the domestic factors, and thus a change in the price of imports causes a large change in the demand for imports.

The analysis of Chapter VI suggests one reason why many empirical studies may have underestimated the own price elasticity of demand for imports. In Chapter VI I use an econometric model that incorporates the assumption that firms in the production sector adjust slowly following any change in the price of imports. The empirical evidence indicates that the adjustment takes place over a period of at least four years. The assumption that the adjustment is completed within one year - an assumption which is rejected by the data - significantly reduces the size of the estimated own price elasticity of demand for imports. Thus the use of this assumption in many empirical studies may have led researchers to underestimate the extent to which the demand for imports changes following a change in the price of imports.

Finally, the own price elasticity of demand for imports (holding domestic factor supplies fixed) is an important determinant of the welfare gains that would result from any reduction of tariff barriers. Using the elasticity estimate of -2.4 (from Chapter VI), I find that Canada would gain very little from a unilateral elimination of all tariffs on imports. If, however, Canada's trading partners reciprocated by eliminating their tariffs on Canada's exports, the overall welfare gain for Canada would be approximately three percent of GNP.

BIBLIOGRAPHY

Articles

Appelbaum, E., "On the Choice of Functional Forms", International Economic Review, XX (1979), 449-458.

__________, and Kohli, U.R., "Canada-U.S. Trade: Tests for the Small Open Economy Hypothesis", Canadian Journal of Economics, XII (1979), 1-15.

Balassa, B., "Tariff Protection in Industrial Countries: An Evaluation", Journal of Political Economy, LXXIII (1965), 573-594.

Barber, C.L., "Canadian Tariff Policy", Canadian Journal of Economics and Political Science, XXI (1955), 513-530.

Bauesi, G., "The U.S. Tariff Structure: An Estimate of the Effective Rate of Protection of U.S. Industries and U.S. Labour", Review of Economics and Statistics, XLVIII (1966), 147-160.

Berndt, E.R. and Christensen, L.R., "The Translog Function and the Substitution of Equipment, Structures and Labour in U.S. Manufacturing 1929-68", Journal of Econometrics, 1 (1973), 81-114.

__________ and __________, "The Internal Structure of Functional Relationships: Separability, Substitution and Aggregation", Review of Economic Studies, XL (1973), [illegible]3-410.

__________ and __________, "Testing for the Existence of a Consistent Aggregate Index of Labour Inputs", American Economic Review, LXIV (1974A), 391-404.

__________, Hall, B.H., Hall, R.E., and Hausman, J.A., "Estimation and Inference in Non-Linear Structural Models", Annals of Economic and Social Measurement, III (1974B), 653-665.

__________ and Savin, N.E., "Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances", Econometrica, XLIII (1975), 937-957.

__________, Darrough, M.N., and Diewert, W.E., "Flexible Functional Forms and Expenditure Distributions: An Application to Canadian Consumer Demand Functions", Discussion Paper 76-06, Department of Economics, University of British Columbia (1976).

Box, G.E.P. and Cox, D.R., "An Analysis of Transformations", Journal of the Royal Statistical Society, Series B, XXVI (1964), 211-252.

Burgess, D.F., "A Cost Minimization Approach to Import Demand Equations", Review of Economics and Statistics, LVI (1974A), 225-234.

__________, "Production Theory and the Derived Demand for Imports", Journal of International Economics, IV (1974B), 103-117.

__________, "Duality Theory and Pitfalls in the Specification of Technologies", Journal of Econometrics, III (1975), 105-121.

__________, "Tariffs and Income Distribution: Some Empirical Evidence for the U.S.", Journal of Political Economy, LXXXIV (1976), 17-45.

__________, "Protection, Real Wages, and the Neoclassical Ambiguity with Inter-Industry Flows", Journal of Political Economy, LXXXIX (1980), 783-802.

__________, "Protection, Real Wages, Real Incomes, and Foreign Ownership", Canadian Journal of Economics, XIII (1980), 594-615.

__________, "The Impact of Foreign Trade Distortions on the Social Rate of Discount", Department of Economics, University of Western Ontario (1982).

Christensen, L.R., Jorgensen, D.W., and Lau, L.J., "Transcendental Logarithmic Production Frontiers", Review of Economics and Statistics, LV (1973), 28-45.

Coen, R.M., and Hickman, B.G., "Constrained Joint Estimation of Factor Demand and Production Functions", Review of Economics and Statistics, LII (1970), 287-300.

Davis, T.E., "A Model of the Canadian Current Account", Canadian Journal of Economics and Political Science, XXXII (1966), 468-488.

Denny, M., and Fuss, M., "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates", American Economic Review, LXVII (1977) 404-419.

Diewert, W.E., "An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function", Journal of Political Economy, LXXIX (1971), 481-508.

_____________, "Functional Forms for Profit and Transformation Functions", Journal of Economic Theory, VI (1973), 284-316.

_____________, "Annual Employment, Industry by Occupation in Canada", Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration, Ottawa (1975).

_____________, "Hicks' Aggregation Theorem and the Existence of a Real Value Added Function", in Fuss, M., and McFadden, D., eds., Production Economics: A Dual Approach to Theory and Applications, Volume II, (Amsterdam: North Holland, 1978).

Geary, P.T., and McDonnell, E.J., "Implications of the Specifications of Technologies", Journal of Econometrics, XIV (1980), 247-255.

Gray, H.P., "The Demand for International Travel by the United States and Canada", International Economic Review, VII (1966), 83-93.

Hall, R.E., "The Specification of Technologies With Several Kinds of Outputs", Journal of Political Economy, LXXXI (1973), 878-892.

Hotelling, H., "Edgeworth's Taxation Paradox and the Nature of Supply and Demand Functions", Journal of Political Economy, XL (1932), 577-616.

Jones, R.W., "The Structure of Simple General Equilibrium Models", Journal of Political Economy, LXXIII (1965), 557-573.

_____________, "A Three Factor Model in Theory, Trade, and History" in Bhagwati, J., ed., Trade, Balance of Payments, and Growth (Amsterdam: North-Holland, 1971).

__________, and Scheinkman, J.A., "The Relevance of the Two Sector Production Model in Trade Theory", Journal of Political Economy, LXXXV (1977), 909-937.

Khang, C., "An Isovalue Locus Involving Intermediate Goods and Its Applications to the Pure Theory of International Trade", Journal of International Economics, I (1971), 315-325.

Kohli, U.R., "Construction of Price and Quantity Components of Canadian Foreign Trade: 1948-1972", Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration, Ottawa (1975).

__________, "Canadian Technology and Derived Import Demand and Export Supply Functions", Doctoral Dissertation, University of British Columbia (1975).

__________, "A Gross National Product Function and the Derived Demand for Imports and Supply of Exports", Canadian Journal of Economics, XI (1978), 167-182.

Lau, L.J., "Applications of Duality Theory: A Comment", in Intrilligator, M., and Kendrick, D., eds., Frontiers of Quantitative Economics, Volume II, (Amsterdam: North-Holland, 1974).

__________, "A Characterization of the Normalized Restricted Profit Function", Journal of Economic Theory, XII (1976), 131-163.

__________, "Testing and Imposing Monotonicity, Convexity and Quasiconvexity Constraints", in Fuss, M., and McFadden, D., eds., Production Economics: A Dual Approach to Theory and Applications, (Amsterdam: North-Holland, 1978).

Mayer, W., "Short-Run and Long-Run Equilibrium for a Small Open Economy", Journal of Political Economy, LXXXII (1974), 455-465.

McFadden, D., "Cost, Revenue and Profit Functions", in Fuss, M., and McFadden, D., eds., An Econometric Approach to Production Theory, (Amsterdam: North-Holland, 1978).

Melvin, J., "The Effects of Tariff Preferences on Canadian Imports: An Empirical Analysis", Canadian Journal of Economics, V (1972), 48-70.

Mussa, M., "Tariffs and the Distribution of Income", Journal of Political Economy, LXXXII (1974), 1191-1204.

________, "The Two Sector Model in Terms of Its Dual: A Geometric Exposition", Journal of International Economics, IX (1979), 513-527.

Nadiri, M.I., and Rosen, S., "Interrelated Factor Demand Functions", American Economic Review, LIX (1969), 457-471.

Neary, J.P., "Short-Run Capital Specificity and the Pure Theory of International Trade", The Economic Journal, LXXXVII (1978), 488-510.

________, "Dynamic Stability and the Theory of Factor-Market Distortions", American Economic Review, LXVIII (1978), 671-682.

Postner, H.H., "Factor Content of Canadian International Trade: Input-Output Analysis", Information Canada (1975).

Rhomberg, R.R., "A Model of the Canadian Economy Under Fixed and Floating Exchange Rates", Journal of Political Economy, LXXII (1964), 1-31.

Robinson, T.R., "Canada's Imports and Economic Stability", Canadian Journal of Economics, I (1968), 401-428.

Ruffin, R. and Jones, R.W., "Protection and Real Wages: The Neoclassical Ambiguity", Journal of Economic Theory, XIV (1977), 337-348.

Samuelson, P.A., "Prices of Factors and Goods in General Equilibrium", Review of Economic Studies, XXI (1954), 1-20.

Stolper, W., and Samuelson, P.A., "Protection and Real Wages", Review of Economic Studies, IX (1941), 58-73.

Travis, W.P., "The Effective Rate of Protection and the Question of Labour Protection in the United States", Journal of Political Economy, LXXVI (1968), 443-461.

Uzawa, H., "Production Functions With Constant Elasticities of Substitution", Review of Economic Studies, XXIX (1962), 291-299.

Wahl, D.F., "Capital and Labour Requirements of Canada's Foreign Trade", Canadian Journal of Economics and Political Science, XXVII (1961), 349-358.

Woodland, A.D., "The Construction of Price and Quantity Components of Inputs for Canadian Industries, 1927-1969", Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration, Ottawa, (1972).

______________, "Estimation of a Variable Profit and Of Planning Price Functions for Canadian Manufacturing, 1947-1970", Canadian Journal of Economics, X (1977), 355-378.

Wurzburger, B.W., "An Examination of the Small Open Economy for Canadian Exports", Bank of Canada Technical Report No. 14 (1978).

Zellner, A., "An Efficient Method for Estimating Seemingly Unrelated Regressions, and Tests for Aggregation Bias", Journal of the American Statistical Association, LVII (1962), 348-368.

Books

Allen, R.D.G., Mathematical Analysis for Economists, (London: Macmillan, 1938).

Caves, R., and Jones, R.W., World Trade and Payments, 2nd ed., (Boston: Little, Brown, 1977).

Dales, J.H., The Protective Tariff in Canada's Development, (Toronto: University of Toronto Press, 1966).

Debreu, G., Theory of Value, (New York: Wiley, 1959).

Eastman, H.C., and Stykolt, S., The Tariff and Competition in Canada, (Toronto: Macmillan, 1967).

Green, H.A.J., Aggregation in Economic Analysis: An Introductory Survey, (Princeton: Princeton University Press, 1964).

Hicks, J.R., Value and Capital, 2nd ed., (London: Oxford University Press).

Kemp, M.C., The Demand for Canadian Imports, 1926-1955, (Toronto: University of Toronto Press, 1962).

Leamer, E.E., and Stern, R.M., Quantitative International Economics, (Boston: Allyn and Bacon, 1970).

Mackintosh, W.A., The Economic Background of Dominion-Provincial Relations, ed. Dales, J.H., (Toronto: McClelland and Stuart, 1964).

Malinvaud, E., Statistical Methods of Econometrics, 2nd ed., (Amsterdam: North-Holland, 1970).

Melvin, J., and Wilkinson, B.W., Effective Protection in the Canadian Economy, Special Study No. 9, prepared for the Economic Council of Canada (Ottawa: Queen's Printer, 1968).

Nadiri, M.I., and Rosen, S., A Disequilibrium Model of Demand for Factors of Production, (New York: Columbia University Press, 1973).

Shearer, R.A., Monetary Policy and the Current Account of the Balance of International Payments, Working Paper prepared for the Royal Commission on Banking and Finance, (Ottawa: Queen's Printer, 1962).

Slater, D.W., Canada's Imports, Study prepared for the Royal Commission on Canada's Economic Prospects, (Ottawa: Queen's Printer, 1957).

Wilkinson, B.W., Canada's International Trade: An Analysis of Recent Trends and Patterns, (Montreal: Private Planning Association of Canada, 1968).

Wilkinson, B.W., and Norrie, K., Effective Protection and the Return to Capital, Economic Council of Canada (Ottawa: Queen's Printer, 1976).

Young, J.H., Canadian Commercial Policy, Royal Commission on Canada's Economic Prospects, (Ottawa: Queen's Printer, 1957).

Econometric Models

Aubry, J.-P., "Sectoral Analysis of RDX2 Estimated to 4Q72", Bank of Canada Technical Report No. 6 (1977).

Choudry, N.K., Kobowitz, Y., Sawyer, J.A., and Winder, J.W.L., The Trace Econometric Model of the Canadian Economy, (Toronto: University of Toronto Press, 1972).

Waslander, H.B., "Candide, Model 1.2: A Description for Model Users", Economic Council of Canada, Ottawa (1975).

END

18 01 83

FIN