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# Effects Of Exchange Rate Changes On Prices, Wages And Employment In Canada

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## ABSTRACT

In this study, we investigate the effects of a devaluation (equivalently an increase in the rate of either an import tax or an export subsidy) with respect to the following short run issues: (a) How output prices adjust in different sectors of the Canadian economy; (b) What happens to employment; and (c) How the movement of wages is related to the movements of different output prices.

In order to accomplish this objective, we construct a short run econometric model, which is a synthesis of two strands of current literature: Phillips curve and devaluation analysis. The model is designed to take into account (a) the importance of changes in absolute prices (including the price of labour), and (b) the importance of relative prices. The model contains three sectors producing importable, non-tradable and exportable goods. We assume the exchange rate is exogenous even in the flexible exchange rate periods. We estimate the model for three different exchange rate periods, and use statistical tests to determine the significance of each estimated coefficient as well as to detect any structural change from one exchange rate period to another.

Finding the model to be reasonable in terms of statistical tests and the size of the coefficients, we conduct multiplier analyses of a devaluation and of a change in the domestic price of importables or a change

To my parents

Mr. and Mrs. DƯỚNG VĂN NGẪU

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Finding the model to be reasonable in terms of statistical tests and the size of the coefficients, we conduct multiplier analyses of a devaluation and of a change in the domestic price of importables or a change

in the foreign price of Canadian exports without taking into account the balance of payments constraint caused by a hypothetical shock. The following are the results.

(a) Sectoral price effects.

Immediately after a devaluation, the increase in the domestic price of exportables is always greater than the increase in the domestic price of non-tradables. By our assumption, the impact effect on the price of importables is of the same size of the devaluation. Therefore, the effects immediately after a devaluation are in favor of the foreign trade sectors. This holds in all three exchange rate periods.

If all devaluation effects are allowed to work out in the system, the relative positions in terms of the relative output prices of different sectors (importable, exportable and non-tradable) are not clear for the flexible exchange rate periods. However, during the fixed exchange rate period, the output price of the sector producing exportable goods increases more than the output prices of other sectors as the result of a devaluation.

If the shock is caused by a 1% increase in the domestic price of importables, the sector producing importable goods is always relatively better off in terms of relative output prices. As a result of this shock, in the fixed exchange rate period, the increase in the output price of non-tradable goods is lowest; whereas in the flexible exchange rate periods, the increase in the output price of exportable goods is less than the increase in the other output prices

If the shock is caused by a 1% decrease in the foreign price of Canadian exports due to an export subsidy, there is some increase in the price of non-tradable goods. But there is no increase in the domestic price of importables due to our assumption. As a result of this shock, the increase in the domestic price of exportable goods is always highest, but it is much higher in the fixed exchange rate period than in the flexible exchange rate periods.

(b) Employment effects.

Employment always increases after a devaluation in all exchange rate periods. However, the speed and the shape of the adjustment path of employment are different in different exchange rate periods. In the first flexible exchange rate period, the effect on employment builds up slowly in the first year with most of the increase in the second year after the devaluation. In the fixed exchange rate period, employment increases immediately at a faster rate than in the first flexible exchange rate period. Consequently, the cumulative effect in the fixed exchange rate period reaches its maximum at around four years after the devaluation and then levels off. In the second flexible exchange rate period, the level of employment adjusts slowly in the first two years after the devaluation, then increases greatly for up to five years or more after the exchange rate change.

The increase in employment after a devaluation may be the result of the decrease in real wages and/or a shift in the structure of employment. In the flexible exchange rate periods, real wages go down in all sectors of the economy. However, during the fixed exchange rate period, it is not clear whether or not general real wages go down since the increase in money wages is higher than the increases in the domestic prices on non-tradables and importables, but less than the increase in the domestic price of exportable goods.

Employment effects due to a change in the domestic price of importables are much greater than those due to a change in the foreign price of Canadian exports. This result holds in all three exchange rate periods.

(c) Direct price effects on the wage equation.

We have found that the three output prices significantly influence the wage equation in all exchange rate periods. The increase in money wages responds more rapidly to the increases in the prices of external sectors than to the increase in the price of non-tradable goods. If we use multiplier analyses to study the dynamic behavior of the whole model, we find that wage inflation follows closely the pattern of changes in the price of exportable goods. The "dynamic" correlation between money wages and the price of exportables is higher during the flexible exchange rate periods than during the fixed exchange rate period.

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# CHAPTER I

## INTRODUCTION

In an open economy such as Canada, changes in the exchange rate may have important consequences for economic activity in different sectors and for domestic employment. The reason is that the magnitudes and speeds of adjustment of induced price changes may vary between sectors. Increases in output prices will influence money wages. Wage-price inflation will affect domestic labour demand by changing the structure of employment. This change is caused by differential price increases among the sectors and/or by changing real wages.

From a policy point of view, it is important to know how prices, wages and employment adjust after an exchange rate change, since the speeds and magnitudes of these adjustments will affect not only the nature of domestic economic activities, but also the balance of payments.

The objective of this thesis is to investigate the short run adjustment paths of prices, wages and employment after a hypothetical devaluation.

At the present state of the art, devaluation effects have been studied at both the theoretical and empirical levels. However, to date the question raised in this thesis has not been answered.

Dornbusch investigated the role of money in a model of devaluation[16]. The basic assumption is that devaluation is a monetary phenomenon. The effects of a devaluation are analyzed in terms of relative price(s) and the domestic rate of hoarding, in which the real balance effect plays a major role.

Jones and Corden used a standard pure trade model of two goods (tradables and non-tradables), two countries (domestic and the rest of the world) and two factors of production (labour and capital) to study the effects of a devaluation [28]. In this model, perfect competition and full employment are assumed. The economy is small in the sense that foreign demand for exportable goods and the foreign supply of importable goods are infinitely elastic. The long run devaluation effects resulting from this model depend on the equilibrium price of non-tradable goods.

Comparative statics is the tool used in the above theoretical investigations. Qualitative results which depend on some assumptions of fiscal and monetary policies are derived when the model moves from one equilibrium to another. The intermediate adjustment paths of domestic variables and the quantitative nature of these adjustments cannot be determined.

At the empirical level, Kwack has investigated devaluation effects on the domestic economy taking into account the concept of an interdependent world [32,33]. Import commodities are assumed to be material inputs in the production of one composite good , of which the price is represented by the domestic consumer price index. The export price of each country is identical to its consumer price index. The import price is a weighted average of the export prices of other countries adjusted by the exchange rates. The model is constructed in terms of two-equation wage-price dynamics for each country. Results of a devaluation in each country are reported in terms of impact and equilibrium multipliers which are derived within the framework of Phillips' trade-off curve (1).

In the context of the Canadian economy, there are at least three important points that cannot be answered from Kwack's model:

1) Sectoral effects after a devaluation: this is a major concern of Canadian policy makers when the exchange rate is an issue. For instance, in the 1970 annual report to the Minister of Finance, the Governor of the Bank of Canada stated [2]

> ... the exchange rate is a very important price in a country that trades with the outside world on the scale that Canada does, changes in it have important effects on the level and nature of economic activity in Canada, particularly on the position of industies

that export and that compete with imports. It is not therefore possible to ignore it, even when it floats.

2) Employment effects after a devaluation: in the context of the Canadian economy, unemployment has been one of the main issues discussed in connection with a possible change of the exchange rate$_{(2)}$.

3) Direct price effects on wage inflation after a devaluation: Perry has pointed out that export prices have been found to be a significant factor in determining domestic wages in Italy, The Netherlands, Sweden and the United Kingdom. In Belgium and Germany, import prices are significant in the wage equations [49]. The explanation for this phenomenon is that export and import prices significantly influence wages in sectors producing export and import competing goods. These effects are diffused to other industries, and directly influence the general wages. Wonnacott also argued that there is some direct pressure of external prices on the general wage-price inflation in Canada [60].

This thesis is specifically designed to shed some light on the above three points applied to the Canadian economy. Particularly, we will concentrate on the short run adjustment paths of sectoral prices, wages and employment after a devaluation. The knowledge of these adjustment paths which include the speeds and magnitudes of the responses of different variables is important for a "fine tuning" policy package.

To accomplish this objective, we disaggregate the Canadian economy into three sectors producing importable, non-tradable and exportable goods. The assumption is that the foreign supply of importable goods is infinitely elastic, and there is perfect substitution between import competing goods and imports. The foreign demand for exports is downward sloping$_{(3)}$.

The reason why imports and exports are not aggregated into a composite tradable good is that the percentage changes in import and export prices are significantly different. Hence, from Hicks' composite commodity theorem, it is not justifiable to aggregate the two goods together [26]. For the same reason, exportable goods are not aggregated with domestic non-tradable goods. [Please see Figures (3.3), (3.4) and (3.6)].

The specifications of the supply and demand sides of the three sectors are summarized in Table 1.1. On the supply side, we allow the possibility that labour and the three goods produced by the three sectors are variable inputs in the short-run production function of each sector. On the demand side, we allow for possible shifts of the demands due to changes of relative output prices. Hence, the linkages among the three sectors are through the interdependence of the demand and cost structures.

Table 1.1 Supply and demand characteristics of the model

| | Importable goods | Non-tradable goods | Exportable goods |
|---|---|---|---|
| Supply of | Infinitely elastic foreign supply<br>Upward sloping domestic MC curve | Upward sloping domestic MC curve | Upward sloping domestic MC curve |
| Demand for | Downward sloping domestic demand | Downward sloping domestic demand | Downward sloping domestic and foreign demands |
| Equilibrium | Determined by foreign supply price adjusted by the exchange rate | Determined by the mark-up theory | Determined by the mark-up theory |

Prices and outputs are determined once the demand and cost have been perceived by producers. Labour demand is obtained from the inversion of the production function of each sector. In the labour market, we assume that the labour supply is exogenous. We explain only aggregate wages and employment in Canada. The reason is that we do not have appropriate disaggregated data on wages and employment.

The money wages are explained by a modified Phillips wage equation, in which the percentage change in wages is a function of the unemployment rate and the domestic rate of inflation (4). The unemployment rate represents the pressure of the labour market, whereas the domestic rate of inflation represents inflation expectations in determining money wages. The inflation expectation is incorporated either because the appropriate context is bargaining, and the expected real wages is the objective of the bargaining; or because the appropriate context is market clearing, and the labour supply is defined in terms of expected real wages.

In our model, the inflation expectation is replaced by percentage changes in the prices of importable, non-tradable and exportable goods. The percentage change in the consumer price index is not used for two reasons:

1) Using disaggregated prices, we do not force the estimated coefficients of the inflation expectation variables into some weighting scheme of a particular price index. Hence the error of the estimation is reduced.

2) Incorporation of disaggregated prices in the wage equation will allow us to identify the relative importance of each price in its effect on aggregate money wages.

Due to the assumption that the foreign supply of importables is infinitely elastic, we need to consider only the prices of sectors producing non-tradable and exportable goods. These two equations coupled with an aggregate wage equation and an aggregate employment equation constitute our model. All variables in the model are measured in terms of percentage changes since the money wage equation is estimated in that form.

Using historical data from 1953 to 1973, we estimated the model for three exchange rate periods in Canada: the first flexible exchange rate period, the fixed exchange rate period, and the second flexible exchange rate period. The basic assumption is that the exchange rate is exogenous, even during the flexible exchange rate periods(5).

A change in the exchange rate affects prices and labour demand in the model by changing the domestic prices of importables and the foreign price of Canadian exports. Once the model has been estimated, we shock the model by a 1% change in the exchange rate and trace out the adjustment paths of wages, prices and employment. This experiment is designed to answer the three questions about the devaluation effects in the Canadian economy. In our simulation, labour supply is exogenous and its actual values are used.

We next separate the effects of a change in the exchange rate into the effects due to a change in the domestic price of importables and the effects due to a change in the foreign price of Canadian exports. These selective effects can be achieved by commercial policies, either by an import tax or an export subsidy. The comparison of these effects will shed some light on the sensitivity of Canadian economic conditions to different commercial policies.

The organization of this thesis is as follows. The detailed specifications and mechanics of the model are presented in Chapter II. In Chapter III and IV, we discuss the quality of the data and the estimation procedure respectively. We then present the results of the estimation in Chapter V. Simulation results and the conclusions are presented in Chapter VI.

## CHAPTER II

## SPECIFICATION OF THE MODEL

As discussed in Chapter I, our objective is to trace out short-run adjustment paths of sectoral prices, wages and employment resulting from a hypothetical change in the exchange rate or a commercial policy, by which either the domestic price of imports or the foreign price of Canadian exports is changed. The model consists of an aggregate wage equation, two price equations to describe the prices of sectors producing non-tradable and exportable goods, and an aggregate employment equation.

Our econometric model is derived from two strands of current literature: Phillips curve and devaluation analyses. The Phillips curve analysis appears in the wage and individual price equations, whereas the devaluation analysis is concerned with the relative adjustment of different prices and employment. The model is designed to take into account (a) the importance of changes in absolute prices (including the price of labour), and (b) the importance of relative prices. Thus if only devaluation analysis is used, then only the relative price is a major concern. The short-run feed back effects with all expectations on the changes of absolute prices, peculiar to wages and prices, cannot be taken into account. On the other hand, if only Phillips curve analysis is used, we concentrate only on the wage-price inflation, in which the short-run feed-back effects and expectations play a major role. As wages and prices change, economic theory predicts that there is a rearrangement and a possible change in employment. This change results either from a change in relative output prices, or from different changes in sectoral wage rates. The Phillips curve analysis does not address itself to what happens to labour demand and labour supply when both wages and prices are changing$_{(6)}$.

Although our short-run econometric model does not say anything about the labour supply, it does take into account changes in employment. During our simulation, labour supply is assumed exogenous and its actual values are used. Hence, the model provides a necessary framework for an empirical analysis of the short-run adjustment paths of sectoral prices, wages and employment after a devaluation or a change in a commercial policy.

In this Chapter, we will make the detailed specification of the model. We start with the supply side or the cost structure of each sector. In this part, the wage equation will be discussed and contrasted with other specifications of Phillips wage inflation. To derive the short-run supply curve (marginal cost curve), we assume the technology in each sector follows a Cobb-Douglas production function. The reason is that this function has performed well at the aggregate level and has been used in large scale Canadian econometric models [13,21,58]. Having specified the supply side of each sector, we then specify the demands. The prices of sectors producing non-tradable and exportable goods are derived from the interactions of the supply and demand curves in each sector. Once the wages and prices are established, employment in each sector is obtained by the inversion of the production function. Since we do not have sectoral data of employment, we aggregate employment in each sector into an aggregate employment function.

The model as outlined above is considered to be complete. However, to make it more specific to our objective of studying the devaluation effects and the effects of a selective commercial policy, we separate the domestic price of importables into two components: the foreign price of Canadian imports and the exchange rate. Similarly, the foreign price of Canadian exports is separated into the Canadian price of exports and the exchange rate. Hence, if the effects of a devaluation are studied, we compare the solutions of the model in the case the exchange rate is changed and in the case there is no change in the exchange rate, other things such as foreign prices and labour supply are identical in both cases. If the effects of a commercial policy are studied, we repeat the above experiment, but the shock this time is a change in the foreign price, other things such as the exchange rate and labour supply are identical between the shock and the reference solutions.

1. Cost structure of each sector

We allow the possibility that labour and the outputs of the three sectors are variable inputs in the production function of each sector. We assume that no difference exists between the final demand prices and the material input prices of the three goods (non-tradable, importable and exportable). Therefore, the prices of the three goods that may be used as material inputs in the production are determined by the output prices of the three sectors. On the cost side, we still have to specify the labour cost and derive the supply curve of each sector.

1.1 Wage equation

Ideally, we have to specify three wage equations to take into account differences in the labour characteristics of the three sectors. Existing data do not allow us to do so. Therefore, we have to assume either homogeneous labour in the economy or, if there are differences, the magnitude of the differences does not change significantly over time. This assumption allows us to use one wage equation for the whole economy.

At the present state of the art , the issue of what determines the wage movement remains unsettled. Nordhaus, in his paper about the wage inflation in different countries, has tested five theories of wage determination [45]. He was able to reject conclusively three of the five theories: a simple Phillips curve in which current unemployment is the only explanatory variable, his version of the monetarist approach in which real output and the money supply are the explanatory variables; and a "frustration" hypothesis in which real consumption is the main explanatory variable. The other two theories are expectation Phillips curve in which anticipated inflation as well as a tight labour market produce the wage changes, and the hypothesis about the effects of foreign prices. Leaving aside the issue of whether or not Nordhaus' tests are fair to all theories concerned, it is rather convincing from empirical evidence of the wage behavior in North America that the wage inflation is affected by the two broad classes of variables which represent the tightness of the labour market and the rates of change in certain prices (7).

The issues here are i) what type of variables may represent the tightness of the labour market and ii) what price increases are appropriate for the wage equation. There is no clear cut agreement on either of these.

Perry argued that the use of the overall rate of unemployment to represent the tightness of the labour market in the wage equation is not appropriate for a time-series analysis [48]. He proposed three variables to replace the conventional unemployment rate: i) a weighted unemployment rate based on the wage rates and work hours of various ages and sex groups in labour force, ii) a measure of unemployment dispersion among various sectors of the labour market to take into account the fact that various labour groups are imperfect substitutes for one another, and iii) hidden unemployment. Again, leaving the question whether or not the incorporation of these proposals can do any good for the Canadian wage equation, we note that in re-estimating CANDIDE version 1.1, Bodkin and Siedule found none of the above proposals can be put to an empirical test due to data limitations [6]. They used the unemployment rate as a proxy for labour market tightness. Parkin and Laidler, in their review article, also found that the rate of unemployment is a "natural" variable to use as an indicator of labour market tightness in a competitive model or as an indicator of the relative bargaining strength of the two parties in the monopolistic analysis [34]. We use the unemployment rate in the wage equation.

On the issue of what prices should be in the wage equation, there are several versions: i) consumer price index. The argument is that the increase in the consumer price index represents the cost of living adjustment. It is real wages that are bargained for in wage settlements, or the labour supply is determined by real wages in a competitive model [5,34]. ii) increases in wages either from other sectors of the domestic economy or from foreign countries. This is the wage drift hypothesis [50,52,56]. iii) value added prices. It is argued by Perry that the incorporation of these prices will take into account the producers' side in wage settlement [49]. iv) increases in export and import prices [49].

In terms of our model, we have three output prices: prices of importable, non-tradable and exportable goods. These prices constitute a general price index of the economy. Therefore, using disaggregated prices, we do take into account the cost of living adjustment, but at the same time do not force the estimated coefficients of the inflation expectation variable into some weighting scheme of a general price index (e.g., consumer price index). Furthermore, using disaggregated prices, we can identify the relative importance of each price in affecting the general wage equation, and can take into account the effects of export and import prices. The wage equation in our model is specified as follows:

$$[d \ln W] = a_1 + a_2[\Psi(U)]_* + a_3[d \ln P_N]_* + a_4[d \ln P_M]_* + a_5[d \ln P_X]_* + e_W \tag{2.1}$$

where $d \ln W = \ln W_t - \ln W_{t-1}$ = the first difference of natural log of the money wages. This is an approximation of the percentage change in the money wages (14).

$\Psi(U)$ = some function of percentage labour force unemployed

$d \ln P_N$ = $\ln(P_N)_t - \ln(P_N)_{t-1}$ = the first difference of natural log of the price of non-tradable goods.

$d \ln P_M$ = $\ln(P_M)_t - \ln(P_M)_{t-1}$ = the first difference of natural log of the price of importable goods.

$d \ln P_X$ = $\ln(P_X)_t - \ln(P_X)_{t-1}$ = the first difference of natural log of the price of exportable goods.

$a_i$ = parameters of the equation (i=1,2,..,5)

$e_W$ = error term of which the nature is not known a priori.

The subscript (*) represents the expectation of the relevant variable. This expectation will be determined empirically.

In the following, we derive equation (2.1) from a competitive model to show that it contains the essential theoretical features of the wage equation(8).

Let us consider a typical labour sub-market (i), in which the percentage change in money wages is a function of the percentage change in the excess labour demand

$$[d(W_i) \;/\; W_i(t)] = f_i[q_i^x(t) \;/\; q_i(t)] \qquad (2.2)$$

where $d(W_i) = (W_i)_{t+1} - (W_i)_t$

$W_i$ = money wages at time t

$q_i^x$ = excess labour demand in sub-market i

$q_i^{(t)}$ = labour supply in sub-market i

If a Walrasian price adjustment is assumed, the function $f_i$ in equation (2.2) is a constant

$$f_i[q_i^x(t) / q_i(t)] = k_i[q_i^x(t) / q_i(t)] \qquad (2.3)$$

Equation (2.2) coupled with equation (2.3) means that the percentage change in money wages is proportional to the percentage change in excess labour demand. This relation is symmetrical in the sense that the response of money wages to excess labour demand will be of the same magnitude but opposite direction to excess labour supply.

Following Hansen [25] we look at the Laspeyres macro wage index at time t=0.

$$W(1) = \frac{\sum W_i(1)\ q_i(0)}{\sum W_i(0)\ q_i(0)} \qquad (2.4)$$

and

$$W(1) - W(0) = \frac{\sum [W_i(1) - W_i(0)]\ q_i(0)}{\sum W_i(0)\ q_i(0)} = \frac{\sum k_i\ W_i(0)\ q_i^x(0)}{\sum W_i(0)\ q_i(0)} \qquad (2.5)$$

Choosing the input of measurement so that $W_i(0) = 1$, and assuming $k_i = k$ for all sub markets, we have

$$\frac{d(W)}{W} = \frac{W(1) - W(0)}{W(0)} = k\frac{\sum q_i^x(0)}{\sum q_i(0)} = k\frac{\sum q_i^x(0)}{N(0)} = kr^x(0) \qquad (2.6)$$

where N(0) is total labour force, and $r^x$ may be called the average rate of excess labour demand as a whole.

The derived macro relationship is thus similar to the previously postulated micro relationship: the rate of wage change is a linear and increasing function of the rate of excess labour demand. Money wages are constant when the rate of excess labour demand is zero.

If the reaction function in equation (2.2) is . non-linear, or kinked at the origin, excess labour demand and excess labour supply cause asymmetric effects on money wages. In this case, the aggregate labour demand from sub-markets has a positive intercept at zero aggregate excess labour demand [35]. Hence equation (2.6) becomes

$$[d(W)/W] = a_1 + k\, r^x(0) \tag{2.7}$$

The specification of equation (2.7) was criticized on the ground that it does not explain large fluctuations in wages relative to excess labour demand [34]. It has also been argued that there are systematic factors causing a shift in the short-run wage change which are independent of the excess labour demand [20,25,52]. Let $S_i$ be a shifting factor in the wage equation of the sub-market (i), the micro relationship is

$$[d(W_i) / W_i(0)] = k_i[q_i^x(0) / q_i(0)] + S_i \tag{2.8}$$

With the assumption that $k_i = k$ and $S_i = S$ for all sub-markets, we derive the macro relationship in the same manner as above.

$$[d(W)/W] = a_1 + k\, r^x(0) + S \qquad (2.9)$$

Next, we want to relate the average excess labour demand ($r^x$) to the unemployment rate. We define the following:

$v = q_i^{+x}/N$ = average rate of vacancies

$u = q_i^{-x}/N$ = average rate of unemployment

where $q_i^{+x}$ = sum of excess labour demand

$q_i^{-x}$ = sum of excess labour supply

Hence $r^x(0) = [\Sigma q_i^{+x}/N] - [\Sigma q_i^{-x}/N] = v - u \qquad (2.10)$

and equation (2.9) becomes

$$[d(W)/W] = a_1 + k\,(v - u) + S \qquad (2.11)$$

There are different theories relating the average rate of vacancies to the average rate of unemployment [25,51,52]. Without going into details of these theories, we can write equation (2.11) as

$$[d(W)/W] = a_1 + a_2\,[\Psi(U)]_* + S \qquad (2.12)$$

where $[\Psi(U)]_*$ is a functional form of the unemployment rate, and represents expected excess labour demand.

For the shifting factor S, Friedman argues that real wages, not money wages, respond to excess labour demand. If that is the case, money wages will respond both to excess labour demand and expected changes in prices [34].

in APPENDIX B.

$$\ln \hat{Q}_N = g_{oN}+g_{1N} \ln \hat{W}+g_{2N} \ln \hat{P}_N+g_{3N} \ln \hat{P}_M+g_{4N} \ln\hat{P}_X +g_{5N} t +g_{6N} \ln \hat{I}_d \qquad (2.24)$$

where $g_{oN}$, $g_{1N}$, $g_{2N}$, $g_{3N}$, $g_{4N}$, $g_{5N}$, and $g_{6N}$ are constant with the following expected signs: $g_{1N} > 0$, $g_{2N} < 0$, $g_{3N} > 0$, $g_{4N} > 0$, $g_{5N} < 0$ and $g_{6N} > 0$.

If non-tradable goods are used in the production function of the sector producing exportable goods, equation (2.22) holds, and we have to derive an equation to explain the output of exportable goods.

2.3 Expected demand in the sector producing exportable goods

Total demand in this sector ($\hat{D}_X$) is equal to foreign demand($\hat{D}_X{}^f$) plus domestic demand ($\hat{D}_X{}^d$). The domestic demand is in turn equal to consumption demand ($\hat{D}_X{}^C$) and production demands in the three sectors $(\hat{D}_X{}^I)_i$, (i=N,M,X).

$$\hat{D}_X = \hat{D}_X{}^d + \hat{D}_X{}^f \qquad (2.25)$$

$$\hat{D}_X{}^d = \hat{D}_X{}^c + (\hat{D}_X{}^I)_N + (\hat{D}_X{}^I)_M + (\hat{D}_X{}^I)_X \qquad (2.26)$$

Substituting equation (2.26) into equation (2.25), we have

$$\hat{D}_X = \hat{D}_X{}^C + (\hat{D}_X{}^I)_N + (\hat{D}_X{}^I)_M + (\hat{D}_X{}^I)_X + \hat{D}_X{}^f \qquad (2.27)$$

The domestic consumption demand is a function of relative prices and domestic real income.

$$\hat{D}_X{}^C = \hat{D}_X{}^C (\hat{P}_N, \hat{P}_M, \hat{P}_X, \hat{I}_d) \qquad (2.28)$$

$$\ln(MC_i) = \ln(B_i/\beta_i) + (\ell_i/\beta_i) \ln W + (n_i/\beta_i) \ln P_N + (m_i/\beta_i) \ln P_M + (x_i/\beta_i) \ln P_X + ((1-\beta_i)/\beta_i) \ln Q_i - (h_i/\beta_i) t \qquad (i = N, M, X) \tag{2.14}$$

where $MC_i$ = marginal cost of sector $i (i = N,M,X)$

$Q_i$ = output of sector i $(i = N,M,X)$

$\ell_i, n_i, m_i, x_i$ = shares of labour, non-tradable, importable and exportable goods in the production function of sector i $(i = N,M,X)$

$\beta_i = \ell_i + n_i + m_i + x_i$ = share of all inputs except capital in the production function of sector i

$h_i$ = Hicks' neutral technological change plus the growth rate of capital stock in the sector i

$B_i$ = constant

t = time trend

Equation (2.14) represents the supply curve of each sector. The output price of each sector is determined by the interaction of the supply and demand curves. Having specified the supply curve, we now turn to the demand side to derive the expected demand of each sector.

2. Expected demand of each sector

In this section, we will specify arguments that influence the expected demand for output from the producers' point of view.

## 2.1 Expected demand in the sector producing importable goods

In this sector, we do not make a distinction between imports and importables. What are actually imported are importables. Since the foreign supply of importable goods is assumed infinitely elastic, the domestic price of importable goods in Canadian dollars is determined by exogenous foreign export prices adjusted by the exchange rate and import tax(9). Given the expected domestic price of importables and other input prices in this sector, the expected supply is determined at an equilibrium condition

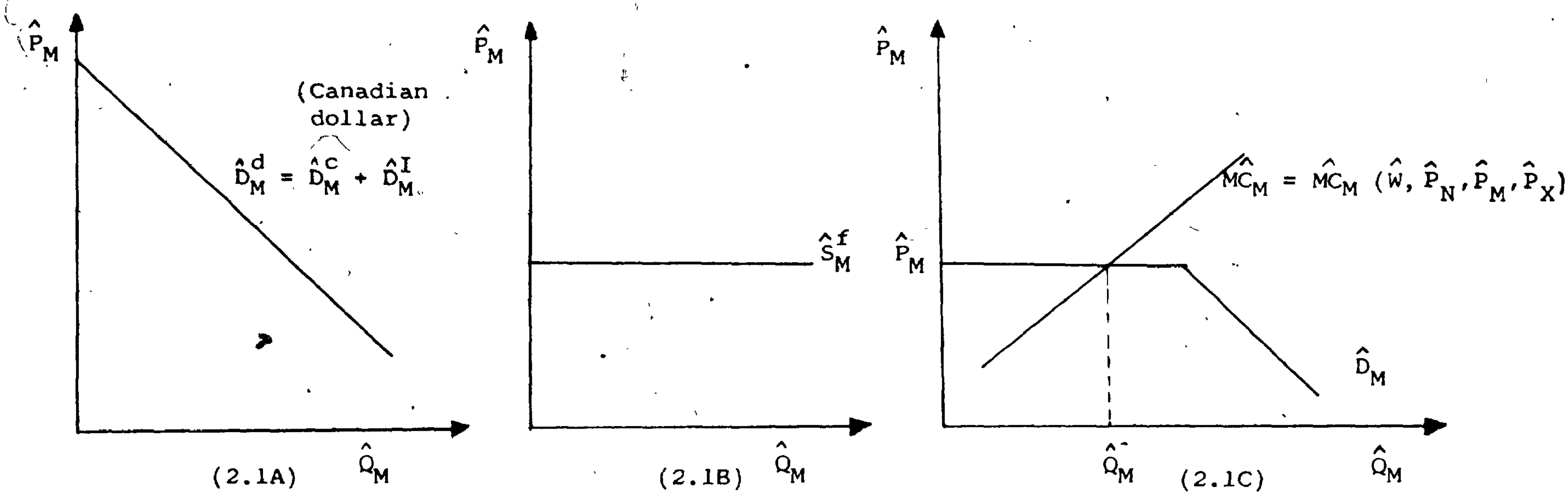
$$P_M = \hat{MC}_M \ (\hat{W}, \ \hat{P}_N, \ \hat{P}_M, \ \hat{P}_X, \ \hat{Q}_M) \qquad (2.15)$$

where the superscript (^) denotes the expected value of the relevant variable. The expected output $(\hat{Q}_M)$ is derived from equation (2.15) as:

$$\hat{Q}_M = \hat{Q}_M \ (\hat{W}, \ \hat{P}_N, \ \hat{P}_M, \ \hat{P}_X) \qquad (2.16)$$

The output determination of domestically produced importable goods is illustrated in Figure 2.1. Total domestic demand for importable goods is the sum of domestic demands for consumption and production (Figure 2.1A). On the supply side, we have importable goods which can be imported or produced domestically. Hence

Figure 2.1 Price and output determination of domestically produced importables




$\hat{D}^d_M$ = expected total domestic demand for importables

$\hat{D}^c_M$ = expected domestic consumption demand for importables

$\hat{D}^I_M$ = expected domestic demand for intermediate goods

$\hat{S}^f_M$ = expected foreign supply of importables

$\hat{D}_M$ = expected relevant demand for domestic producers

$\hat{MC}_M$ = expected marginal cost of sector producing importables.

the demand faced by domestic producers is equal to the total domestic demand minus the foreign supply (Figure 2.1C). Given the expected domestic price of importable goods ($\hat{P}_M$) and the expected cost of production ($\widehat{MC}_M$), the expected domestic output of importable goods is $\hat{Q}_M$ in Figure 2.1C.

Mathematically, if the production technology is of the Cobb-Douglas type, the expected domestic output of importable goods is

$$\ln \hat{Q}_M = -[(\beta_M/(1-\beta_M))\ \ln(B_M/\beta_M)] - (\ell_M/(1-\beta_M))\ \ln \hat{W}$$
$$-(n_M/(1-\beta_M))\ \ln \hat{P}_N + ((\beta_M - m_M)/(1-\beta_M))\ \ln \hat{P}_M$$
$$-(x_M/(1-\beta_M))\ \ln \hat{P}_X + (h_M/(1-\beta_M))\ t \qquad (2.17)$$

The derivation of equation (2.17) is in APPENDIX B (equation B.6).

### 2.2 Expected demand in the sector producing non-tradable goods

In this sector, total domestic demand for non-tradable goods is the sum of consumption demand and production demand. Since we allow the possibility that non-tradable goods are used in the production functions of the three sectors, we take the total production demand for non-tradable goods as the sum of the demands used as inputs in the three sectors.

$$\hat{D}_N = \hat{D}_N^{\,C} + (\hat{D}_N^{\,I})_N + (\hat{D}_N^{\,I})_M + (\hat{D}_N^{\,I})_X \qquad (2.18)$$

where $\hat{D}_N$ = total domestic demand for non-tradable goods

$\hat{D}_N^C$ = domestic consumption demand for non-tradable goods

$(\hat{D}_N^I)_N$, $(\hat{D}_N^I)_M$, $(\hat{D}_N^I)_X$ = production demands for non-tradable goods in the sectors producing non-tradable, importable, and exportable goods, respectively

From consumer theory, consumption demand is a function of all prices and domestic real income. This means that for any expected prices ($\hat{P}_N$, $\hat{P}_M$, $\hat{P}_X$) and expected domestic real income ($\hat{I}_d$), the expected consumption demand for non-tradable goods is

$$\hat{D}_N^C = \hat{D}_N^C \; (\hat{P}_N, \hat{P}_M, \hat{P}_X, \hat{I}_d) \qquad (2.19)$$

Production demands for non-tradable goods are derived from the production functions of the three sectors (APPENDIX B).

$$(\hat{D}_N^I)_i = (\hat{D}_N^I)_i \; (\hat{W}, \hat{P}_N, \hat{P}_M, \hat{P}_X, \hat{Q}_i), \; (i = N, M, X) \qquad (2.20)$$

where $\hat{Q}_i$ = expected output in sector i. Substituting equation (2.16) into equation (2.20), we have expected production demand for non-tradable goods in the sector producing importable goods. Similarly, let $\hat{Q}_N$ and $\hat{Q}_X$ be expected outputs in the sector producing non-tradable and exportable goods, equation (2.20) gives expected production demands for non-tradable goods in the sectors producing non-tradable and exportable goods.

Substituting consumption demand (equation 2.19) and production demands (given by equation 2.20) into equation (2.18), we have expected total demand for non-tradable goods:

$$\hat{D}_N = F\ (\hat{W},\ \hat{P}_N,\ \hat{P}_M,\ \hat{P}_X,\ \hat{I}_d,\ \hat{Q}_X,\ \hat{Q}_N) \qquad (2.21)$$

For any given set of expected prices and costs, the expected output of non-tradable goods is equal to the expected demand i.e., $\hat{D}_N = \hat{Q}_N$. Hence the expected output of non-tradable goods is

$$\hat{Q}_N = \hat{Q}_N\ (\hat{W},\ \hat{P}_N,\ \hat{P}_M,\ \hat{P}_X,\ \hat{I}_d,\ \hat{Q}_X) \qquad (2.22)$$

In equation (2.22), we observe that the expected output of exportable goods also affects the expected output of non-tradable goods. The reason is that input demand for non-tradable goods in the production of exportable goods will increase as the output of exportable goods increases. If non-tradable goods are not used as material inputs in the production of exportable goods, equation (2.22) becomes

$$\hat{Q}_N = \hat{Q}_N\ (\hat{W},\ \hat{P}_N,\ \hat{P}_M,\ \hat{P}_X,\ \hat{I}_d) \qquad (2.23)$$

We can assume that equation (2.23) has a log -linear functional relationship between the dependent and independent variables. Alternatively, the same result can be derived if we start from the Cobb-Douglas production function for each sector. The detailed derivation is in APPENDIX B.

$$\ln \hat{Q}_N = g_{oN}+g_{1N} \ln \hat{W}+g_{2N} \ln \hat{P}_N+g_{3N} \ln \hat{P}_M+g_{4N} \ln\hat{P}_X$$
$$+g_{5N} t +g_{6N} \ln \hat{I}_d \qquad (2.24)$$

where $g_{oN}$, $g_{1N}$, $g_{2N}$, $g_{3N}$, $g_{4N}$, $g_{5N}$, and $g_{6N}$ are constant with the following expected signs: $g_{1N} > 0$, $g_{2N} < 0$, $g_{3N} > 0$, $g_{4N} > 0$, $g_{5N} < 0$ and $g_{6N} > 0$.

If non-tradable goods are used in the production function of the sector producing exportable goods, equation (2.22) holds, and we have to derive an equation to explain the output of exportable goods.

2.3 Expected demand in the sector producing exportable goods

Total demand in this sector ($\hat{D}_X$) is equal to foreign demand($\hat{D}_X{}^f$) plus domestic demand ($\hat{D}_X{}^d$). The domestic demand is in turn equal to consumption demand ($\hat{D}_X{}^C$) and production demands in the three sectors $(\hat{D}_X{}^I)_i$, (i=N,M,X).

$$\hat{D}_X = \hat{D}_X{}^d + \hat{D}_X{}^f \qquad (2.25)$$

$$\hat{D}_X{}^d = \hat{D}_X{}^c + (\hat{D}_X{}^I)_N + (\hat{D}_X{}^I)_M + (\hat{D}_X{}^I)_X \qquad (2.26)$$

Substituting equation (2.26) into equation (2.25), we have

$$\hat{D}_X = \hat{D}_X{}^C + (\hat{D}_X{}^I)_N + (\hat{D}_X{}^I)_M + (\hat{D}_X{}^I)_X + \hat{D}_X{}^f \qquad (2.27)$$

The domestic consumption demand is a function of relative prices and domestic real income.

$$\hat{D}_X{}^C = \hat{D}_X{}^C (\hat{P}_N, \hat{P}_M, \hat{P}_X, \hat{I}_d) \qquad (2.28)$$

The production demands for exportable goods are obtained from the production functions of the three sectors.

$$(\hat{D}_X{}^I)_i = (\hat{D}_X{}^I)_i\ (\hat{W}, \hat{P}_N, \hat{P}_M, \hat{P}_X, \hat{Q}_i) \qquad (2.29)$$

where $(\hat{D}_X{}^I)_i$ = input demand for exportable goods in the production of sector i (i = N, M, X).

Foreign demand for exportable goods $(\hat{D}_X{}^f)$ is specified according to Armington's demand theory [1,7].

$$\hat{D}_X{}^f = \hat{D}_X{}^f\ (\hat{I}_f, \hat{P}_X/\hat{P}_f) \qquad (2.30)$$

$\hat{I}_f$ = a variable representing the activity of foreign markets

$\hat{P}_f$ = expected price in Canadian dollars of close substitutes for Canadian exports. These commodities are produced and sold in foreign markets.

If there is an export subsidy at the rate S, the relative price in equation (2.30) is

$$\hat{P}_X\ (1 - S)/\hat{P}_f \doteq \hat{P}_X/P_f^* \qquad (2.31)$$

where $P_f{}^* = P_f/(1-S)$

Armington's demand theory is based on two assumptions.

i) The first assumption is called "Independence". This assumption is a sufficient condition for the utility of a typical foreign consumer to be a function of different composite goods $(X_i)$. Each composite good is a function of that good produced in different countries $(X_{ik})$.

ii) The functional relationship of a composite good and its components is homogeneous of degree 1. This assumption is necessary to have a price index $P_i$ of the composite good such that

$$P_i X_i = \sum_{k=1}^{n} P_{ik} X_{ik} \quad (2.32)$$

where k denotes the country of origin.

Using equations (2.16) and (2.22) to replace the expected outputs of importable and non-tradable goods in equation (2.29), we have expected production demands for exportable goods. Substituting consumption demand [equation (2.28)], production demands given by equation (2.29) and foreign demand [equation (2.30)] into equation (2.27), we have the expected output of exportable goods which is equal to its expected demand, i.e., $\hat{Q}_X = \hat{D}_X$. Hence

$$\hat{Q}_X = \hat{Q}_X\ (\hat{W},\ \hat{P}_N, \hat{P}_M,\ \hat{P}_X,\ \hat{I}_d,\ \hat{I}_f,\ \hat{P}_f) \quad (2.33)$$

The explicit functional form of equation (2.33) can be derived using a Cobb-Douglas production function for each sector and log-linear domestic consumption demand and foreign demand (APPENDIX B).

$$\ln \hat{Q}_X = k_{oX} + k_{1X} \ln \hat{W} + k_{2X} \ln \hat{P}_N + k_{3X} \ln \hat{P}_M + k_{4X} \ln \hat{P}_X + k_{5X}\, t + k_{6X} \ln \hat{I}_d + k_{7X} \ln \hat{I}_f + k_{8X} \ln \hat{P}_f \quad (2.34)$$

where $k_{oX}$, $k_{1X}$, $k_{2X}$, $k_{3X}$, $k_{4X}$, $k_{5X}$, $k_{6X}$, $k_{7X}$ and $k_{8X}$ are constants with the following expected signs: $k_{1X}>0$, $k_{2X}>0$, $k_{3X}>0$, $k_{4X}<0$, $k_{5X}<0$, $k_{6X}>0$, $k_{7X}>0$, $k_{8X}>0$.

In the case that non-tradable goods are used as material inputs in the production of exportable goods, we substitute equation (2.33) into equation (2.22).

$$\hat{Q}_N = \hat{Q}_N(\hat{W}, \hat{P}_N, \hat{P}_M, \hat{P}_X, \hat{I}_d, \hat{I}_f, \hat{P}_f) \qquad (2.35)$$

The log-linear functional relationship for equation (2.35) can be derived in the same manner as above.

$$\ln \hat{Q}_N = k_{oN}+k_{1N} \ln \hat{W}+k_{2N} \ln \hat{P}_N+k_{3N} \ln \hat{P}_M+k_{4N} \ln \hat{P}_X + k_{5N} t+k_{6N} \ln \hat{I}_d+k_{7N} \ln \hat{I}_f+k_{8N} \ln \hat{P}_f \qquad (2.36)$$

It is expected that $k_{1N}>0$, $k_{2N}<0$, $k_{3N}>0$, $k_{4N}>0$, $k_{5N}<0$, $k_{6N}>0$, $k_{7N}>0$, and $k_{8N}>0$. If non-tradable goods are not used as material inputs in the production of exportable goods then $k_{7N} = k_{8N} = 0$.

We now have derived both demand and supply curves of each sector. These specifications will be used in the next section to derive output prices.

## 3. Price equation of each sector

In the following, we will derive the output price of each sector. These price equations will be used in the estimation of the model.

### 3.1 Sector producing importable goods

The domestic price of importable goods is determined by the exogenous foreign export prices adjusted by the exchange rates and the import tax.

3.2 Sector producing non-tradable goods

The demand for non-tradable goods is not infinitely elastic. Given the expected marginal cost, producers in this sector have a desired price at an equilibrium.

$$P_N^e = k_N \hat{MC}_N (\hat{W}, P_N^e, \hat{P}_M, \hat{P}_X, \hat{Q}_N) ; k_N > 1 \qquad (2.37)$$

where $P_N^e$ = desired price for non-tradable goods

$\hat{MC}_N$ = expected marginal cost of sector producing non-tradable goods.

$k_N$ = mark-up factor between price and cost

In equation (2.37) the desired price of non-tradable goods is used instead of its expected price as a variable in the marginal cost function because producers in this sector know their set price. The meaning of $k_N > 1$ is that producers have sufficient market power to maintain price above marginal cost in the sector producing non-tradable goods. If $k_N = 1$, the marginal cost curve can be interpreted as the supply curve of the sector. In this case, equilibrium price is determined by the intersection of the supply and demand curves. In empirical works, the mark-up factor is usually assumed constant [3,14]. However, in some works, the mark-up factor is assumed to be a function of demand pressure. The argument for using pressure of demand variable is that as the sector moves to its maximum capacity, the difference between price and cost tends to be greater. Theoretically, the assumption of the relationship between the mark-up factor and the pressure of demand is unnecessary as long as we estimate the producer price. The reason is that an increase in the price via the demand effect has already been incorporated in the equilibrium price [4]. Therefore, we assume that the mark-up factor is constant.

We further assume that the production technology is of Cobb-Douglas type and take natural logs on the both sides of equation (2.37).

$$\ln P_N^{\,e} = \ln k_N + \ln(B_N/\beta_N) + (\ell_N/\beta_N)\ \ln \hat{W} + (n_N/\beta_N)\ \ln P_N^{\,e}$$
$$+ (m_N/\beta_N)\ \ln \hat{P}_M + (x_N/\beta_N)\ \ln \hat{P}_X + ((1-\beta_N)/\beta_N)\ \ln \hat{Q}_N$$
$$- (h_N/\beta_N)\ t \qquad (2.38)$$

Substituting the value of $\ln \hat{Q}_N$ from equation (2.36) into equation (2.38), we have (15).

$$\ln P_N^{\,e} = b_{oN} + b_{1N}\ t + b_{2N}\ \ln \hat{W} + b_{3N}\ \ln \hat{P}_M + b_{4N}\ \ln \hat{P}_X$$
$$+ b_{5N}\ \ln \hat{I}_d + b_{6N}\ \ln \hat{I}_f + b_{7N}\ \ln \hat{P}_f \qquad (2.39)$$

where, let $b_{8N} = (1/(1 - ((1 - \beta_N)/\beta_N)k_{2N} - (n_N/\beta_N))>0$,

$$b_{oN} = b_{8N}\ [((1 - \beta_N)/\beta_N)k_{oN} + \ln k_N + \ln(B_N/\beta_N)]$$

$$b_{1N} = b_{8N}\ [((1 - \beta_N)/\beta_N)k_{5N} - (h_N/\beta_N)]<0$$

$$b_{2N} = b_{8N}\ [((1 - \beta_N)/\beta_N)k_{1N} + (\ell_N/\beta_N)]>0$$

$$b_{3N} = b_{8N}\ [((1 - \beta_N)/\beta_N)k_{3N} + (m_N/\beta_N)]>0$$

$$b_{4N} = b_{8N}\ [((1 - \beta_N)/\beta_N)k_{4N} + (x_N/\beta_N)]>0$$

$$b_{5N} = b_{8N}\ ((1 - \beta_N)/\beta_N)k_{6N}>0$$

$$b_{6N} = b_{8N}\ ((1 - \beta_N)/\beta_N)k_{7N}>0$$

$$b_{7N} = b_{8N}\ ((1 - \beta_N)/\beta_N)k_{8N}>0$$

If non-tradable goods are not used as material inputs in the production function of exportables, then $b_{6N}=b_{7N}=0$.

The desired price of non-tradable goods in equation (2.39) is different from actual price due to imperfect information and/or the high cost of rapid change. In most empirical works, the desired price is connected to the actual price by a partial adjustment mechanism [15, 24,42]. The derivation of this mechanism is presented in APPENDIX C. Using this adjustment mechanism, the actual price of non-tradable goods is

$$\begin{aligned} \ln P_N = {} & \lambda_N b_{oN} + \lambda_N b_{1N} t + \lambda_N b_{2N} \ln \hat{W} + \lambda_N b_{3N} \ln \hat{P}_M \\ & + \lambda_N b_{4N} \ln \hat{P}_X + \lambda_N b_{5N} \ln \hat{I}_d + \lambda_N b_{6N} \ln \hat{I}_f \\ & + \lambda_N b_{7N} \ln \hat{P}_f + (1 - \lambda_N)[\ln P_N]_* + e_N \end{aligned} \tag{2.40}$$

where $\lambda_N$ is the adjustment coefficient in the sector producing non-tradable goods. We use the subscript (*), to represent a general distributed lag of the dependent variable rather than a one period lag, since there is no reason why firms in this sector adjust their price from quarter to quarter. Error due to adjustment mechanism is $e_N$.

In equation (2.40), most of the independent variables are in expected forms. Therefore, we have to specify firms' expectation mechanism. A mechanism usually used in empirical works is that the expected value is a distributed lag of past values [36]. The lag structure is determined empirically. Hence, equation (2.40) becomes

$$\ln P_N=\lambda_N b_{0N}+\lambda_N b_{1N} t + \lambda_N b_{2N} [\ln W]_*+ \lambda_N b_{3N} [\ln P_M]_* +\lambda_N b_{4N} [\ln P_X]_*+\lambda_N b_{5N}[\ln I_d]_*+\lambda_N b_{6N}[\ln I_f]_* +\lambda_N b_{7N}[\ln P_f]_* + (1 - \lambda_N)[\ln P_N]_*+ e_N \quad (2.41)$$

where the subscript (*) represents the lag-structure of the relevant variable. Since money wages are modeled in the form of *the rate of* change, price variables should also be in the *same form*. Differentiating equation (2.41), we have

$$d(\ln P_N)=\lambda_N b_{1N}+\lambda_N b_{2N}[d(\ln W)]_*+\lambda_N b_{3N}[d(\ln P_M)]_* +\lambda_N b_{4N}[d(\ln P_X)]_*+\lambda_N b_{5N}[d(\ln I_d)]_* +\lambda_N b_{6N}[d(\ln I_f)]_*+\lambda_N b_{7N}[d(\ln P_f)]_* + (1 -\lambda_N)[d(\ln P_N)]_* + (e_{N,t}-e_{N,t-1}) \quad (2.42)$$

This is the general form for the estimation of the price of non-tradable goods in our model.

3.3 <u>Sector producing exportable goods</u>

From the discussion in section 2.3 of this Chapter, the demand for exportable goods is not infinitely elastic. Given the expected marginal cost, producers in this sector have a desired price at an equilibrium.

$$P_X^e = k_X \hat{MC}_X (\hat{W}, \hat{P}_N, \hat{P}_M, P_X^e, \hat{Q}_X) \quad (2.43)$$

where $P_X^e$ = desired price of exportable goods

$\hat{MC}_X$ = expected marginal cost of sector producing exportable goods

$k_X$ = mark-up factor between price and cost

The desired price of exportable goods is used instead of its expected price in the marginal cost curve, because producers in this sector know their set price. Similar to the argument taken in the sector producing non-tradable goods, we assume that the mark-up factor between price and cost in the sector producing exportable goods is constant. We further assume that the production technology is of Cobb-Douglas type. Hence, equation (2.14) can be used to replace the marginal cost in equation (2.43). Taking natural logs on both sides of equation (2.43), we have

$$\begin{aligned} \ln P_X^e = {} & \ln k_X + \ln(B_X/\beta_X) + (\ell_X/\beta_X) \ln \hat{W} \\ & + (n_X/\beta_X) \ln \hat{P}_N + (m_X/\beta_X) \ln \hat{P}_M \\ & + (x_X/\beta_X) \ln P_X^e + ((1-\beta_X)/\beta_X) \ln \hat{Q}_X \\ & - (h_X/\beta_X)\, t \end{aligned} \tag{2.44}$$

Substituting equation (2.34) for the value of $\ln \hat{Q}_X$ in equation (2.44), we have(15)

$$\begin{aligned} \ln P_X^e = {} & b_{oX} + b_{1X}\, t + b_{2X} \ln \hat{W} + b_{3X} \ln \hat{P}_N + b_{4X} \ln \hat{P}_M \\ & + b_{5X} \ln \hat{I}_d + b_{6X} \ln \hat{I}_f + b_{7X} \ln \hat{P}_f \end{aligned} \tag{2.45}$$

where, let $b_{8X} = (1/(1 - ((1-\beta_X)/\beta_X)k_{4X} - (x_X/\beta_X))>0$,

$$b_{oX} = b_{8X}\ [((1-\beta_X)/\beta_X)k_{oX} + \ln k_X + \ln(B_X/\beta_X)]$$

$$b_{1X} = b_{8X}\ [((1-\beta_X)/\beta_X)k_{5X} - (h_X/\beta_X)]<0$$

$$b_{2X} = b_{8X}\ [((1-\beta_X)/\beta_X)k_{1X} + (\ell_X/\beta_X)]>0$$

$$b_{3X} = b_{8X}\ [((1-\beta_X)/\beta_X)k_{2X} + (n_X/\beta_X)]>0$$

$$b_{4X} = b_{8X}\ [((1-\beta_X)/\beta_X)k_{3X} + (m_X/\beta_X)]>0$$

$$b_{5X} = b_{8X}\ ((1-\beta_X)/\beta_X)k_{6X}>0$$

$$b_{6X} = b_{8X}\ ((1-\beta_X)/\beta_X)k_{7X}>0$$

$$b_{7X} = b_{8X}\ ((1-\beta_X)/\beta_X)k_{8X}>0$$

Equation (2.45) gives the desired price of exportable goods. Using the partial adjustment mechanism (APPENDIX C), the actual price of exportable goods is

$$\begin{aligned}\ln P_X = {} & \lambda_X\ b_{oX}+\lambda_X b_{1X}\ t + \lambda_X b_{2X}\ \ln \hat{W} + \lambda_X b_{3X}\ \ln \hat{P}_N \\ & + \lambda_X\ b_{4X}\ \ln \hat{P}_M + \lambda_X b_{5X}\ \ln \hat{I}_d + \lambda_X b_{6X}\ \ln \hat{I}_f \\ & + \lambda_X\ b_{7X}\ \ln \hat{P}_f + (1-\lambda_X)[(\ln P_X)]_* + e_X \qquad (2.46)\end{aligned}$$

Similar to the above, the expected values of the variables on the right-hand side of equation (2.46) are the distributed lag of the past values. The lag structure is determined empirically. Hence, equation (2.46) becomes

$$\begin{aligned}\ln P_X = {} & \lambda_X\ b_{oX}+\lambda_X\ b_{1X}\ t + \lambda_X\ b_{2X}[\ln W]_* + \lambda_X\ b_{3X}[\ln P_N]_* \\ & + \lambda_X\ b_{4X}[\ln P_M]_* + \lambda_X\ b_{5X}[\ln I_d]_* + \lambda_X\ b_{6X}[\ln I_f]_* \\ & + \lambda_X\ b_{7X}[\ln P_f]_* + (1-\lambda_X)[\ln P_X]_* + e_X \qquad (2.47)\end{aligned}$$

The subscript ($_*$) represents the lag-structural form of the relevant variable. Since money wages are modeled in the form of the rate of change, price variables should be also in the same form. Differentiating equation (2.47), we have

$$\begin{aligned} d(\ln P_X) = {} & \lambda_X b_{1X} + \lambda_X b_{2X}[d(\ln W)]_* + \lambda_X b_{3X}[d(\ln P_N)]_* \\ & + \lambda_X b_{4X}[d(\ln P_M)]_* + \lambda_X b_{5X}[d(\ln I_d)]_* \\ & + \lambda_X b_{6X}[d(\ln I_f)]_* + \lambda_X b_{7X}[d(\ln P_f)]_* \\ & + (1 - \lambda_X)[d(\ln P_X)]_* + (e_{X,t} - e_{X,t-1}) \end{aligned} \tag{2.48}$$

This is the general estimated form of the price of exportable goods in our model.

4. Employment.

Employment in each sector can be derived from the production function. For any expected input prices and output level, the desired labour demand in each sector is given by equation (A-23) of APPENDIX A.

$$\ln L_i^e = \ln(\ell_i B_i/\beta_i) - ((\beta_i - \ell_i)/\beta_i) \ln \hat{W}$$

$$+ (n_i/\beta_i) \ln \hat{P}_N + (m_i/\beta_i) \ln \hat{P}_M + (x_i/\beta_i) \ln \hat{P}_X$$

$$+ (1/\beta_i) \ln \hat{Q}_i - (h_i/\beta_i) t$$

$$(i = N,M,X) \qquad (2.49)$$

Desired labour demand is different from actual labour demand due to the high cost of rapid changes. Using the partial adjustment mechanism (APPENDIX C), actual labour demand in each sector is

$$\ln L_i = \lambda_{Li} \ln(\ell_i B_i/\beta_i) - \lambda_{Li}((\beta_i - \ell_i/\beta_i) \ln \hat{W}$$

$$+ \lambda_{Li}(n_i/\beta_i) \ln \hat{P}_N + \lambda_{Li}(m_i/\beta_i) \ln \hat{P}_M$$

$$+ \lambda_{Li}(x_i/\beta_i) \ln \hat{P}_X + \lambda_{Li}(1/\beta_i) \ln \hat{Q}_i$$

$$- \lambda_{Li}(h_i/\beta_i) t + (1 - \lambda_{Li})[\ln L_i]_* + e_{Li} \qquad (2.50)$$

where $\lambda_{Li}$ = labour adjustment coefficient in each sector $(i = N,M,X)$

Now if we substitute the variables that affect the expected demand $\hat{Q}_i$ of sector i $(i = N,M,X)$, we have the actual labour demand in that sector. This is done in the following sub-sections.

4.1 Employment in the sector producing importable goods

The expected domestic output of importable goods is given by equation(2.17) if the production function in this sector is of Cobb-Douglas type. Substituting equation(2.17) into equation(2.50), and replacing expected variables by their distributed lag functional form, we have

$$\ln L_M = c_{oM} + c_{1M}\, t + c_{2M}[\ln W]_* + c_{3M}[\ln P_N]_* + c_{4M}[\ln P_M]_*$$
$$+ c_{5M}[\ln P_X]_* + c_{6M}[\ln L_M]_* + e_{LM} \qquad (2.51)$$

where $c_{oM} = \lambda_{LM} \ln(\ell_M B_M/\beta_m) - (\lambda_{LM}/(1 - \beta_M)) \ln (B_M/\beta_M)$

$c_{1M} = \lambda_{LM}(h_M/(1-\beta_M)) > 0$. Positive technological progress will increase the domestic production of importable goods. This increase in output will require more inputs including labour. The increase in labour demand is off-set partly by labour being more productive due to technological progress.

$c_{2M} = -\lambda_{LM}((1 - \beta_M + \ell_M)/(1 - \beta_M)) < 0$. An increase in wages will reduce labour demand through input substitution. The labour demand will decrease further as a result of a decrease in the domestic output of importable goods due to the increase in cost.

$c_{3M} = \lambda_{LM}(n_M/(1 - \beta_M)) < 0$. An increase in the price of non-tradable goods will decrease the domestic output of importable goods due to an upward shift of the marginal cost curve. The decrease in the output will suppress the labour demand in this sector. This decrease in labour demand is off-set partly by input substitution between non-tradable goods and labour.

$c_{4M} = \lambda_{LM}((1 - m_M)/(1 - \beta_M)) > 0$. An increase in the price of importable goods will cause an increase in labour demand, not only through input substitution but also through increase in the domestic output of importable goods.

$c_{5M} = -\lambda_{LM}(x_M/(1 - \beta_M)) < 0$ An increase in the price of exportable goods will decrease the domestic output of importable goods due to an upward shift of the marginal cost curve. The decrease in output will suppress labour demand in this sector. This decrease in labour demand is off-set partly by the input substitution between exportable goods and labour.

$c_{6M} = (1 - \lambda_{LM}) > 0$

## 4.2 Employment in the sector producing non-tradable goods

The expected domestic output of non-tradable goods is represented by equation (2.36). Substituting this equation into equation (2.50), and replacing expected variables by their distributed lag functional forms, we have

$$\ln L_N = c_{oN} + c_{1N}\, t + c_{2N}[\ln W]_* + c_{3N}[\ln P_N]_* + c_{4N}[\ln P_M]_*$$
$$+ c_{5N}[\ln P_X]_* + c_{6N}[\ln L_N]_* + c_{7N}[\ln I_d]_*$$
$$+ c_{8N}[\ln I_f]_* + c_{9N}[\ln P_f]_* + e_{LN} \qquad (2.52)$$

where $c_{oN} = \lambda_{LN} \ln(\ell_N B_N/\beta_N) + (\lambda_{LN}/\beta_N) k_{oN}$

$c_{1N} = -(\lambda_{LN}/\beta_N)(h_N - k_{5N}) < 0$

$c_{2N} = -(\lambda_{LN}/\beta_N)(\beta_N - \ell_N - k_{1N})$. The sign of $c_{2N}$ is indeterminate.

$c_{3N} = (\lambda_{LN}/\beta_N)(n_N + k_{2N})$. The sign of $c_{3N}$ is indeterminate.

$c_{4N} = (\lambda_{LN}/\beta_N)(m_M + k_{3N}) > 0$

$c_{5N} = (\lambda_{LN}/\beta_N)(x_N + k_{4N}) > 0$

$c_{6N} = (1 - \lambda_{LN}) > 0$

$c_{7N} = (\lambda_{LN}/\beta_N)\; k_{6N} > 0$

$c_{8N} = (\lambda_{LN}/\beta_N)\; k_{7N} > 0$

$c_{9N} = (\lambda_{LN}/\beta_N)\; k_{8N} > 0$

4.3 Employment in the sector producing exportable goods

The expected output of exportable goods is represented by equation (2.34). Substituting this equation into equation (2.50), and replacing expected variables by their distributed lag functional forms, we have

$$\ln L_X = c_{oX} + c_{1X}\, t + c_{2X}[\ln W]_* + c_{3X}[\ln P_N]_* + c_{4X}[\ln P_M]_*$$
$$+ c_{5X}[\ln P_X]_* + c_{6X}[\ln L_X]_* + c_{7X}[\ln I_d]_* + c_{8X}[\ln I_f]_*$$
$$+ c_{9X}[\ln P_f]_* + e_{LX} \qquad (2.53)$$

where $c_{oX} = \lambda_{LX} \ln(\ell_X B_X/\beta_X) + (\lambda_{LX}/\beta_X)k_{oX}$

$c_{1X} = -(\lambda_{LX}(h_X/\beta_X) - (\lambda_{LX}/\beta_X)k_{5X}) < 0$

$c_{2X} = -(\lambda_{LX}/\beta_X)(\beta_X - \ell_X - k_{1X})$. The sign of $c_{2X}$ is indeterminate.

$c_{3X} = (\lambda_{LX}/\beta_X)(n_X+k_{2X}) > 0$

$c_{4X} = (\lambda_{LX}/\beta_X)(m_X+k_{3X}) > 0$

$c_{5X} = (\lambda_{LX}/\beta_X)(x_X+k_{4X})$. The sign of $c_{5X}$ is indeterminate.

$c_{6X} = (1 - \lambda_{LX}) > 0$

$c_{7X} = (\lambda_{LX}/\beta_X)\; k_{6X} > 0$

$c_{8X} = (\lambda_{LX}/\beta_X)\; k_{7X} > 0$

$c_{9X} = (\lambda_{LX}/\beta_X)\; k_{8X} > 0$

Theoretically, the specification of employment for an empirical estimation has been completed. However, we are not able to obtain the data of employment in each sector. We have to aggregate these into total employment in the economy.

4.4 Total employment.

Let L be the total employment, then we have,

$$L = L_N + L_M + L_X \qquad (2.54)$$

To express ln L in the form of the natural log of its components, we use the first order approximation of Taylor series (10).

$$\ln L = d_{oL} + d_{1L} \ln L_N + d_{2L} \ln L_M + d_{3L} \ln L_X \qquad (2.55)$$

where $d_{oL}$, $d_{1L}$, $d_{2L}$ and $d_{3L}$ are constants. Numerical values of $d_{1L}$, $d_{2L}$ and $d_{3L}$ are positive, and smaller than 1. Substituting equations (2.51), (2.52) and (2.53) into equation (2.55), we have (15).

$$\ln L = c_o + c_1 t + c_2[\ln W]_* + c_3[\ln P_N]_* + c_4[\ln P_M]_*$$
$$+ c_5[\ln P_X]_* + c_6[\ln L]_* + c_7[\ln I_d]_* + c_8[\ln I_f]_*$$
$$+ c_9[\ln P_f]_* + e_L \qquad (2.56)$$

where $c_o = d_{1L}\, c_{oN} + d_{2L}\, c_{oM} + d_{3L}\, c_{oX}$

$c_1 = d_{1L}\, c_{1N} + d_{2L}\, c_{1M} + d_{3L}\, c_{1X}$. The sign is indeterminate.

$c_2 = d_{1L}\, c_{2N} + d_{2L}\, c_{2M} + d_{3L}\, c_{2X}$. The sign is indeterminate.

$c_3 = d_{1L}\, c_{3N} + d_{2L}\, c_{3M} + d_{3L}\, c_{3X}$. The sign is indeterminate.

$c_4 = d_{1L}\, c_{4N} + d_{2L}\, c_{4M} + d_{3L}\, c_{4X} > 0$

$c_5 = d_{1L}\, c_{5N} + d_{2L}\, c_{5M} + d_{3L}\, c_{5X}$. The sign is indeterminate.

$c_6 = (1 - \lambda_L) > 0$ ; $(1 - \lambda_L)$ is the weighted average of $(1 - \lambda_{LN})$, $(1 - \lambda_{LM})$ and $(1 - \lambda_{LX})$.

$c_7 = d_{1L}\, c_{7N} + d_{3L}\, c_{7X} > 0$

$c_8 = d_{1L}\, c_{8N} + d_{3L}\, c_{8X} > 0$

$c_9 = d_{1L}\, c_{9N} + d_{3L}\, c_{9X} > 0$

$e_L = d_1\, e_{LN} + d_2\, e_{LM} + d_3\, e_{LX}$

Since money wages and prices are expressed in terms of the rate of change, we differentiate equation (2.56).

$$d(\ln L) = c_1 + c_2[d(\ln W)]_* + c_3[d(\ln P_N)]_* + c_4[d(\ln P_M)]_* + c_5[d(\ln P_X)]_* + c_6[d(\ln L)]_* + c_7[d(\ln I_d)]_* + c_8[d(\ln I_f)]_* + c_9[d(\ln P_f)]_* + (e_{L,t} - e_{L,t-1}) \quad (2.57)$$

Equation (2.57) is the general estimated form of labour demand in our model.

5. The model.

There are three sectors and an aggregate labour market in the model. We specify an aggregate wage, and price equation in each sector. The aggregate employment is derived from the production function of each sector. All these equations are in the form of percentage changes. Following is the model which consists of equations (2.1), (2.42), (2.48) and (2.57).

$$d(\ln W) = a_1 + a_2\left[\psi(U)\right]_* + a_3\left[d(\ln P_N)\right]_* + a_4\left[d(\ln P_M)\right]_*$$
$$+ a_5\left[d(\ln P_X)\right]_* + e_w \quad (2.58)$$

$$d(\ln P_N) = \lambda_N b_{1N} + \lambda_N b_{2N}\left[d(\ln W)\right]_* + \lambda_N b_{3N}\left[d(\ln P_M)\right]_*$$
$$+ \lambda_N b_{4N}\left[d(\ln P_X)\right]_* + \lambda_N b_{5N}\left[d(\ln I_d)\right]_* + \lambda_N b_{6N}\left[d(\ln I_f)\right]_*$$
$$+ \lambda_N b_{7N}\left[d(\ln P_f)\right]_* + (1 - \lambda_N)\left[d(\ln P_N)\right]_* + (e_{N,t} - e_{N,t-1}) \quad (2.59)$$

$$d(\ln P_X) = \lambda_X b_{1X} + \lambda_X b_{2X}\left[d(\ln W)\right]_* + \lambda_X b_{3X}\left[d(\ln P_N)\right]_*$$
$$+ \lambda_X b_{4X}\left[d(\ln P_M)\right]_* + \lambda_X b_{5X}\left[d(\ln I_d)\right]_* + \lambda_X b_{6X}\left[d(\ln I_f)\right]_*$$
$$+ \lambda_X b_{7X}\left[d(\ln P_f)\right]_* + (1 - \lambda_X)\left[d(\ln P_X)\right]_* + (e_{X,t} - e_{X,t-1}) \quad (2.60)$$

$$d(\ln L) = c_1 + c_2\left[d(\ln W)\right]_* + c_3\left[d(\ln P_N)\right]_* + c_4\left[d(\ln P_M)\right]_*$$
$$+ c_5\left[d(\ln P_X)\right]_* + c_6\left[d(\ln L)\right]_* + c_7\left[d(\ln I_d)\right]_*$$
$$+ c_8\left[d(\ln I_f)\right]_* + c_9\left[d(\ln P_f)\right]_* + (e_{L,t} - e_{L,t-1}) \quad (2.61)$$

Our next step is to introduce explicitly the exchange rate into the model. The channels through which the exchange rate can enter the model are via the domestic price of importable goods and the foreign price of domestic exports. In terms of our notation in equations (2.58), (2.59), (2.60) and (2.61), the exchange rate is incorporated in $d(\ln P_M)$ and $d(\ln P_f)$.

Since imports come from different countries, we adopt the following two assumptions to derive the rate of change in the price of importable goods:

i) the assumption of independence among composite goods

ii) the quantity index of importables is homogenous of degree 1.

The implications of these assumptions were explored previously. With the two assumptions, Armington[1] proved that:

$$d \ln P_M = \sum_{j=1}^{n} m_j \, d \ln P_M^j \qquad (2.62)$$

where $m_j$ = the share of imports from the jth country in total Canadian imports.

$d \ln P_M^j$ = the rate of change in the natural log of the price of imports from the jth country.

Let $P_X^j$ be the export price of the jth country in its currency, $E^j$ be the price of jth currency in terms of Canadian dollars, and T be the import tax. The price of imports from the jth country in Canadian dollars is

$$P_M^j = (1 + T) \, P_X^j \, . \, E^j \qquad (2.63)$$

$$\text{or } \ln P_M^j = \ln(1+T) + \ln P_X^j + \ln E^j \qquad (2.64)$$

Differentiating equation (2.64) with respect to time, we have

$$d \ln P_M^j = d \ln(1+T) + d \ln P_X^j + d \ln E^j \qquad (2.65)$$

Assuming the tax rate is uniform, we substitute equation (2.65) into equation (2.62):

$$d(\ln P_M) = \sum_{j=1}^{n} m_j [d \ln(1+T) + d \ln P_X^j + d \ln E^j] \quad (2.66)$$

From equation (2.66), we observe that a 1% change in $d \ln P_M$ can result from:

a) a 1% change in the exchange rate.

$d \ln P_M = \sum m_j \; d \ln E^j = 1\%; d \ln(1+T) = d \ln P_X^j = 0$

b) a 1% change in all foreign prices of imports.

$d \ln P_M = \sum m_j \; d \ln P_X^j = 1\% \; ; \; d \ln(1+T) = d \ln E^j = 0$

c) a change in the import tax such that

$d \ln P_M = \sum_{j=1}^{n} m_j \; d \ln(1+T) = d(T)/(1+T) = 1\%; \; d \ln E^j = d \ln P_X^j = 0.$

Since we do not have quarterly data of import tax rate, we have to use equation (2.66) in the following form

$$d \ln P_M = \sum_{j=1}^{n} m_j [d \ln P_X^j + d \ln E^j] \quad (2.67)$$

Equation (2.67) will be used to replace $d \ln P_M$ in the model for the estimation purpose.

Similarly, to derive the rate of change in the foreign produced price of exportables, converted to Canadian dollars, we note from equation (2.31) that if there exists an export subsidy ( or tax ), $d \ln P_f$ must be replaced by $d \ln P_f^*$, and

$$d \ln P_f^* = d \ln P_f - d \ln(1 - S) \quad (2.68)$$

or $$d \ln P_f^* = d \ln P_f + d(S)/(1-S) \tag{2.69}$$

Similar to the derivation of $d \ln P_M$ in equation (2.67), we have:

$$d \ln P_f = \sum x_j [d \ln P_M^j + d \ln E^j] \tag{2.70}$$

where $x_j$ = the share of Canadian exports to the jth country in total Canadian exports.

$P_M^j$ = import price of the jth country in its currency

Hence, substituting equation (2.70) into equation (2.69), we have;

$$d \ln P_f^* = \sum x_j [d \ln P_M^j + d \ln E^j] + d(S)/(1-S) \tag{2.71}$$

From equation (2.71), we observe that a 1% change in $d \ln P_f^*$ can result from

a) a 1% change in the exchange rate

$d \ln P_f^* = \sum x_j \; d \ln E^j = 1\%$; $d(S)/(1-S) = \sum x_j d \ln P_M^j = 0$

b) a 1% change in all foreign prices

$d \ln P_f^* = \sum x_j \; d \ln P_M^j = 1\%$ ; $d(S)/(1-S) = \sum x_j \; d \ln E^j = 0$

c) a change in the rate of export subsidy

$d \ln P_f^* = d(S)/(1-S) = 1\%$; $d \ln E^j = d \ln P_M^j = 0$

We do not have quarterly data of the rate of export subsidy. Therefore, equation (2.70) is used in the place of equation (2.71) in the estimation.

Replacing $d \ln P_M$ and $d \ln P_f$ in equations (2.58), (2.59), (2.60) and (2.61) by the relationships in equations (2.67) and (2.70), we have a complete model for estimation.

$$d(\ln W) = a_1 + a_2[\Psi(U)]_* + a_3[d(\ln P_N)]_* + a_4[\Sigma m_j (d(\ln P_X^{\,j}) + d(\ln E_j))]_* + a_5[d(\ln P_X)]_* + e_W \tag{2.72}$$

$$d(\ln P_N) = \lambda_N\, b_{1N} + \lambda_N\, b_{2N}[d(\ln W)]_* + \lambda_N\, b_{3N}[\Sigma m_j\, d(\ln P_X^{\,j}) + d(\ln E_j))]_* + \lambda_N\, b_{4N}[d(\ln P_X)]_* + \lambda_N\, b_{5N}[d(\ln I_d)]_* + \lambda_N\, b_{6N}[d(\ln I_f)]_* + \lambda_N\, b_{7N}[\Sigma x_j (d(\ln P_M^{\,j}) + d(\ln E_j))]_* + (1-\lambda_N)[d(\ln P_N)]_* + (e_{N,t} - e_{N,t-1}) \tag{2.73}$$

$$d(\ln P_X) = \lambda_X\, b_{1X} + \lambda_X\, b_{2X}[d(\ln W)]_* + \lambda_X\, b_{3X}[d(\ln P_N)]_* + \lambda_X\, b_{4X}[\Sigma m_j (d(\ln P_X^{\,j}) + d(\ln E_j))]_* + \lambda_X\, b_{5X}[d(\ln I_d)]_* + \lambda_X\, b_{6X}[d(\ln I_f)]_* + \lambda_X\, b_{7X}[\Sigma x_j (d(\ln P_M^{\,j}) + d(\ln E_j))]_* + (1-\lambda_X)[d(\ln P_X)]_* + (e_{X,t} - e_{X,t-1}) \tag{2.74}$$

$$d(\ln L) = c_1 + c_2[d(\ln W)]_* + c_3[d(\ln P_N)]_* + c_4[\Sigma m_j (d(\ln P_X^{\,j}) + d(\ln E_j))]_* + c_5[d(\ln P_X)]_* + c_6[d(\ln L)]_* + c_7[d(\ln I_d)]_* + c_8[d(\ln I_f)]_* + c_9[\Sigma x_j (d(\ln P_M^{\,j}) + d(\ln E_j))]_* + (e_{L,t} - e_{L,t-1}) \tag{2.75}$$

a certain level (5).

However, the nature of the expectation may be different and/or the structure of the economy may have changed significantly from one period of the exchange rate to another. For that reason, we separate the available data into three periods corresponding to the first flexible, the fixed and the second flexible exchange rate period. The model is fitted with the three sets of data. To test whether or not this "prior information" is justified statistically, we use a Chow test with the null hypothesis that the structure of the model does not change significantly from one period to another[27].

# CHAPTER III

## DESCRIPTION OF THE DATA

In table 3.1, we present the variables which are used in the empirical estimation of the model [equation (2.72), (2.73), (2.74) and (2.75)], and the data sources. Quarterly data from the first quarter 1953 to the fourth quarter 1973 are used in this study.

The model is fitted with the three periods corresponding to the first flexible exchange rate period (2nd quarter 1956 - 1st quarter 1962), fixed exchange rate period (3rd quarter 1962 - 1st quarter 1970), and the second flexible exchange rate period (3rd quarter 1970 - 4th quarter 1973). The division of data into the three periods is applied to the dependent variables. Due to the lag structure in our estimation procedure, the first period can start only from the second quarter of 1956. For the second and third periods of the exchange rate, we assume that exogenous variables from the previous periods still influence the behavior of economic agents, although the pattern of the influence may change from one period to another. Therefore, the lagged data used to estimate the model for the second and third periods are extended from the previous periods(1).

All data are taken from CANSIM data bank except the foreign prices of exports ($P_X^j$) and of imports ($P_M^j$) which are taken from International Financial Statistics published by International Monetary Fund. Technically, the

Table 3.1

Summary of the data

| Variable | Description of the variable | Data source |
|---|---|---|
| $P_X$ | National Account Price Deflator of exports | CANSIM |
| $P_N$ | National Account Price Deflator of services | CANSIM |
| $m_j, E^j, x_j$ | ( j = 1,...,8). Variables from the following eight countries are used: the U.S., Belgium, France, West Germany, Italy, Japan, the Netherlands, and U.K. | CANSIM |
| $P_X^j$, $P_M^j$ | | I.M.F. financial statistics |
| W | Total labour income/ Total labour employed | CANSIM |
| L | Number of people employed | CANSIM |
| U | Average unemployment rate of four months | CANSIM |
| $I_d$ | Canadian real income | CANSIM |
| $I_f$ | U.S. real income | CANSIM |

All variables are seasonally adjusted except exchange rate $E^j$.

foreign price index $P_X^j$ and $P_M^j$ are calculated from a vector of goods relevant to the foreign country j. This vector of goods and the relative weights within this basket may be different from those relevant to the Canadian economy. Therefore there is a potential but unknown error in the foreign export and import prices.

The Canadian price of exportable goods is taken from the national account price deflator of exports. Theoretically, the price of non-tradable goods can be derived from the national account price deflators of gross national expenditure, exports and imports. However, the outputs of the three sectors which can be used for constructing appropriate weights are not available. For that reason, we use the national account price deflator of services as a proxy for the price of non-tradable goods. The national account implicit price index of Business and Residential Construction has also been tried as a proxy for the price of non-tradable goods, but the results are much inferior to the use of service price for the price of non-tradables.

Values for $E^j$, $m_j$, $x_j$, $P_X^j$ and $P_M^j$ are based on the quarterly data of the eight largest trading partners, namely, the U.S., Belgium, France, West Germany, Italy, Japan, the Netherlands, and the U.K. The data of import shares from each country in total Canadian imports ($m_j$) and the data of the share of exports to each country in total Canadian exports ($x_j$) are obtained from Imports and Exports by Country of Origin reported in the CANSIM data bank. Values for $m_j$ and $x_j$ from the above eight countries are presented in APPENDIX D. For comparison, we draw a graph of the percentage of total Canadian exports to the eight countries and to the U.S. in Figure 3.1. We observe that, on average, the above trading partners import around 85%, while the U.S. alone takes 60% of the total Canadian exports. We also draw a graph of the percentage of total Canadian imports originating from the eight countries (Figure 3.2). On average, 86% of the total Canadian imports come from these countries.

We present a graph of percentage change in the prices of non-tradable, exportable, and importable goods in Figures 3.3, 3.4 and 3.5, respectively. Comparison of Figures 3.3 and 3.4 shows that the percentage changes in the prices of non-tradable and exportable goods are not the same. Therefore, by Hicks' composite commodity theorem [26], we cannot aggregate these goods. For that reason, we do not assume that the price of exportable goods is the same as that of domestic goods. Comparison of Figures 3.4 and 3.5 reveals that the percentage changes in the prices of exportable goods and importable goods are not the same. This can be seen in Figure 3.6, showing the ratio of percentage change in the price of exportable goods to the change in the price of importable goods. Since the

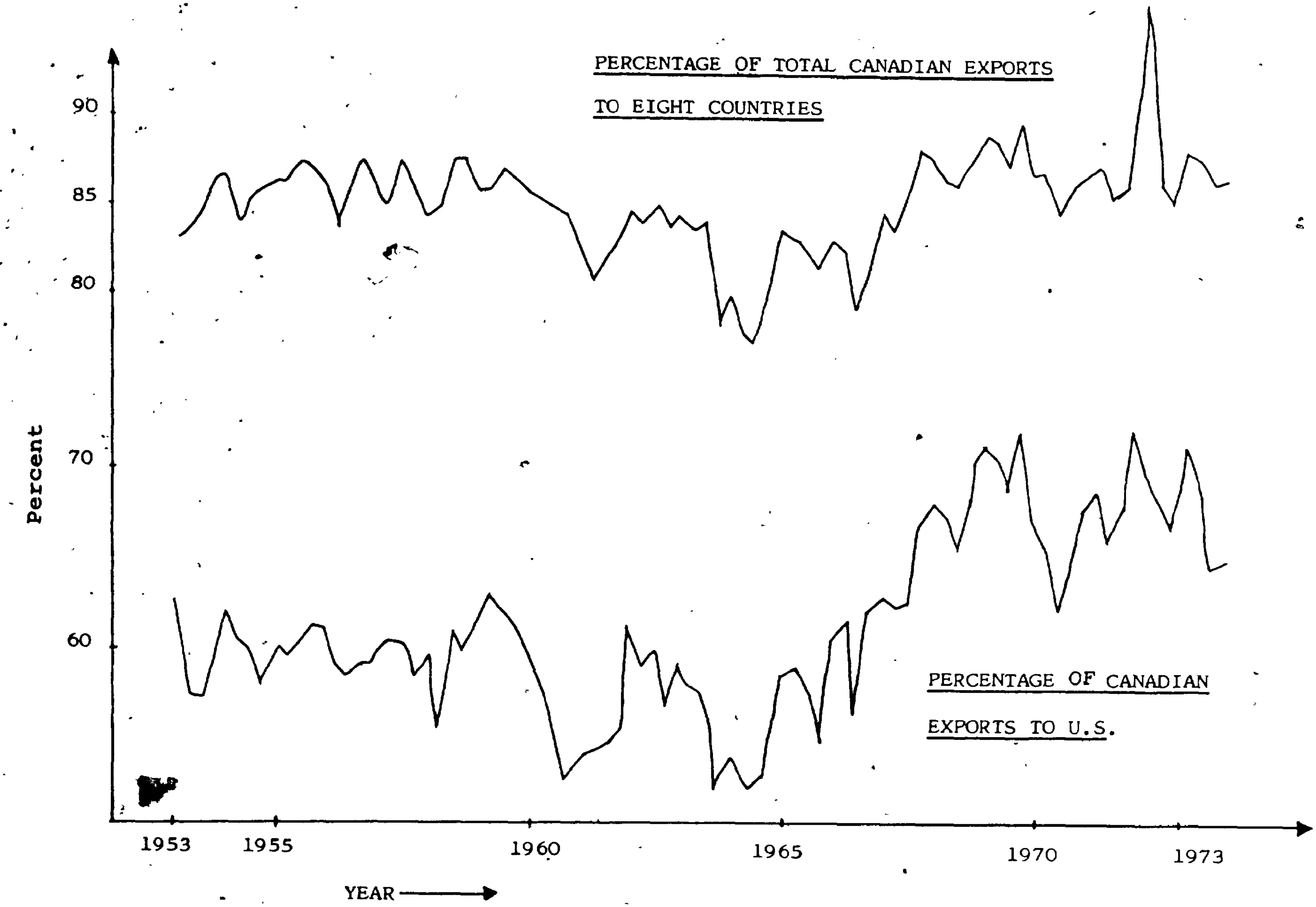



FIGURE 3 .1 Percentage of total Canadian exports to U.S. and other countries

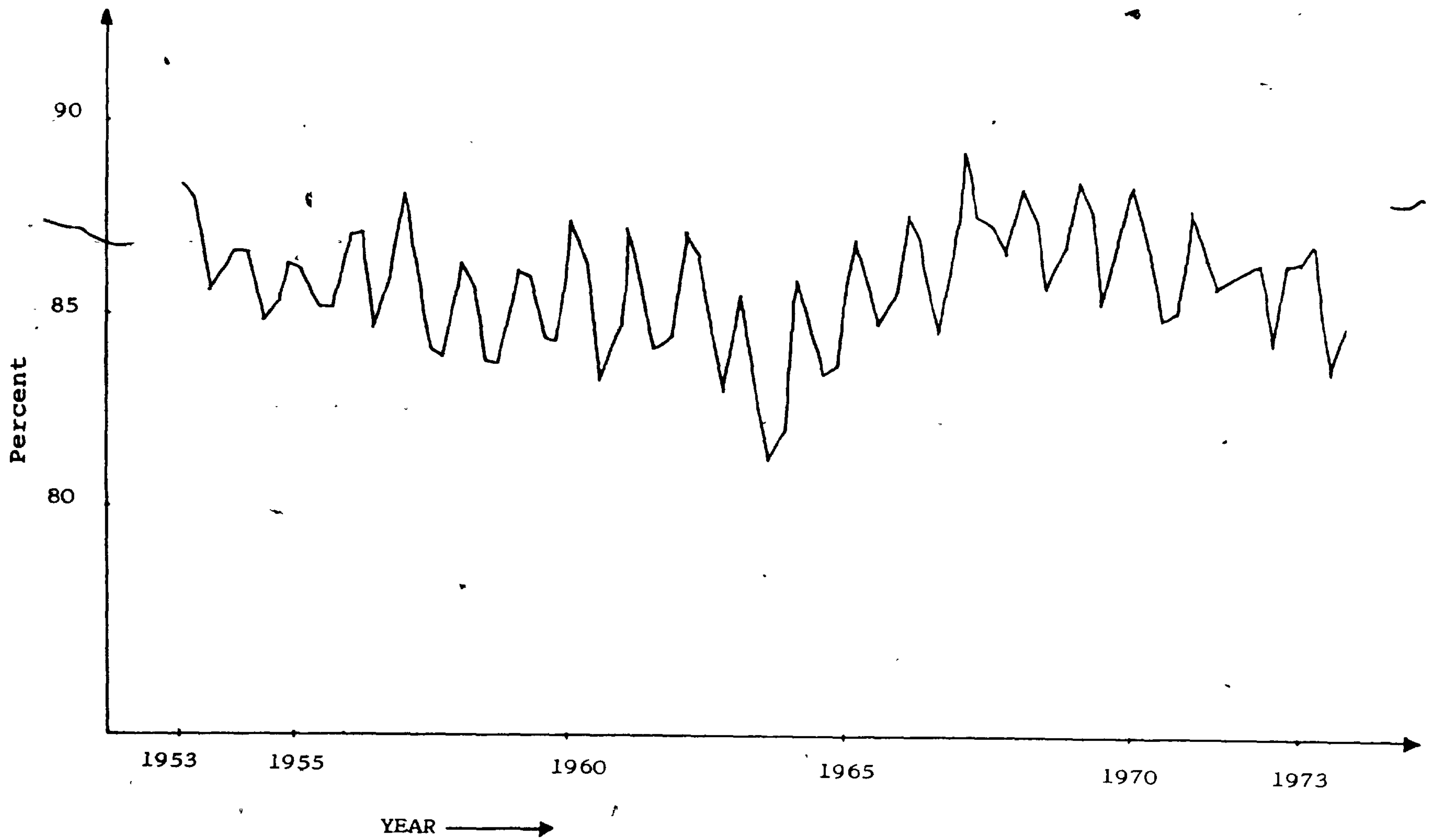



FIGURE 3.2 Percentage of total Canadian imports from eight countries

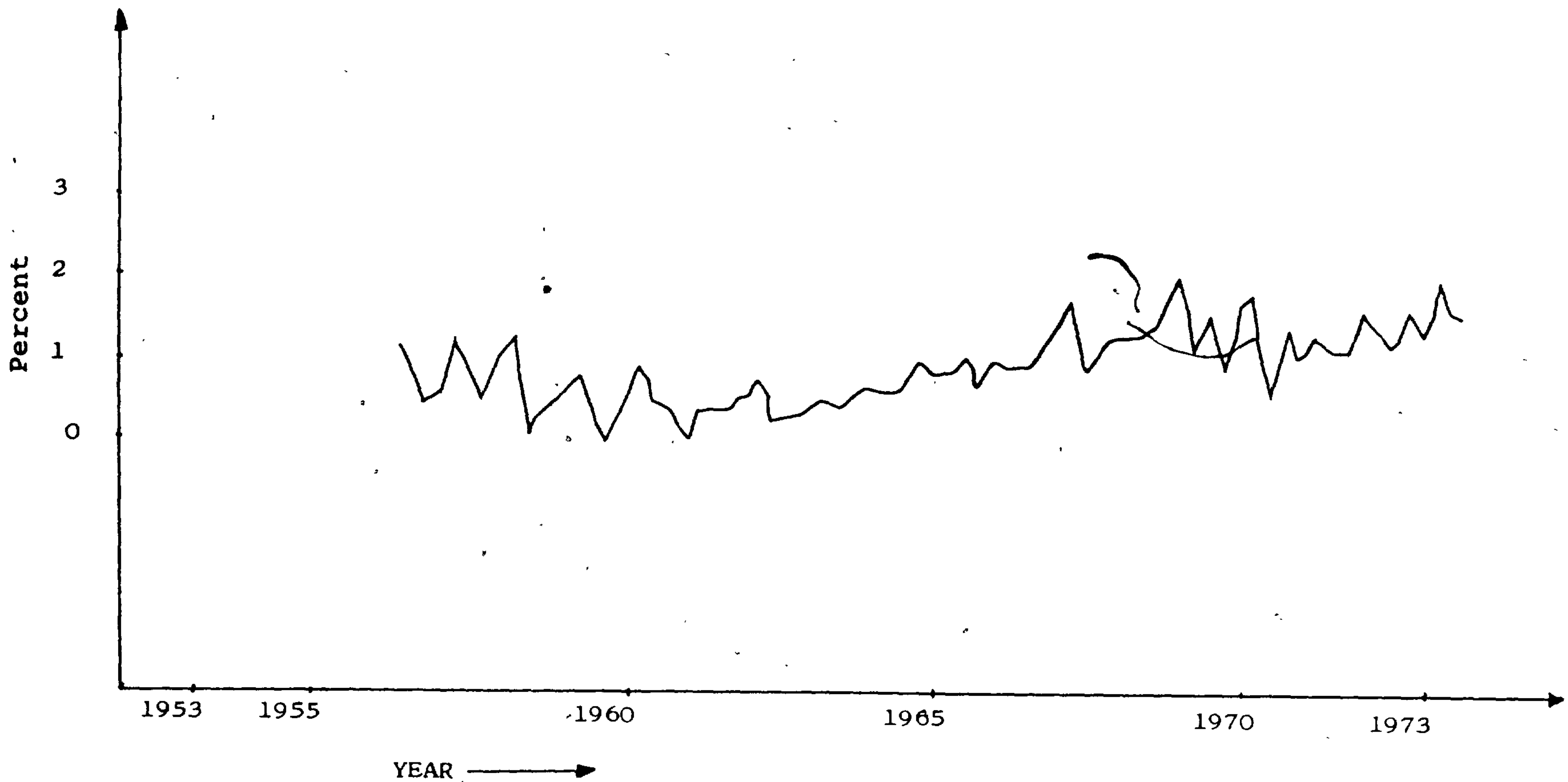



FIGURE 3.3 Percentage change in the price of services

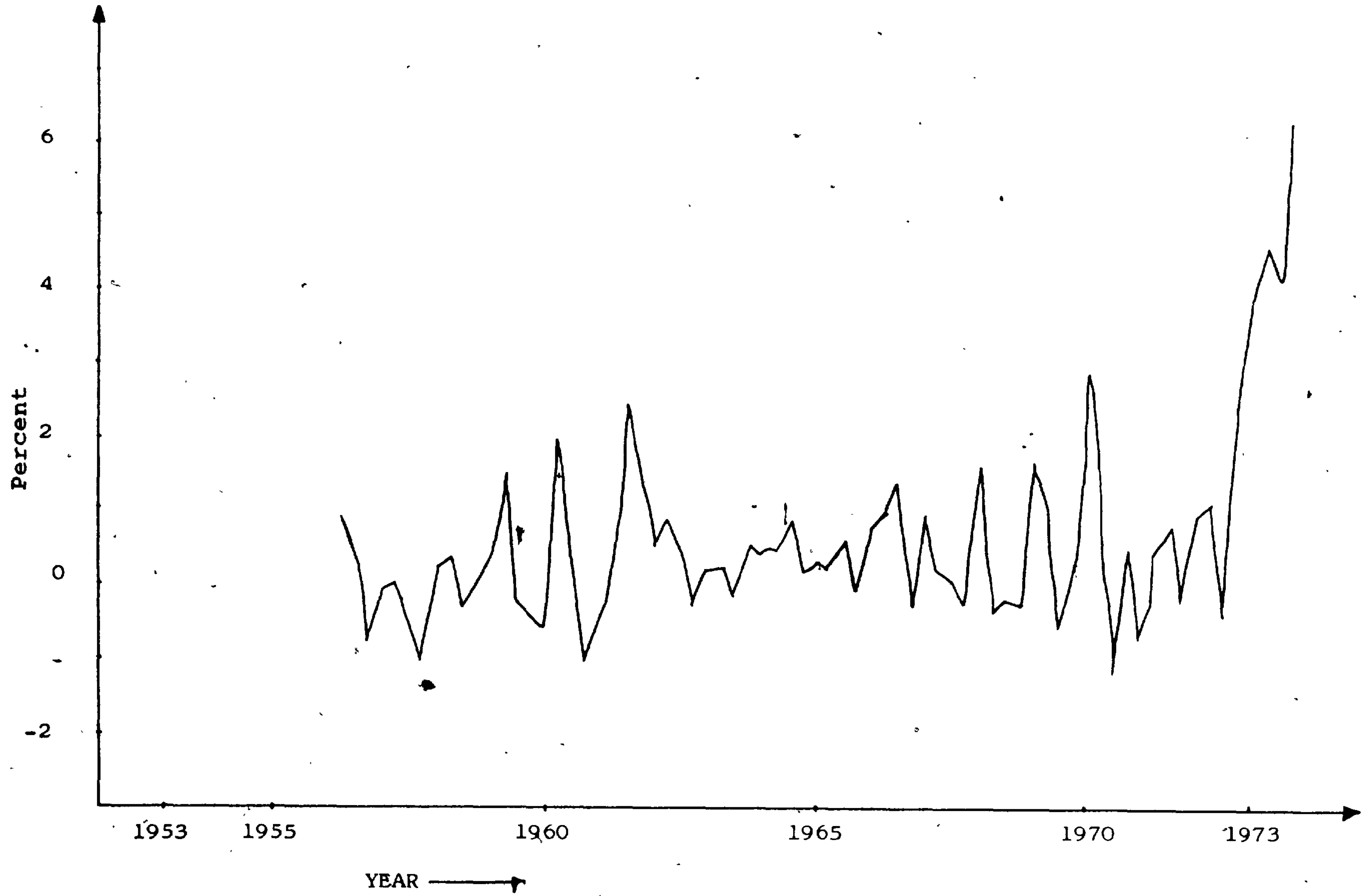



FIGURE 3.4 Percentage change in the price of exportables

FIGURE 3.5 . Percentage change in the price of importables

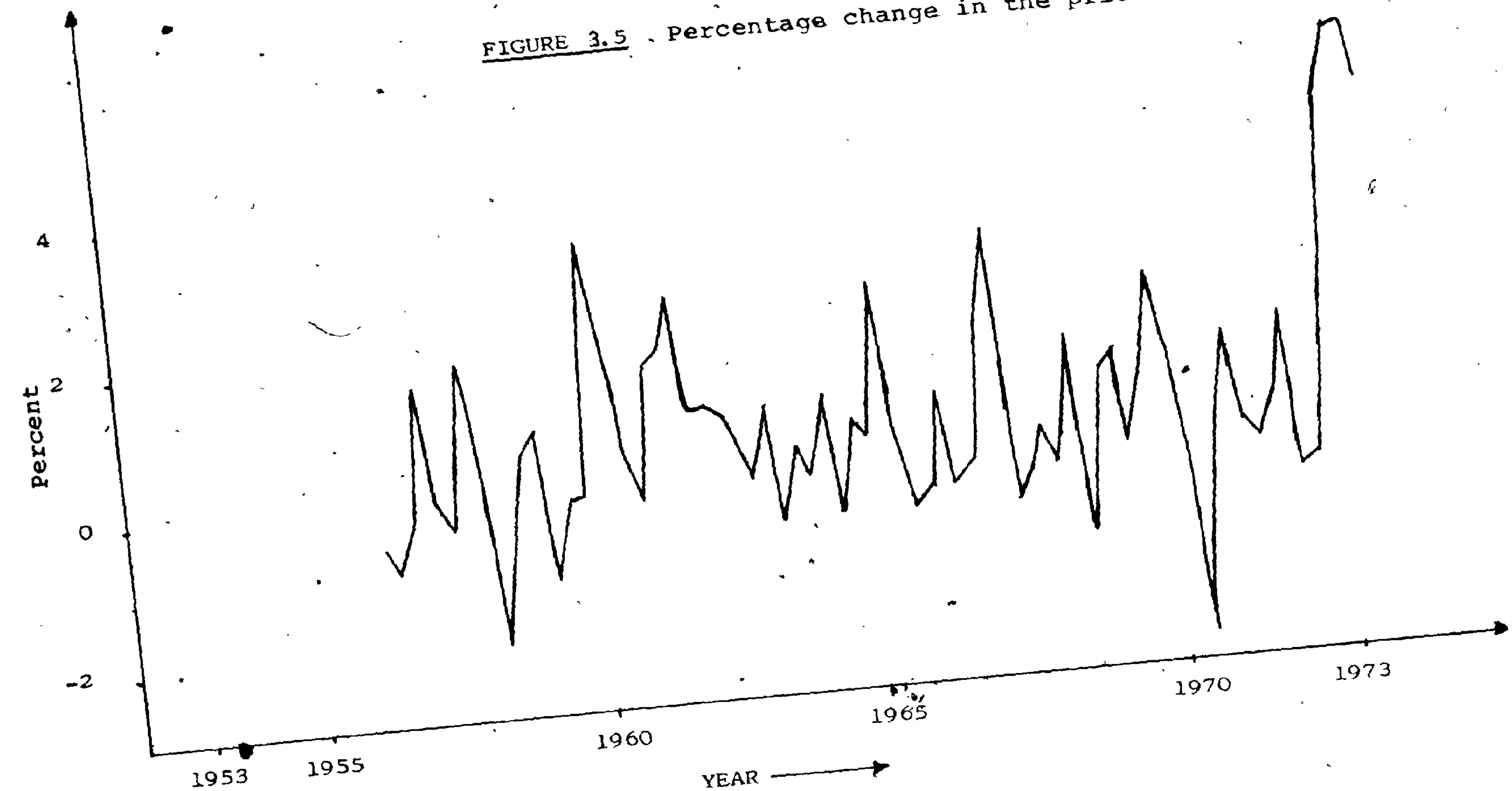
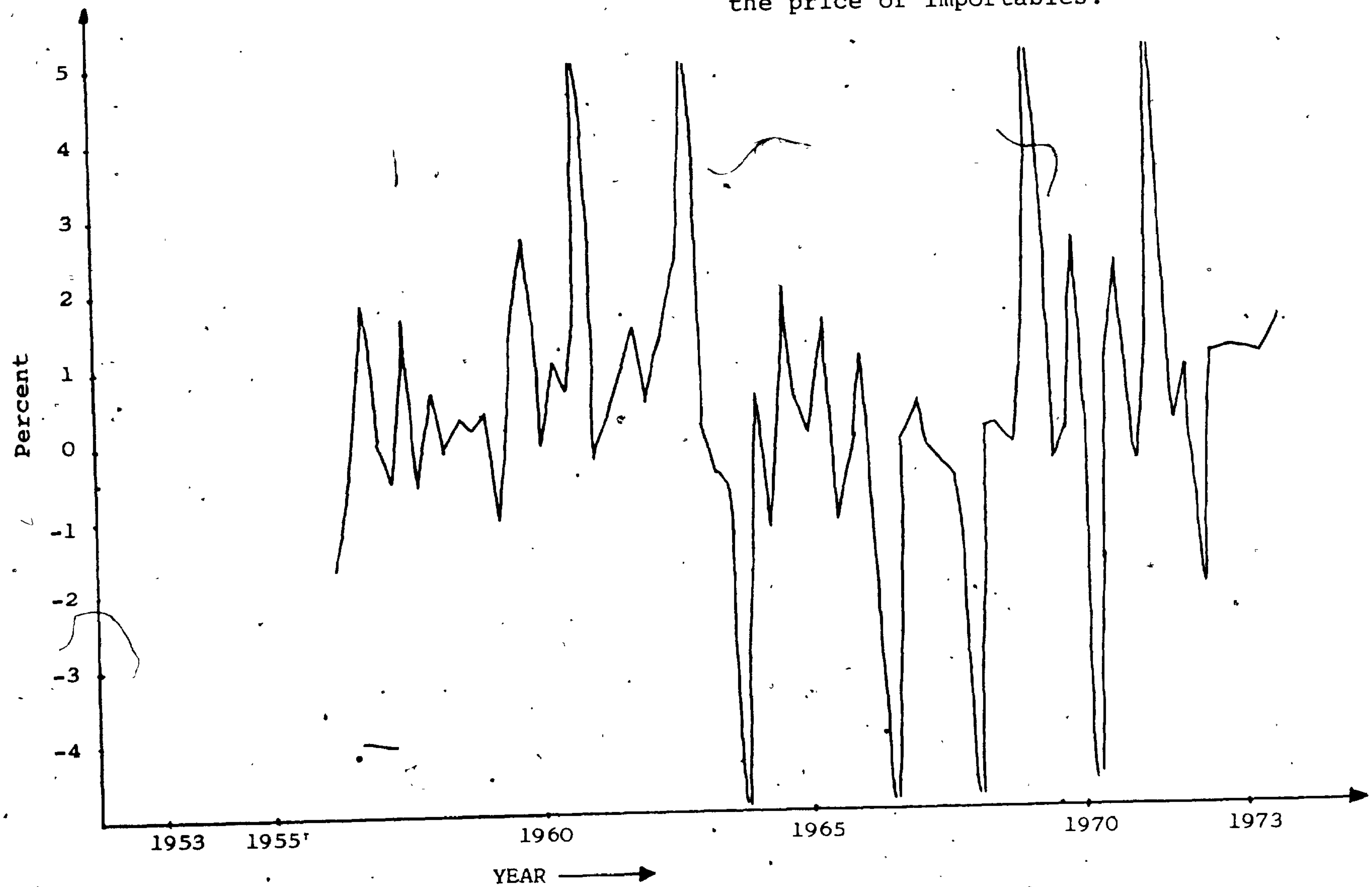


FIGURE 3.6 Ratio of percentage change in the price of exportables to percentage change in the price of importables.



ratio is significantly different from 1, we do not aggregate importable and exportable goods.

The wage-rate variable is derived from Wages, Salaries and Supplementary Labour Income divided by total labour employed. The data of labour employed are in terms of number of people rather than in terms of man-hours. The reason is that our model is specified in this way, and quarterly data of man-hours are not available. Consequently, this approach ignores some adjustment in the labour market that arises when man-hours change. The unemployment rate is calculated from monthly data by a simple average.

We follow the TRACE and CANDIDE models in the use of U.S. real income as a proxy for $I_f$ (activity in the foreign market), since the quarterly data of other Canadian trading partners are not available for the full periods of our model.

CHAPTER IV

# ESTIMATION PROCEDURE

The model we are going to estimate consists of equations (2.72), (2.73), (2.74) and (2.75), which describe wages, the price of non-tradables, the price of exportables, and employment, respectively. In each equation, right-hand side variables are expressed as expected values. These expected values, in quantitative terms, can be expressed as distributed lags of the variables. Notationally, we can represent each equation as

$$Y_t = \beta_0 + \beta_1[X_1]_* + \ . \ . \ . \ + \beta_m[X_m]_* + \beta_n[Y]_* + e_t \qquad (4.1)$$

where $Y$ = dependent variable

$X_i$ = independent variable ($i = 1, \ldots, m$)

$\beta_j$ = constant ($j = 0, 1, \ldots, m, n$)

$e_t$ = residual error, which consists of errors due to adjustment and expectation mechanisms.

We do not have prior information on the nature of the error term. The subscript($_*$) represents the distributed lag function of the variable.

Among the distributed lag structures developed so far, we can distinguish two classes: infinite lag and finite lag [15,24]. A particular form of an infinite lag is a geometric lag structure. It is assumed in this structure that an expected value is a declining geometric weight of past values.

" the shortness of social memory".

In the class of finite lag structures, we have two general categories: unrestricted finite lags and restricted finite lags. It is assumed in an unrestricted finite lag structure that an expected value is a certain weighted average of past values. The weighting coefficients are not constrained to any distribution.

$$[X_j]_* = \alpha_{j,o} + \alpha_{j,1} X_{j,t-1} + \cdots + \alpha_{j,n} X_{j,t-n} \qquad (4.6)$$

If each expected variable follows the unrestricted finite lag of order up to one period, equation (4.1) becomes

$$Y_t = \beta_o' + \beta_1' X_{1,t-1} + \cdots + \beta_n' Y_{t-1} + e_t \qquad (4.7)$$

Equation (4.7) is identical to equation (4.5) except for the error term. Hence, under conditions specified above, in the case in which expected values have geometric lags, the form of the equation to be estimated is identical to the form of the equation in the case in which expected values have unrestricted finite lag structures. In general, the unrestricted finite lag structures of expected variables on the right-hand side of equation (4.1) have the following form.

$$Y_t = \beta_o' + \beta_1 \sum_{\tau=1}^{m} \alpha_{1,\tau} X_{1,t-\tau} + \cdots + \beta_n \sum_{\tau=1}^{m} \alpha_{n,\tau} Y_{t-\tau} + e_t \qquad (4.8)$$

If we assume that there is only one expected variable on the right-hand side of equation (4.1), equation (4.8) becomes

$$Y_t = \beta_o' + \beta \sum_{\tau=1}^{m} \alpha_\tau X_{t-\tau} + e_t \tag{4.9}$$

or $$Y_t = \beta_o' + \sum_{\tau=1}^{m} w_\tau X_{t-\tau} + e_t \tag{4.10}$$

where $w_\tau = \beta \alpha_\tau$ = weighted coefficient. This weighted coefficient is unrestricted in the case of an unrestricted finite lag. If the weighted coefficient w is restricted to a certain distribution by the approximation of a polynomial of degree k, we have a polynomial lag structure of order n and degree k.

$$w_\tau = \sum_{i=0}^{k} \gamma_i \tau^i \tag{4.11}$$

Substituting equation (4.11) into equation (4.10), we have

$$Y_t = \beta_o' + \sum_{\tau=1}^{m} \left[ \sum_{i=0}^{k} \gamma_i \tau^i \right] X_{t-\tau} + e_t \tag{4.12}$$

$$Y_t = \beta_o' + \sum_{i=0}^{k} \gamma_i \left[ \sum_{\tau=i}^{m} \tau^i X_{t-\tau} \right] + e_t \tag{4.13}$$

Let $Z_{t,i} = \sum_{\tau=1}^{m} \tau^i X_{t-\tau}$ ; equation (5.13) becomes

$$Y_t = \beta_o' + \sum_{i=0}^{k} \gamma_i Z_{t,i} + e_t \tag{4.14}$$

The Ordinary Least Squares (OLS) estimates of $\beta_o'$ and $\gamma_i$, $(i=1,\ldots,k)$, in equation (4.14) are the Best Linear Unbiased Estimators according to the Gauss Markov theorem[15]. Furthermore, it has been shown that the OLS estimates of $\gamma_i$'s, and hence $w_\tau$'s, are more efficient than the direct estimates of $w_\tau$'s from equation (4.10) if the restriction on the shape of the weighted coefficients is correct, and if the degree of polynomial is less than the maximun lag period, i.e., $k < n$ [15]. If the right-hand side contains lagged endogenous variables, the OLS estimators of equation (4.14) will have different properties depending on assumptions concerning the error term. If the errors of all observations are normally and independently distributed, the OLS estimators will be biased but consistent. If the error term is autocorrelated, the OLS estimators will become inconsistent. However, the asymptotic bias of the OLS estimators is small when exogenous variables exist on the right-hand side of the equation [38]. Even though there are some other consistent estimation techniques, e.g., instrumental variables [37], they are very difficult to apply to our model because we do not know the exact form of the estimated equation [55]. For that reason, we use OLS to estimate the parameters under the null hypothesis that no serial correlation exists. The validity of this null hypothesis is then tested.

To summarize the discussion, we note that each distributed lagged variable can be represented either as an unrestricted lag, or as a polynomial lag of order n and degree k. In our estimation, the maximum degree of polynomial is 2, and the maximum lag is 12 periods. This choice is based on two considerations

i) maximum lag used in RDX2 model of the Bank of Canada is 12 periods (i.e., three years). This model is fitted exclusively with polynomial distributed lags [57].

ii) The higher the degree of polynomial, the greater is the problem of multicollinearity. Preliminary estimation favoured the condition that the maximum degree of polynomial is 2.

The maximum lag of 12 periods is also used for the unconstrained lag structure. This formulation means that we have many different possibilities for each distributed lag variable. Therefore, $[X_j]_*$ can be represented as one of the following variables or as a combination of these.

$$X_t,\ X_{t-1},\ X_{t-2},\ \ldots,\ X_{t-12} \qquad (4.15a)$$

$$\sum_{\tau=1}^{n} X_{t-\tau}\ ;\ (n=1,2,\ldots,12) \qquad (4.15b)$$

$$\sum_{\tau=1}^{n} \tau\, X_{t-\tau}\ ;\ (n=1,2,\ldots,12) \qquad (4.15c)$$

$$\sum_{\tau=1}^{n} \tau^2\, X_{t-\tau}\ ;\ (n=1,2,\ldots,12) \qquad (4.15d)$$

The set of possibilities of $[X_j]_*$ in equations (4.15a), (4.15b), (4.15c) and (4.15d) are applied for all expected variables in the model except the unemployment rate. The functional forms of the unemployment rate variable are $[U^*]^{-1}$ and $[U^*]^{-2}$, where $[U^*]$ is defined as

i) the unemployment rate U ( expressed as the percentage of labour force unemployed). This unemployment rate takes all possibilities of $[X_j]_*$ in (4.15a), (4.15b), (4.15c) and (4.15d).

ii) $\bar{U}_t$, $\bar{U}_{t-1}$, ..., $\bar{U}_{t-8}$

where $\bar{U}_t = (1/8)\ U_t + (1/4) \sum_{i=1}^{3} U_{t-i} + (1/8)\ U_{t-4}$. This is the definition of an unemployment rate variable used by Bodkin et.al.[3].

iii) average of two quarters and lagged from zero to seven quarters; average of three quarters and lagged from zero to six quarters; ..... ; average of eight quarters and lagged from zero to one quarter; average of nine quarters and no lag. This scheme is adopted from the definition of the unemployment rate variable used by Lipsey and Parkin [36].

In equations (4.15a), (4.15b), (4.15c) and (4.15d), we also use current variables. Theoretically, an expected value at any moment can be based only on past values. However, if the interaction time is too short, there will be no change shown in our data. Therefore, if we find empirically a current endogenous variable on the right-hand side of equation (4.1), we assume that the decision on this variable is made before the value of the left-hand side variable is set. This assumption is similar to the one usually made in estimating price equations, namely, the output decision is made prior to the price decision.

The central problem here is how to choose one or a combination of a few possibilities for each distributed lag variable. This is a common problem in empirical work where lagged variables enter a model. In a paper presented at the University of Western Ontario, Professor Nagar has proposed a scheme to determine the order and degree of polynomial distributed lags [43]. According to this scheme, the combination of order and degree of a polynomial distributed lag is the one which minimizes the variance of the estimated parameter. The paper deals only with one distributed lag variable on the right-hand side of an equation, whose intercept is at the origin. Furthermore, the proposed scheme is designed specifically for polynomial distributed lags. This means that a prior restriction must be made on the expectation hypothesis of each variable.

In practice, most economists use the strategy of trial and error, in which different possibilities of a variable are tried. The selected form(s) are the one(s) which give(s) the highest $R^2$ or the greatest reduction in the sum of squares of errors. The criterion of minimizing the sum of squares of errors is criticized on the ground that the more variables there are in the equation, the less the sum of squares of errors is. Moreover, the selection procedures are never described explicitly in many empirical works. In the following, we describe our strategy, which uses the same criterion as in most empirical works but seems to be more logical.

Refering to equation (4.1), we have to choose an appropriate form of $[X_j]_*$ among all possibilities discussed above, conditionally on any given forms of other distributed lag variables. The appropriate variable would be the one which has the highest partial correlation with the dependent variable partialed on the variables conditionally chosen in the equation. The entering of this variable will make the greatest reduction in the sum of squares of errors among all other possibilities of $[X_j]_*$. Alternatively, the entering variable will make the greatest improvement in $R^2$ of the equation. To determine whether or not another possibility of $[X_j]_*$ should enter the equation, the criterion is how this new variable significantly improves the predictive power of the model, i.e., how this new variable significantly reduces the sum of squares of errors. To this end, step-wise regression analysis coupled with the analysis of variances can be used to choose the form of $[X_j]_*$ . Therefore, conditionally on the existing form of other distributed lag variables in the equation, the choice of the appropriate form for $[X_j]_*$ is not biased due to the order of entering different possibilities of $[X_j]_*$ . Furthermore, conditionally on the forms of other distributed lag variables, the estimated parameters of $[X_j]_*$ are the Best Linear Unbiased Estimators if the assumptions of OLS hold.

The calculation steps are:

1) Predetermined forms of all other expected variables except $[X_j]_*$ are "forced" into the equation.

2) The partial correlation coefficient and F-statistics (square of t-statistics) of each possibility of $[X_j]_*$ are calculated.

3) Among all possibilities of $[X_j]_*$, which have F-statistics greater than the minimum "F to enter", the one with the highest

F-value will be added to the equation.

4) The regression coefficient, its standard error and F-value of all variables in the equation are calculated.

5) If any variable of $[X_j]_*$ , which is in the equation, has an F-value smaller than the specified "F to remove", the one with the smallest F-value will be removed.

6) Calculation is repeated from step 2 to step 5 for the remaining possibilities of $[X_j]_*$.

7) If no variable is added or removed, the procedure is terminated.

The next stage is to move to another expected variable $[X_{j+1}]_*$ , keeping $[X_j]_*$ at the form selected in the first stage. Stepwise regression, coupled with the analysis of variance, are used to choose the appropriate form of $[X_{j+1}]_*$. This iterative procedure is stopped when the sum of squared residuals cannot be improved any further. This means that no variable outside the equation has passed the criterion of "F to enter" and no variable in the equation has failed the criterion of "F to remove".

A few comments on our selection procedure are:

i) In each step, stepwise regression is used after the analysis of variance to choose an appropriate variable to enter the equation. A usual criticism associated with the use of stepwise regression alone is that this procedure tends to discriminate against the last regressor, and the variables appearing in the final model may depend on the order in which they are brought into consideration[59]. This criticism does not hold in our case, since the variable is selected according to the criterion that gives the estimated parameter the highest t-value, or in turn makes the most reduction of the sum of squared residuals[59](17).

ii) If the minimum sum of squared residuals is the only criterion, the number of variables can be added until we have zero degrees of freedom, or a perfect fit. This is not applicable to our procedure, since the inclusion of any additional variable must pass the significance test, in which the adding variable significantly improves the predictive power of the model.

iii) A variable may be shown as significant at an early stage, but when some other variables are added, it may turn out to be insignificant. The insignificant variable will be removed automatically depending on the minimum t-statistics that we specify.

The program we use at each step to select the form of one particular distributed lag variable is BMD 02R stepwise regression of the Health Science Computing Facility, University of California. In this program, a large number of variables can be handled efficiently. To move from one step to the next, a simplified search procedure is used[46,53].

# CHAPTER V

## RESULTS OF THE ESTIMATION

In this Chapter, we report the results of our estimation and of the Chow test on whether or not the structure of the model has changed significantly from one period to another.

1. <u>The first flexible exchange rate period</u> ($2^{nd}$ quarter 1956 to 1st quarter 1962)

There are four equations in the model. We discuss the estimated form of each equation separately.

1.1 Wage equation.

The estimated result of the wage equation in this period is

$$[d \ln W]_t = \underset{(-2.33)}{-7.9063 \times 10^{-3}} + \underset{(2.08)}{.03874}[U^{-1}] + \underset{(4.54)}{.4239}[d \ln P_X]_t$$

$$+ \underset{(3.12)}{.0118}[d \ln P_X]_{t-5} + \underset{(4.77)}{.1465}[d \ln P_N]_{t-7}$$

$$+ \underset{(3.22)}{.2109}[\Sigma m_j (d \ln P_X^j + d \ln E^j)]_{t-4} \tag{5.1}$$

$R^2 = .840$; D.W. = 2.2; d.f. = 18; $F_{5/18} = 18.8$; N = 24

The numbers in parentheses are the t-statistics of the corresponding estimated parameter.

D.W. = Durbin-Watson statistic

d.f. = degrees of freedom

N = number of observations

F = F-statistic for the whole equation

All coefficients in equation (5.1) have the expected signs. As indicated by the t-statistics, all estimated parameters are statistically significant at over 95% confidence level. The F-value for the whole equation, which indicates how well the right hand side variables explain the dependent variable, is significant at over 99% confidence level. The rate of change of wages does not enter the right hand side of equation (5.1). In such a situation, the Durbin-Watson statistics can be used to test the validity of the null hypothesis that there is no first order auto-correlation in the wage equation. The value of Durbin-Watson statistic shows that no negative auto-correlation exists at .025 significance level. To see how good the estimated equation is, a comparison between actual and estimated values of the rate of change in money wages is presented graphically in Figure 5.1. The estimated values trace quite well the actual values of the dependent variable.

It is observed in equation (5.1) that the current value of $d \ln P_X$ and [U], endogenous variables, are on the right hand side. As discussed in Chapter IV, when a current endogenous variable is selected, we assume that the value of this variable is known before a decision is made on the endogenous variable on the left hand side. Since the interaction time is too short, the available data cannot pick up the difference in the sequence.

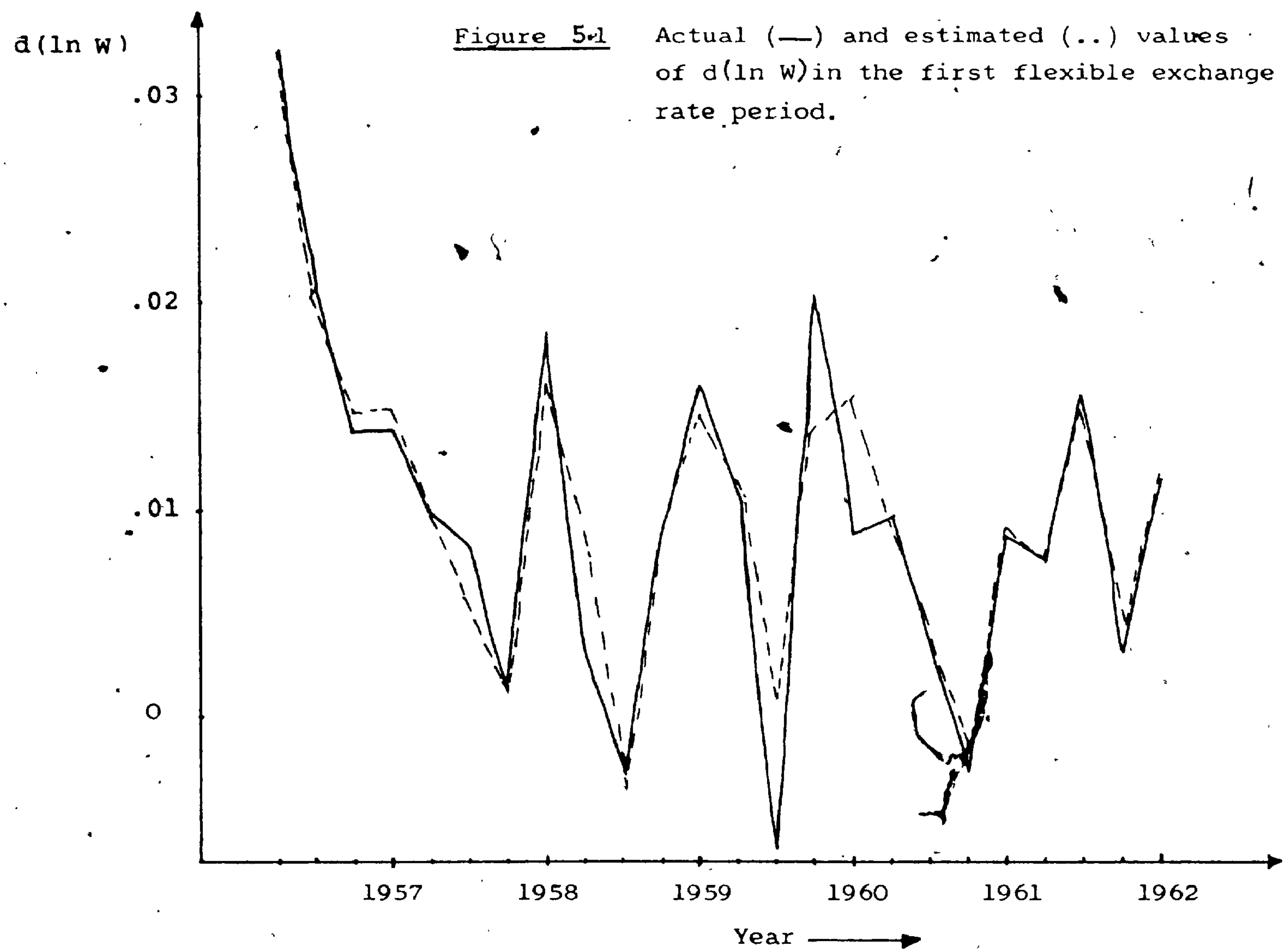



Figure 5.1 Actual (—) and estimated (..) values of d(ln W) in the first flexible exchange rate period.

Nevertheless, from a purely econometric point of view, if d ln $P_X$ and [U] are correlated with the current error term of d ln W, the estimation of equation (5.1), in general, has a certain degree of bias, and is inconsistent.

Theoretically, it is very difficult to apply some consistent estimation techniques to our case since we do not know the exact structure of the model prior to the estimation. Theil has shown that Two Stage Least Squares (2SLS) yields inconsistent estimators if there is a specification error of neglecting one variable [55].

Empirically, Bodkin et. al. estimated wage and price equations for the Canadian economy; their results indicate that estimated equations using OLS and 2SLS are not significantly different[3]. Therefore, we accept the form of equation (5.1), and use this equation for further analysis of the model.

1.2 <u>Equation describing the price of non-tradable goods</u>.

The estimated equation is

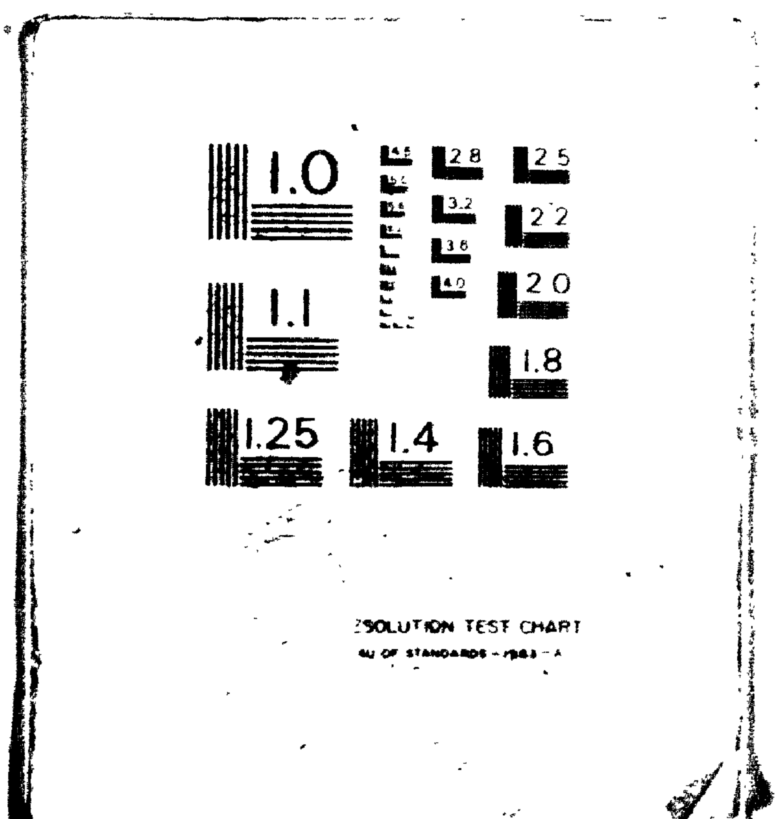
$$[d \ln P_N]_t = \underset{(-3.72)}{-5.749 \times 10^{-3}} + \underset{(3.69)}{.0872}[d \ln I_d]_{t-11}$$

$$+ \underset{(2.66)}{.0736}[\Sigma m_j (d \ln P_X^j + d \ln E^j)]_{t-1}$$

$$+ \underset{(6.35)}{.295}[d \ln W]_{t-1} + \underset{(5.31)}{.3018}[d \ln W]_{t-7}$$

$$+ \underset{(3.59)}{.4773}[d \ln P_N]_{t-12} + \underset{(2.08)}{.1074}[d \ln P_X]_{t-4} \qquad (5.2)$$

2


1.0
2.8
2.5
3.2
2.2
3.6
2.0
4.0
1.1
1.8
1.25
1.4
1.6
SOLUTION TEST CHART
OF STANDARDS - 1963 - A

distribution of the following variable[18];

$$h = [1 - .5(D.W.)]\sqrt{[N/(1 - N \cdot \hat{V}(b_1))]} \qquad (5.3)$$

where D.W. = Durbin-Watson statistic

N = total number of observations

$\hat{V}(b_1)$ = estimated variance of the most recent lagged endogenous variable.

We can test h as a standard normal variate. The test is asymptotically valid for the case of a large sample. Using the information from equation (5.2), we have

$$h = .64 \qquad (5.4)$$

This corresponds to the probability of .2611 for the right hand tail. Therefore, the null hypothesis cannot be rejected even at a 75% confidence level.

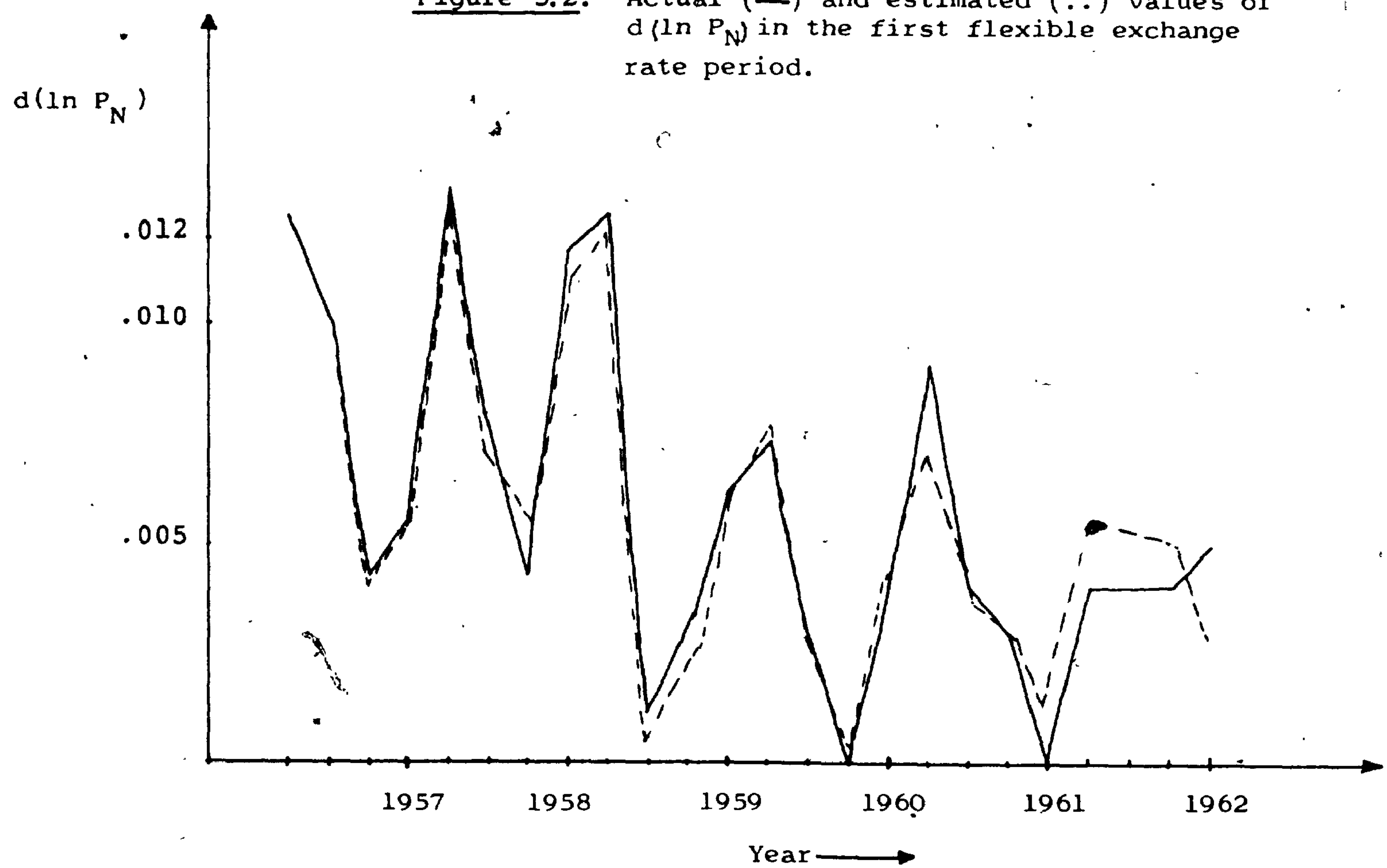
The actual and estimated values of the price of non-tradable goods in the first period are presented in Figure 5.2.

1.3 <u>Equation describing the price of exportable goods</u>.

The estimated result of the equation for the price of exportable goods in the first flexible exchange rate period is

$$\begin{aligned}[d \ln P_X]_t = &\underset{(-3.88)}{-21.2071 \times 10^{-3}} + \underset{(8.89)}{.5045}[\Sigma m_j(d \ln P_X^j + d \ln E^j)]_{t-1} \\ &+ \underset{(3.87)}{.2037}[\Sigma x_j(d \ln P_M^j + d \ln E^j)]_{t-6} + \underset{(5.81)}{.3844}[d \ln I_d]_{t-1} \\ &+ \underset{(2.86)}{.2668}[d \ln W]_{t-9} + \underset{(2.6)}{.0273}[d \ln P_N]_{t-12} \\ &+ \underset{(2.09)}{.1633}[d \ln P_X]_{t-11} \qquad (5.5)\end{aligned}$$

<u>Figure 5.2.</u> Actual (—) and estimated (..) values of d(ln $P_N$) in the first flexible exchange rate period.



$R^2 = .9023$; D.W. = 2.223; d.f. = 17; $F_{6/17} = 26.15$; N = 24

All estimated coefficients have the expected signs, and are significant at over 95% confidence level. The smallest t-value is from the lagged endogenous variable, but the coefficient is still significant at 95% confidence level for a one tail test. This is an appropriate test for the variable, since from the theory we expect that the sign of the parameter must be positive. In equation (5.5), the variable $d(\ln I_f)$ is not included because its influence on the price of exportables is insignificant. As discussed in Chapter III, we use U.S. real income as a proxy for $d(\ln I_f)$. The insignificance of U.S. real income in equation (5.5) does not imply that the export theory is incorrect. Rather, this means that the proxy variable is not good enough, or the activity of the foreign market does not change significantly throughout the first estimation period. Whatever the reason could be, we let this variable be absorbed by the error term. The implication of this decision is that the export demand for Canadian goods depends only on the relative price of Canadian and foreign produced "exportable goods". The F-statistics of the overall equation is significant at 99% confidence level. Furthermore, judging from the value of $R^2$, the exclusion of $d(\ln I_f)$ does not significantly affect the explanatory power of the estimated equation. Since the Durbin-Watson statistic is greater than 2, we should test for negative serial correlation. To do this, the relevant Durbin-Watson statistic is 4 - 2.223 = 1.777. The existence of a lagged endogenous variable in equation (5.5) requires a correct test based on the normal variate h as previously mentioned. Given the information in equation (5.5), we can calculate h according to equation (5.3).

$$h = .5912 \tag{5.6}$$

This corresponds to a probability of .2776 for the right hand tail. Therefore, the null hypothesis cannot be rejected even at a 75% confidence level.

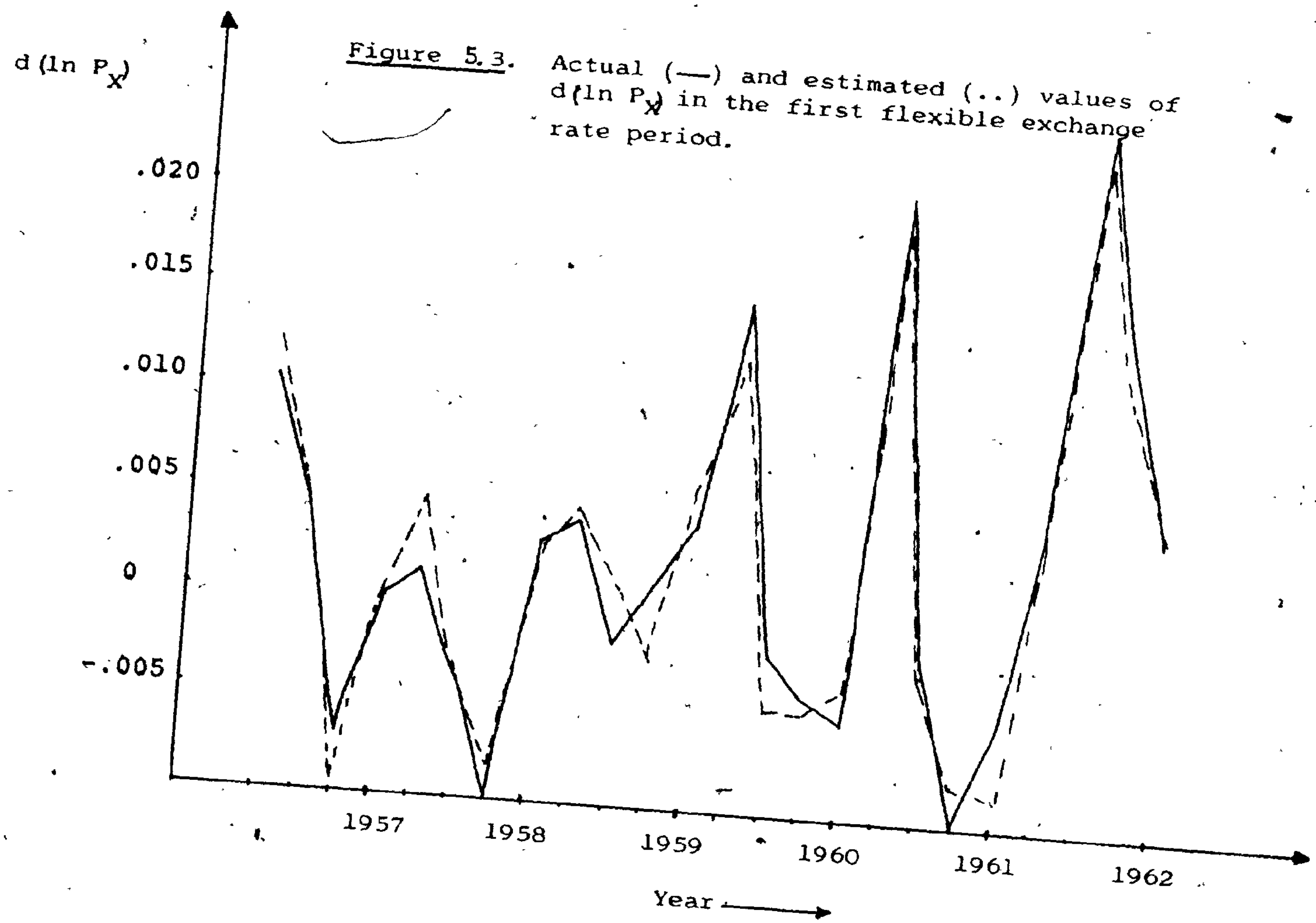
Actual and estimated values of the price of exportables in the first flexible exchange rate period are presented in Figure 5.3. The predicted values track quite well the actual values.

1.4 Employment equation.

The estimated form of the equation in the first flexible exchange rate period is:

$$\begin{aligned}
[d \ln L]_t = & -6.1338 \times 10^{-3} + .0029[\sum_{\tau=1}^{7} \tau^2 (\Sigma m_j (d \ln P_X^j + d \ln E^j))_{-\tau}] \\
& \quad (-4.2) \qquad\qquad\qquad (5.80) \\
& + .0715[\Sigma x_j (d \ln P_M^j + d \ln E^j)]_{t-5} + .1575[d \ln I_d]_{t-1} \\
& \quad (2.99) \qquad\qquad\qquad\qquad\qquad (4.01) \\
& + .0806[d \ln I_f]_{t-10} - .4646[d \ln W]_{t-7} + .558[d \ln P_N]_{t-10} \\
& \quad (2.16) \qquad\qquad\qquad (-7.13) \qquad\qquad (9.71) \\
& + .3515[d \ln P_X]_{t-12} + .2544[d \ln L]_{t-3} \\
& \quad (6.15) \qquad\qquad\qquad (3.60)
\end{aligned} \tag{5.7}$$

Figure 5.3. Actual (—) and estimated (..) values of $d(\ln P_X)$ in the first flexible exchange rate period.



$R^2 = .9321$; D.W. = 2.17; d.f. = 15; $F_{8/15} = 25.84$; N = 24

All estimated coefficients have the expected signs and are significant at over 95% confidence level. The values for $R^2$ and the F-statistic indicate the significant explanatory power of equation (5.7). To test for negative serial correlation, the Durbin-Watson statistic is 4 - 2.171 = 1.829. Given the null hypothesis that no serial correlation exists, the correct test based on the standard normal variate h of equation (5.3) is:

$$h = .4459 \qquad (5.8)$$

This corresponds to .33 probability of the right hand tail. Therefore, the null hypothesis cannot be rejected even at a confidence level of 80%.

Actual and estimated values of d ln L are presented in Figure 5.4. The predicted values of the percentage change in employment track very well the actual values through out the estimation period.

2. The fixed exchange rate period (3rd quarter 1962 to 1st quarter 1970).

2.1 Wage equation.

The estimated wage equation for the fixed exchange rate period is:

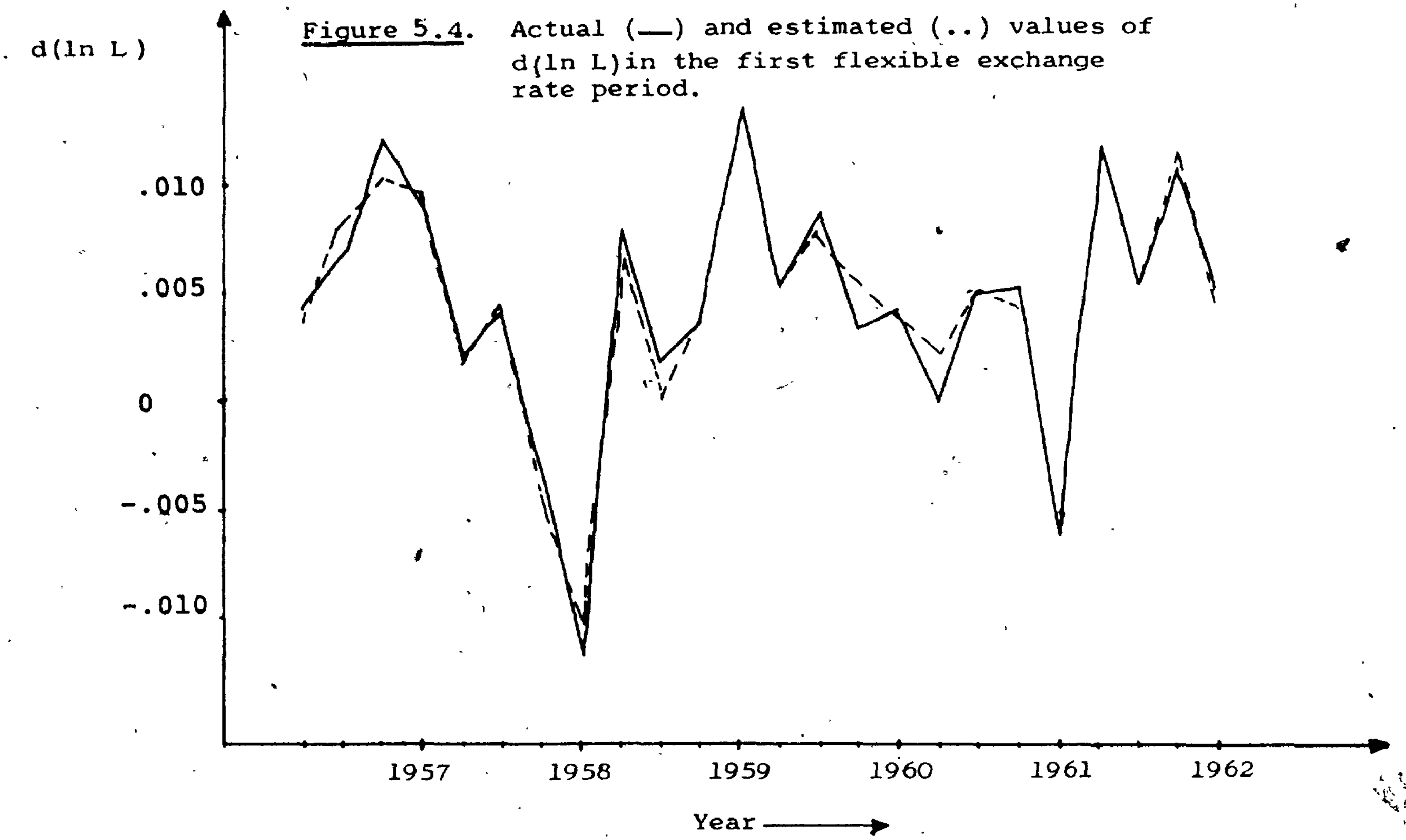



Figure 5.4. Actual (—) and estimated (..) values of d(ln L) in the first flexible exchange rate period.

$$[d \ln W]_t = \underset{(3.31)}{.1293}[U^{-2}] + \underset{(1.49)}{.0865}[\Sigma m_j(d \ln P_X^j + d \ln E^j)]_{t-2}$$

$$+ \underset{(1.77)}{.1776}[\sum_{\tau=1}^{3}(d \ln P_X)_{t-\tau}] + \underset{(4.10)}{.059}[\sum_{\tau=1}^{3}\tau^2(d \ln P_N)_{t-\tau}] \quad (5.9)$$

$\bar{R}^2 = .5218$; D.W. = 2.51; d.f. = 27; $F_{4/27} = 7.3$; N = 31

All coefficients have the expected signs. The constant is insignificant and is removed from the equation. The estimated coefficient of $d(\ln P_X)$ is significant at a 95% confidence level for a one tail test. However, the coefficient of $[\Sigma m_j(d \ln P_X^j + d \ln E^j)]$ is only significant at a 90% confidence level. The Durbin-Watson statistic of equation (5.9) indicates that we have to test the hypothesis of residual independence against the alternative hypothesis that the disturbances are negatively correlated. The relevant Durbin-Watson statistic is 4 - 2.51 = 1.49. This indicates that we cannot reject the null hypothesis at a 1% significance level. However, at a 5% significance level, the Durbin-Watson statistics is inconclusive. We next use an approximation proposed by Theil and Nagar[54]. This shows that the null hypothesis is rejected at 95% confidence level. Since the problem of serial correlation of the disturbances is not removed satisfactorily, we re-estimate equation (5.9) by assuming that first order auto-correlation exists. The wage equation adjusted for the first order auto-correlation is:

$$[d \ln W]_t = .0961[\Sigma m_j (d \ln P_X^j + d \ln E^j)]_{t-2} + .1294[U^{-2}]$$
$$(1.6) \qquad\qquad\qquad\qquad (4.01)$$

$$+ .1609[\sum_{\tau=1}^{3} (d \ln P_X)_{t-\tau}] + .0603[d \ln P_N]_{t-3}$$
$$(1.68) \qquad\qquad (5.25)$$

$R^2 = .5452$ ; D.W. = 1.91 ; d .f. = 26 ; N = 30.

(5.10)

Comparing equation (5.9) with equation (5.10), the estimated coefficients are very similar. Since equation (5.10) is better than equation (5.9) in terms of t-statistics for the estimated coefficients, we use equation (5.10) as the estimated wage equation under the fixed exchange rate period. In equation (5.10), all estimated coefficients have expected signs and are significant. Actual and estimated values of d ln W are presented in Figure 5.5.

2.2 <u>Equation describing the price of non-tradable goods</u>

Estimated equation of the price of non-tradable goods in the fixed exchange rate period is

$$[d \ln P_N]_t = -1.468 \times 10^{-3} + .0896[\Sigma m_j (d \ln P_X^j + d \ln E^j)]_{t-1}$$
$$(-1.31) \qquad (2.60)$$

$$+ .0833[d \ln I_d]_{t-3} + .7041[d \ln P_N]_{t-7}$$
$$(2.16) \qquad\qquad (5.17)$$

$$+ .0827[d \ln P_X]_{t-12} + .0238[d \ln W]_{t-1}$$
$$(1.88) \qquad\qquad (1.98)$$

(5.11)

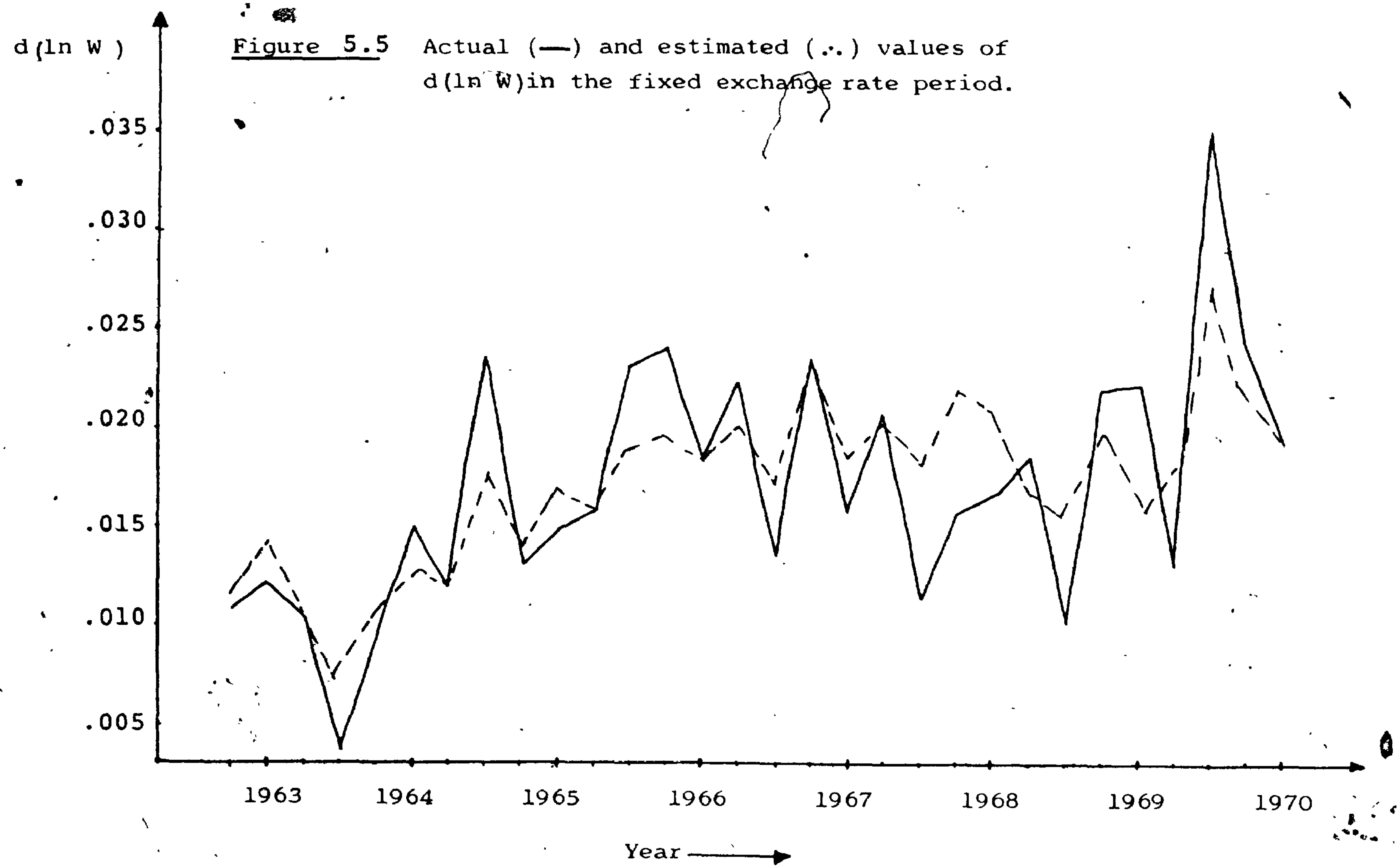



Figure 5.5 Actual (—) and estimated (.-.) values of d(ln W)in the fixed exchange rate period.

$R^2 = .8541$ ; D.W. = 2.10 ; d.f. = 25 ; $F_{5/25} = 29.27$ ; N = 31.

All estimated coefficients have the expected signs and are significant at over 95% confidence level, except the constant term. The t-value of this constant term is significant at a 90% confidence level. The F-statistic of the whole equation is significant at over 99% confidence level. Since a lagged endogenous variable exists on the right-hand side, the correct test of the null hypothesis that no serial correlation exists in the error terms must be based on the standard normal variate h as discussed previously.

$$h = .44 \tag{6.16}$$

This corresponds to .33 probability of the right-hand tail. Therefore, the null hypothesis cannot be rejected even at a 70% confidence level. Actual and estimated values of $d \ln P_N$ are presented in Figure (5.6).

2.3 Equation describing the price of exportable goods

Estimated equation of the price of exportable goods in the fixed exchange rate period is

$$\begin{aligned}[d \ln P_X]_t = & -24.7472 \times 10^{-3} + .573[\Sigma x_j (d \ln P_M^j + d \ln E^j)]_{t-1} \\ & \quad (-3.99) \qquad\qquad\quad (4.72) \\ & + .4939[\Sigma m_j (d \ln P_M^j + d \ln E^j)]_{t-4} + .3834[d \ln I_W]_{t-12} \\ & \quad (5.23) \qquad\qquad\qquad\qquad\qquad\qquad (3.42) \\ & + .1458[\sum_{\tau=1}^{7} (d \ln I_d)_{t-\tau}] + .2449[d \ln W]_{t-3} \\ & \quad (2.83) \qquad\qquad\qquad\qquad (1.72) \\ & + .4132[d \ln P_X]_{t-8} \\ & \quad (3.14) \end{aligned} \tag{5.13}$$

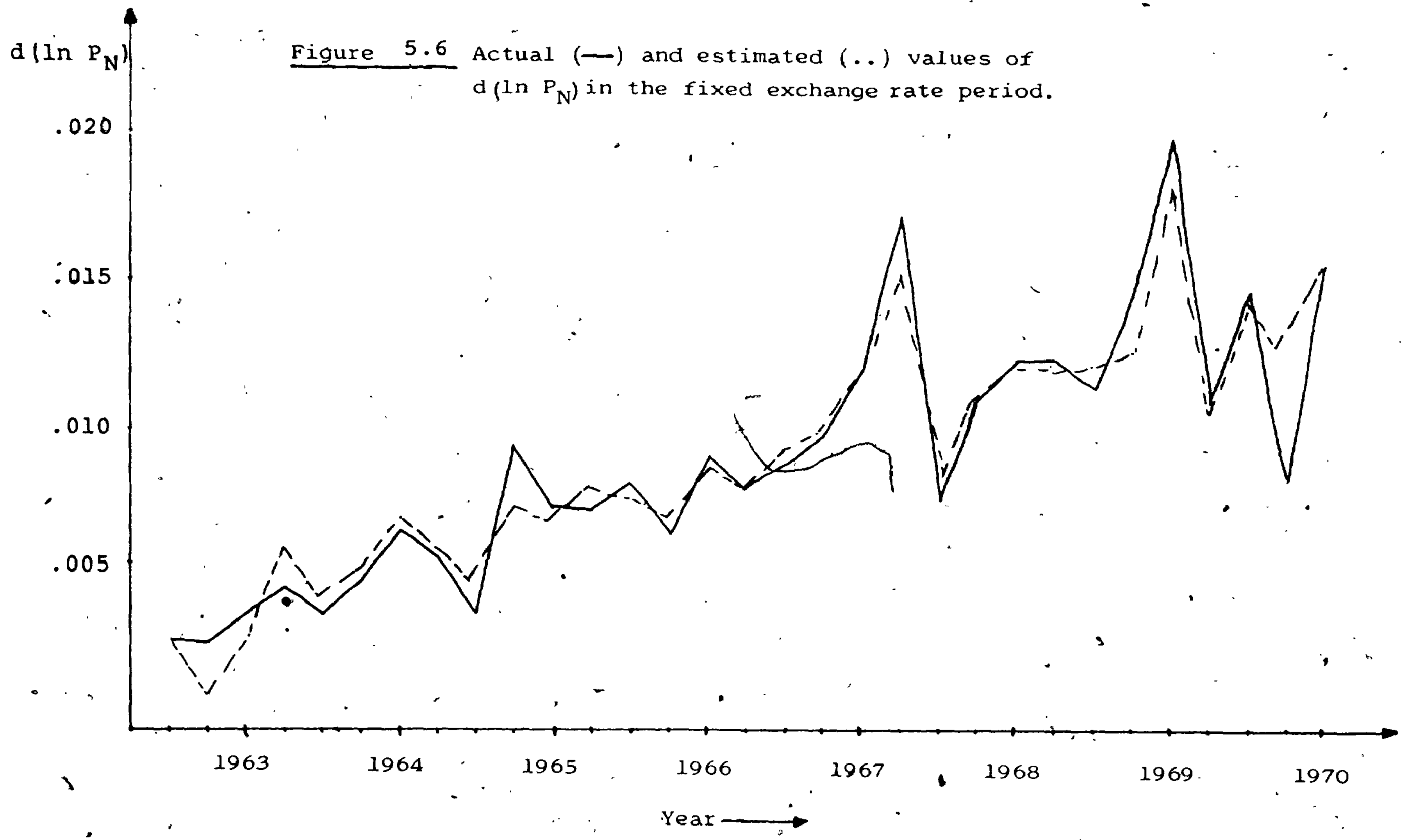



Figure 5.6 Actual (—) and estimated (..) values of d(ln $P_N$) in the fixed exchange rate period.

$R^2 = .7203$ ; D.W. = 2.31 ; d.f. = 24 ; $F_{6/24} = 10.30$ ; N = 31.

All estimated coefficients have the expected signs and are significant at over 95% confidence level. The F-statistic for the whole equation is also significant. To test the null hypothesis of independent disturbances versus the alternative hypothesis of negative autocorrelation, we use equation (5.3) to calculate the standard normal variate h.

$$h = 1.25 \tag{5.14}$$

This corresponds to .1075 probability. Therefore, the null hypothesis cannot be rejected at a 90% confidence level. Actual and estimated values of d ln $P_X$ are presented in Figure (5.7)

2.4 Employment equation

The employment equation in the fixed exchange rate period is estimated by adjusting for first order serial correlation similar to the estimation of equation (5.10). The result is

$$\begin{aligned}
[d \ln L]_t = {} & \underset{(5.11)}{.1754}\Big[\sum_{\tau=1}^{5}(\Sigma m_j(d \ln P_X^j + d \ln E^j)_{t-\tau}\Big] \\
& + \underset{(3.84)}{.2916}[d \ln I_d]_{t-1} + \underset{(1.82)}{.2482}[\Sigma x_j (d \ln P_M^j + d \ln E^j)]_t \\
& + \underset{(2.63)}{.0491}\Big[\sum_{\tau=1}^{9}(d \ln I_f)_{t-\tau}\Big] + \underset{(3.90)}{.5168}[d \ln L]_{t-1} \\
& - \underset{(-2.17)}{.1676}[d \ln P_X]_{t-10} - \underset{(-1.79)}{.2361}[d \ln W]_{t-3} \\
& - \underset{(-1.83)}{.2776}[d \ln P_N]_{t-7}
\end{aligned} \tag{5.15}$$

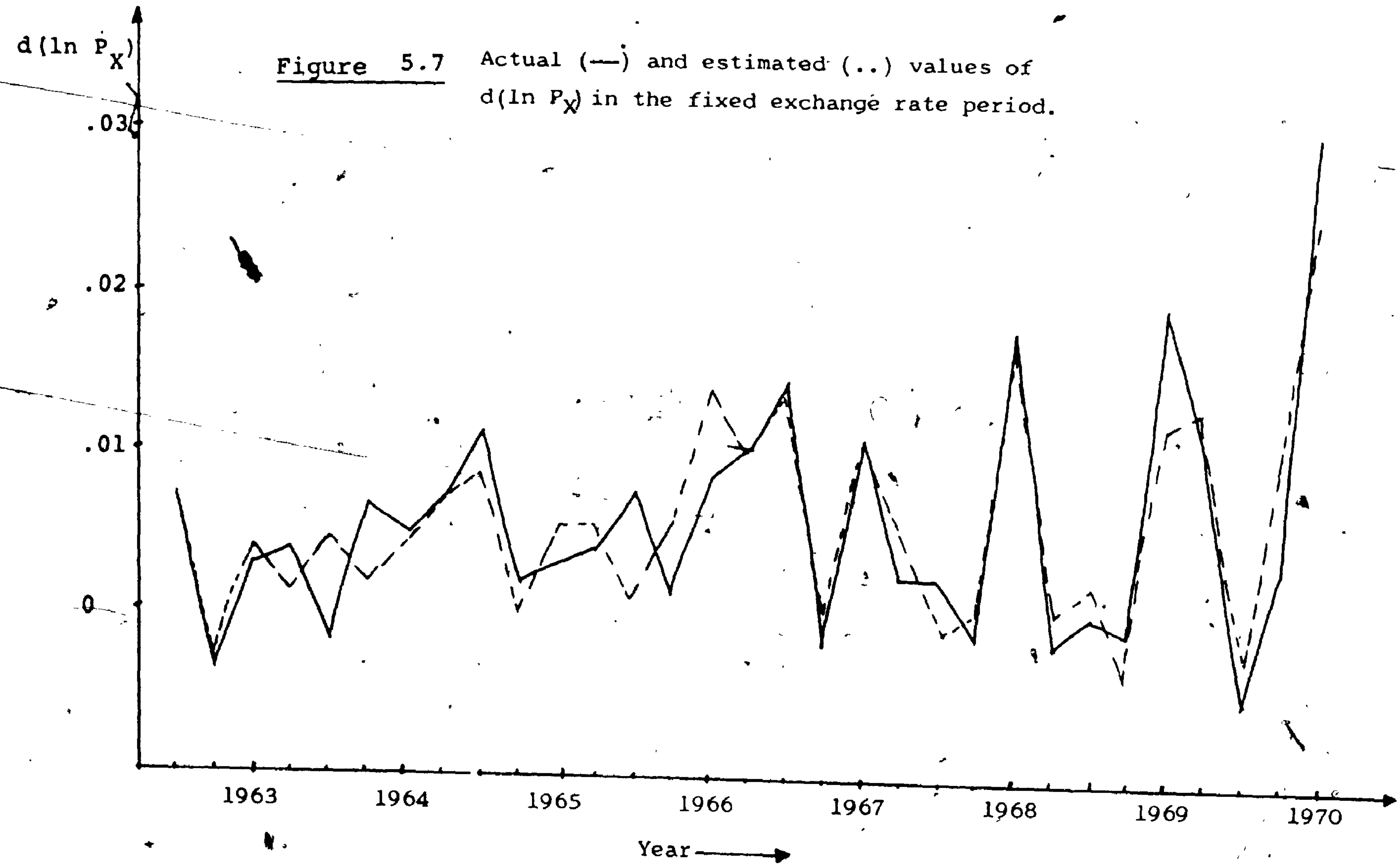



**Figure 5.7** Actual (—) and estimated (..) values of d(ln $P_X$) in the fixed exchange rate period.

$R^2 = .7533$ ; D.W. = 1.99 ; d.f. = 22 ; N = 30

All estimated coefficients have the expected signs, and are significant at a 95% confidence level.

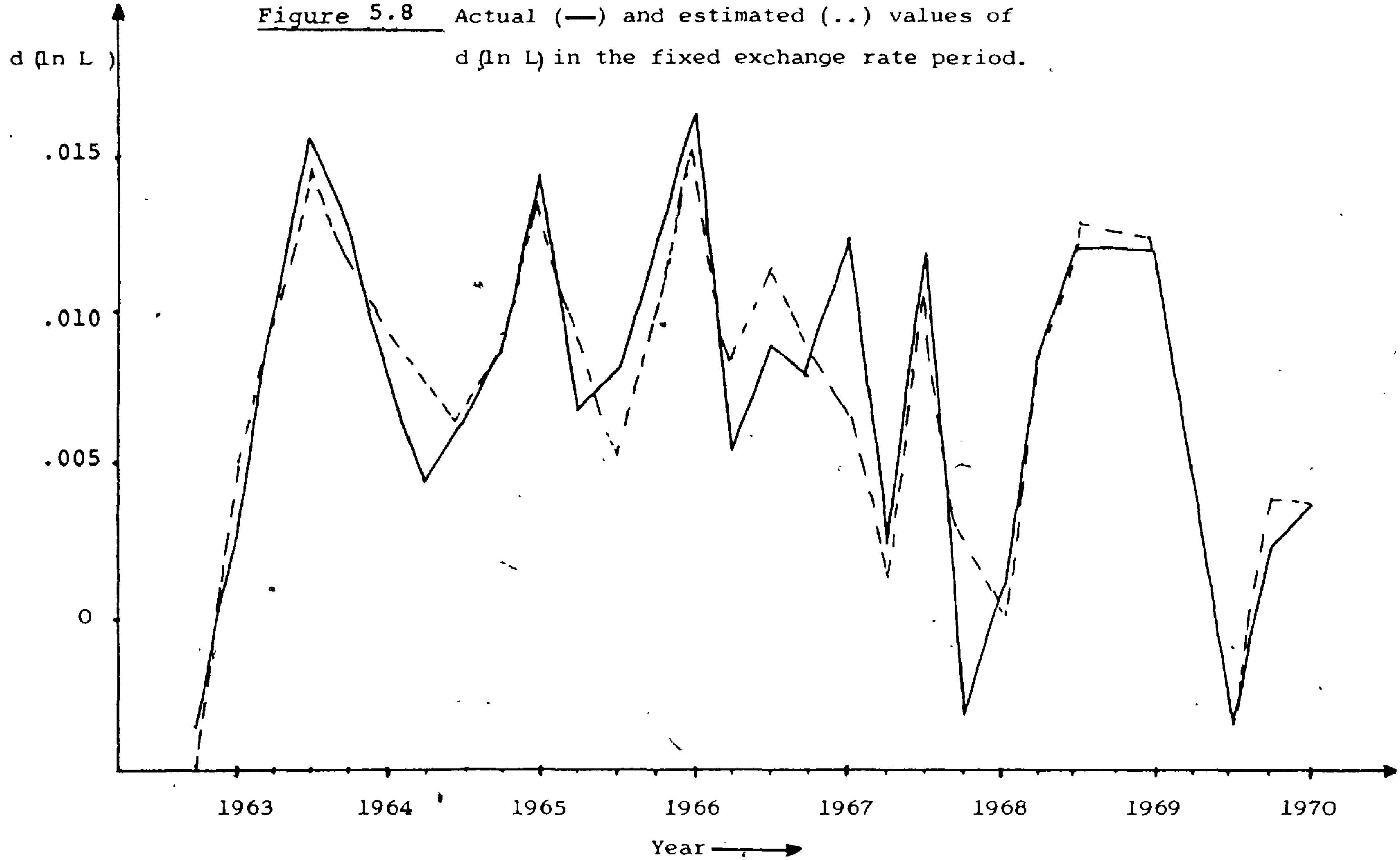
Actual and estimated values of [d ln L] in the fixed exchange rate period are presented in Figure 5.8.

3. The second flexible exchange rate period (3rd quarter 1970 to 4th quarter 1973).

3.1 Wage equation.

The wage equation of the second flexible exchange rate period is estimated by adjusting for first order serial correlation similar to the estimation used for equation (5.10). The result of this estimation is:

Figure 5.8 Actual (—) and estimated (..) values of d (ln L) in the fixed exchange rate period.



$$[d \ln W]_t = \underset{(-5.24)}{-.2209} + \underset{(6.14)}{.7548}\left[\Sigma m_j (d \ln P_X^j + d \ln E^j)\right]_{t-2}$$

$$+ \underset{(5.75)}{1.12}[2/(U + U_{t-1})]_{t-1} + \underset{(3.80)}{.4762}[d \ln P_X]_{t-5}$$

$$+ \underset{(3.23)}{.0083}[d \ln P_N]_{t-11} \qquad (5.16)$$

$R^2 = .8778$ ; d.f. = 8 ; $F_{4/8} = 14.36$ ; N = 13

All estimated coefficients have the expected signs and are significant at a confidence level of over 99% . The F-statistic for the whole equation is also significant ( at over 99% confidence level ). Actual and estimated values of [ d ln W ] are presented in Figure (5.9).

3.2 <u>Equation describing the price of non-tradable goods</u>

The estimated equation for the price of non-tradable goods in the second flexible exchange rate period is also adjusted for first order auto-correlation. The result is

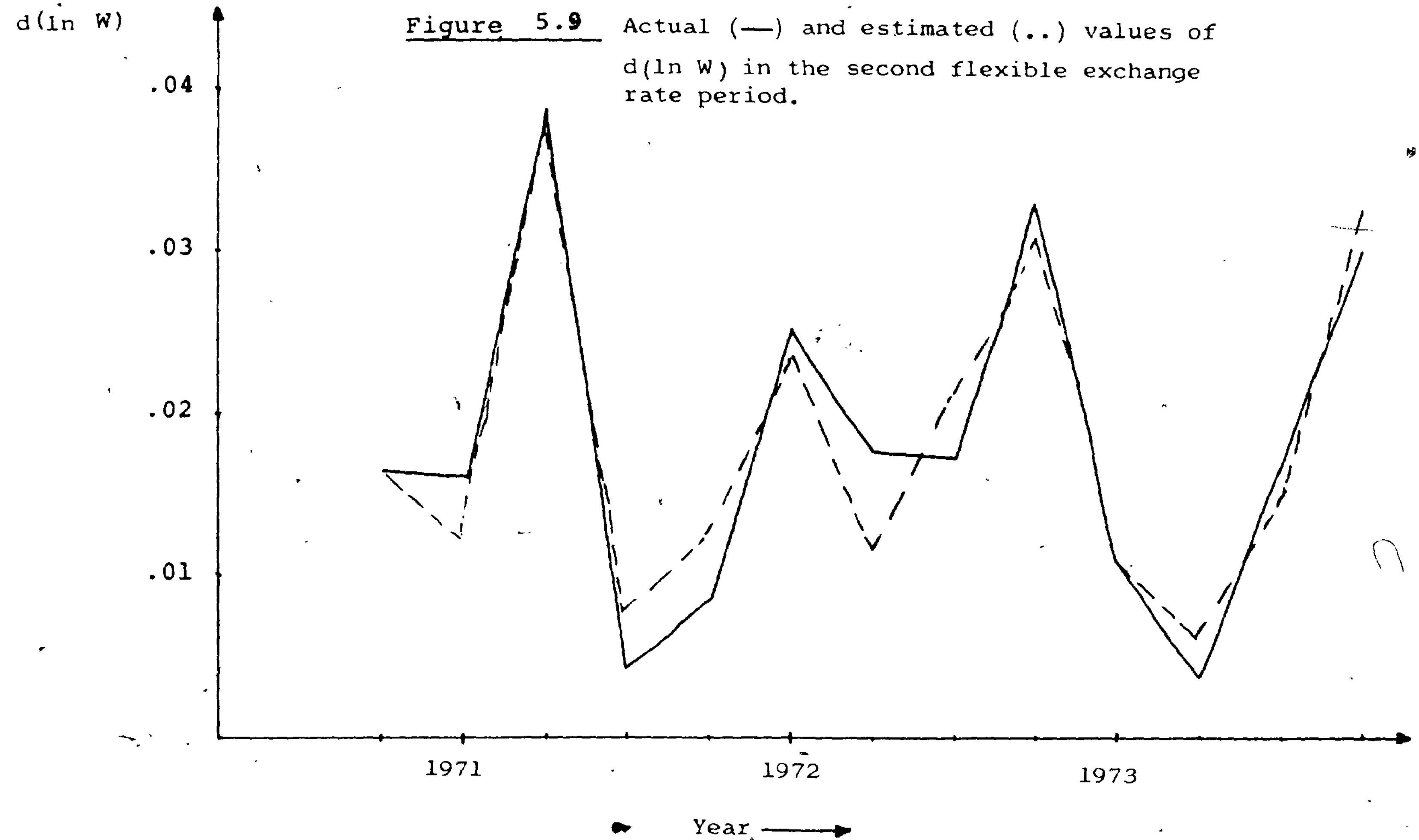
$$[d \ln P_N]_t = \underset{(-10.51)}{-.0289} + \underset{(25.42)}{.5671}[d \ln I_d]_{t-1} + \underset{(20.52)}{.348}[d \ln P_N]_{t-8}$$

$$+ \underset{(7.60)}{.0006}\left[\sum_{\tau=1}^{9} \tau^2 (\Sigma m_j (d \ln P_X^j + d \ln E^j))_{t-\tau}\right]$$

$$+ \underset{(4.86)}{.3504}[d \ln P_N]_{t-2} + \underset{(13.77)}{.3988}[d \ln W]_{t-2}$$

$$+ \underset{(40.31)}{.3154}[d \ln P_X]_{t-2} \qquad (5.17)$$

**Figure 5.9** Actual (—) and estimated (..) values of d(ln W) in the second flexible exchange rate period.



$R^2 = .9955$ ; d.f. = 6 ; $F_{6/6} = 221.58$ ; n = 13

All estimated coefficients have the right signs and are significant at a confidence level of over 99%. The high explanatory power of the equation is indicated by the values of $R^2$ and the F-statistic . Actual and estimated values of $[d \ln P_N]$ are presented in Figure 5.10. We observe that the predicted values of equation (5.17) track very well the actual values throughout the estimation period.

3.3 Equation describing the price of exportable goods

Similar to the equations of money wages and the price of non-tradable goods, the estimated equation of the price of exportable goods is adjusted for first order auto-correlation. The result is

$$[d \ln P_X]_t = \underset{(20.23)}{-.1405} + \underset{(4.15)}{.2855}[\Sigma m_j (d \ln P_X^j + d \ln E^j)]$$

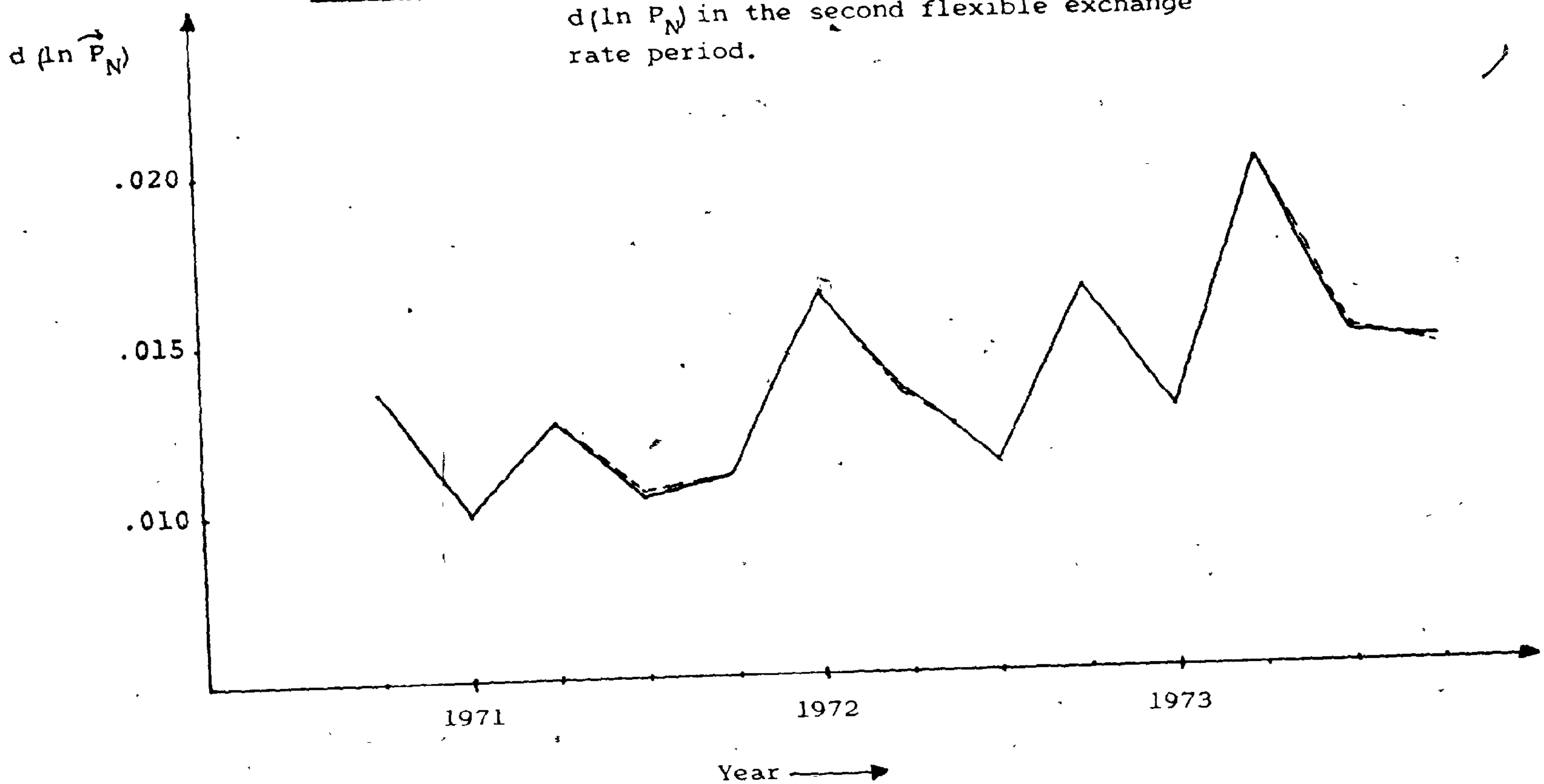
$$+ \underset{(14.39)}{.089}[\Sigma x_j (d \ln P_M^j + d \ln E^j)] + \underset{(7.41)}{.3649}[d \ln I_d]_{t-7}$$

$$+ \underset{(3.54)}{.1348}[d \ln P_X]_{t-9} + \underset{(17.84)}{.0181}[d \ln P_N]_{t-11}$$

$$+ \underset{(8.96)}{.4088}[d \ln W]_{t-10} + \underset{(23.94)}{.0139}[\sum_{\tau=1}^{7} \tau^2 (d \ln I_w)_{t-\tau}] \qquad (5.18)$$

$R^2 = .9990$ ; d.f. = 5 ; $F_{7/5} = 730.41$ ; N = 13

**Figure 5.10** Actual (—) and estimated (..) values of $d(\ln P_N)$ in the second flexible exchange rate period.



All estimated coefficients have the right signs and are significant at a confidence level of over 99%. The F-value of the whole equation indicates the high explanatory power of equation (5.18). Actual and estimated values of $[d \ln P_X]$ are presented in Figure 5.11. The predicted values of equation (5.18) track very well the actual values throughout the estimation period.

3.4 Employment equation

The estimated employment equation for the second flexible exchange rate period is

$$[d \ln L]_t = \underset{(5.00)}{.0210} + \underset{(1.98)}{.1376}[\Sigma m_j (d \ln P_X^j + d \ln E^j)]_{t-7}$$

$$+ \underset{(7.13)}{.0859}[\Sigma x_j (d \ln P_M^j + d \ln E^j)]_{t-7} + \underset{(2.33)}{.1088}[d \ln I_d]_{t-7}$$

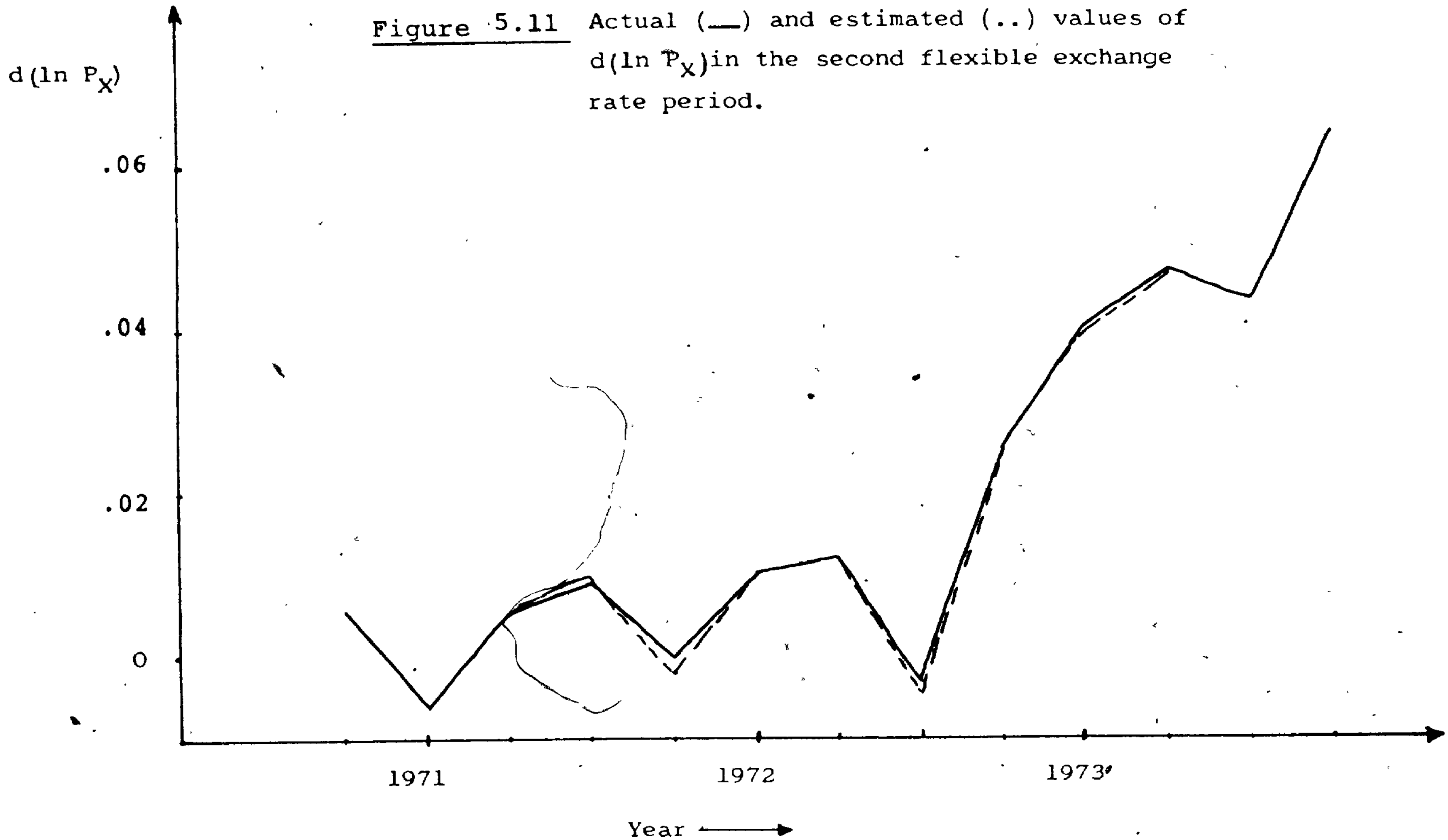
$$+ \underset{(4.30)}{.0407}[\sum_{\tau=1}^{2} \tau^2 (d \ln I_f)_{t-\tau}] + \underset{(1.47)}{.0972}[d \ln L]_{t-1}$$

$$- \underset{(-5.25)}{.1899}[d \ln W]_{t-6} + \underset{(8.85)}{.319}[d \ln P_X]_{t-12}$$

$$+ \underset{(4.16)}{.0068}[\sum_{\tau=1}^{8} \tau^2 (d \ln P_N)] \qquad (5.19)$$

$R^2 = .9894$ ; D.W. = 2.14 ; d.f. = 5 ; $F_{8/5} = 58.40$ ; N = 14

Figure 5.11 Actual (—) and estimated (..) values of $d(\ln P_X)$ in the second flexible exchange rate period.



All estimated coefficients have the expected signs. Judging from the t-statistics, all parameters except those associated with $[\Sigma m_j (d \ln P_X^j + d \ln E^j)]_{t-7}$ and $[d \ln L]_{t-1}$ are significant at a confidence level of over 99%. The coefficients of the two mentioned variables are significant at 90% confidence level. The F-statistic of the whole equation is also significant at over 99% confidence level.

To test the serial correlation of equation (5.19), we use the null hypothesis of independent disturbances. The correct test is based on the standard normal variate h of equation (5.3).

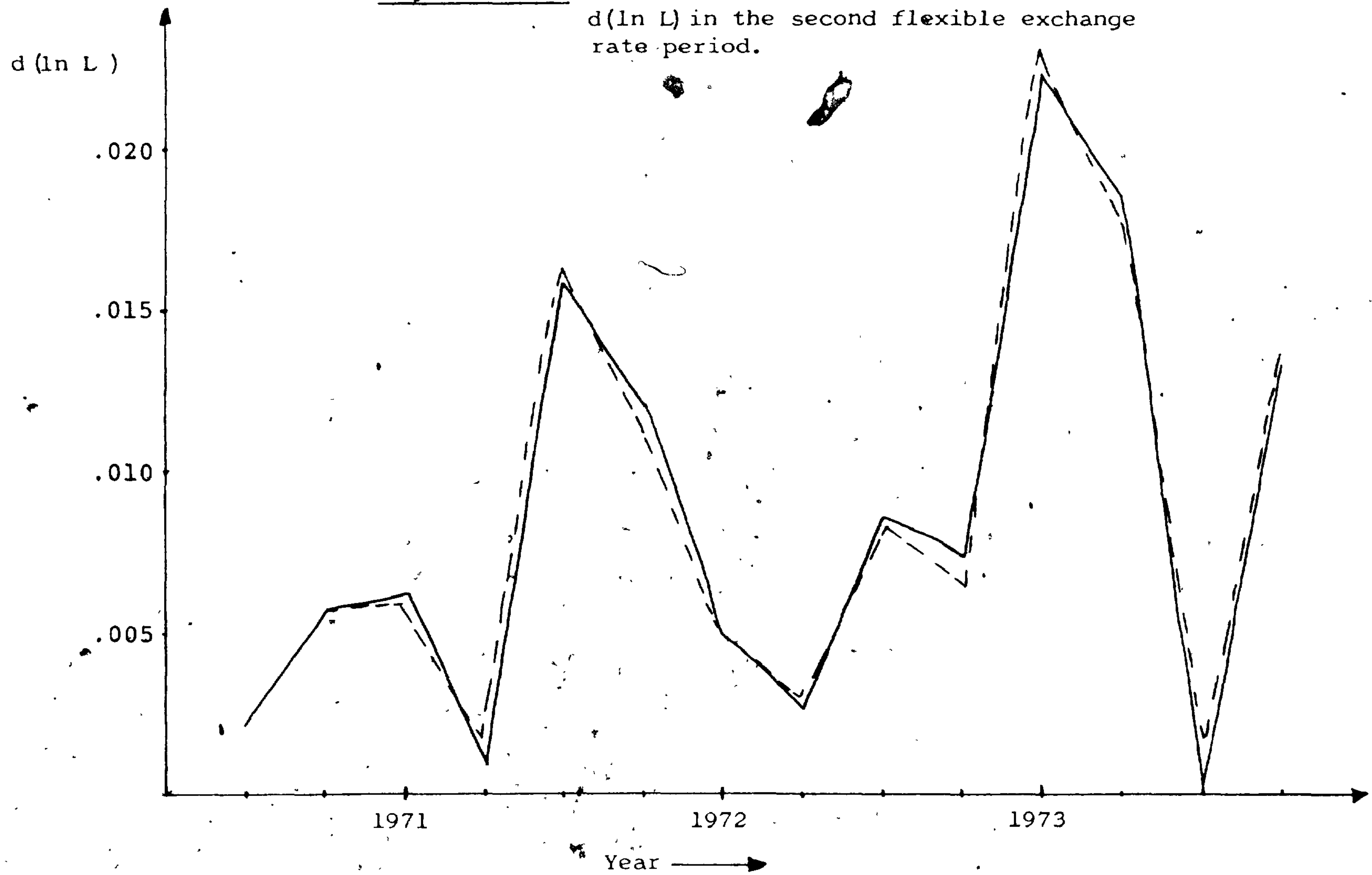
$$h = .288 \qquad (5.20)$$

This corresponds to .38 probability of the right hand tail. Therefore, the null hypothesis cannot be rejected even at 70% confidence level.

Actual and estimated values of $[d \ln L]$ are shown in Figure 5.12. The predicted values trace very well the actual values over the entire period of the estimation.

The above estimated results are based on the three sets of data corresponding to the first flexible, the fixed, and the second flexible exchange rate periods of the Canadian economy. The decision to separate the data set into three periods is that economic expectation and/or the structure of the model may change from period to period. To test statistically this "prior information", we use

**Figure 5.12** Actual (—) and estimated (..) values of d(ln L) in the second flexible exchange rate period.



the Chow test with the null hypothesis that the structure of the model does not change significantly from period to period[27].

4. Chow test of the structural change of the model from one period of the exchange rate to another.

Let the model with a unified structure from 1956 to 1973 be represented as

$$Y = X B + U \qquad (5.21)$$

and estimated models corresponding to the three periods are:

$$Y_1 = X_1 B_1 + U_1 \qquad (5.22)$$

$$Y_2 = X_2 B_2 + U_2 \qquad (5.23)$$

$$Y_3 = X_3 B_3 + U_3 \qquad (5.24)$$

where $Y, Y_1, Y_2, Y_3$ = matrices of dependent variables

$X, X_1, X_2, X_3$ = matrices of independent variables

$B, B_1, B_2, B_3$ = matrices of estimated coefficients

$U, U_1, U_2, U_3$ = matrices of error terms.

To test whether or not systems 5.22, 5.23 and 5:24 are significantly different from system 5.21, we have to specify the structure of matrix X in system (5.21).

The following hypotheses are made

1) The functional form of X is identical to $X_1$. This means that the structure in the first flexible exchange rate period does not change from 1956 to 1973.

2) The functional form of X is identical to $X_2$. This means that total observed data from 1956 to 1973 can be represented by the structure of the fixed exchange rate period.

3) The functional form of X is identical to $X_3$. This means that total data observed from 1956 to 1973 can be represented by the structure of the second flexible exchange rate period.

4) The functional form of X is unrestricted, and is found by the search procedure described in Chapter IV. This hypothesis implies that none of the above estimated structures can be represented for the whole period. Nevertheless, total observed data from 1956 to 1973 can be represented by one unified structure.

The Chow test is related to the question of whether or not the model, divided into three different periods and represented by 5.22, 5.23 and 5.24 , significantly improves the sum of squared residuals compared to the unified structure of 5.21. The improvement of the sum of squared residuals is tested by means of an F-test. This test is valid as long as we have the usual assumptions that error terms are independently and normally distributed. Hence, the sum of squared residuals has a Chi-square distribution. Under the null hypothesis, the ratio of two Chi-square distributions adjusted by appropriate degrees of freedom is an F-distribution.

To estimate the unified structure of system 5.21, we use data from 1956 to 1973 to re-estimate each equation of the model according to the above four hypotheses on the structure of X . We found that under hypotheses (1), (2) and (3), some estimated parameters have wrong signs and are insignificant. Furthermore, due to the nature of our estimation procedure, for the same loss of degrees of freedom, the sum of squared residuals of (5.21) under the unrestricted functional form of X must be less than or equal to the sum of squared residuals under the other three hypotheses. Therefore, it is sufficient to report the test results under the hypothesis that the matrix X of (5.21) is unrestricted. These results are presented in Table 5.1, from which we can reject the null hypothesis that the structure of the model does not change from 1956 to 1973 at a confidence level of 99%. We, next, do pairwise tests to see whether or not the structure of the model has changed significantly between:

i) the first flexible exchange rate period and the fixed exchange rate period.

Table 5.1

Chow test on the structure of the model

Null hypothesis: the structure of the model does not change significantly from 1956 to 1973

| Equation | The model separated into three periods | | The unified model | | $\sum u'u - \sum e'e$ | F-statistics under the null hypothesis | F critical at 99% confidence |
|---|---|---|---|---|---|---|---|
| | $\sum e'e$ | d.f. | $\sum u'u$ | d.f. | | | |
| Wages | 941.93 | 52 | 2164.65 | 61 | 1222.72 | 7.5 | 2.78 |
| The price of non-tradables | 124.5 | 48 | 290. | 58 | 165.5 | 6.38 | 2.71 |
| The price of exportables | 681.193 | 46 | 3205.552 | 59 | 2524.359 | 13.11 | 2.60 |
| Employment | 260.518 | 42 | 652.299 | 56 | 391.781 | 4.51 | 2.54 |

$\sum u'u$, $\sum e'e$ = sum of squared residuals

d.f. = degrees of freedom

ii) the first flexible exchange rate period and the second flexible exchange rate period.

iii) the fixed exchange rate period and the second flexible exchange rate period.

Test procedure is similar to the above illustration, in which system (5.21) covers two periods at a time instead of three periods. These results are shown in Tables 5.2, 5.3 and 5.4. At a confidence level of 99%, we can reject the null hypothesis that the structure of the model does not change significantly from one period to another.

5. Discussion of the estimation results.

We have reported our estimation results for three different periods of the exchange rate and the Chow test, which consistently reject the null hypothesis that the structure of the model does not change significantly from one period of the exchange rate to another. The estimation of individual equation shows that most coefficients are significant at over 95% confidence level. The question raised at this point is how seriously can we rely on the estimation results and on the testing significance.

A complete analysis of this question is far beyond the scope of the thesis. However, at the present state of the art, we can say how seriously we can rely on the model (or any model) depending on what we want to use it for and how we view the system (12).

Table 5.2

Chow test on the structure of the model

<u>Null hypothesis</u>: the structure of the model does not change significantly between the first flexible exchange rate period and the fixed exchange rate period.

| Equation | The model separated into two periods | | The unified model | | $\sum u'u - \sum e'e$ | F-statistics under the null hypothesis | F critical at 99% confidence |
|---|---|---|---|---|---|---|---|
| | $\sum e'e$ | d.f. | $\sum u'u$ | d.f. | | | |
| Wages | 770.045 | 44 | 1115.41 | 48 | 345.365 | 4.93 | 3.78 |
| The price of non-tradables | 124.068 | 42 | 235.02 | 46 | 110.952 | 9.39 | 3.80 |
| The price of exportables | 675.287 | 41 | 1568.766 | 48 | 893.479 | 7.75 | 3.12 |
| Employment | 253.923 | 37 | 533.835 | 46 | 279.911 | 4.53 | 2.94 |

$\sum u'u$, $\sum e'e$ = sum of squared residuals

d.f. = degrees of freedom

Table 5.3

Chow test on the structure of the model

<u>Null hypothesis</u>: the structure of the model, does not change significantly between the first flexible exchange rate period and the second flexible exchange rate period

| Equation | The model separated into two periods | | The unified model | | $\Sigma u'u - \Sigma e'e$ | F-statistics under the null hypothesis | F critical at 99% confidence |
|---|---|---|---|---|---|---|---|
| | $\Sigma e'e$ | d.f | $\Sigma u'u$ | d.f | | | |
| Wages | 413.125 | 26 | 896.916 | 28 | 483.791 | 15.22 | 5.53 |
| The price of non-tradables | 44.297 | 23 | 174.378 | 30 | 130.081 | 9.65 | 3.54 |
| The price of exportables | 194.135 | 22 | 1106.748 | 26 | 912.613 | 25.80 | 4.41 |
| Employment | 60.323 | 20 | 283.075 | 27 | 222.752 | 10.55 | 3.71 |

$\Sigma u'u$, $\Sigma e'e$ = sum of squared residuals

d.f. = degrees of freedom

Table 5.4

Chow test on the structure of the model

Null hypothesis: the structure of the model does not change significantly between the fixed exchange rate period and the second flexible exchange rate period

| Equation | The model separated into two periods | | The unified model | | $\Sigma u'u - \Sigma e'e$ | F-statistics under the null hypothesis | F critical at 99% confidence |
|---|---|---|---|---|---|---|---|
| | $\Sigma e'e$ | d.f | $\Sigma u'u$ | d.f | | | |
| Wages | 700.69 | 34 | 1240.0 | 36 | 539.31 | 13.09 | 5.29 |
| The price of non-tradables | 80.65 | 31 | 133.293 | 34 | 52.643 | 6.75 | 4.51 |
| The price of exportables | 492.964 | 29 | 1226.791 | 37 | 733.827 | 5.40 | 3.20 |
| Employment | 206.79 | 27 | 459.511 | 37 | 252.721 | 3.29 | 3.06 |

$\Sigma u'u$, $\Sigma e'e$ = sum of squared residuals

d.f. = degrees of freedom

In our analysis, we use classical statistics coupled with economic knowledge to construct a model for studying short run adjustment paths of prices, wages and employment after a devaluation or a change in a selective commercial policy. In the process of building the model, we spell out as clearly as possible the quality of the data, the exact estimation and testing procedures that make up our model. Technically speaking, the reported confidence levels of estimated parameters and of testing significance are valid within the conventional framework of classical statistics i.e. 95% confidence level.

We did not do the following: (a) specify a "loss" function which depicts clearly how much of a penalty is imposed when, for example, some estimated parameters are "bad".

(b) formally take into account all information concerning the economic system, quality of the data and the knowledge of estimation techniques in the estimation of the model and in constructing the confidence limit. The loss function in (a) and formal prior information in (b) depend on the subjective preference of model users. This is not the scope of the thesis.

Thus, our work is limited to an empirical proposition subjected to qualifications which have been specified. This empirical proposition, when used, will enter as a component in the decision analysis of a user. Staying in the limited goal as an empirical proposition using classical statistics as a tool, we have a model estimated in three different periods of the Canadian exchange rate. The model is suitable for studying the short run effects of a devaluation or a change in a commercial policy. All estimated coefficients in the model are significant. From the discussion in Chapter IV, the selection procedure used in our estimation is free from bias due to "human" experimentation with different specifications and different variables.

We observe in equation (5.1), (5.10) and (5.16) that all disaggregated prices significantly influence the wage equations. The direct price effects on wages are at different weights and different time lags. In the first two periods of the exchange rate, the response of wages to the prices of exportables, of importables and of non-tradables are in a decreasing order respectively. However, in the third period of the exchange rate, wages are more sensitive to the price of importables than to the price of exportables. In all periods, money wages respond more rapidly to the prices of external sectors than to the price of non-tradable goods. This analysis is based only on the wage equations and does not take into account the the lag structure and the internal dynamics of the whole model. To take these into account, we have to simulate the model. This will be discussed in the next Chapter.

Simulations will be done for the three periods of the exchange rate when a devaluation or a change in a commercial policy were suddenly imposed. These represent the shock solutions. Comparison between a shock solution and a reference solution yields multiplier effects of the shock. We will discuss , in detail in the next chapter, the concept of multiplier analysis and the results obtained from our model.

of the exchange rate to another. Our hypothetical experiment assumes no structural change of the model and is designed to demonstrate the effects of only one shock at a time.

In Appendix E, we report multiplier effects derived from the simulation results of a 1% devaluation of the Canadian dollar against all other currencies (Tables E.1, E.2 and E.3). These multiplier effects are presented in Figures E.1 to E.12 for percentage changes in wages, prices and employment. We next calculate the cumulative effects and report these in Tables E.4, E.5 and E.6 (Appendix E). The cumulative effects are presented in Figure 6.1 as solid lines.

Similarly, multiplier effects derived from a 1% change in the domestic price of importables and from a 1% change in the foreign price of Canadian exports are calculated and tabulated in Tables E.7 to E.12. We then calculate the cumulative effects and summarize these results as broken lines and dotted lines in Figure 6.1.

Thus all of our results are presented in Figure 6.1. The multiplier effects can be read from the slope of an appropriate curve, whereas the magnitude of a curve gives the size of the response of an endogenous variable at any time after the shock. Figure 6.1 is used to analyze the multiplier effects in the next section. In deriving the results from Figure 6.1, we assume no structural change of the model, and leave aside the balance of payments problem caused by a hypothetical shock.

of these results are compared with empirical propositions suggested by other models. We close this Chapter by summarizing our empirical findings and give some suggestions for further improvement of the model.

1. Meaning of the simulation

In this section, we first describe the characteristics of our model and make a distinction between endogenous and exogenous variables for the purpose of simulation. We then discuss the procedure of the simulation and the potential source of errors that may affect the results. At the end of this section, we argue that the comparison of simulation solutions can be used to study the effects of a shock which is caused by a devaluation or a change in a commercial policy.

1.1 Characteristics of the model

The model reported in Chapter V is non-linear and dynamic. The non-linearity comes from the inclusion of the inverse of the unemployment rate. Since there are lagged endogenous variables, once the initial values of exogenous variables are given, the system will generate the values of endogenous variables which are the results of both simultaneous effects and the lag structure of the dependent variables. This is the internal dynamic structure of the model.

The dynamic properties of such a model are usually investigated in terms of multiplier analysis. In this analysis, we have to identify endogenous and exogenous variables. Exogenous variables in the model are the labour supply, foreign prices and the exchange rate. Endogenous variables are wages, prices and employment. The unemployment rate is endogenous in the sense that it is determined by endogenous labour demand and exogenous labour supply. Given an initial unemployment rate, and values of other variables on the right-hand side of the model, wages, prices and employment are determined. In the next period, the unemployment rate is affected by changes in the labour supply and demand.

Having identified endogenous and exogenous variables, we now conduct different types of simulations to study the behavior of the model.

1.2 Simulation and multiplier analysis

In Chapter V, we reported the difference between actual and calculated values of the endogenous variable from each estimated equation. The calculated values are called the ex-post forecast. At any observation point, the ex-post forecast is calculated from the actual values of the variables on the right-hand side of the equation. Hence by comparing the ex-post forecasts with the actual values of the dependent variable, we can see how much error is due to the structure of each equation; resulting from the specification and estimation stages. The performance of ex-post forecasts is important for policy analysis and for short-run projections. Since if the model does not yield accurate ex-post forecast, the model multipliers may not represent the "true world" multipliers accurately. In general, a policy model must pass another test of stability. It was shown in Chapter V that ex-post forecasts of our estimated equations trace quite well the actual values of endogenous variables. From F-statistics of the whole model, all ex-post forecasts are significant at 99% confidence level according to classical statistics. We will show in our simulation results that the model is also stable in the three exchange rate periods.

The ex-post forecasts cover only the sample period. If the forecast is extended beyond that period, we have two additional sources of errors: the prediction error and the error from generated endogenous variables. These errors are confined to the simulation of one equation at a time. This type of simulation does not take into account errors transmitted from one equation to others due to the simultaneous nature of the model.

The model simulation is designed to bring out dynamic effects within each equation and among different equations. In this type of simulation, the whole model is solved simultaneously from period to period. If generated endogenous variables are used instead of actual endogenous variables, then within the sample period, we have errors due to the specification and estimation of each equation, errors transmitted from one equation to others and errors from generated endogenous variables. If the model simulation is extended beyond the sample period, we also have prediction errors.

Multiplier analysis is a useful tool to bring out the dynamic behavior of the model, and at the same time to reduce the effects of the errors caused by model simulation to a minimum. This is accomplished by running two sets of solutions. One is called a reference solution and the other is a "shock" solution. Exogenous variables are identical in the two cases except for one variable. The experiment is designed to study the effects of changing one variable at a time. This is similar to comparative statics used in economic theory. The difference is that in comparative statics, we study the effects of a change in one variable when the model moves from one equilibrium to another; whereas in the multiplier analysis, we study the effects of a change in one variable over a particular period of time, in which the equilibrium of the model is not necessarily attained. If the model is stable, the per period effects of one shock in the model should be reduced in magnitude as time passes, or the cumulative effects of the shock should level off.

The advantages of the multiplier analysis are: i) that specific answers from period to period can be given to questions on what happens to other variables if there is a change in one exogenous variable at a particular time and, ii) that the dynamic structural behaviour of the model can be taken into account with a minimum of "noise" from the model. These are the properties we need for deducing empirical propositions concerning the issues set out in Chapter I.

1.3 Shocks due to a devaluation or to a change in a commercial policy

In our model, we are interested in the effects of a change in the exchange rate. We first estimate the model, without taking into account the rates of import tax and export subsidy.

Therefore the fluctuation of the domestic price of importables and the foreign produced price of Canadian exports is caused only by the fluctuations of the exchange rate and foreign prices. Having estimated the model and performed different statistical tests to ensure that the model is reasonable for our purpose, we now ask a hypothetical question: What will happen to endogenous variables (namely wages, prices and employment) if there is a hypothetical devaluation?

Suppose that the exchange rate is initially at a constant level, i.e., $d \ln E_j = 0$ $(j = 1,2,\ldots, 8)$. Now if the Canadian dollar is devalued by 1% against all other currencies, $d \ln E_j$ $(j = 1,2,\ldots, 8)$ will increase by 1% uniformly. Both $[\Sigma m_j \, d \ln E_j]$ and $[\Sigma x_j \, d \ln E_j]$ are increased by 1%. The multiplier effects of a 1% devaluation of the

Canadian dollar are the differences between the solutions of the endogenous variables resulting from the case: $\Sigma m_j \, d \ln Ej = \Sigma x_j \, d \ln Ej = 1\%$ and the case: $\Sigma m_j \, d \ln Ej = \Sigma x_j \, d \ln E^j = 0$; all exogenous variables are identical in the reference and the shock solutions. The labour supply is assumed to be exogenous, but the unemployment rate is endogenous due to changes in employment generated by the model.

In the experiment of an exchange rate devaluation, the shock solution results when both $\Sigma m_j \, d \ln Ej$ and $\Sigma x_j \, d \ln Ej$ are equal to 1%. This means that the devaluation effects are the results of two shocks: the first one is to change the domestic price of importables and the second one is to change the foreign price of Canadian exports. We demonstrated in Chapter II that a 1% change in the domestic price of importables can be accomplished by a change in an import tax rate $(dT/(1+T))$ [equation (2.66)], and that a 1% change in foreign price of Canadian exports can be accomplished by a change in the rate of export subsidy $(dS/(1-S) = 1\%)$ [equation (2.71)]. Therefore, besides shedding some light on the devaluation effects, the model can also be used to answer the hypothetical question of what will happen to wages, prices and employment when the rates of import tax or export subsidy are suddenly changed.

Having discussed the meaning and nature of our experiments, we now present the multiplier effects of a 1% devaluation of the Canadian dollars and a change of the rate of import tax or export subsidy.

2. Results of the multiplier analyses

The simulations cover from the first quarter 1957 to the fourth quarter 1966 for the first flexible exchange rate period (estimated from 2nd quarter 1956 to 1st quarter 1962). There is no particular reason why we choose the first quarter 1957 as a starting date and the fourth quarter 1966 as the end of the simulations except that the simulation period must be long enough so that all effects of one shock can be fully traced out. For the fixed exchange rate period (estimated from 3rd quarter 1962 to 1st quarter 1970), the simulations cover from the first quarter 1963 to the fourth quarter 1972. For the second flexible exchange rate period (estimated from 3rd quarter 1970 to 4th quarter 1973), the simulations cover from the first quarter 1971 to the fourth quarter 1975. The simulations during the second flexible exchange rate period cover only 5 years time because labour supply data were available only to 1975 at the time of this experiment.

We note that in all three periods of the exchange rate, the simulations are extended beyond the sample periods used to estimate the model. This means that there may be some additional error due to structural change from one period of the exchange rate to another. Our hypothetical experiment assumes no structural change of the model and is designed to demonstrate the effects of only one shock at a time.

In Appendix E, we report multiplier effects derived from the simulation results of a 1% devaluation of the Canadian dollar against all other currencies (Tables E.1, E.2 and E.3). These multiplier effects are presented in Figures E.1 to E.12 for percentage changes in wages, prices and employment. We next calculate the cumulative effects and report these in Tables E.4, E.5 and E.6 (Appendix E). The cumulative effects are presented in Figure 6.1 as solid lines.

Similarly, multiplier effects derived from a 1% change in the domestic price of importables and from a 1% change in the foreign price of Canadian exports are calculated and tabulated in Tables E.7 to E.12. We then calculate the cumulative effects and summarize these results as broken lines and dotted lines in Figure 6.1.

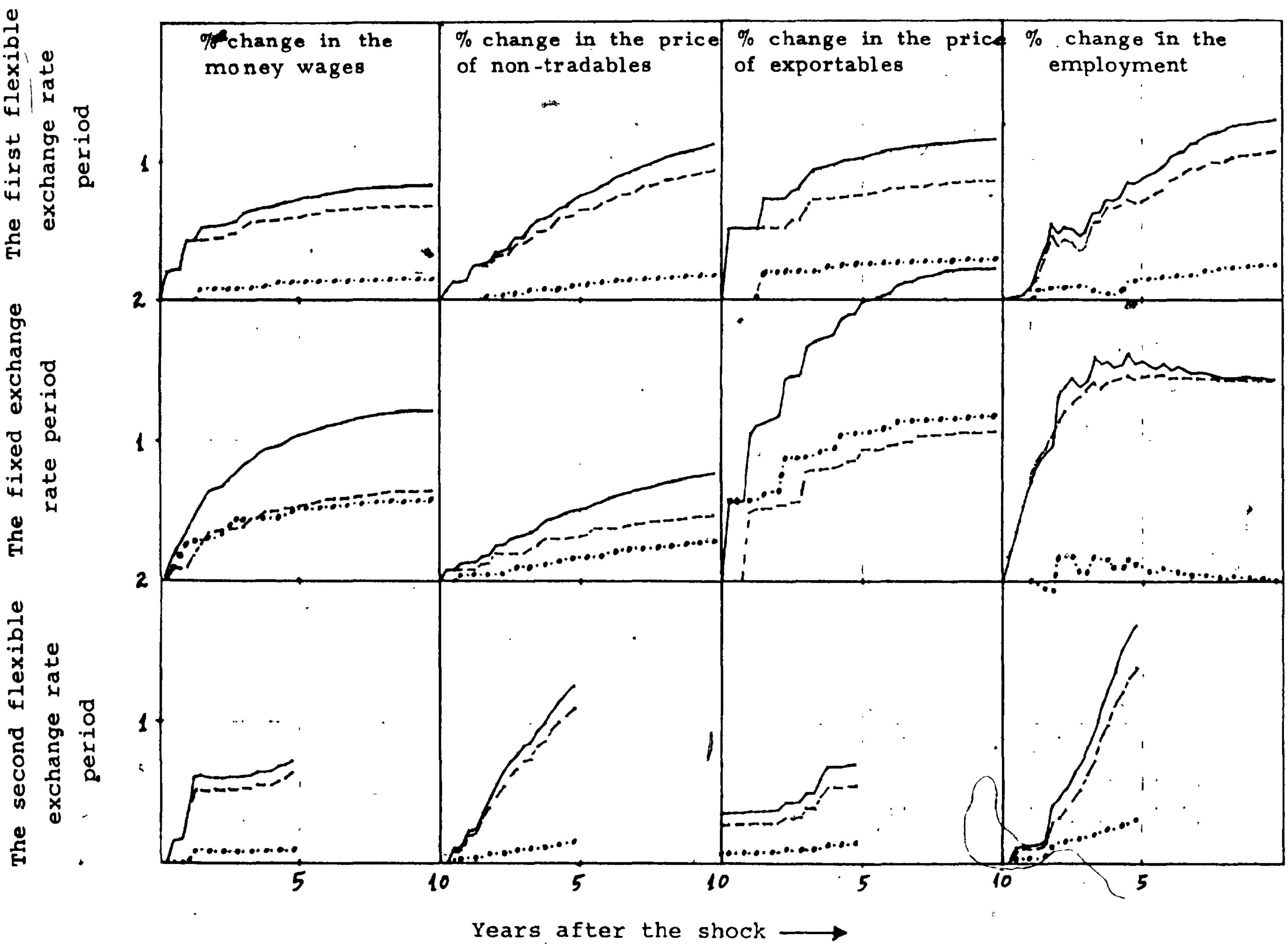
Thus all of our results are presented in Figure 6.1. The multiplier effects can be read from the slope of an appropriate curve, whereas the magnitude of a curve gives the size of the response of an endogenous variable at any time after the shock. Figure 6.1 is used to analyze the multiplier effects in the next section. In deriving the results from Figure 6.1, we assume no structural change of the model, and leave aside the balance of payments problem caused by a hypothetical shock.

Figure 6.1 Cumulative effects of a 1% devaluation of Canadian dollars, of a 1% increase in the domestic price of imports, and of a 1% decrease in the foreign price of Canadian exports

Solid line (——) : Effects of a 1% devaluation of Canadian dollars

Broken line (- - - -) : Effects of a 1% increase in the domestic price of importables caused by a change in Canadian import tax

Dotted line (-•-•-•-) : Effects of a 1% decrease in the foreign price of Canadian exports caused by a change in Canadian export subsidy


The first flexible exchange rate period
The fixed exchange rate period
The second flexible exchange rate period
% change in the money wages
% change in the price of non-tradables
% change in the price of exportables
% change in the employment
1
2
5
10
Years after the shock →

3. Analysis of the multiplier effects

From Figure 6.1, the multiplier effects of a devaluation or of a selective commercial policy can be analyzed by: i) comparing responses of different endogenous variables within one period of the exchange rate (along the row) and ii) comparing responses of each endogenous variable in different periods of the exchange rate (along the column). The comparisons will be presented in terms of

a) the relative responses of the three output prices in the model so that some light may be shed on the issue of sectorial effects. We must note here that the adjustment of the price of importables is according to the assumption in the model and is not derived empirically as in the cases of the output prices of non-tradable and exportable goods,

b) the relative speed and magnitude of adjustments, and the correlation between wages and prices so that some light may be shed on the "dynamic" correlation between general wages and different prices, and on the issue of real wage adjustments in different sectors which affect employment.

c) the employment effects.

3.1 The first flexible exchange rate period

In this period, we will analyze the effects due to a devaluation and due to a change in a commercial policy.

a) Effects of a devaluation

We observe that in the first flexible exchange rate period, immediately after the devaluation, the price of exportables increases substantially compared to the price of non-tradables. But after 5 years, the rate of increases in the price of exportables slows down. We expect that the price of importables increases by the amount of the devaluation within 5 years after the shock. Therefore, if the devaluation effects are sterilized within five years, the sectors producing tradable goods (exportable and importable) will be in better positions relative to before than the sector producing non-tradable goods. However, if all devaluation effects are allowed to work out in the system, the relative positions of different sectors resulting from the devaluation are not clear.

We also observe that the wage adjustment follows closely the adjustment pattern of the price of exportables. This indicates that there is a high "dynamic" correlation between increases in wages and in the price of exportables after the devaluation. This result takes into account not only a single wage equation, but also the internal dynamic structure of the model. Within four years after the devaluation, the total increase in wages is greater than the total increase in the price of non-tradables. But after that period, general wages start to level off, whereas the price of non-tradables continues to increase.

The result is that the magnitude of the total effects on money wages is less than the total effects on all individual output prices. Hence, real wages will ultimately go down in all sectors of the economy after the devaluation.

Employment increases slowly in the first year and then accelerates for up to six or seven years after the devaluation. There are some "noise" effects in employment in the period from two to four years after the devaluation.

b) Effects of a change in the domestic price of imports or in the foreign price of Canadian exports

It is obvious from Figure 6.1 that a 1% change in domestic import price has much greater effects on our endogenous variables than the same size of change in the foreign price of Canadian exports. The pattern of the effects and the speeds of adjustments of the endogenous variables due to a 1% change in domestic import prices follow closely those resulting from a devaluation. This explains why the price of importables is so important to Canadian inflation that it is included as an explanatory variable in most Canadian price models.

We note here that an increase in the domestic price of importables will affect the other variables through both demand (due to substitution) and supply sides (due to the use of importables as material inputs). Whereas an increase in the foreign price of Canadian exports does not affect the domestic price of importables, and affects the other variables in the model only through the excess foreign demand.

Similar to the effects of a devaluation, the immediate effects of an import tax will make the sector producing tradable goods (importable and exportable) in a better position relative to before than the sector producing non-tradable goods. But if all effects are allowed to work out in the system, the sector producing exportable goods seems to be worse off. On the contrary, if an export subsidy is imposed, the foreign export demand is stimulated, but due to the assumption of our model, nothing will happen to the domestic price of importables. The result is that the sector producing exportables is better off and the sector producing importables is worse off in terms of relative prices.

In the two shocks caused by changes in commercial policies, the wage adjustment follows closely the pattern of the price of exportables. Real wages ultimately go down in all sectors after an increase in an import tax. But if an export subsidy is imposed, real wages go up in the sector producing importable goods and down in the other two sectors.

### 3.2 The fixed exchange rate period

#### a) Effects of a devaluation

In this period, the increase in the price of exportables due to a devaluation clearly dominates the increase in the price of non-tradables. The difference is due not only to the faster speeds of adjustment but also to the higher magnitude of response of the price of exportables than that of the price of non-tradables. There is a significant lag in the adjustment of the price of non-tradables, whereas most of the effects on the price of exportables fall within 5 years after the devaluation. Comparing the total effects on the prices of the three goods in the model, the devaluation clearly turns against the sector producing non-tradable goods in the fixed exchange rate period. By assumption, the price of importables increases by the same amount as the devaluation. Therefore, looking at the total effects on output prices, we can say that the devaluation helps to improve the position of sectors producing exportables at the expense of the sector producing non-tradable goods.

The increase in money wages also follows closely the increase in the price of exportables; although the degree of correlation is less than that in the first flexible exchange rate period. The real wages are up in the sectors producing importable and non-tradable goods, but down in the sector producing exportables. Hence it is not clear whether or not the average real wage is down due to the devaluation.

Employment is increased rapidly in the first three years after the devaluation, then it starts to level off. Since the real wages go up in sectors producing non-tradable goods and importable goods, we expect that employment in these sectors may be reduced. In order to make general employment increase, the sector producing exportable goods must absorb not only the transfer of employment from the other two sectors but also other labour in the labour force. Hence, for industrial strategy, a devaluation seems to be appropriate within the context of our model to stimulate the sector producing exportable goods during this period of the exchange rate.

b) Effects of a change in the domestic price of imports or in the foreign price of Canadian exports

Due to the feature that the price of exportables is very sensitive in this period, the differences between the effects resulting from a change in the domestic import price and a change of the same size in the foreign export price is reduced significantly. The effects on the price of non-tradables and on money wages are still greater due to a shock in the domestic import price than due to a shock in the foreign price of Canadian exports. However, this difference is reversed in the effects on the price of exportable goods.

For the effects of a change in the domestic price of importables, the sectors producing importable and exportable goods are better off at the expense of the sector producing non-tradables in terms of output prices. However, if the shock is due to an increase in the foreign price of Canadian exports, the sector producing exportable goods is much better off at the expense of the sector producing importable goods.

The wage adjustments, due to the two shocks caused by the commercial policies, have a certain degree of correlation with the price of exportable goods; but not as high as in the case of the first flexible exchange rate period. The real wages go down in the sectors producing exportable and importable goods but up in the sector producing non-tradable goods if the shock is caused by a change in the domestic price of importables. However, if the shock is caused by a change in the foreign price of Canadian exports, the real wages go down in the sector producing exportable goods, but up in the other two sectors.

One interesting thing is the effect on employment. The effect caused by a change in the domestic import price is still much greater than the effect caused by a change in the foreign price of Canadian exports.

3.3 The second flexible exchange rate period

Before analyzing the results of this period, we want to make some reservations. First, there are only three years of observations which were actually used to estimate the model. Second, the simulation is extended only to a five-year period, therefore some effects may not yet have worked out completely in the system. Taking cautiously these qualifications, we now look at the simulation results in this period.

a) Effects of a devaluation

The impact effects on the price of exportable goods are still greatest compared to the responses of other endogenous variables. The price of non-tradable goods responds faster than it did in the previous two periods of the exchange rate.

The increase in money wages has a high degree of correlation with the increase in the price of exportable goods. Similar to the first flexible exchange rate period, the money wage inflation is less than the increases of all output prices. Hence real wages are definitely going down in all sectors after a devaluation.

Employment increases slowly at the beginning. But the rate of adjustment increases sharply at around two years after the devaluation.

b) Effects of a change in the domestic price of imports or in the foreign price of Canadian exports

The pattern of effects from a change in the domestic price of imports or in the foreign price of Canadian exports are very similar to those in the first flexible exchange rate period.

3.4 Comparison of the multiplier effects in the different periods of the exchange rage

In this section, we are going to compare the multiplier effects on each endogenous variable in different periods of the exchange rate.

a) Price of exportable goods

In all periods of the exchange rate, most of the effects on the price of exportables fall within three years after the devaluation. Whereas, the effects on other endogenous variables have longer lags due to the interrelationships among variables within the model.

The pattern of response of the price of exportables is different in each exchange rate period. In the flexible exchange rate periods, the price of exportables seems to respond immediately and then levels off. In the fixed exchange rate period, the effect of the devaluation is also highest in the first year, but the effect continues to build. The result is that the magnitude of the total effect on the price of exportables is greater in the fixed exchange rate period than in the flexible exchange rate periods.

The dynamic response of the price of exportables due to a change in the domestic price of importables or to a change in the foreign price of Canadian exports is also different in different exchange rate periods. In the flexible exchange rate periods, the dynamic response due to a change in the price of importables is much greater than that due to a change in the foreign price of Canadian exports. However, in the fixed exchange rate period, the dynamic response is greater for a change in the foreign price of Canadian exports than for a change in the price of importables.

b) Price of non-tradable goods

Similar to the effects on the price of exportable goods, the speeds of adjustment of the price of non-tradables after a devaluation are greater in the flexible exchange rate periods than in the fixed exchange rate period. The adjustments in the flexible exchange rate periods do not level off immediately as in the case of the price of exportables, but rather they take a longer time than does the price of exportables before all effects are worked out. The result is that the total effect on the price of non-tradables after a devaluation is greater in the flexible exchange rate periods than in the fixed exchange rate period.

In terms of commercial policies, the price of non-tradables is dynamically more sensitive to a change in the domestic price of imports than to an exogenous change in the foreign price of Canadian exports. The magnitude of this difference is significantly greater in the flexible exchange rate periods than in the fixed exchange rate period.

c) Money wages

In the flexible exchange rate periods, most of the effects on money wages appear within two to three years after the devaluation. In the fixed exchange rate period, the adjustment process takes a longer time. However, the total magnitude of the response of money wages is greater in the fixed exchange rate period than in the flexible exchange rate periods.

The response of wages due to a change in the domestic price of imports is greater in the flexible exchange rate periods than in the fixed exchange rate periods. However the response of wages due to a change in the foreign price of Canadian exports is greater in the fixed exchange rate period than in the flexible exchange rate periods.

d) Employment

The speed of adjustment of employment after a devaluation is faster in the fixed exchange rate period than in the flexible exchange rate periods. However, the total effect on employment is not significantly different in different exchange rate periods.

The responses of employment to selective commercial policies are significantly different from the responses of other prices and wages. The speed of the response is always faster and the magnitudes are always greater in the case of a change in an import tax than in the case of a change in an export subsidy.

Having analyzed our results, we now try to compare some of our empirical propositions with those derived from other empirical studies. Strictly speaking, it is not very meaningful to compare, especially quantitatively, the

In this respect, it can be seen that the 1-year total effect of an increase in the price of importables in our model is comparable in magnitude with the impact effect obtained in the TRACE model. (We use approximate weights, in that the output shares of exports and imports are .25 each. Hence, the output share of non-tradable goods is approximately .5 ). However, the total effect found in our model is larger than the .55 reported by Bodkin. Therefore, our results indicate that the Canadian economy is more open than the result suggested by the simplified version of the wage-price sub-model derived from TRACE. Besides the disparity in model specifications and the nature of the experiment, this difference may be due to the channels through which the price of importables is allowed to influence domestic prices in the two models. In the simplified version of the TRACE wage-price sub-model, the price of importables is allowed to affect the aggregate price through the cost side. There is a simultaneous effect between the aggregate price and wages in this model. On the other hand, the price of importables in our model is allowed to enter the cost channel of each sector to affect the wage equation, and to enter the demands for three goods.

4.2 <u>Comparison with Kwack's model</u>

We present in Table 6.2 multiplier effects of a devaluation of the Canadian dollar in the three estimation periods. We want to compare these results with those non-agriculture business sector [5]. With this assumption, Bodkin linearized wage and price equations in TRACE to form the wage-price sector which conformed to the Phillips framework. It is found in this wage-price sub-model that the impact effect of a 1% change in the price of importables on the consumer price index is .37%, and the equilibrium effect is .55%.

Before comparing these results with ours, we need to point out basic differences between the TRACE model and our model. In the TRACE model, annual data are used with a distinction between fixed and flexible exchange rate periods of the Canadian economy. Under the flexible exchange rate system, the exchange rate is endogenous. The wage equation is fitted for the period 1949-1966, whereas the price equation is fitted for the years 1928-1940 and 1947-1966. The above impact and equilibrium effects of the TRACE model are derived in the trade-off framework, in which only the wage and price equations are used. The assumption in this framework is that the structural forms of the wage and price equations will continue to hold in the steady state, in which the rate of changes in employment is equal to the rate of changes in labour supply, and the unemployment rate is exogenous. Hence, for any given unemployment rate, the percentage change in the consumer price index can be calculated. This experiment is different in nature from our experiment, in which our model is actually simulated.

During simulation, the labour supply is exogenous but employment is generated within the system so that the unemployment rate is endogenous. Ideally, our results should be compared to the simulated results from the TRACE model under the same conditions of labour supply and demand. Employment is explained endogenously in the TRACE model. Unfortunately, we do not have direct access to the model. Consequently, we use our one year total effect to compare with the impact effect, and our 10-year total effect to compare with the equilibrium effect in their model. In the case of the second flexible exchange rate period, we use our 5-year total effect instead of our 10-year total effect. An implicit assumption is that most of the effects will appear in the first 10 years after the devaluation, or within 5 years in the case of the second flexible exchange rate period.

In our model, quarterly data were used. The exchange rate is assumed to be exogenous under both fixed and flexible exchange rate systems. The equations are estimated for three different periods corresponding to different exchange rate systems in Canada. We present the multiplier effects of a 1% increase in the price of importables derived from our model in Table 6.1.

The aggregate price reported by Bodkin [5] can be considered as an index of our three prices, i.e., the prices of non-tradable, exportable and importable goods.

Table 6.1

Multiplier effects of a 1% increase in the price of importable goods

| | 1st flexible exchange rate period | Fixed exchange rate period | 2nd flexible exchange rate period |
|---|---|---|---|
| Percentage change in the price of non-tradables | | | |
| 1-year total effect | .139 | .092 | .1 |
| 5-year total effect | .606 | .322 | 1.109 |
| 10-year total effect | .921 | .471 | - |
| Percentage change in the price of exportables | | | |
| 1-year total effect | .509 | .0 | .288 |
| 5-year total effect | .735 | .854 | .565 |
| 10-year total effect | .841 | 1.062 | - |

In this respect, it can be seen that the 1-year total effect of an increase in the price of importables in our model is comparable in magnitude with the impact effect obtained in the TRACE model. (We use approximate weights, in that the output shares of exports and imports are .25 each. Hence, the output share of non-tradable goods is approximately .5 ). However, the total effect found in our model is larger than the .55 reported by Bodkin. Therefore, our results indicate that the Canadian economy is more open than the result suggested by the simplified version of the wage-price sub-model derived from TRACE. Besides the disparity in model specifications and the nature of the experiment, this difference may be due to the channels through which the price of importables is allowed to influence domestic prices in the two models. In the simplified version of the TRACE wage-price sub-model, the price of importables is allowed to affect the aggregate price through the cost side. There is a simultaneous effect between the aggregate price and wages in this model. On the other hand, the price of importables in our model is allowed to enter the cost channel of each sector to affect the wage equation, and to enter the demands for three goods.

4.2 Comparison with Kwack's model

We present in Table 6.2 multiplier effects of a devaluation of the Canadian dollar in the three estimation periods. We want to compare these results with those

Table 6.2

Multiplier effects of a 1% devaluation of the Canadian dollar

| | 1st flexible exchange rate period | Fixed exchange rate period | 2nd flexible exchange rate period |
|---|---|---|---|
| Percentage change in money wages | | | |
| 1-year total effect | .222 | .28 | .163 |
| 5-year total effect | .713 | 1.014 | .733 |
| 10-year total effect | .830 | 1.223 | - |
| Percentage change in the price of non-tradables | | | |
| 1-year total effect | .139 | .142 | .128 |
| 5-year total effect | .707 | .504 | 1.276 |
| 10-year total effect | 1.109 | .764 | - |
| Percentage change in the price of importables | 1 | 1 | 1 |
| Percentage change in the price of exportables | | | |
| 1-year total effect | .509 | .573 | .378 |
| 5-year total effect | 1.0 | 1.906 | .713 |
| 10-year total effect | 1.134 | 2.245 | - |
| Percentage change in the employment | | | |
| 1-year total effect | .042 | .525 | .131 |
| 5-year total effect | .829 | 1.545 | 1.689 |
| 10-year total effect | 1.288 | 1.443 | - |

obtained by Kwack [32].

Kwack reported that a 1% devaluation of the Canadian dollar has impact and equilibrium effects on the Canadian consumer price index as .21 and .92, respectively, under the condition that the unemployment rate is exogenous. Again, it is useful to point out the basic differences between Kwack's model and our model. Kwack used annual data from 1957 to 1973 with no distinction between fixed and flexible exchange rate periods. Furthermore, Kwack used a one sector model, in which the export price from one country is identical to the domestic price. Feedback effects from one country to another are taken into account in Kwack's simultaneous model. In our model, we assume that the foreign prices are exogenous. We use quarterly data and estimate the model separately for different periods of the exchange rate. The price of exportables and the price of non-tradables are considered to be different in our model. Furthermore, both demand and supply effects are considered in our model. On the other hand, in Kwack's model only the supply effect is considered. Kwack obtains his results by estimating wage-price equations in the Phillips' framework and assumes that these structural equations will continue to hold in the steady state, where the rate of change in labour supply is equal to the rate of change in employment. Our results are obtained from the direct simulation of the model, in which the labour supply is exogenous but employment is endogenous.

Taking these differences into account, our results indicate that the Canadian economy is more open than is suggested by Kwack's model.

To sum up this section, we observe that if the openness of an economy can be measured in terms of the size of the changes in domestic variables in response to an exogenous change in the foreign price of imports or in the exchange rate, our results indicate greater openness of the Canadian economy due to the greater response of domestic variables in our model than those derived from the wage-price sub-model of TRACE or from Kwack's model.

5. Conclusion

We have outlined in Chapter I that our objective is to shed some light on the following short-run issues resulting from a hypothetical devaluation or a change in some commercial policies:

a) How output prices adjust in different sectors.

b) What happens to employment in various sectors.

c) How the movement of wages is related to the movement of different output prices.

In order to accomplish this objective, we constructed a short-run econometric model, which is a synthesis from two strands of current literature: Phillips curve and devaluation analyses. The model is designed to take into account a) the importance of changes in absolute prices (including the price of labour), and b) the importance of relative prices. We estimated the model for three different exchange rate periods, and used statistical tests to determine the significance of each estimated coefficient as well as to detect any structural change from one exchange rate period to another.

Having found that the model is "reasonable", we conducted multiplier analyses of a devaluation and of a change in the domestic price of importables or a change in the foreign price of Canadian exports. We then compared some empirical implications of our results with those derived from TRACE and Kwack's model. The comparisons did not have a direct link to our objective since the other models were not designed specifically to study the adjustment paths of prices, wages and employment. However, by doing this comparison, we have some information on how different basic assumptions lead to different results. Thus, if we compare the multiplier analyses obtained from this thesis with the results derived from the wage-price sub-sector of TRACE and from Kwack's model, our results indicate greater domestic price response to a devaluation or to an exogenous change of the foreign price of imports.

At the present state of the art, multiplier analyses and a comparison with other econometric models are the only available tools to understand the behavior of the model (13). However, judging from the theoretical specification of our model, the size of the coefficients and the dynamic responses of the model, we can reasonably draw the following conclusions:

a) Sectorial price effects

Immediately after a devaluation, the increase in the price of exportables is always greater than the increase in the price of non-tradables. We expect that the impact effects on the price of importables is also substantially greater than the effects on the price of non-tradables. Therefore, the effects immediately after a devaluation, are in favor of the foreign trade sectors. This holds in all three exchange rate periods.

If all devaluation effects are allowed to work out completely in the system, the relative positions in terms of the relative output prices of different sectors (importable, exportable and non-tradable) are not clear for the flexible exchange rate periods. However, during the fixed exchange rate period, the sector producing exportable goods is definitely better off as the result of a devaluation.

If the shock is caused by a 1% increase in the domestic price of importables, the sector producing importable goods is always better off in terms of relative output prices. As the results of this shock, in the fixed exchange rate period, the sector producing non-tradable goods is worse off; whereas in the flexible exchange rate periods, the sector producing exportable goods is worse off.

If the shock is caused by a 1% decrease in the foreign price of Canadian exports due to an export subsidy, the sector producing importable goods is worse off. As the results of this shock, the sector producing exportable goods is always better off; but it is much better off in the fixed exchange rate period than in the flexible exchange rate periods.

b) Employment effects

Employment always increases after a devaluation in all exchange rate periods. However, the speed and the shape of the adjustment path of employment are different in different exchange rate periods. In the first flexible exchange rate period, the effect on employment builds up slowly in the first year with most of the increase in the second year after the devaluation. In the fixed exchange rate period, employment increases immediately at a faster rate than in the first flexible exchange rate period. Consequently, the cumulative effect in the fixed exchange rate period reaches its maximum at around four years after the devaluation and then levels off. In the second flexible exchange rate period, the employment effect adjusts slowly in the first two years after the devaluation, then increases greatly for up to five years or more after the exchange rate change.

The increase in employment after a devaluation may be the result of the decrease in real wages and/or a shed considerable light on the short-run effects of a devaluation or of a change in some commercial policies. However, the quality of the results could be improved if better data were available. We feel that much more information can be derived if disaggregated labour markets can be considered explicitly to take into account the labour characteristics of different sectors. Another possibility that may improve the model is to endogenize foreign prices to take into account economic interdependence between countries within the world economic system.

## APPENDIX A

### Derivation of marginal cost and input demands from the production function

A General Cobb-Douglas production technology which has labour (L), capital (K), non-tradables (N), importables (M) and exportables (X) as inputs is

$$Q = A_1 e^{h_1 t} L^{\ell} N^{n} M^{m} X^{x} K^{\alpha} \qquad \text{(A-1)}$$

where $Q$ = output

$A_1$ = a constant

$h_1$ = Hicks' neutral technological change

$t$ = time trend

$\ell, n, m, x, \alpha$ = shares of labour, non-tradable, importable and exportable goods, and capital in the production function.

If long-run constant return to scale is imposed on the production function, we have

$$\ell + n + m + x + \alpha = 1 \qquad \text{(A-2)}$$

The derived results used in our estimation do not depend crucially on this constraint. From equation (A-1), if one input is not used in the production function, the share of that input is zero. Furthermore, if capital is assumed to be constant or to grow at a constant rate (c), we can simplify equation (A-1) as:

$$Q = A e^{ht} L^{\ell} N^{n} M^{m} X^{x} \qquad \text{(A-3)}$$

where $A = A_1 \overline{K}^{\alpha}$ and $h = h_1$ if capital stock is constant,

$A = A_1 K_0^{\alpha}$ and $h = h_1 + c\,\alpha$ if capital stock is growing at a constant rate c

$K_o$ = initial capital stock

Due to our assumption that the capital stock is either constant or growing at a constant rate, the price of capital does not enter the variable cost equation. To derive the marginal cost curve or the supply side of the sector, we have to derive a variable cost function in which inputs are chosen to minimize the cost at any production point. The problem is to choose L, N, M and X to minimize

$$C = W L + P_N N + P_M M + P_X X$$

subject to $Q = Q^*$. W, $P_N$, $P_M$ and $P_X$ are prices of labour, non-tradable, importable and exportable goods respectively.

A Lagrange function for this minimization problem is

$$\Psi = W L + P_N N + P_M M + P_X X - \lambda (A e^{ht} L^{\ell} N^n M^m X^x - Q^*) \quad \text{(A-4)}$$

The necessary conditions for the minimization are

$$\partial\Psi/\partial L = W - \lambda \ell (Q/L) = 0 \quad ; \quad L = (\lambda \ell Q/W) \quad \text{(A-5)}$$

$$\partial\Psi/\partial N = P_N - \lambda n (Q/N) = 0 \quad ; \quad N = (\lambda n Q/P_N) \quad \text{(A-6)}$$

$$\partial\Psi/\partial M = P_M - \lambda m (Q/M) = 0 \quad ; \quad M = (\lambda m Q/P_M) \quad \text{(A-7)}$$

$$\partial\Psi/\partial X = P_X - \lambda x (Q/X) = 0 \quad ; \quad X = (\lambda x Q/P_X) \quad \text{(A-8)}$$

$$\partial\Psi/\partial \lambda = Q^* - A e^{ht} L^{\ell} N^n M^m X^x = 0 \quad \text{(A-9)}$$

Substitute the values of L, N, M and X from equations (A-5), (A-6), (A-7) and (A-8) into equation (A-9), and solve for $\lambda$ we have

$$\lambda = (Q^*/A)^{(1/\beta)} e^{-(ht/\beta)} Q^{-1} (\ell/W)^{-(\ell/\beta)} (n/P_N)^{-(n/\beta)} (m/P_M)^{-(m/\beta)} (x/P_X)^{-(x/\beta)} \quad \text{(A-10)}$$

where $\beta = \ell + n + m + x$ = shares of all other inputs except capital in the production function.

Substituting the value of $\lambda$ from equation (A-10) into equations (A-5), (A-6), (A-7) and (A-8), we have

$$L^* = (Q^*/A)^{(1/\beta)} e^{-ht/\beta} (\ell/W)^{1-(\ell/\beta)} (n/P_N)^{-n/\beta} (m/P_M)^{-m/\beta} (x/P_X)^{-x/\beta} \quad \text{(A-11)}$$

$$N^* = (Q^*/A)^{1/\beta} e^{-ht/\beta} (\ell/W)^{-\ell/\beta} (n/P_N)^{1-(n/\beta)} (m/P_M)^{-m/\beta} (x/P_X)^{-x/\beta} \quad \text{(A-12)}$$

$$M^* = (Q^*/A)^{1/\beta} e^{-ht/\beta} (\ell/W)^{-\ell/\beta} (n/P_N)^{-n/\beta} (m/P_M)^{1-(m/\beta)} (x/P_X)^{-x/\beta} \quad \text{(A-13)}$$

$$X^* = (Q^*/A)^{1/\beta} e^{-ht/\beta} (\ell/W)^{-\ell/\beta} (n/P_N)^{-n/\beta} (m/P_M)^{-m/\beta} (x/P_X)^{1-(x/\beta)} \quad \text{(A-14)}$$

Equations (A-11), (A-12), (A-13) and (A-14) give the optimal input demands for the production of output at $Q^*$. Given the prices of inputs, if we substitute the optimal input demands from equations (A-11), (A-12), (A-13) and (A-14) into the variable cost equation, we have the variable cost function

$$C = W L^* + P_N N^* + P_M M^* + P_X X^* \quad \text{(A-15)}$$

$$\text{or} \quad C = B\, W^{l/\beta} P_N^{n/\beta} P_M^{m/\beta} P_X^{x/\beta} Q^{*1/\beta} e^{-(h/\beta)t} \quad \text{(A-16)}$$

$$\text{where} \quad B = \beta(A\, l^l n^n m^m x^x)^{-(1/\beta)}$$

Marginal cost to produce any level of output $Q^*$ is

$$MC = \partial C/\partial Q^* = (B/\beta) W^{l/\beta} P_N^{n/\beta} P_M^{m/\beta} P_X^{x/\beta} (Q^*)^{(1-\beta)/\beta} e^{-(h/\beta)t} \quad \text{(A-17)}$$

Input demands to produce the output $Q^*$ are given by equations (A-11), (A-12), (A-13) and (A-14). Simplifying these equations, we have

$$L = (lB/\beta) W^{-(\beta-l)/\beta} P_N^{n/\beta} P_M^{m/\beta} P_X^{x/\beta} (Q^*)^{1/\beta} e^{-(h/\beta)t} \quad \text{(A-18)}$$

$$N = (nB/\beta) W^{l/\beta} P_N^{-(\beta-n)/\beta} P_M^{m/\beta} P_X^{x/\beta} (Q^*)^{1/\beta} e^{-(h/\beta)t} \quad \text{(A-19)}$$

$$M = (mB/\beta) W^{l/\beta} P_N^{n/\beta} P_M^{-(\beta-m)/\beta} P_X^{x/\beta} (Q^*)^{1/\beta} e^{-(h/\beta)t} \quad \text{(A-20)}$$

$$X = (xB/\beta) W^{l/\beta} P_N^{n/\beta} P_M^{m/\beta} P_X^{-(\beta-x)/\beta} (Q^*)^{1/\beta} e^{-(h/\beta)t} \quad \text{(A-21)}$$

Taking natural log on both sides of equations (A-17), (A-18), (A-19), (A-20) and (A-21), we have

$$\ln MC = \ln(B/\beta) + (\ell/\beta)\ln W + (n/\beta)\ln P_N + (m/\beta)\ln P_M + (x/\beta)\ln P_X + ((1-\beta)/\beta)\ln Q^* - (h/\beta)\,t \tag{A-22}$$

$$\ln L = \ln(\ell B/\beta) - ((\beta-\ell)/\beta)\ln W + (n/\beta)\ln P_N + (m/\beta)\ln P_M + (x/\beta)\ln P_X + (1/\beta)\ln Q^* - (h/\beta)t \tag{A-23}$$

$$\ln N = \ln(nB/\beta) + (\ell/\beta)\ln W - ((\beta-n)/\beta)\ln P_N + (m/\beta)\ln P_M + (x/\beta)\ln P_X + (1/\beta)\ln Q^* - (h/\beta)t \tag{A-24}$$

$$\ln M = \ln(mB/\beta) + (\ell/\beta)\ln W + (n/\beta)\ln P_N - ((\beta-m)/\beta)\ln P_M + (x/\beta)\ln P_X + (1/\beta)\ln Q^* - (h/\beta)\,t \tag{A-25}$$

$$\ln X = \ln(xB/\beta) + (\ell/\beta)\ln W + (n/\beta)\ln P_N + (m/\beta)\ln P_M - ((\beta-x)/\beta)\ln P_X + (1/\beta)\ln Q^* - (h/\beta)\,t \tag{A-26}$$

## APPENDIX B

### Derivation of the expected demands of the three sectors when production technology in each sector is of Cobb-Douglas type

If the production technology is of Cobb-Douglas type, expected input demands in each sector to produce an expected output $\hat{Q}_i$ (i = N, M, X) are represented by equations (A-23), (A-24), (A-25) and (A-26) in Appendix A. Let superscript (^) represent the expected value of the relevant variable, we have:

$$\ln \hat{L}_i = \ln(\ell_i B_i/\beta_i) - ((\beta_i-\ell_i)/\beta_i) \ln \hat{W} + (n_i/\beta_i) \ln \hat{P}_N + (m_i/\beta_i) \ln \hat{P}_M + (x_i/\beta_i) \ln \hat{P}_X + (1/\beta_i) \ln \hat{Q}_i - (h_i/\beta_i)\, t \qquad \text{(B-1)}$$

$$\ln \hat{N}_i = \ln(n_i B_i/\beta_i) + (\ell_i/\beta_i) \ln \hat{W} - ((\beta_i-n_i)/\beta_i) \ln \hat{P}_N + (m_i/\beta_i) \ln \hat{P}_M + (x_i/\beta_i) \ln \hat{P}_X + (1/\beta_i) \ln \hat{Q}_i - (h_i/\beta_i)\, t \qquad \text{(B-2)}$$

$$\ln \hat{M}_i = \ln(m_i B_i/\beta_i) + (\ell_i/\beta_i) \ln \hat{W} + (n_i/\beta_i) \ln \hat{P}_N - ((\beta_i-m_i)/\beta_i) \ln \hat{P}_M + (x_i/\beta_i) \ln \hat{P}_X + (1/\beta_i) \ln \hat{Q}_i - (h_i/\beta_i)\, t \qquad \text{(B-3)}$$

$$\ln \hat{X}_i = \ln(x_i B_i/\beta_i) + (\ell_i/\beta_i) \ln \hat{W} + (n_i/\beta_i) \ln \hat{P}_N$$
$$+ (m_i/\beta_i) \ln \hat{P}_M - ((\beta_i - x_i)/\beta_i) \ln \hat{P}_X + (1/\beta_i) \ln \hat{Q}_i$$
$$- (h_i/\beta_i)\, t \qquad \text{(B-4)}$$

Sector producing importable goods.

In this sector, the foreign supply of importable goods is assumed to be infinitely elastic. Given the expected domestic price of importable goods, domestic producers in this sector will equate this expected price to expected marginal cost.

$$\ln \hat{P}_M = \ln(B_M/\beta_M) + (\ell_M/\beta_M) \ln \hat{W} + (n_M/\beta_M) \ln \hat{P}_N$$
$$+ (m_M/\beta_M) \ln \hat{P}_M + (x_M/\beta_M) \ln \hat{P}_X$$
$$+ ((1-\beta_M)/\beta_M) \ln \hat{Q}_M - (h_M/\beta_M)\, t \qquad \text{(B-5)}$$

The expected output in the sector producing importable goods is:

$$\ln \hat{Q}_M = -((\beta_M/(1-\beta_M)) \ln(B_M/\beta_M)) - (\ell_M/(1-\beta_M)) \ln \hat{W}$$
$$- (n_M/(1-\beta_M)) \ln \hat{P}_N + ((\beta_M - m_M)/(1-\beta_M)) \ln \hat{P}_M$$
$$- (x_M/(1-\beta_M)) \ln \hat{P}_X + (h_M/(1-\beta_M))\, t \qquad \text{(B-6)}$$

Sector producing non-tradable goods.

Total domestic demand for non-tradable goods is the sum of consumption demand and production demand. Production demand for non-tradable goods is the sum of demands used as material inputs in the production of the three sectors.

$$\hat{D}_N^d = \hat{D}_N^c + (\hat{D}_N^I)_N + (\hat{D}_N^I)_M + (\hat{D}_N^I)_X \quad \text{(B-7)}$$

where $\hat{D}_N^d$ = domestic demand for non-tradable goods.

$\hat{D}_N^c$ = domestic consumption demand for non-tradable goods.

$(\hat{D}_N^I)_N$, $(\hat{D}_N^I)_M$, $(\hat{D}_N^I)_X$ = production demands for non-tradable goods in the sectors producing non-tradable, importable and exportable goods.

Using a simple log-linear consumption demand for non-tradable goods, we have: (11)

$$\ln \hat{D}_N^c = b_N + c_N \ln(\hat{P}_M/\hat{P}_N) + d_N \ln(\hat{P}_X/\hat{P}_N) + e_N \ln \hat{I}_d \quad \text{(B-8)}$$

This demand relationship is homogeneous of degree zero with respect to prices and money income. It is expected that the sign of $c_N$, $d_N$ and $e_N$ are all positive. Equation (B-8) can be written as

$$\ln \hat{D}_N^c = b_N - (c_N + d_N) \ln \hat{P}_N + c_N \ln \hat{P}_M + d_N \ln \hat{P}_X + e_N \ln \hat{I}_d \quad \text{(B-9)}$$

Production demand for non-tradable goods in the three sectors are given by equation (B-2), in which i = N, M, X.

$$\ln(\hat{D}_N^I)_N = \ln(n_N B_N/\beta_N) + (\ell_N/\beta_N) \ln \hat{W} - ((\beta_N - n_N)/\beta_N) \ln \hat{P}_N + (m_N/\beta_N) \ln \hat{P}_M + (x_N/\beta_N) \ln \hat{P}_X + (1/\beta_N) \ln \hat{Q}_N - (h_N/\beta_N)\, t \tag{B-10}$$

$$\ln(\hat{D}_N^I)_M = \ln(n_M B_M/\beta_M) + (\ell_M/\beta_M) \ln \hat{W} - ((\beta_M - n_M)/\beta_M) \ln \hat{P}_N + (m_M/\beta_M) \ln \hat{P}_M + (x_M/\beta_M) \ln \hat{P}_X + (1/\beta_M) \ln \hat{Q}_M - (h_M/\beta_M)\, t \tag{B-11}$$

$$\ln(\hat{D}_N^I)_X = \ln(n_X B_X/\beta_X) + (\ell_X/\beta_X) \ln \hat{W} - ((\beta_X - n_X)/\beta_X) \ln \hat{P}_N + (m_X/\beta_X) \ln \hat{P}_M + (x_X/\beta_X) \ln \hat{P}_X + (1/\beta_X) \ln \hat{Q}_X - (h_X/\beta_X)\, t \tag{B-12}$$

Using equations (B-9), (B-10), (B-11) and (B-12), total domestic demand for non-tradable goods in equation (B-7) can be calculated. This is in level form. To express the relationship of equation (B-7) in the log-linear form, we linearize equation (B-7), using a first order approximation of the Taylor series (10).

$$\ln(\hat{D}_N^d) = d_{ON} + d_{1N} \ln \hat{D}_N^c + d_{2N} (\hat{D}_N^I)_N + d_{3N} (\hat{D}_N^I)_M + d_{4N} (\hat{D}_N^I)_X \tag{B-13}$$

where $d_{oN}$, $d_{1N}$, $d_{2N}$, $d_{3N}$ and $d_{4N}$ are constant. The values of $d_{1N}$, $d_{2N}$, $d_{3N}$ and $d_{4N}$ are smaller than 1. Producers in the sector producing non-tradable goods have their expected output equal to their expected demand, i.e., $\ln \hat{D}_N^d = \ln \hat{Q}_N$. Substituting equations (B-9) to (B-12) into equation (B-13), we have:

$$\ln \hat{Q}_N = g_{oN} + g_{1N} \ln \hat{W} + g_{2N} \ln \hat{P}_N + g_{3N} \ln \hat{P}_M + g_{4N} \ln \hat{P}_X + g_{5N}\, t + g_{6N} \ln \hat{I}_d + g_{7N} \ln \hat{Q}_X \tag{B-14}$$

where

$$g_{oN} = (\beta_N/(\beta_N - d_{2N}))(d_{oN} + d_{1N}\, b_N + d_{2N} \ln(n_N B_N/\beta_N) + d_{3N} \ln(n_M B_M/\beta_M) + d_{4N} \ln(n_X B_X/\beta_X) - d_{3N}(1/\beta_M)(\beta_M/(1-\beta_M)) \ln(B_M/\beta_M))$$

$$g_{1N} = (\beta_N/(\beta_N - d_{2N}))(d_{2N}(\ell_N/\beta_N) + d_{3N}(\ell_M/\beta_M) + d_{4N}(\ell_X/\beta_X) - d_{3N}(1/\beta_M)(\ell_M/(1-\beta_M)))$$

$$g_{2N} = -(\beta_N/(\beta_N - d_{2N}))(d_{1N}(c_N + d_N) + d_{2N}((\beta_N - n_N)/\beta_N) + d_{3N}((\beta_M - n_M)/\beta_M) + d_{4N}((\beta_X - n_X)/\beta_X) + d_{3N}(1/\beta_M)(n_M/(1-\beta_M)))$$

$$g_{3N} = (\beta_N/(\beta_N - d_{2N}))(d_{1N} c_N + d_{2N}(m_N/\beta_N) + d_{3N}(m_M/\beta_M) + d_{4N}(m_X/\beta_X) + d_{3N}(1/\beta_M)((\beta_M - m_M)/(1-\beta_M)))$$

$$g_{4N} = (\beta_N/(\beta_N - d_{2N}))(d_{1N} d_N + d_{2N}(x_N/\beta_N) + d_{3N}(x_M/\beta_M) + d_{4N}(x_X/\beta_X) - d_{3N}(1/\beta_M)(x_M/(1-\beta_M)))$$

$$g_{5N} = -(\beta_N/(\beta_N - d_{2N}))(d_{2N}(h_N/\beta_N) + d_{3N}(h_M/\beta_M) + d_{4N}(h_X/\beta_X)$$

$$- d_{3N}(1/\beta_M)(h_M/(1-\beta_M)))$$

$$g_{6N} = (\beta_N/(\beta_N - d_{2N}))\ d_{1N}\ e_N$$

$$g_{7N} = (\beta_N/(\beta_N - d_{2N}))\ d_{4N}(1/\beta_X)$$

It is expected that:

$(\beta_N - d_{2N}) > 0$. The value of $\beta_N$ is the total share of all inputs (including non-tradable goods), except capital, in the production of non-tradable goods; whereas, $d_{2N}$ is the only share of non-tradable goods used as an input in the production of non-tradable goods.

$g_{1N} > 0$. An increase in money wages will increase demand for non-tradable goods as inputs in the production functions of the three sectors. This increase is off-set partly by a decrease in the production of importables due to an increase in the cost of this sector.

$g_{2N} < 0$. An increase in the price of non-tradable goods will decrease consumption and production demands for non-tradable goods through substitution effects, and further decrease production demand for non-tradable goods in the sector producing importable goods due to the decrease in the total output in this sector.

$g_{3N} > 0$. An increase in the price of importable goods will increase both consumption and production demands for non-tradable goods through price substitution effects, and further increase the production demand for non-tradable goods due to an increase in the output of importable goods.

$g_{4N} > 0$. An increase in the price of exportable goods will increase both consumption and production demands for non-tradable goods through price substitution effects. This increase is off-set partly by a decrease in the production of importables due to an increase in the cost.

$g_{5N} < 0$. Positive technological change coupled with the accumulation of capital stock will make inputs in the production functions of the three sectors more productive. Hence, the requirement of these inputs decreases when the same amount of output is produced. This decrease is offset partly by an increase in input demands due to the increase in output of importable goods.

$g_{6N} > 0$. An increase in real domestic product will increase consumption demand for non-tradables.

$g_{7N} > 0$

<u>Sector producing exportable goods</u>.

In this sector, total demand is equal to foreign demand plus domestic demand. The domestic demand is in turn equal to

$$\ln \hat{D}^f_X = b^f_X + c^f_X \ln (\hat{P}_f) - c^f_X \ln \hat{P}_X + d^f_X \ln \hat{I}_f \tag{B-21}$$

Production demands for exportable goods in the three sectors are given by equation (B-4), in which i = N, M, X.

$$\ln(\hat{D}^I_X)_N = \ln(x_N B_N/\beta_N) + (\ell_N/\beta_N) \ln \hat{W} + (n_N/\beta_N) \ln \hat{P}_N + (m_N/\beta_N) \ln \hat{P}_M - ((\beta_N - x_N)/\beta_N) \ln \hat{P}_X + (1/\beta_N) \ln \hat{Q}_N - (h_N/\beta_N)\ t \tag{B-22}$$

$$\ln(\hat{D}^I_X)_M = \ln(x_M B_M/\beta_M) + (\ell_M/\beta_M) \ln \hat{W} + (n_M/\beta_M) \ln \hat{P}_N + (m_M/\beta_M) \ln \hat{P}_M - ((\beta_M - x_M)/\beta_M) \ln \hat{P}_X + (1/\beta_M) \ln \hat{Q}_M - (h_M/\beta_M)\ t \tag{B-23}$$

$$\ln(\hat{D}^I_X)_X = \ln(x_X B_X/\beta_X) + (\ell_X/\beta_X) \ln \hat{W} \quad (n_X/\beta_X) \ln \hat{P}_N + (m_X/\beta_X) \ln \hat{P}_M - ((\beta_X - x_X)/\beta_X) \ln \hat{P}_X + (1/\beta_X) \ln \hat{Q}_X - (h_X/\beta_X)\ t \tag{B-24}$$

Similar to the derivation in the sector producing non-tradable goods, we express total demand for exportable goods in equation (B-17) in log-linear form, using the first order approximation of the Taylor series (10)

$$\ln \hat{D}_X = d_{oX} + d_{1X} \ln \hat{D}^C_X + d_{2X}(\hat{D}^I_X)_N + d_{3X}(\hat{D}^I_X)_M + d_{4X}(\hat{D}^I_X)_X + d_{5X} \ln \hat{D}^f_X \tag{B-25}$$

where $d_{oX}$, $d_{1X}$, $d_{2X}$, $d_{3X}$, $d_{4X}$ and $d_{5X}$ are constant. The values of $d_{1X}$, $d_{2X}$, $d_{3X}$, $d_{4X}$ and $d_{5X}$ are smaller than 1. (Alternatively, final result can be obtained by deriving functional relationship of total demand for exportable goods, and we assume that this relationship is in log-linear form). Producers in the sector producing exportable goods have their expected output equal to their expected demand, i.e., $\ln \hat{D}_X = \ln \hat{Q}_X$. Substituting equations (B-20) to (B-24) into equation (B-25), we have

$$\ln \hat{Q}_X = g_{oX} + g_{1X} \ln \hat{W} + g_{2X} \ln \hat{P}_N + g_{3X} \ln \hat{P}_M + g_{4X} \ln \hat{P}_X$$
$$+ g_{5X}\, t + g_{6X} \ln \hat{I}_d + g_{7X} \ln \hat{I}_f + g_{8X} \ln \hat{P}_f + g_{9X} \ln \hat{Q}_N \quad \text{(B-26)}$$

where
$$g_{oX} = (\beta_X/(\beta_X-d_{4X}))(d_{oX} + d_{1X} b_X^c + d_{2X} \ln(x_N B_N/\beta_N)$$
$$+ d_{3X} \ln(x_M B_M/\beta_M) + d_{4X} \ln(x_X B_X/\beta_X) + d_{5X} b_X^f$$
$$- d_{3X}(1/(1-\beta_M)) \ln(B_M/\beta_M))$$

$$g_{1X} = (\beta_X/(\beta_X-d_{4X}))(d_{2X}(\ell_N/\beta_N) + d_{3X}(\ell_M/\beta_M) + d_{4X}(\ell_X/\beta_X)$$
$$- d_{3X}(1/\beta_M)(\ell_M/(1-\beta_M)))$$

$$g_{2X} = (\beta_X/(\beta_X-d_X))(d_{1X} d_X^c + d_{2X}(n_N/\beta_N) + d_{3X}(n_M/\beta_M)$$
$$+ d_{4X}(n_X/\beta_X) - d_{3X}(1/\beta_M)(n_M/(1-\beta_M)))$$

$$g_{3X} = (\beta_X/(\beta_X-d_X))(d_{1X} c_X^c + d_{2X}(m_N/\beta_N) + d_{3X}(m_M/\beta_M)$$
$$+ d_{4X}(m_X/\beta_X) + d_{3X}(1/\beta_M)((\beta_M-m_M)/(1-\beta_M))),$$

$$g_{4X} = -(\beta_X/(\beta_X-d_X))(d_{1X}(c_X^c+d_X^c) + d_{2X}((\beta_N-x_N)/\beta_N)$$

$$+ d_{3X}((\beta_M-x_M)/\beta_M) + d_{4X}((\beta_X-x_X)/\beta_X) + d_{5X}\ c_X^f$$

$$+ d_{3X}(1/\beta_M)(x_M/(1-\beta_M)))$$

$$g_{5X} = -(\beta_X/(\beta_X-d_X))(d_{2X}(h_N/\beta_N) + d_{3X}(h_M/\beta_M) + d_{4X}(h_X/\beta_X)$$

$$- d_{3X}(1/\beta_M)(h_M/(1-\beta_M)))$$

$$g_{6X} = d_{1X}\ e_X^c$$

$$g_{7X} = d_{5X}\ d_X^f$$

$$g_{8X} = d_{5X}\ c_x^f$$

$$g_{9X} = d_{2X}(1/\beta_N)$$

It is expected that:

$(\beta_X - d_{4X}) > 0$. The value of $\beta_X$ is the total share of all inputs (including exportable goods) except capital in the production of exportable goods, whereas $d_{4X}$ is the only share of exportable goods used as inputs in the production of exportable goods.

$g_{1X} > 0$. An increase in money wages will cause an increase in demand for exportable goods in the production functions of the three sectors. This increase is offset partly by a decrease in the production of importables due to the increase in the cost.

$g_{2X} > 0$. An increase in the price of non-tradables will cause an increase in both consumption and production demands for exportable goods through price substitution effect. This increase is offset partly by a decrease in the production of importable goods due to an increase in cost.

$g_{3X} > 0$. An increase in the price of importables causes an increase in both consumption and production demands for exportable goods through the price substitution effect. Demand for exportable goods is further increased due to an increase in the output of importable goods, which will require more inputs.

$g_{4X} < 0$. An increase in the price of exportables will cause a decrease in domestic consumption, production demands and foreign demand for exportable goods through price substitution effects. Demand for exportable goods is further decreased in the sector producing importable goods due to a decrease in the total output in this sector.

$g_{5X} < 0$. Positive technological change coupled with the accumulation of capital stock will make inputs in the production functions of the three sectors more productive. Hence, the requirement of these inputs decrease . This decrease is offset partly by an increase in input demands due to the increase in output of importable goods.

$g_{6X} > 0$; $g_{7X} > 0$; $g_{8X} > 0$ and $g_{9X} > 0$.

Substituting equation (B-26) into equation (B-14), we have expected output of non-tradable goods in terms of expected prices and costs.

$$\ln \hat{Q}_N = k_{oN} + k_{1N} \ln \hat{W} + k_{2N} \ln \hat{P}_N + k_{3N} \ln \hat{P}_M + k_{4N} \ln \hat{P}_X$$
$$+ k_{5N}\, t + k_{6N} \ln \hat{I}_d + k_{7N} \ln \hat{I}_f + k_{8N} \ln \hat{P}_f \qquad \text{(B-27)}$$

where $k_{oN} = (1/(1-g_{7N}g_{9N}))(g_{0N}\ g_{7N}g_{oX})$

$k_{1N} = (1/(1-g_{7N}g_{9X}))(g_{1N}\ g_{7N}g_{1X})$

$k_{2N} = (1/(1-g_{7N}g_{9X}))(g_{2N}\ g_{7N}g_{2X})$

$k_{3N} = (1/(1-g_{7N}g_{9X}))(g_{3N}\ g_{7N}g_{3X})$

$k_{4N} = (1/(1-g_{7N}g_{9X}))(g_{4N}\ g_{7N}g_{4X})$

$k_{5N} = (1/(1-g_{7N}g_{9X}))(g_{5N}\ g_{7N}g_{5X})$

$k_{6N} = (1/(1-g_{7N}g_{9X}))(g_{6N}\ g_{7N}g_{6X})$

$k_{7N} = (1/(1-g_{7N}g_{9X}))(g_{7N}g_{7X})$

$k_{8N} = (1/(1-g_{7N}g_{9X}))(g_{7N}g_{8X})$

It is expected that:

$$g_{7N}g_{9X} = (\beta_N/(\beta_N - d_{2N}))(d_{4N}/\beta_X) = (d_{4N}/(\beta_N - d_{2N}))(d_{2X}/\beta_X) < 1$$

since $d_{4N} < (\beta_N - d_{2N})$ and $d_{2X} < \beta_X$

$k_{1N} > 0$; $k_{2N} < 0$ ( since we expect that $|g_{2N}| > |g_{7N}g_{2X}|$ );

$k_{3N} > 0$; $k_{4N} > 0$; $k_{5N} < 0$; $k_{6N} > 0$; $k_{7N} > 0$ and $k_{8N} > 0$.

If non-tradable goods are not used as material inputs in the production of exportable goods, then $d_{4N} = 0$ or equivalently $k_{7N} = k_{8N} = 0$.

To find the expected output of exportable goods in terms of expected prices and costs, we substitute equation (B-27) into equation (B-26).

$$\ln \hat{Q}_X = k_{oX} + k_{1X} \ln \hat{W} + k_{2X} \ln \hat{P}_N + k_{3X} \ln \hat{P}_M + k_{4X} \ln \hat{P}_X + k_{5X} t + k_{6X} \ln \hat{I}_d + k_{7X} \ln \hat{I}_f + k_{8X} \ln \hat{P}_f \quad \text{(B-28)}$$

where $k_{oX} = g_{oX} + g_{9X} k_{oN}$ ; $k_{1X} = g_{1X} + g_{9X} k_{1N} > 0$ ;

$k_{2X} = g_{2X} + g_{9X} k_{2N} > 0$ ; $k_{3X} = g_{3X} + g_{9X} k_{3N} > 0$ ;

$k_{4X} = g_{4X} + g_{9X} k_{4N} < 0$ ; $k_{5X} = g_{5X} + g_{9X} k_{5N} < 0$ ;

$k_{6X} = g_{6X} + g_{9X} k_{6N} > 0$ ; $k_{7X} = g_{7X} + g_{9X} k_{7N} > 0$ ;

$k_{8X} = g_{8X} + g_{9X} k_{8N} > 0$ .

## APPENDIX C

### Partial adjustment mechanism leading to the actual variable from a desired variable

Let $Y^e$ stand for ln $P_N^e$ in equation (2.39) and A.X be vectors of the corresponding right hand side variables. Equation (2.39) can be represented as

$$Y^e = A \cdot X \qquad (C\text{-}1)$$

The partial adjustment mechanism that is postulated is

$$Y_t - Y_{t-1} = \lambda (Y_t^e - Y_{t-1}) + e_t \; ; \quad (0 \leq \lambda \leq 1) \qquad (C\text{-}2)$$

$Y_t^e$ is interpreted as the desired level of $Y_t$, and $\lambda$ is the adjustment coefficient. It is implied in equation (C-2) that the adjustment is not instantaneous, due either to high cost of adjustment and/or inertia within some economic units. Hence, the partial adjustment mechanism attributes the lags to technological and psychological inertia, and to resistance due to the cost of rapid change. Substituting equation (C-1) into equation (C-2), we have

$$Y_t = \lambda A \cdot X + (1 - \lambda) Y_{t-1} + e_t \qquad (C\text{-}3)$$

In the above adjustment mechanism, we implicitly assume that firms make their adjustment from period to period; in our case, it is from quarter to quarter. Since there is no reason why the time span should be one quarter, we choose a more flexible scheme where $Y_{t-1}$ is replaced by $[Y]_*$, a lagged endogenous variable, which will be determined empirically. Hence, equation (C-3) becomes

$$Y_t = \lambda\, A \,.\, X + (1 - \lambda)[Y]_* + e_t \qquad \text{(C-4)}$$

APPENDIX D

Import and export shares of the eight largest trading partners of the Canadian economy

Table D.1

| | Share of imports from U.S. in total — Canadian imports | | | | Share of exports to U.S. in total — Canadian Exports | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| 1953 | .764 | .764 | .711 | .713 | .631 | .576 | .574 | .593 |
| 1954 | .745 | .726 | .705 | .72 | .621 | .606 | .60 | .58 |
| 1955 | .751 | .738 | .716 | .717 | .601 | .593 | .608 | .613 |
| 1956 | .755 | .732 | .699 | .723 | .611 | .586 | .584 | .592 |
| 1957 | .757 | .717 | .685 | .68 | .593 | .604 | .604 | .591 |
| 1958 | .722 | .691 | .669 | .662 | .602 | .554 | .615 | .60 |
| 1959 | .715 | .678 | .648 | .656 | .616 | .63 | .622 | .609 |
| 1960 | .709 | .674 | .65 | .657 | .596 | .585 | .553 | .525 |
| 1961 | .698 | .666 | .66 | .66 | .535 | .544 | .547 | .552 |
| 1962 | .719 | .693 | .67 | .668 | .614 | .587 | .598 | .567 |
| 1963 | .729 | .682 | .652 | .656 | .591 | .576 | .572 | .515 |
| 1964 | .727 | .688 | .671 | .677 | .541 | .525 | .523 | .551 |
| 1965 | .738 | .698 | .679 | .692 | .585 | .589 | .581 | .547 |
| 1966 | .737 | .728 | .678 | .718 | .605 | .619 | .567 | .623 |
| 1967 | .758 | .73 | .712 | .727 | .63 | .623 | .644 | .669 |
| 1968 | .759 | .739 | .708 | .724 | .684 | .675 | .657 | .693 |
| 1969 | .76 | .725 | .693 | .723 | .713 | .708 | .687 | .728 |
| 1970 | .748 | .723 | .691 | .68 | .669 | .66 | .622 | .64 |
| 1971 | .734 | .712 | .684 | .68 | .675 | .69 | .66 | .674 |
| 1972 | .691 | .697 | .667 | .701 | .73 | .697 | .684 | .669 |
| 1973 | .709 | .724 | .685 | .709 | .716 | .69 | .647 | .651 |

Table D.2

| | Share of imports from Belgium in total Canadian imports | | | | Share of exports to Belgium in total Canadian exports | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| 1953 | .00553 | .00767 | .00729 | .0067 | .0137 | .0175 | .0182 | .0173 |
| 1954 | .00594 | .00586 | .00668 | .00684 | .0117 | .0127 | .014 | .0174 |
| 1955 | .004444 | .00627 | .00576 | .00844 | .0108 | .0125 | .0164 | .0126 |
| 1956 | .00512 | .0106 | .011 | .0109 | .0099 | .0125 | .012 | .0133 |
| 1957 | .00621 | .0104 | .00873 | .00659 | .0134 | .0106 | .0112 | .0145 |
| 1958 | .0048 | .00586 | .00753 | .0101 | .0089 | .0226 | .015 | .0101 |
| 1959 | .00526 | .00801 | .00923 | .00978 | .0105 | .0087 | .0135 | .0114 |
| 1960 | .00513 | .00852 | .00826 | .00799 | .0093 | .0108 | .0152 | .0159 |
| 1961 | .00484 | .00642 | .00836 | .0107 | .0114 | .013 | .0134 | .0139 |
| 1962 | .00497 | .00859 | .00865 | .00865 | .0118 | .0112 | .0094 | .0113 |
| 1963 | .00446 | .00678 | .00823 | .00886 | .0102 | .0086 | .0102 | .0152 |
| 1964 | .00471 | .00689 | .00912 | .0104 | .0094 | .0083 | .014 | .0166 |
| 1965 | .00609 | .0103 | .00926 | .00736 | .0145 | .0129 | .0125 | .0184 |
| 1966 | .00454 | .0059 | .00718 | .00661 | .0115 | .0092 | .0132 | .0121 |
| 1967 | .0061 | .00534 | .0072 | .00525 | .0079 | .0083 | .0107 | .009 |
| 1968 | .00388 | .00403 | .00541 | .00525 | .0087 | .0095 | .0095 | .0099 |
| 1969 | .00352 | .00494 | .00431 | .00436 | .0071 | .0076 | .0082 | .0089 |
| 1970 | .00279 | .0038 | .00397 | .00421 | .0103 | .0124 | .0112 | .0117 |
| 1971 | .00321 | .00392 | .00375 | .00412 | .0102 | .0105 | .0109 | .0095 |
| 1972 | .00417 | .00497 | .00522 | .00492 | .006 | .0103 | .0097 | .0129 |
| 1973 | .00436 | .0045 | .00438 | .00455 | .0111 | .01 | .0119 | .0121 |

Table D.3

| | Share of imports from France in total Canadian imports | | | | Share of exports to France in total Canadian exports | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| 1953 | .0043 | .0059 | .00467 | .00581 | .0074 | .0072 | .0069 | .01 |
| 1954 | .00462 | .00531 | .00564 | .00654 | .0101 | .0095 | .0074 | .008 |
| 1955 | .00444 | .00508 | .0055 | .00653 | .0084 | .0114 | .0099 | .0102 |
| 1956 | .00416 | .00627 | .00672 | .00617 | .0123 | .0103 | .0102 | .0118 |
| 1957 | .00457 | .00717 | .00769 | .0069 | .0146 | .014 | .011 | .0084 |
| 1958 | .00463 | .0069 | .00928 | .0109 | .0095 | .0126 | .0083 | .007 |
| 1959 | .00788 | .0105 | .0128 | .00999 | .0074 | .0084 | .0056 | .0119 |
| 1960 | .00648 | .01 | .0106 | .00943 | .0156 | .0124 | .0126 | .0141 |
| 1961 | .00718 | .00973 | .0101 | .0103 | .0138 | .0138 | .0127 | .0097 |
| 1962 | .00701 | .009 | .0102 | .00961 | .0075 | .0093 | .0085 | .0116 |
| 1963 | .00629 | .00925 | .0095 | .00992 | .0125 | .0088 | .0082 | .0086 |
| 1964 | .00604 | .00972 | .00934 | .0111 | .0091 | .011 | .0086 | .0103 |
| 1965 | .00614 | .0115 | .0128 | .0131 | .01 | .0097 | .0101 | .0109 |
| 1966 | .00894 | .00958 | .0114 | .0122 | .0089 | .0065 | .0103 | .008 |
| 1967 | .0102 | .0104 | .0148 | .0125 | .007 | .0075 | .007 | .0077 |
| 1968 | .00879 | .0094 | .011 | .0102 | .0054 | .0064 | .007 | .0058 |
| 1969 | .0103 | .00995 | .0125 | .0104 | .009 | .01 | .0083 | .0085 |
| 1970 | .00875 | .011 | .0127 | .0131 | .0092 | .0096 | .0093 | .0094 |
| 1971 | .0114 | .0135 | .0154 | .0141 | .0086 | .0087 | .0099 | .0082 |
| 1972 | .0132 | .0127 | .0159 | .0122 | .0074 | .0078 | .0081 | .0084 |
| 1973 | .013 | .0138 | .0153 | .014 | .0071 | .007 | .0102 | .01 |

| Table D.4 | Share of imports from West Germany in total Canadian imports | | | | Share of exports to West Germany in total Canadian exports | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| 1953 | .00573 | .00725 | .00972 | .0108 | .0081 | .024 | .0155 | .0316 |
| 1954 | .00671 | .0111 | .0137 | .0134 | .0106 | .0229 | .0265 | .0275 |
| 1955 | .00847 | .0115 | .0136 | .0143 | .0159 | .0223 | .0238 | .0234 |
| 1956 | .0121 | .0157 | .0173 | .019 | .0176 | .0288 | .0302 | .033 |
| 1957 | .0138 | .0178 | .0191 | .0206 | .0321 | .0249 | .0298 | .0397 |
| 1958 | .0166 | .0188 | .024 | .0218 | .0304 | .0508 | .0364 | .0459 |
| 1959 | .0188 | .0217 | .0247 | .0245 | .0241 | .025 | .0257 | .0269 |
| 1960 | .0207 | .0245 | .0221 | .025 | .0248 | .0247 | .0359 | .0381 |
| 1961 | .0211 | .0243 | .0241 | .0246 | .0312 | .0246 | .0272 | .0452 |
| 1962 | .0182 | .0262 | .0225 | .0229 | .0246 | .0254 | .0239 | .0386 |
| 1963 | .0153 | .0235 | .0221 | .0256 | .0205 | .0255 | .0238 | .0297 |
| 1964 | .0188 | .0222 | .0233 | .0262 | .0246 | .0262 | .0278 | .0257 |
| 1965 | .0187 | .0241 | .0238 | .029 | .0209 | .0192 | .0224 | .0249 |
| 1966 | .0191 | .0233 | .0271 | .0234 | .0186 | .016 | .0181 | .0171 |
| 1967 | .0208 | .0218 | .0259 | .026 | .0112 | .0164 | .0158 | .0194 |
| 1968 | .0197 | .025 | .0259 | .0257 | .0159 | .0164 | .0183 | .0175 |
| 1969 | .0188 | .027 | .0257 | .0282 | .0165 | .0199 | .0204 | .0186 |
| 1970 | .0215 | .0248 | .0272 | .033 | .0197 | .0208 | .0223 | .0291 |
| 1971 | .0257 | .026 | .0273 | .0305 | .0196 | .0199 | .0165 | .0165 |
| 1972 | .0261 | .0265 | .0301 | .0274 | .0116 | .0174 | .016 | .0175 |
| 1973 | .0264 | .0259 | .0267 | .0253 | .0138 | .0171 | .0219 | .0179 |

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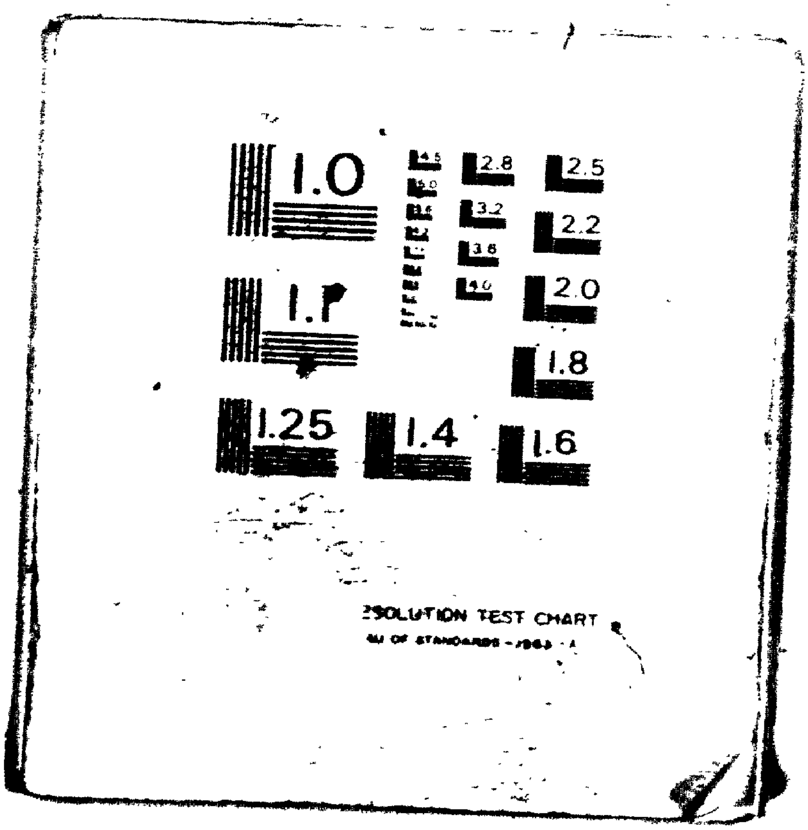


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Table D.6. Share of imports from Japan in total Canadian imports / Share of exports to Japan in total Canadian exports

| | Imports 1st | Imports 2nd | Imports 3rd | Imports 4th | Exports 1st | Exports 2nd | Exports 3rd | Exports 4th |
|---|---|---|---|---|---|---|---|---|
| 1953 | .00287 | .00245 | .00355 | .00305 | .0221 | .0157 | .0298 | .0464 |
| 1954 | .00319 | .00348 | .00553 | .00723 | .0413 | .0259 | .0159 | .0179 |
| 1955 | .0061 | .00678 | .00842 | .0104 | .0217 | .0225 | .0212 | .0193 |
| 1956 | .0104 | .0105 | .0117 | .0114 | .0194 | .0282 | .0299 | .0272 |
| 1957 | .0112 | .00982 | .0119 | .0124 | .0292 | .0271 | .0352 | .0226 |
| 1958 | .0112 | .0124 | .0148 | .0169 | .0249 | .0173 | .0208 | .0234 |
| 1959 | .0177 | .0173 | .0208 | .0189 | .0259 | .025 | .0307 | .027 |
| 1960 | .019 | .0187 | .0238 | .0192 | .034 | .0273 | .0369 | .0349 |
| 1961 | .0188 | .0192 | .0229 | .0199 | .037 | .0414 | .0425 | .0365 |
| 1962 | .018 | .0191 | .0227 | .0202 | .0354 | .0344 | .034 | .0324 |
| 1963 | .0165 | .0195 | .0224 | .0206 | .0433 | .0389 | .0453 | .0423 |
| 1964 | .0192 | .0211 | .0265 | .0259 | .0435 | .0382 | .0376 | .0415 |
| 1965 | .0217 | .027 | .031 | .0263 | .037 | .0383 | .0327 | .0368 |
| 1966 | .0234 | .0242 | .0289 | .024 | .0363 | .0367 | .0436 | .036 |
| 1967 | .026 | .02555 | .0336 | .0273 | .0561 | .0483 | .0509 | .0467 |
| 1968 | .0242 | .0268 | .0338 | .0314 | .0449 | .0441 | .0483 | .0416 |
| 1969 | .0292 | .033 | .039 | .0387 | .041 | .0418 | .049 | .0373 |
| 1970 | .0379 | .0378 | .0434 | .0484 | .0471 | .0454 | .0552 | .046 |
| 1971 | .0406 | .0466 | .0529 | .0632 | .0475 | .04 | .0511 | .0482 |
| 1972 | .0586 | .0574 | .0596 | .0545 | .0395 | .0472 | .0536 | .0505 |
| 1973 | .048 | .0436 | .0412 | .0413 | .0554 | .0704 | .0805 | .0781 |

Table D.7

| | Share of imports from Netherlands in total Canadian imports | | | | Share of exports to Netherlands in total Canadian exports | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| 1953 | .00328 | .0059 | .00617 | .00542 | .0056 | .0147 | .0105 | .0097 |
| 1954 | .00396 | .00586 | .00731 | .00555 | .007 | .0068 | .0096 | .0167 |
| 1955 | .0032 | .00475 | .00481 | .00541 | .0092 | .0111 | .0102 | .014 |
| 1956 | .0028 | .00464 | .00493 | .00463 | .0094 | .0091 | .0122 | .0144 |
| 1957 | .00299 | .00504 | .00545 | .00496 | .013 | .0126 | .0162 | .0153 |
| 1958 | .00334 | .00535 | .00611 | .00619 | .0185 | .0151 | .0146 | .0137 |
| 1959 | .00386 | .0056 | .00546 | .00607 | .0118 | .0075 | .0113 | .0119 |
| 1960 | .00445 | .00608 | .00602 | .00648 | .0109 | .0111 | .011 | .0138 |
| 1961 | .00507 | .00655 | .00595 | .00558 | .0111 | .0099 | .0126 | .0086 |
| 1962 | .00565 | .00584 | .00581 | .00615 | .0066 | .0129 | .0134 | .014 |
| 1963 | .00453 | .00654 | .0052 | .00591 | .0114 | .0124 | .0126 | .014 |
| 1964 | .00375 | .00572 | .00571 | .00585 | .015 | .0111 | .0101 | .0136 |
| 1965 | .00527 | .00691 | .00699 | .00667 | .0119 | .0134 | .0169 | .0162 |
| 1966 | .00472 | .0059 | .00669 | .0065 | .0142 | .0126 | .0136 | .0153 |
| 1967 | .00466 | .00605 | .00693 | .00619 | .012 | .0153 | .0177 | .0171 |
| 1968 | .00438 | .00612 | .00593 | .00577 | .0107 | .0124 | .0157 | .015 |
| 1969 | .0046 | .00586 | .00578 | .00595 | .0114 | .0119 | .0114 | .016 |
| 1970 | .00542 | .00565 | .0054 | .00614 | .0147 | .0144 | .018 | .0197 |
| 1971 | .0042 | .00419 | .00521 | .00581 | .014 | .0129 | .0127 | .0135 |
| 1972 | .00488 | .00431 | .00588 | .00466 | .0218 | .0954 | .0111 | .0107 |
| 1973 | .00503 | .00502 | .00555 | .00473 | .0072 | .0093 | .0121 | .016 |

**Table D.8**

| | Share of imports from U.K. in total | | | | Share of exports to U.K. in total | | | |
|---|---|---|---|---|---|---|---|---|
| | Canadian imports | | | | Canadian exports | | | |
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| 1953 | .0961 | .103 | .11 | .11 | .137 | .173 | .178 | .151 |
| 1954 | .0956 | .103 | .0976 | .0886 | .157 | .15 | .177 | .181 |
| 1955 | .0869 | .0814 | .0927 | .0838 | .19 | .185 | .179 | .164 |
| 1956 | .0773 | .0909 | .0912 | .083 | .173 | .153 | .175 | .176 |
| 1957 | .0835 | .0941 | .0945 | .0986 | .143 | .147 | .156 | .148 |
| 1958 | .0984 | .11 | .0998 | .101 | .142 | .164 | .158 | .167 |
| 1959 | .0885 | .112 | .114 | .11 | .156 | .148 | .155 | .158 |
| 1960 | .107 | .114 | .102 | .106 | .162 | .173 | .172 | .178 |
| 1961 | .111 | .116 | .101 | .101 | .175 | .148 | .152 | .153 |
| 1962 | .094 | .091 | .0917 | .0839 | .137 | .146 | .15 | .146 |
| 1963 | .0735 | .0836 | .0826 | .0806 | .142 | .151 | .156 | .134 |
| 1964 | .0751 | .0836 | .0739 | .0732 | .15 | .147 | .144 | .141 |
| 1965 | .0718 | .0711 | .0732 | .0709 | .144 | .141 | .134 | .125 |
| 1966 | .0731 | .0619 | .0735 | .0605 | .121 | .11 | .111 | .099 |
| 1967 | .0592 | .0657 | .0618 | .0517 | .108 | .104 | .101 | .101 |
| 1968 | .0565 | .0567 | .0564 | .0559 | .098 | .09 | .092 | .081 |
| 1969 | .0534 | .0614 | .0611 | .0482 | .083 | .076 | .075 | .067 |
| 1970 | .0508 | .0518 | .0546 | .0546 | .085 | .093 | .09 | .089 |
| 1971 | .0505 | .0525 | .0576 | .0536 | .078 | .081 | .079 | .075 |
| 1972 | .0546 | .0533 | .0458 | .0498 | .059 | .081 | .063 | .07 |
| 1973 | .0482 | .044 | .0441 | .0375 | .064 | .06 | .064 | .065 |

APPENDIX E

MULTIPLIER ANALYSES OF THE MODEL

Table E.11 Multiplier effects of a 1% decrease in the foreign price of Canadian exports in the fixed exchange rate period.

Table E.12 Multiplier effects of a 1% decrease in the foreign price of Canadian exports in the second flexible exchange rate period.

Table E.1

Multiplier effeots of a 1% devaluation of Canadian dollars in the first flexible exchange rate period

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1957 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .214 | .074 | .505 | .003 |
| | 3 | .007 | .063 | .002 | .012 |
| | 4 | .001 | .002 | .002 | .027 |
| 1958 | 1 | .211 | .001 | .001 | .050 |
| | 2 | .000 | .116 | .000 | .152 |
| | 3 | .088 | .001 | .207 | .118 |
| | 4 | .003 | .026 | .001 | .182 |
| 1959 | 1 | .011 | .065 | .001 | - .069 |
| | 2 | .010 | .005 | .002 | .043 |
| | 3 | .025 | .025 | .057 | - .018 |
| | 4 | .002 | .071 | .003 | - .046 |
| 1960 | 1 | .053 | .001 | .085 | .031 |
| | 2 | .025 | .077 | .057 | .126 |
| | 3 | .006 | .044 | .002 | .008 |
| | 4 | .020 | .006 | .025 | .093 |
| 1961 | 1 | .001 | .018 | .001 | - .003 |
| | 2 | .020 | .070 | .037 | .027 |

| | | | | | |
|---|---|---|---|---|---|
| 1961 | 3 | .013 | .007 | .005 | .108 |
| | 4 | .003 | .035 | .007 | -.015 |
| 5-year total effect | | .713 | .707 | 1.0 | .829 |
| 1962 | 1 | .012 | .040 | .002 | .030 |
| | 2 | .017 | .012 | .025 | .034 |
| | 3 | .004 | .024 | .007 | .019 |
| | 4 | .010 | .036 | .016 | .052 |
| 1963 | 1 | .017 | .009 | .016 | .050 |
| | 2 | .002 | .048 | .001 | .031 |
| | 3 | .010 | .023 | .011 | .022 |
| | 4 | .008 | .011 | .004 | .050 |
| 1964 | 1 | .005 | .018 | .007 | .002 |
| | 2 | .005 | .030 | .005 | .043 |
| | 3 | .004 | .009 | .007 | .020 |
| | 4 | .002 | .024 | .002 | .012 |
| 1965 | 1 | .003 | .021 | .007 | .018 |
| | 2 | .003 | .012 | .006 | .028 |
| | 3 | .003 | .016 | .003 | .009 |
| | 4 | .003 | .019 | .003 | .008 |
| 1966 | 1 | .003 | .008 | .003 | .008 |
| | 2 | .002 | .020 | .003 | .007 |
| | 3 | .002 | .012 | .003 | .007 |
| | 4 | .002 | .010 | .003 | .009 |
| 10-year total effect | | .830 | 1.109 | 1.134 | 1.288 |

Table E.2

Multiplier effects of a 1% devaluation of Canadian dollars in the fixed exchange rate period

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables $d(\ln P_N)$ | % change in the price of exportables $d(\ln P_X)$ | % change in employment d( ln L) |
|---|---|---|---|---|---|
| 1963 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .000 | .090 | .573 | .175 |
| | 3 | .188 | .000 | .000 | .175 |
| | 4 | .092 | .052 | .000 | .175 |
| 1964 | 1 | .098 | .002 | .494 | .175 |
| | 2 | .080 | .002 | .046 | .131 |
| | 3 | .090 | .043 | .023 | .069 |
| | 4 | .091 | .006 | .024 | .068 |
| 1965 | 1 | .015 | .067 | .020 | .345 |
| | 2 | .013 | .002 | .259 | .069 |
| | 3 | .049 | .039 | .022 | .061 |
| | 4 | .052 | .024 | .004 | - .063 |
| 1966 | 1 | .046 | .005 | .207 | .033 |
| | 2 | .040 | .032 | .031 | .179 |
| | 3 | .040 | .022 | .022 | - .058 |
| | 4 | .042 | .051 | .021 | .031 |
| 1967 | 1 | .014 | .005 | .018 | - .045 |
| | 2 | .011 | .029 | .117 | .014 |

| | | | | | |
|---|---|---|---|---|---|
| 1967 | 3 | .028 | .019 | .020 | .086 |
| | 4 | .025 | .014 | .005 | -.075 |
| 5-year total effect | | 1.014 | .504 | 1.906 | 1.545 |
| 1968 | 1 | .025 | .004 | .088 | .019 |
| | 2 | .019 | .017 | .020 | -.025 |
| | 3 | .019 | .044 | .015 | -.019 |
| | 4 | .021 | .005 | .015 | .035 |
| 1969 | 1 | .009 | .022 | .012 | -.039 |
| | 2 | .009 | .015 | .053 | .007 |
| | 3 | .013 | .011 | .013 | -.017 |
| | 4 | .014 | .022 | .004 | -.025 |
| 1970 | 1 | .012 | .013 | .038 | .017 |
| | 2 | .010 | .011 | .011 | -.012 |
| | 3 | .010 | .007 | .010 | -.013 |
| | 4 | .010 | .016 | .009 | -.009 |
| 1971 | 1 | .006 | .011 | .007 | -.014 |
| | 2 | .005 | .009 | .008 | .007 |
| | 3 | .005 | .010 | .008 | -.004 |
| | 4 | .005 | .011 | .003 | -.003 |
| 1972 | 1 | .005 | .012 | .007 | .001 |
| | 2 | .004 | .005 | .007 | -.007 |
| | 3 | .004 | .011 | .006 | .000 |
| | 4 | .004 | .004 | .005 | -.001 |
| 10-year total effect | | 1.223 | .764 | 2.245 | 1.443 |

Table E.3

Multiplier effects of a 1% devaluation of Canadian dollar in the second flexible exchange rate period

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1971 | 1 | .000 | .000 | .375 | .000 |
| | 2 | .001 | .001 | .000 | .000 |
| | 3 | .157 | .121 | .000 | .119 |
| | 4 | .005 | .006 | .003 | .012 |
| 1972 | 1 | .222 | .115 | .001 | .005 |
| | 2 | .215 | .020 | .002 | .010 |
| | 3 | .004 | .114 | .001 | .018 |
| | 4 | -.006 | .109 | .004 | .256 |
| 1973 | 1 | -.004 | .081 | .003 | .044 |
| | 2 | .004 | .089 | .052 | .079 |
| | 3 | .006 | .072 | .002 | .081 |
| | 4 | .004 | .051 | .002 | .077 |
| 1974 | 1 | .004 | .067 | .066 | .127 |
| | 2 | .003 | .026 | .003 | .116 |
| | 3 | .027 | .085 | .091 | .166 |
| | 4 | .002 | .049 | .090 | .136 |
| 1975 | 1 | .004 | .085 | .003 | .133 |
| | 2 | .034 | .072 | .002 | .133 |
| | 3 | .005 | .057 | .010 | .097 |
| | 4 | .046 | .056 | .003 | .080 |
| 5-year total effect | | .733 | 1.276 | .713 | 1.689 |

Figure E.1 Multiplier effects of a 1% devaluation of Canadian dollars on the money wages in the first flexible exchange rate period.

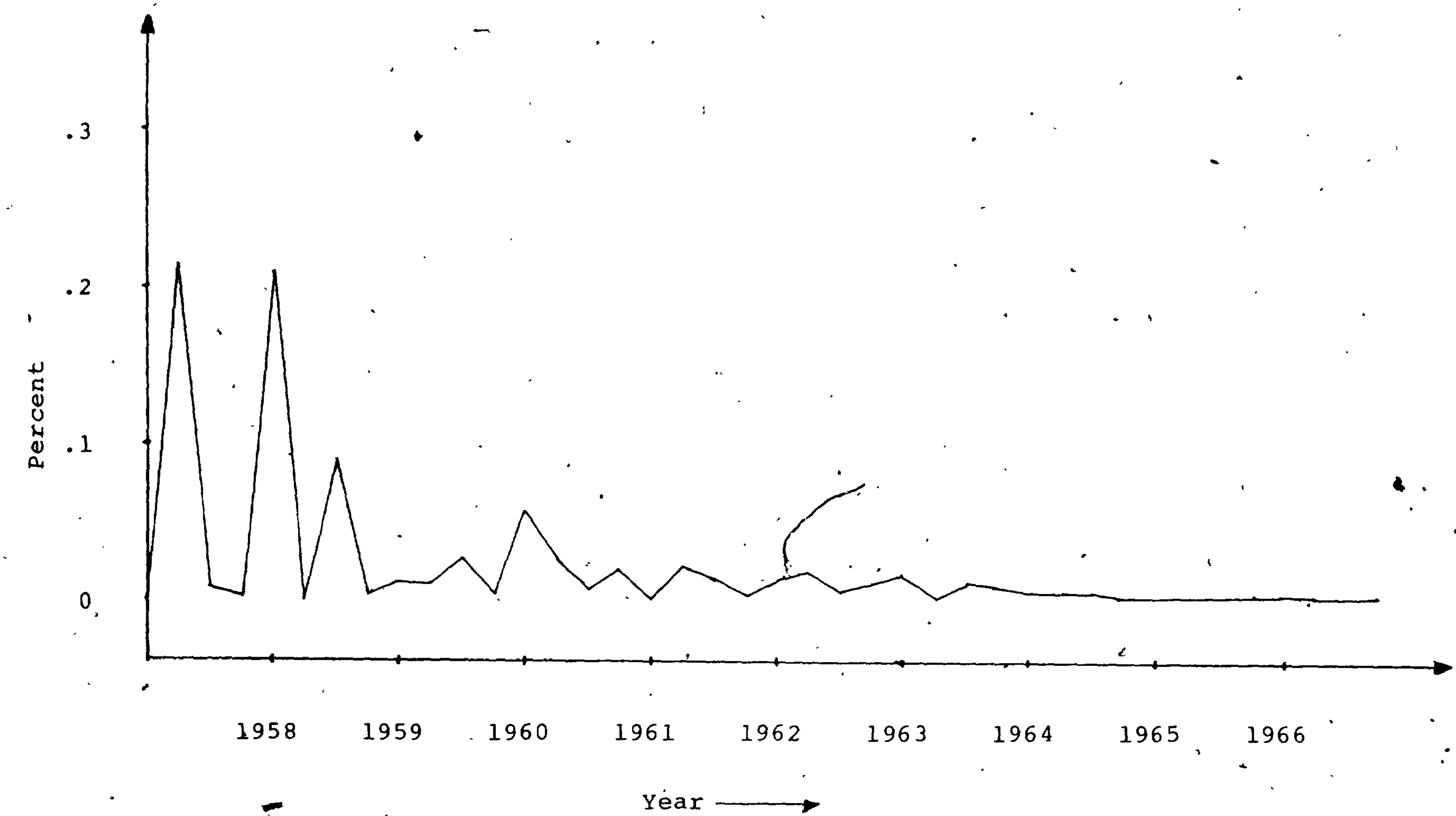
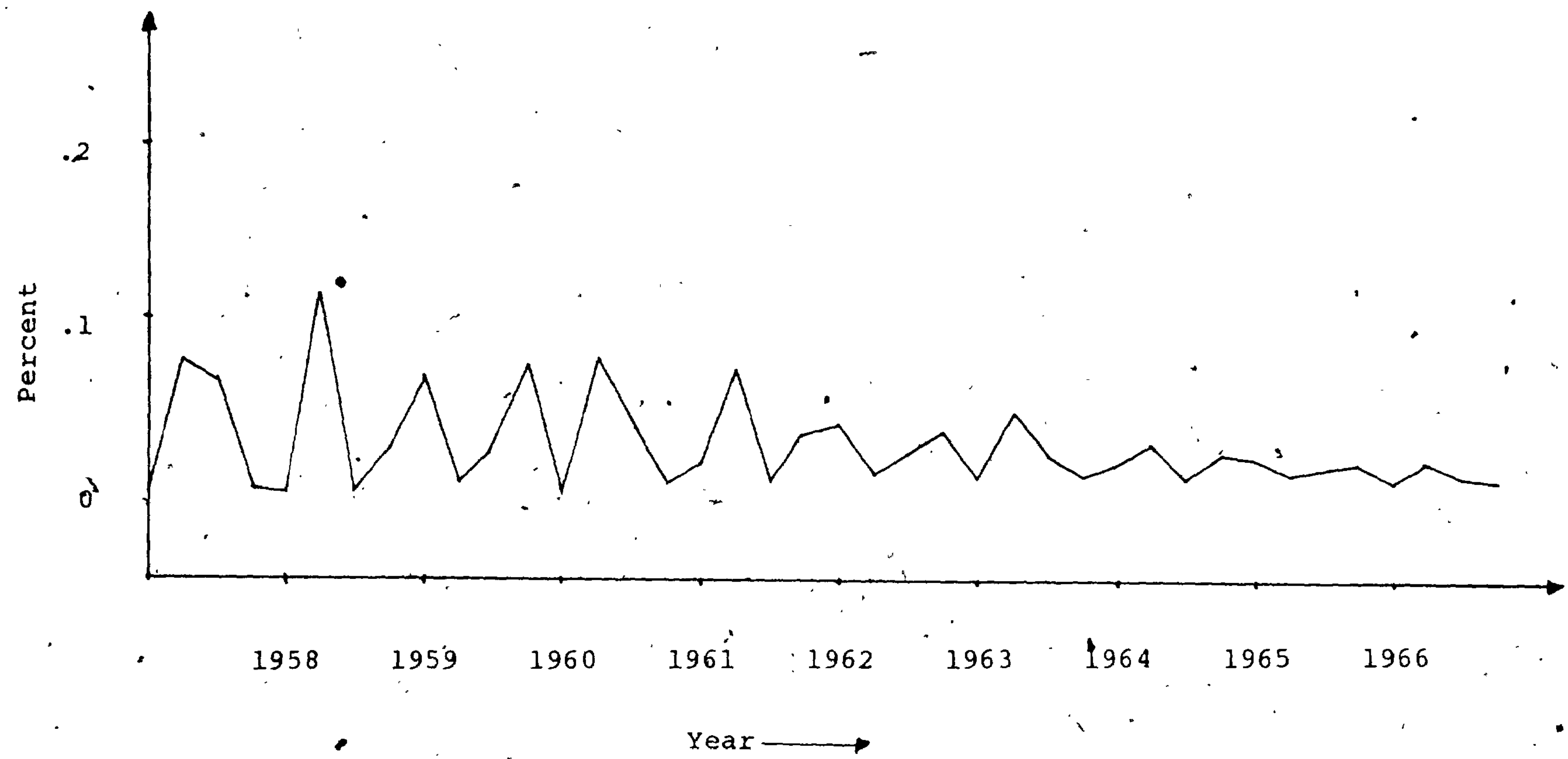


Figure E.2 Multiplier effects of a 1% devaluation of Canadian dollar on the price of non-tradable goods in the first flexible exchange rate period.



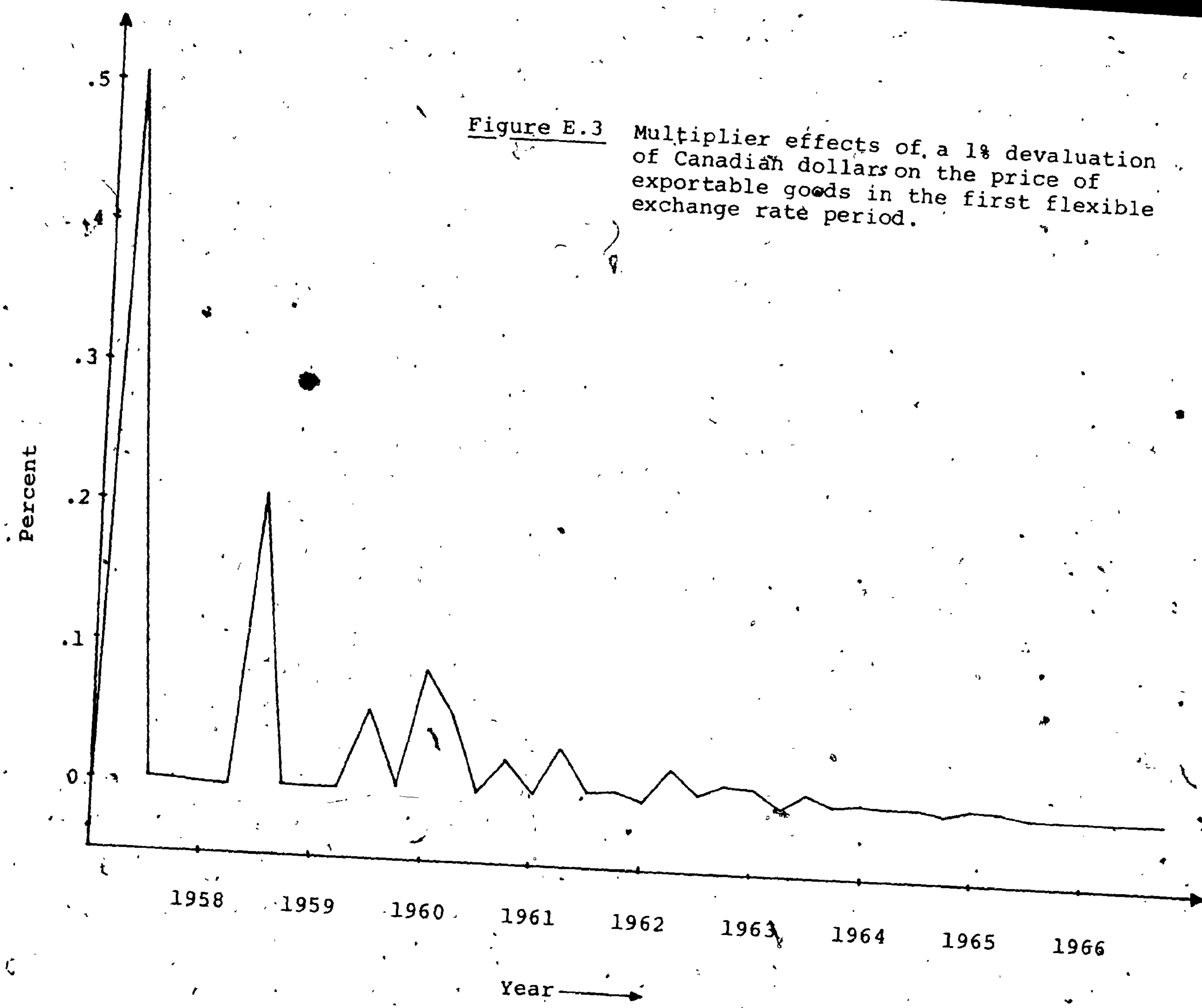
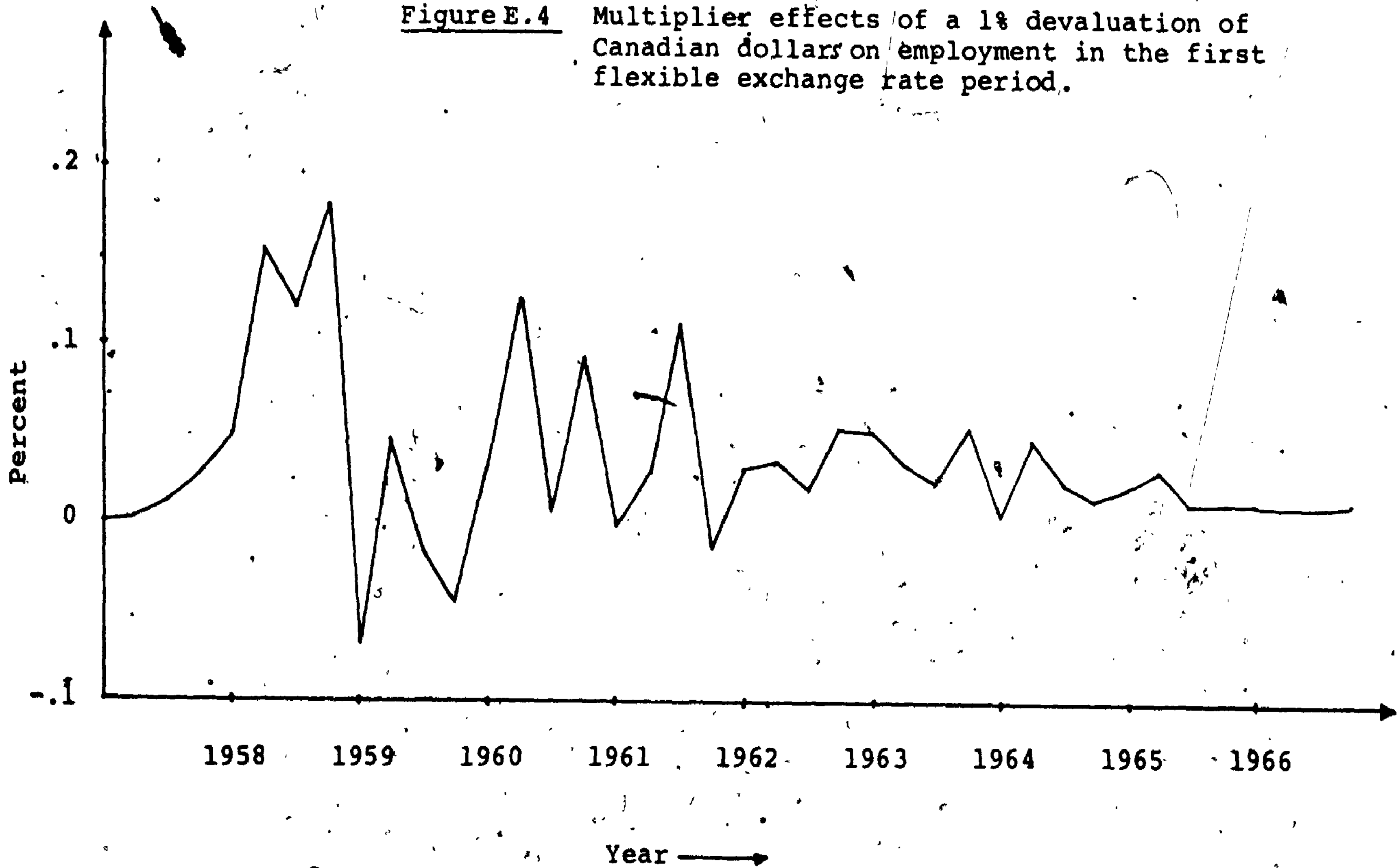



Figure E.3 Multiplier effects of a 1% devaluation of Canadian dollars on the price of exportable goods in the first flexible exchange rate period.

Figure E.4 Multiplier effects of a 1% devaluation of Canadian dollars on employment in the first flexible exchange rate period.



<u>Figure E.5</u> Multiplier effects of a 1% devaluation of Canadian dollar on the money wages in the fixed exchange rate period.

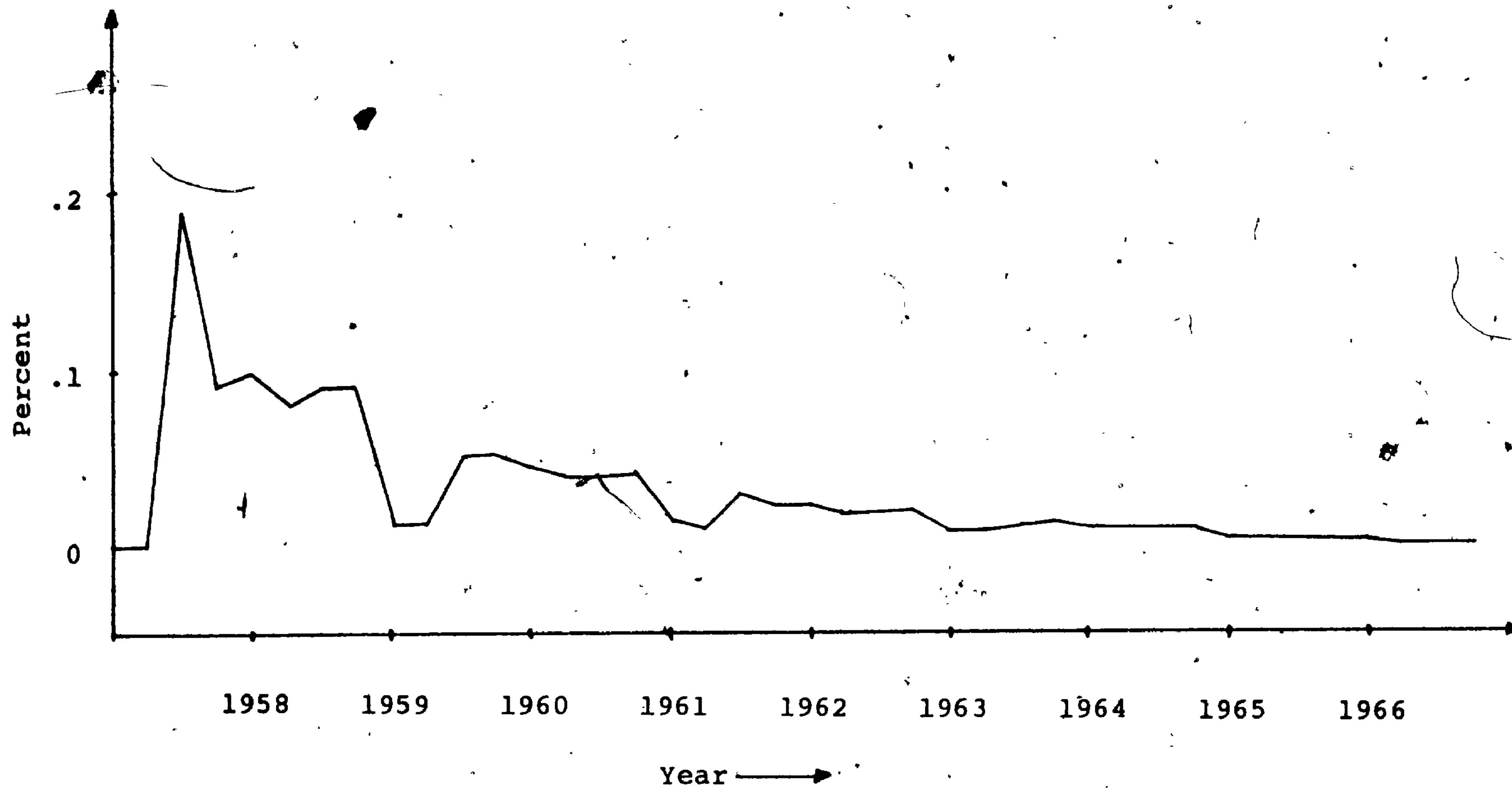


Figure E.6 Multiplier effects of a 1% devaluation of Canadian dollar on the price of non-tradable goods in the fixed exchange rate period.

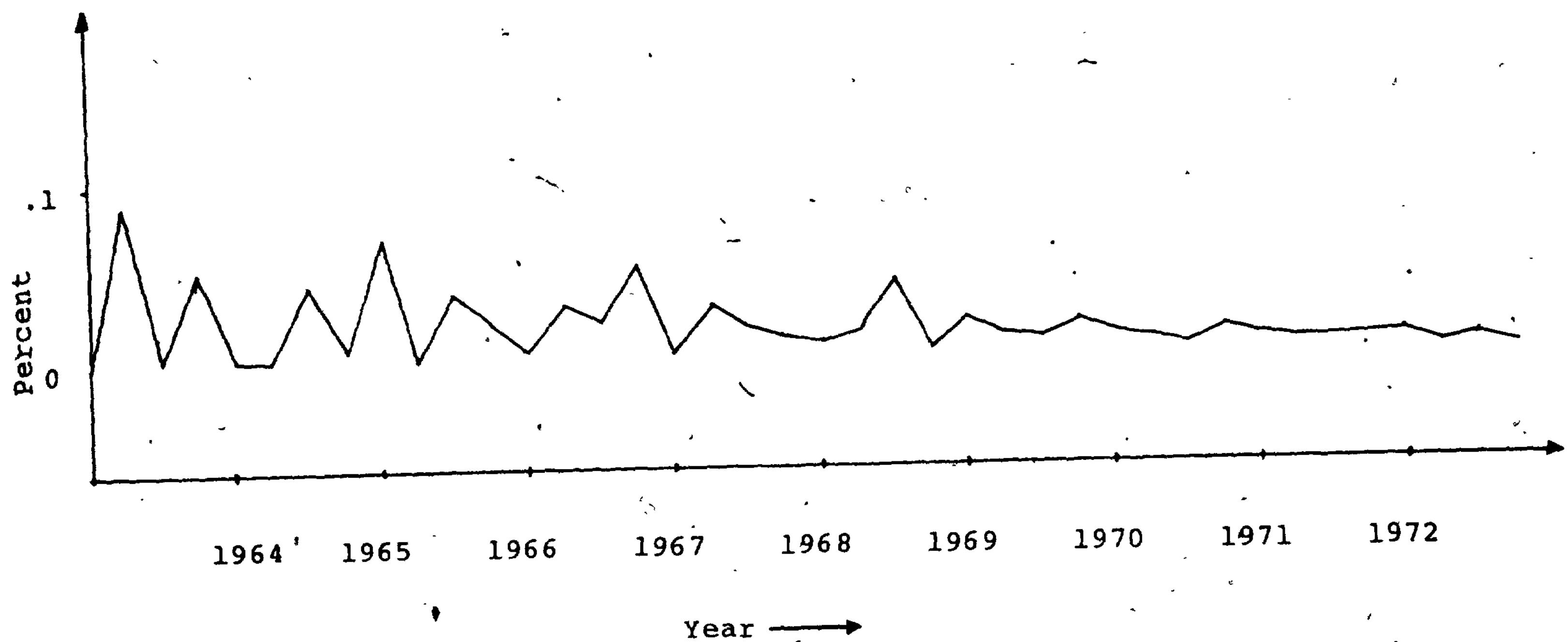


Figure E.10 Multiplier effects of a 1% devaluation of Canadian dollars on the price of non-tradable goods in the second flexible exchange rate period.

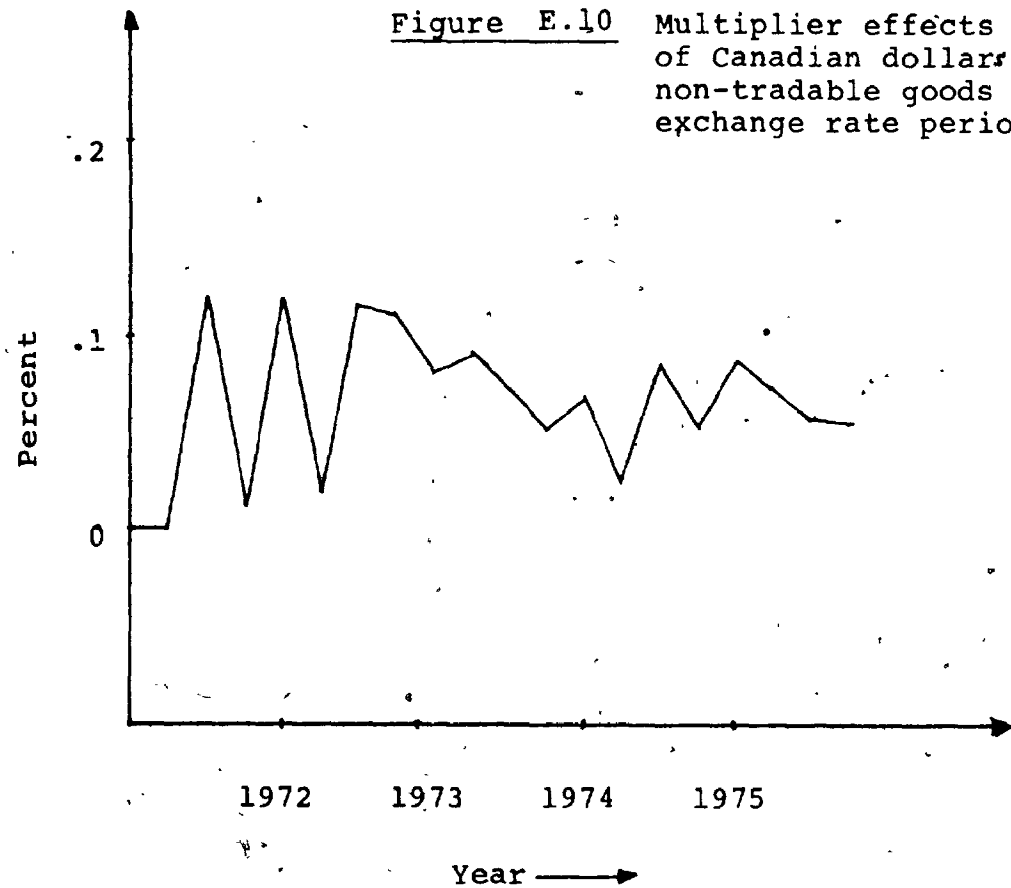


Figure E.8 Multiplier effects of a 1% devaluation of Canadian dollars on employment in the fixed exchange rate period.

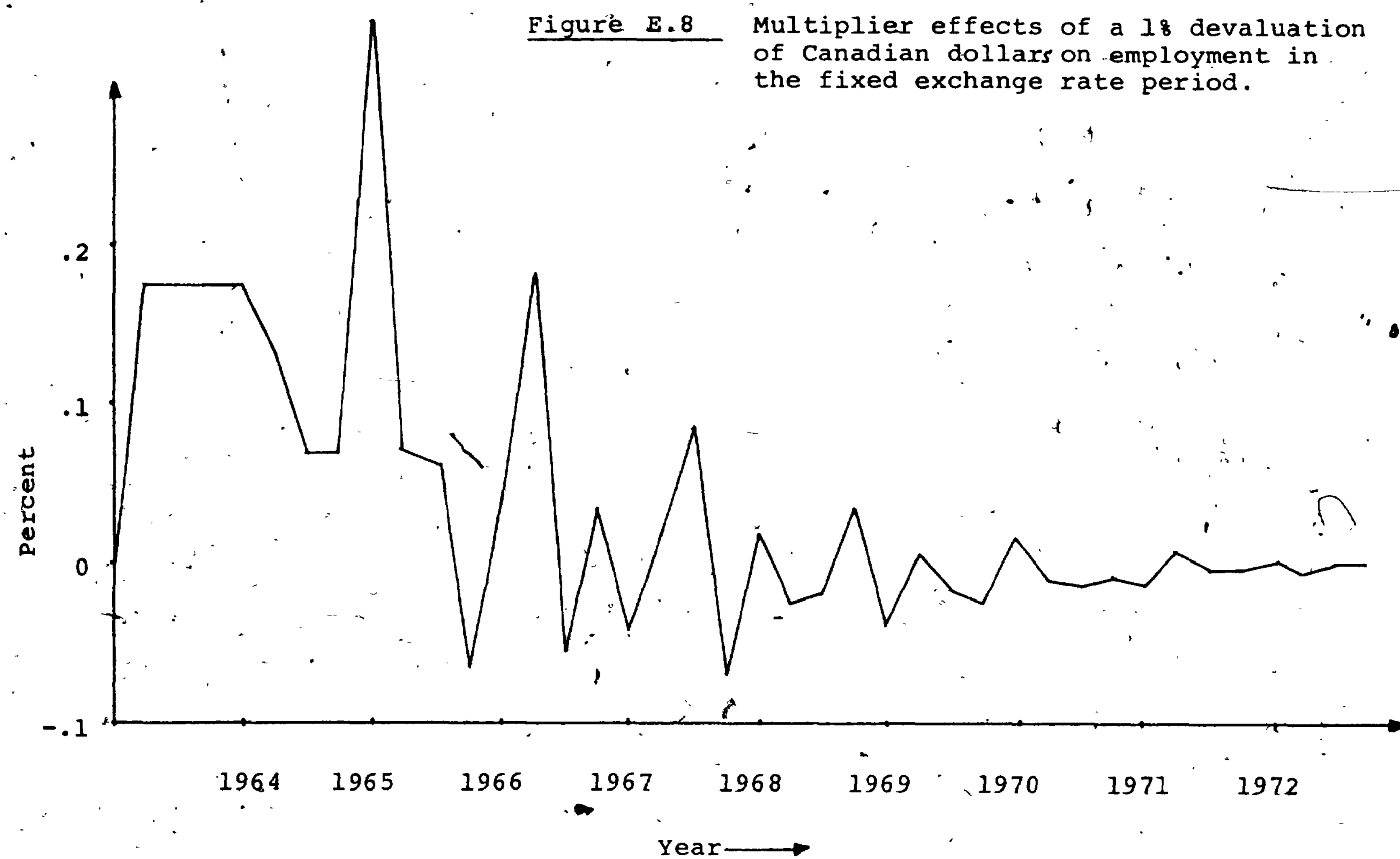
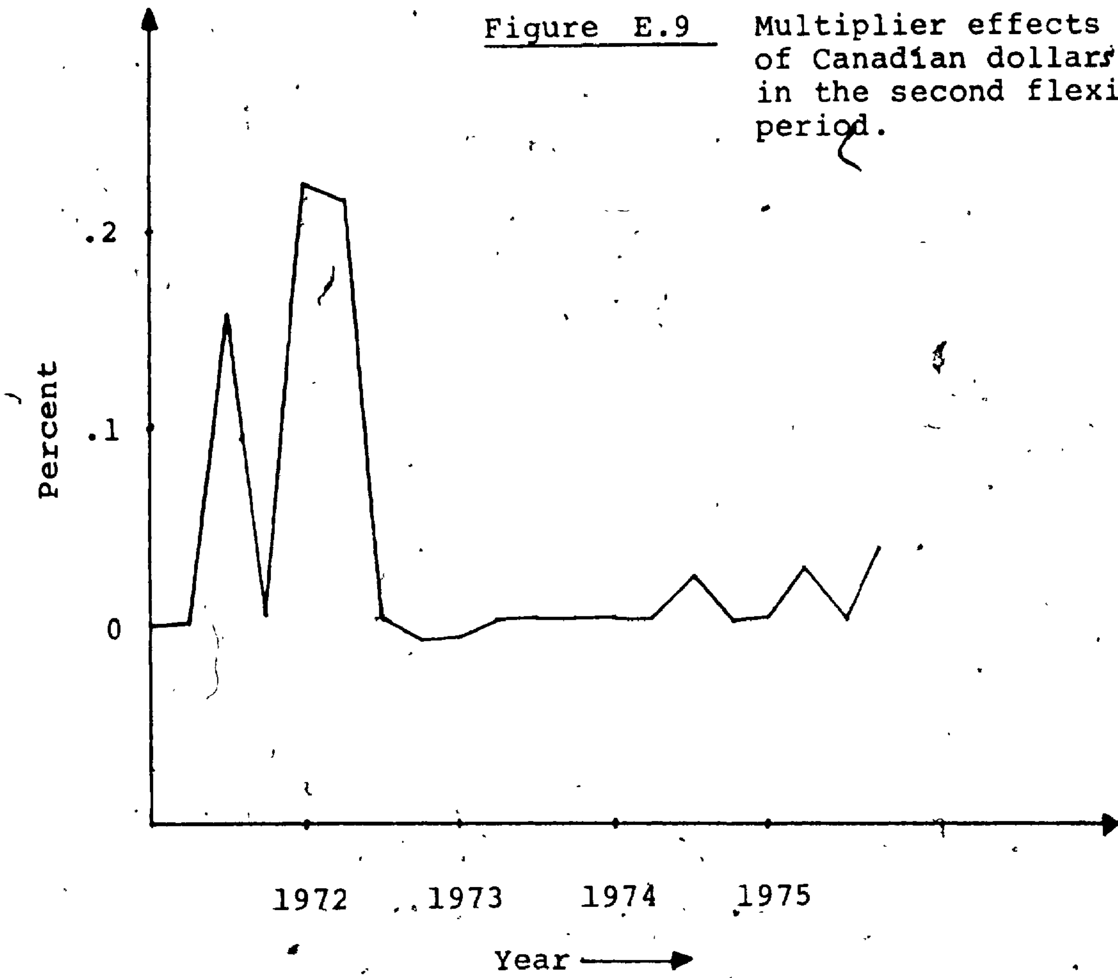


Figure E.9 Multiplier effects of a 1% devaluation of Canadian dollars on the money wages in the second flexible exchange rate period.



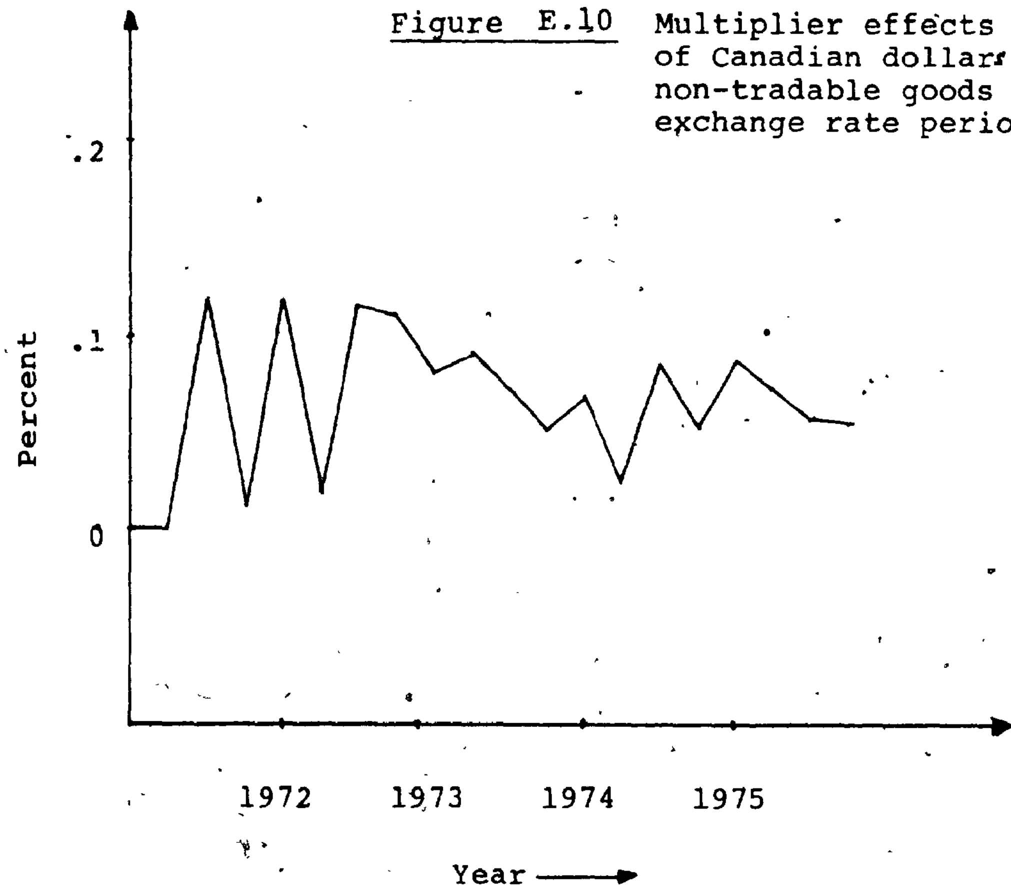



Figure E.10 Multiplier effects of a 1% devaluation of Canadian dollar on the price of non-tradable goods in the second flexible exchange rate period.

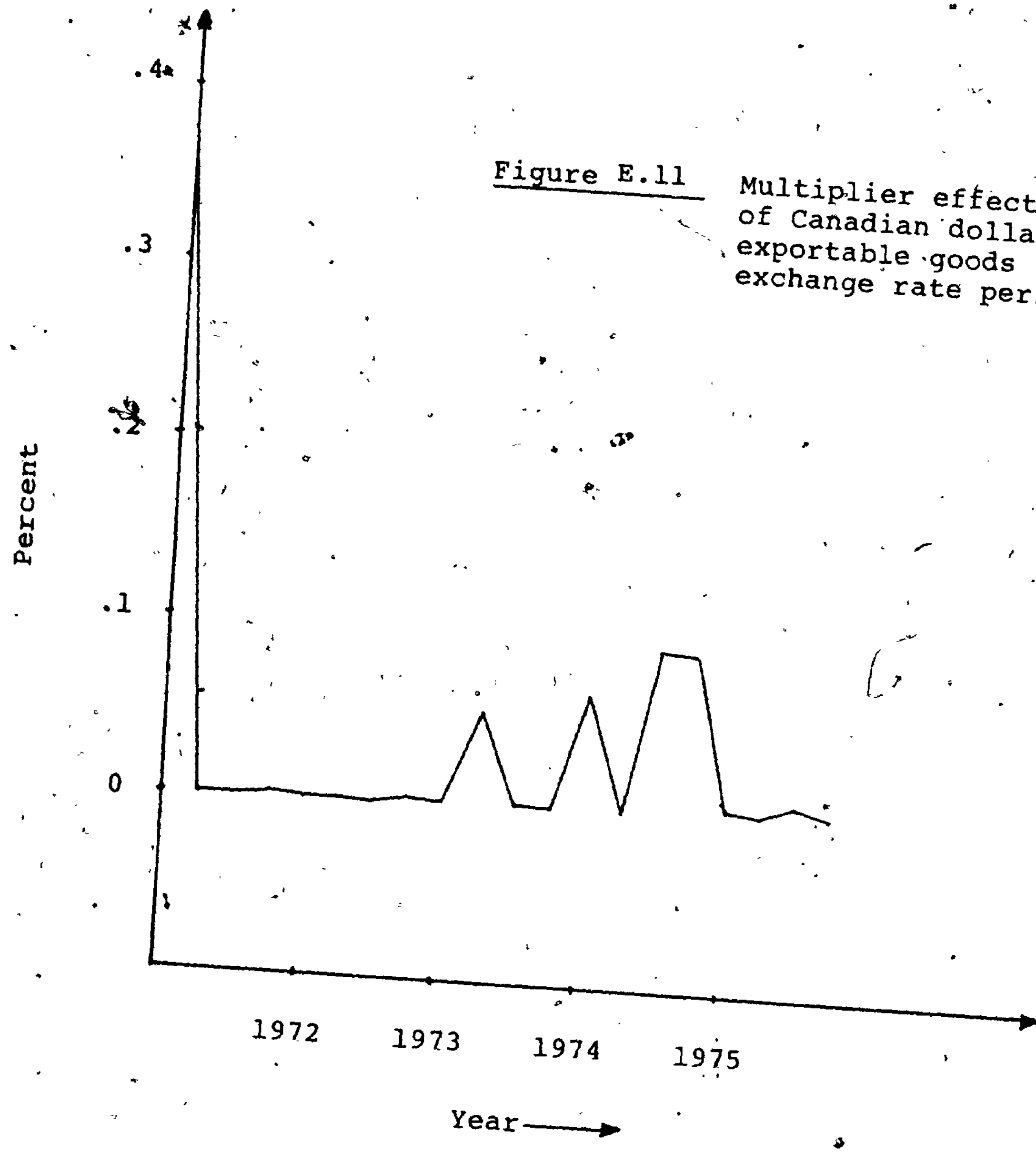



Figure E.11 Multiplier effects of a 1% devaluation of Canadian dollars on the price of exportable goods in the second flexible exchange rate period.

Figure E.12 Multiplier effects of a 1% devaluation of Canadian dollars on employment in the second flexible exchange rate period.

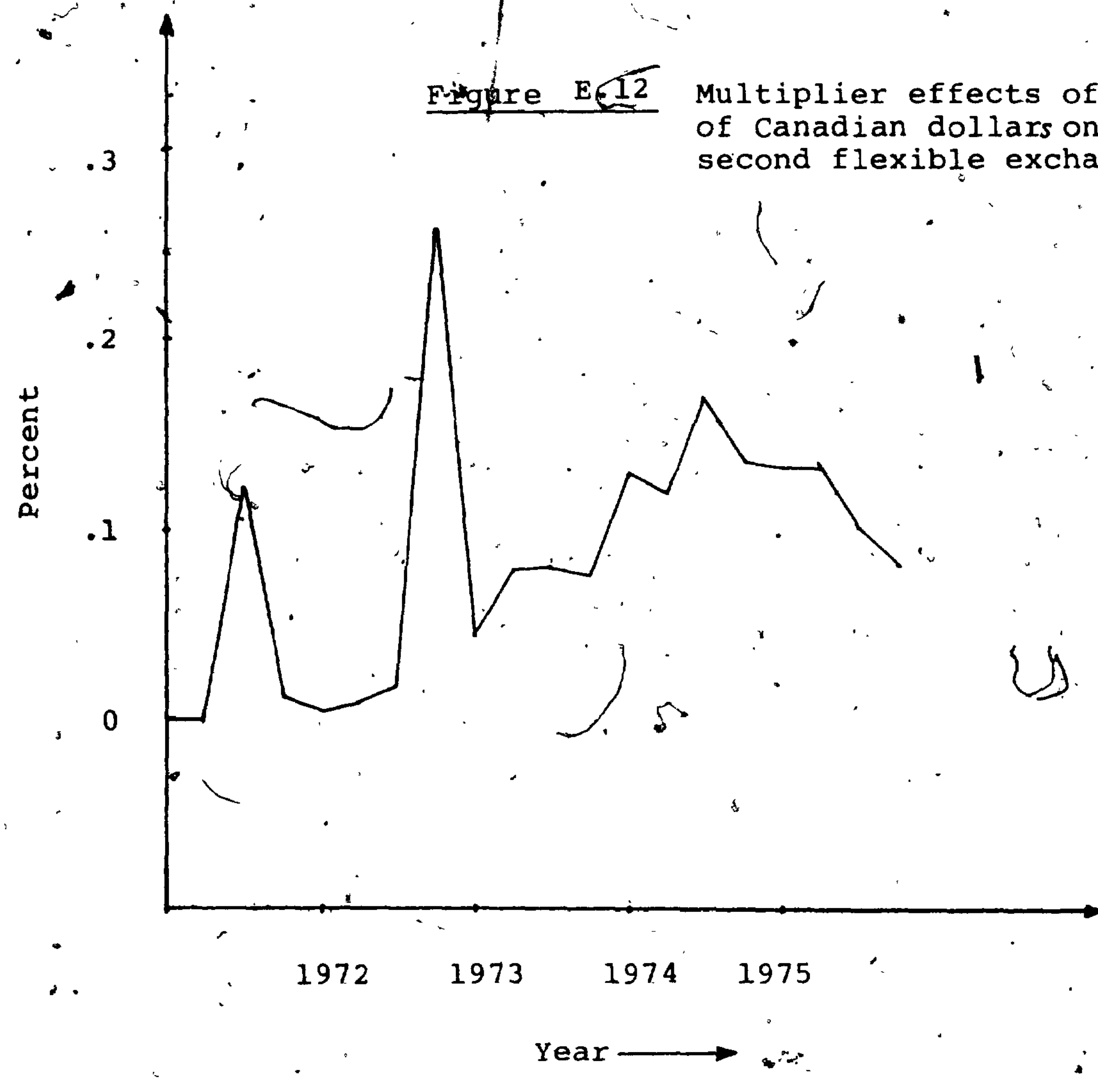


Table E.4

Cumulative effects of a 1% devaluation of Canadian dollar in the first flexible exchange rate period.

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1957 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .214 | .074 | .505 | .003 |
| | 3 | .221 | .137 | .507 | .015 |
| | 4 | .222 | .139 | .509 | .042 |
| 1958 | 1 | .433 | .140 | .510 | .092 |
| | 2 | .433 | .256 | .510 | .244 |
| | 3 | .521 | .257 | .717 | .362 |
| | 4 | .524 | .283 | .718 | .544 |
| 1959 | 1 | .535 | .348 | .719 | .475 |
| | 2 | .545 | .353 | .721 | .518 |
| | 3 | .570 | .378 | .778 | .500 |
| | 4 | .572 | .449 | .781 | .454 |
| 1960 | 1 | .625 | .450 | .866 | .485 |
| | 2 | .650 | .527 | .923 | .611 |
| | 3 | .656 | .571 | .925 | .619 |
| | 4 | .676 | .577 | .950 | .712 |
| 1961 | 1 | .677 | .595 | .951 | .709 |
| | 2 | .697 | .665 | .988 | .736 |

| | | | | | |
|---|---|---|---|---|---|
| 1961 | 3 | .710 | .672 | .993 | .844 |
| | 4 | .713 | .707 | 1.0 | .829 |
| 1962 | 1 | .725 | .747 | 1.002 | .859 |
| | 2 | .742 | .759 | 1.027 | .893 |
| | 3 | .746 | .783 | 1.034 | .912 |
| | 4 | .756 | .819 | 1.05 | .964 |
| 1963 | 1 | .773 | .828 | 1.066 | 1.014 |
| | 2 | .775 | .876 | 1.067 | 1.045 |
| | 3 | .785 | .899 | 1.078 | 1.067 |
| | 4 | .793 | .910 | 1.082 | 1.117 |
| 1964 | 1 | .798 | .928 | 1.089 | 1.119 |
| | 2 | .803 | .958 | 1.094 | 1.162 |
| | 3 | .807 | .967 | 1.101 | 1.182 |
| | 4 | .809 | .991 | 1.103 | 1.194 |
| 1965 | 1 | .812 | 1.012 | 1.110 | 1.212 |
| | 2 | .815 | 1.024 | 1.116 | 1.240 |
| | 3 | .818 | 1.040 | 1.119 | 1.249 |
| | 4 | .821 | 1.059 | 1.122 | 1.257 |
| 1966 | 1 | .824 | 1.067 | 1.125 | 1.265 |
| | 2 | .826 | 1.087 | 1.128 | 1.272 |
| | 3 | .828 | 1.099 | 1.131 | 1.279 |
| | 4 | .830 | 1.109 | 1.134 | 1.288 |

Table E.5

Cumulative effects of a 1% devaluation of Canadian dollars in the fixed exchange rate period

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables $d(\ln P_N)$ | % change in the price of exportables $d(\ln P_X)$ | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1963 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .000 | .090 | .573 | .175 |
| | 3 | .188 | .090 | .573 | .350 |
| | 4 | .280 | .142 | .573 | .525 |
| 1964 | 1 | .378 | .144 | 1.067 | .700 |
| | 2 | .458 | .146 | 1.113 | .831 |
| | 3 | .54[illegible] | .189 | 1.136 | .900 |
| | 4 | .639 | .195 | 1.160 | .968 |
| 1965 | 1 | .654 | .262 | 1.180 | 1.313 |
| | 2 | .667 | .264 | 1.439 | 1.382 |
| | 3 | .716 | .303 | 1.461 | 1.443 |
| | 4 | .768 | .327 | 1.465 | 1.380 |
| 1966 | 1 | .814 | .332 | 1.672 | 1.413 |
| | 2 | .854 | .364 | 1.703 | 1.592 |
| | 3 | .894 | .386 | 1.725 | 1.534 |
| | 4 | .936 | .437 | 1.746 | 1.565 |

| | | | | | |
|---|---|---|---|---|---|
| 1967 | 1 | .950 | .442 | 1.764 | 1.520 |
| | 2 | .961 | .471 | 1.881 | 1.534 |
| | 3 | .989 | .490 | 1.901 | 1.620 |
| | 4 | 1.014 | .504 | 1.906 | 1.545 |
| 1968 | 1 | 1.039 | .508 | 1.994 | 1.564 |
| | 2 | 1.058 | .525 | 2.014 | 1.539 |
| | 3 | 1.077 | .569 | 2.029 | 1.520 |
| | 4 | 1.098 | .574 | 2.044 | 1.555 |
| 1969 | 1 | 1.107 | .596 | 2.056 | 1.516 |
| | 2 | 1.116 | .611 | 2.109 | 1.523 |
| | 3 | 1.129 | .622 | 2.122 | 1.506 |
| | 4 | 1.143 | .644 | 2.126 | 1.481 |
| 1970 | 1 | 1.155 | .657 | 2.164 | 1.498 |
| | 2 | 1.165 | .668 | 2.175 | 1.486 |
| | 3 | 1.175 | .675 | 2.185 | 1.473 |
| | 4 | 1.185 | .691 | 2.194 | 1.464 |
| 1971 | 1 | 1.191 | .702 | 2.201 | 1.450 |
| | 2 | 1.196 | .711 | 2.209 | 1.457 |
| | 3 | 1.201 | .721 | 2.217 | 1.453 |
| | 4 | 1.206 | .732 | 2.220 | 1.450 |
| 1972 | 1 | 1.211 | .744 | 2.227 | 1.451 |
| | 2 | 1.215 | .749 | 2.234 | 1.444 |
| | 3 | 1.219 | .760 | 2.240 | 1.444 |
| | 4 | 1.223 | .764 | 2.245 | 1.443 |

Table E.6

Cumulative effects of a 1% devaluation of Canadian dollars in the second flexible exchange rate period

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1971 | 1 | .000 | .000 | .375 | .000 |
| | 2 | .001 | .001 | .375 | .000 |
| | 3 | .158 | .122 | .375 | .119 |
| | 4 | .163 | .128 | .378 | .131 |
| 1972 | 1 | .385 | .243 | .379 | .136 |
| | 2 | .600 | .263 | .381 | .146 |
| | 3 | .604 | .377 | .382 | .164 |
| | 4 | .598 | .486 | .386 | .420 |
| 1973 | 1 | .594 | .567 | .389 | .464 |
| | 2 | .598 | .656 | .441 | .543 |
| | 3 | .604 | .728 | .443 | .624 |
| | 4 | .608 | .779 | .445 | .701 |
| 1974 | 1 | .612 | .846 | .511 | .828 |
| | 2 | .615 | .872 | .514 | .944 |
| | 3 | .642 | .957 | .605 | 1.110 |
| | 4 | .644 | 1.006 | .695 | 1.246 |
| 1975 | 1 | .648 | 1.091 | .698 | 1.379 |
| | 2 | .682 | 1.163 | .700 | 1.512 |
| | 3 | .687 | 1.220 | .710 | 1.609 |
| | 4 | .733 | 1.276 | .713 | 1.689 |

Table E.7

Multiplier effects of a 1% increase in the domestic price of Canadian imports in the first flexible exchange rate period.

| Year | Quarter | % change in money wages $d(\ln W)$ | % change in the price of non-tradables $d(\ln P_N)$ | % change in the price of exportables $d(\ln P_X)$ | % change in employment $d(\ln L)$ |
|---|---|---|---|---|---|
| 1957 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .214 | .074 | .505 | .003 |
| | 3 | .007 | .063 | .002 | .012 |
| | 4 | .001 | .002 | .002 | .027 |
| 1958 | 1 | .211 | .001 | .001 | .050 |
| | 2 | .000 | .116 | .000 | .080 |
| | 3 | .002 | .000 | .003 | .118 |
| | 4 | .001 | .000 | .000 | .164 |
| 1959 | 1 | .011 | .064 | .000 | - .069 |
| | 2 | .010 | .005 | .002 | .038 |
| | 3 | .025 | .004 | .057 | - .018 |
| | 4 | .002 | .071 | .002 | - .047 |
| 1960 | 1 | .051 | .001 | .085 | .031 |
| | 2 | .025 | .051 | .057 | .166 |
| | 3 | .002 | .043 | .001 | .009 |
| | 4 | .010 | .005 | .002 | .103 |
| 1961 | 1 | .001 | .015 | .000 | - .003 |
| | 2 | .003 | .069 | .004 | .015 |

| | | | | | |
|---|---|---|---|---|---|
| 1961 | 3 | .012 | .002 | .005 | .036 |
| | 4 | .003 | .020 | .007 | -.018 |
| 5-year total effect | | .591 | .606 | .735 | .697 |
| 1962 | 1 | .008 | .039 | .001 | -.001 |
| | 2 | .017 | .006 | .025 | .035 |
| | 3 | .004 | .010 | .007 | .016 |
| | 4 | .009 | .036 | .015 | .038 |
| 1963 | 1 | .016 | .004 | .013 | .057 |
| | 2 | .001 | .035 | .001 | .027 |
| | 3 | .004 | .022 | .002 | .022 |
| | 4 | .007 | .007 | .004 | .043 |
| 1964 | 1 | .002 | .016 | .002 | -.001 |
| | 2 | .003 | .029 | .004 | .021 |
| | 3 | .004 | .004 | .007 | .019 |
| | 4 | .001 | .016 | .001 | .004 |
| 1965 | 1 | .001 | .020 | .006 | .011 |
| | 2 | .003 | .007 | .006 | .028 |
| | 3 | .002 | .010 | .002 | .004 |
| | 4 | .002 | .018 | .002 | .005 |
| 1966 | 1 | .003 | .004 | .003 | .007 |
| | 2 | .000 | .014 | .001 | .006 |
| | 3 | .000 | .011 | .002 | .006 |
| | 4 | .001 | .007 | .002 | .008 |
| 10-year total effect | | .679 | .921 | .841 | 1.052 |

Table E.8

Multiplier effects of a 1% increase in the domestic price of Canadian imports in the fixed exchange rate period.

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d( ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1963 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .000 | .090 | .000 | .175 |
| | 3 | .096 | .000 | .000 | .175 |
| | 4 | .000 | .002 | .000 | .175 |
| 1964 | 1 | .006 | .000 | .494 | .175 |
| | 2 | .080 | .000 | .023 | .153 |
| | 3 | .083 | .043 | .000 | .091 |
| | 4 | .083 | .004 | .001 | .089 |
| 1965 | 1 | .004 | .065 | .020 | .097 |
| | 2 | .006 | .000 | .020 | .071 |
| | 3 | .007 | .004 | .020 | .060 |
| | 4 | .014 | .002 | .001 | .046 |
| 1966 | 1 | .007 | .002 | .205 | .045 |
| | 2 | .037 | .030 | .011 | .060 |
| | 3 | .035 | .021 | .003 | -.049 |
| | 4 | .036 | .048 | .002 | .043 |
| 1967 | 1 | .005 | .002 | .017 | .015 |
| | 2 | .005 | .003 | .017 | .016 |

| | | | | | |
|---|---|---|---|---|---|
| 1967 | 3 | .009 | .003 | .018 | .020 |
| | 4 | .008 | .003 | .002 | - .029 |
| 5-year total effect | | .521 | .322 | .854 | 1.428 |
| 1968 | 1 | .006 | .003 | .086 | .026 |
| | 2 | .017 | .015 | .007 | .011 |
| | 3 | .015 | .041 | .003 | - .015 |
| | 4 | .017 | .002 | .003 | .007 |
| 1969 | 1 | .003 | .002 | .011 | - .019 |
| | 2 | .005 | .003 | .011 | .010 |
| | 3 | .004 | .003 | .011 | .000 |
| | 4 | .006 | .017 | .001 | - .005 |
| 1970 | 1 | .004 | .011 | .036 | .004 |
| | 2 | .008 | .009 | .003 | .001 |
| | 3 | .008 | .005 | .003 | - .010 |
| | 4 | .008 | .002 | .002 | - .002 |
| 1971 | 1 | .003 | .002 | .006 | - .005 |
| | 2 | .002 | .003 | .006 | .001 |
| | 3 | .003 | .007 | .006 | .001 |
| | 4 | .003 | .008 | .001 | - .002 |
| 1972 | 1 | .002 | .010 | .006 | .005 |
| | 2 | .003 | .003 | .003 | - .002 |
| | 3 | .003 | .001 | .002 | - .006 |
| | 4 | .003 | .002 | .001 | .000 |
| 10-year total effect | | .644 | .471 | 1.062 | 1.428 |

Table E.9

Multiplier effects of a 1% increase in the domestic price of Canadian imports in the second flexible exchange rate period.

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1971 | 1 | .000 | .000 | .286 | .000 |
| | 2 | .001 | .001 | .000 | .000 |
| | 3 | .155 | .093 | .000 | .091 |
| | 4 | .003 | .006 | .002 | .010 |
| 1972 | 1 | .215 | .105 | .000 | .004 |
| | 2 | .134 | .019 | .002 | .008 |
| | 3 | .001 | .107 | .000 | .014 |
| | 4 | .000 | .076 | .003 | .164 |
| 1973 | 1 | .004 | .078 | .002 | .027 |
| | 2 | .003 | .080 | .040 | .065 |
| | 3 | .004 | .064 | .002 | .063 |
| | 4 | .003 | .044 | .001 | .076 |
| 1974 | 1 | .003 | .061 | .065 | .114 |
| | 2 | .002 | .024 | .002 | .100 |
| | 3 | .022 | .081 | .088 | .145 |
| | 4 | .002 | .037 | .057 | .113 |
| 1975 | 1 | .004 | .079 | .002 | .121 |
| | 2 | .033 | .054 | .002 | .111 |
| | 3 | .005 | .052 | .008 | .085 |
| | 4 | .045 | .048 | .003 | .071 |
| 5-year total effect | | .639 | 1.109 | .565 | 1.382 |

Table E.10

Multiplier effects of a 1% decrease in the foreign price of Canadian exports in the first flexible exchange rate period.

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1957 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .000 | .000 | .000 | .000 |
| | 3 | .000 | .000 | .000 | .000 |
| | 4 | .000 | .000 | .000 | .000 |
| 1958 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .000 | .000 | .000 | .072 |
| | 3 | .086 | .001 | .204 | .000 |
| | 4 | .002 | .026 | .001 | .018 |
| 1959 | 1 | .000 | .001 | .001 | .000 |
| | 2 | .000 | .000 | .000 | .005 |
| | 3 | .000 | .021 | .000 | .000 |
| | 4 | .000 | .000 | .001 | .001 |
| 1960 | 1 | .002 | .000 | .000 | .000 |
| | 2 | .000 | .026 | .000 | - .040 |
| | 3 | .004 | .001 | .001 | - .001 |
| | 4 | .010 | .001 | .023 | - .010 |
| 1961 | 1 | .000 | .003 | .001 | .000 |
| | 2 | .017 | .001 | .033 | .012 |

| | | | | | |
|---|---|---|---|---|---|
| 1961 | 3 | .001 | .005 | .000 | .072 |
| | 4 | .000 | .015 | .000 | .003 |
| 5-year total effect | | .122 | .101 | .265 | .132 |
| 1962 | 1 | .004 | .001 | .001 | .031 |
| | 2 | .000 | .006 | .000 | -.001 |
| | 3 | .000 | .014 | .000 | .003 |
| | 4 | .001 | .000 | .001 | .014 |
| 1963 | 1 | .001 | .005 | .003 | -.007 |
| | 2 | .001 | .013 | .000 | .004 |
| | 3 | .006 | .001 | .009 | .000 |
| | 4 | .001 | .004 | .000 | .007 |
| 1964 | 1 | .003 | .002 | .005 | .003 |
| | 2 | .002 | .001 | .001 | .022 |
| | 3 | .000 | .005 | .000 | .001 |
| | 4 | .001 | .008 | .001 | .008 |
| 1965 | 1 | .002 | .001 | .001 | .007 |
| | 2 | .000 | .005 | .000 | .000 |
| | 3 | .001 | .006 | .001 | .005 |
| | 4 | .001 | .001 | .001 | .003 |
| 1966 | 1 | .000 | .004 | .000 | .001 |
| | 2 | .002 | .006 | .002 | .001 |
| | 3 | .002 | .001 | .001 | .001 |
| | 4 | .001 | .003 | .001 | .001 |
| 10-year total effect | | .151 | .188 | .293 | .236 |

Table E.11

Multiplier effects of a 1% decrease in the foreign price of Canadian exports in the fixed exchange rate period.

| Year | Quarter | % change in money wages $d(\ln W)$ | % change in the price of non-tradables $d(\ln P_N)$ | % change in the price of exportables $d(\ln P_X)$ | % change in employment $d(\ln L)$ |
|---|---|---|---|---|---|
| 1963 | 1 | .000 | .000 | .000 | .000 |
| | 2 | .000 | .000 | .573 | .000 |
| | 3 | .092 | .000 | .000 | .000 |
| | 4 | .092 | .050 | .000 | .000 |
| 1964 | 1 | .092 | .002 | .000 | .000 |
| | 2 | .000 | .002 | .023 | - .022 |
| | 3 | .007 | .000 | .023 | - .022 |
| | 4 | .008 | .002 | .023 | - .021 |
| 1965 | 1 | .011 | .002 | .000 | .248 |
| | 2 | .007 | .002 | .239 | - .002 |
| | 3 | .042 | .035 | .002 | .001 |
| | 4 | .038 | .022 | .003 | - .109 |
| 1966 | 1 | .039 | .003 | .002 | - .012 |
| | 2 | .003 | .002 | .020 | .119 |
| | 3 | .005 | .001 | .019 | - .009 |
| | 4 | .006 | .003 | .019 | - .012 |
| 1967 | 1 | .009 | .003 | .001 | - .060 |
| | 2 | .006 | .026 | .100 | - .002 |

| | | | | | |
|---|---|---|---|---|---|
| 1967 | 3 | .019 | .016 | .002 | .066 |
| | 4 | .017 | .011 | .003 | - .046 |
| 5-year total effect | | .493 | .182 | 1.052 | .117 |
| 1968 | 1 | .019 | .001 | .002 | - .007 |
| | 2 | .002 | .002 | .013 | - .036 |
| | 3 | .004 | .003 | .012 | - .004 |
| | 4 | .004 | .003 | .012 | .028 |
| 1969 | 1 | .006 | .020 | .001 | - .020 |
| | 2 | .004 | .012 | .042 | - .003 |
| | 3 | .009 | .008 | .002 | - .017 |
| | 4 | .008 | .005 | .003 | - .020 |
| 1970 | 1 | .008 | .002 | .002 | .013 |
| | 2 | .002 | .002 | .008 | - .013 |
| | 3 | .002 | .002 | .007 | - .003 |
| | 4 | .002 | .014 | .007 | - .007 |
| 1971 | 1 | .003 | .009 | .001 | - .009 |
| | 2 | .003 | .006 | .002 | .006 |
| | 3 | .002 | .003 | .002 | - .005 |
| | 4 | .002 | .003 | .002 | - .001 |
| 1972 | 1 | .003 | .002 | .001 | - .004 |
| | 2 | .001 | .002 | .004 | - .005 |
| | 3 | .001 | .010 | .004 | .006 |
| | 4 | .001 | .002 | .004 | - .001 |
| 10-year total effect | | .579 | .293 | 1.183 | .015 |

Table E.12

Multiplier effects of a 1% decrease in the foreign price of Canadian exports in the second flexible exchange rate period.

| Year | Quarter | % change in money wages d(ln W) | % change in the price of non-tradables d(ln $P_N$) | % change in the price of exportables d(ln $P_X$) | % change in employment d(ln L) |
|---|---|---|---|---|---|
| 1971 | 1 | .000 | .000 | .089 | .000 |
| | 2 | .000 | .000 | .000 | .000 |
| | 3 | .002 | .028 | .000 | .028 |
| | 4 | .002 | .000 | .001 | .002 |
| 1972 | 1 | .007 | .010 | .001 | .001 |
| | 2 | .081 | .001 | .000 | .002 |
| | 3 | .003 | .007 | .001 | .004 |
| | 4 | -.006 | .033 | .001 | .092 |
| 1973 | 1 | -.008 | .003 | .001 | .017 |
| | 2 | .001 | .009 | .012 | .014 |
| | 3 | .002 | .008 | .000 | .018 |
| | 4 | .001 | .007 | .001 | .001 |
| 1974 | 1 | .001 | .006 | .001 | .013 |
| | 2 | .001 | .002 | .001 | .016 |
| | 3 | .005 | .004 | .003 | .021 |
| | 4 | .000 | .012 | .033 | .023 |
| 1975 | 1 | .000 | .006 | .001 | .012 |
| | 2 | .001 | .018 | .000 | .022 |
| | 3 | .000 | .005 | .002 | .012 |
| | 4 | .001 | .008 | .000 | .009 |
| 5-year total effect | | .094 | .167 | .148 | .307 |

## FOOTNOTES

(1) Please see footnote (6).

(2) For a chronological review, please see Wonnacott[60] or Courchene[12].

(3) This is also an assumption made by Francis[23].

(4) For a recent survey of the wage-price inflation literature, please see Laidler and Parkin[34].

(5) For the arguments that the exchange rate is fixed in Canada even in the flexible exchange rate periods, please see Parkin[47], Courchene[12] and the exchange rate specification of CANDIDE model, version 1.0,1.1 and 1.2 [9,10,40].

(6) For a discussion about the trade-off curve, please see Bodkin et. al.[3]. To derive the trade-off curve, the wage equation is substituted into the price equation to get a difference equation of price inflation in terms of the unemployment rate and other variables such as the increase in the price of imports or labour productivity. This difference equation is then allowed to go to a mathematical steady state so that no lagged variable appears in the equation. The trade-off curve is the relationship between the price inflation and the unemployment rate, given the values of other variables.

In the concept of the trade-off curve, the unemployment rate becomes a target variable. The rate of increase in labour demand must be equal to the rate of increase in labour supply so that the target unemployment rate can be sustained. This is only an abstract concept as pointed out by Bodkin et.al.[3]. The trade-off curve is designed to answer the question of how much inflation there would be, given that the present condition prevails and the goverment wants to hold the unemployment rate at a certain level. For further discussion on the concept of the trade-off curve and its controversy, please see a review article by Laidler and Parkin and the references cited in this paper[34].

(7) This is also the conclusion of Laidler and Parkin in their detailed survey of wage inflation liturature[34].

(8) To derive equation (2.1) from monopolistic models, please see Laidler and Parkin, and references cited in their paper[34].

(9) Let us consider the trading between Canada and the rest of the World. The domestic price of imports in Canadian dollar is:

$$P_M = (1 + T)\ P_f\ .\ E$$

where $P_M$ = domestic price of imports in Canadian dollar

$P_f$ = foreign price of Canadian imports in the rest of the World currency.

E = the exchange rate; the price of the rest of the World currency in terms of Canadian dollar.

T = import tax rate.

(10) This type of linearization is well known in economic theory. For example, if we linearize C.E.S. production

function using a first order approximation of Taylor series, we have a Cobb-Douglas production function[30,31,39]. The transcendental logarithmic utility function is also based on this linearization which uses a second order approximation of Taylor series for any arbitrary function[11].

Equation (2.55) can be derived as follows. We choose $\alpha_1$, $\alpha_2$ and $\alpha_3$ such that

$$F(L_1, L_2, L_3, \alpha_1, \alpha_2, \alpha_3) = \ln(L_1^{\alpha_1} + L_2^{\alpha_2} + L_3^{\alpha_3})$$
$$- (\alpha_1 (L_1/L) \ln L_1 + \alpha_2 (L_2/L) \ln L_2 + \alpha_3 (L_3/L) \ln L_3)$$
$$= \text{constant} = d_o$$

We next use a Taylor series to linearize $\ln(L_1^{\alpha_1} + L_2^{\alpha_2} + L_3^{\alpha_3})$ around $\alpha_1^*=1$; $\alpha_2^*=1$; $\alpha_3^*=1$, we have

$$\ln L = d_o + (L_1/L) \ln L_1 + (L_2/L) \ln L_2 + (L_3/L) \ln L_3$$

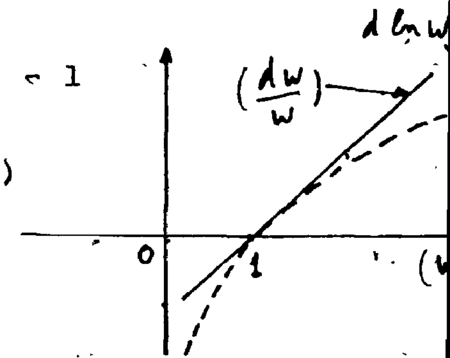
Therefore $d_1$, $d_2$ and $d_3$ in equation (2.55) are positive and smaller than 1.

(11) If a consumer's utility function exhibits constant elasticity of substitution, the demand for each good can be expressed in the log-linear form of the relative price and the real income[41].

(12) For a broader analysis of decision problem in Economics, please see Zellner[61].

(13) Towards the objective of better understanding macro econometric models of the Canadian economy, there is a project of model comparison among CANDIDE 1.2M, TRACE, RDX2 and the University of Toronto Quarterly Forecasting Model. The results of this project will be published in near future[13,21,22,29,58].

(14) The relationship between d(W)/W and d ln W can be shown as follows;




$$d(W)/W = (W_t - W_{t-1})/W_{t-1} = (W_t/W_{t-1}) - 1$$

$$d \ln W = \ln W_t - \ln W_{t-1} = \ln(W_t/W_{t-1})$$

$d(W)/W = d \ln W$ if $W_t = W_{t-1}$ or $d W = 0$

$d(W)/W > d \ln W$ if $W_t > W_{t-1}$ or $d W > 0$

$|d(W)/W| < |d \ln W|$ if $W_t < W_{t-1}$ or $d W < 0$

These conditions are presented graphically in the above graph.

(15) In estimating the equation, we are concerned about the theoretical signs of the estimated parameters. We have no intention of unscrambling these parameters to recover the structural coefficients since our major concern is simulation.

(16) An alternative procedure would have been used data generated during the existing exchange rate regime as the basic for estimating lag structure during that regime. This approach would imply the loss of data from 1962-1965 due to the lag structure under the fixed exchange rate period. However, it was not possible to carry the approach through for the second floating exchange rate regime due to the short length of time available. The use of this alternative approach also poses another problem in testing the structural change from one exchange rate regime to another due to the gap of data caused by the 3-year lag structure.

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