The Trent University Macro-econometric Model for the Canadian Economy: A Simultaneous Estimation

By

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Introduction

The Trent University Small Quarterly Macroeconometric Model for the Canadian economy is designed in a Keynesian macro-model framework, in which the level of economic activity, wages and prices and the level of employment are determined by the interaction of the aggregate demand and the aggregate supply schedules. The model was built by Dr. D. C. A. Curtis and Dr. K. S. R. Murthy of Trent University in Peterborough. Since the original version built in the early 1980's, the model has undergone several modifications in order to meet different objectives.

Compared to some of the other econometric models available for the Canadian economy, namely the Bank of Canada's RDX2 model, with 258 endogenous variables and 322 exogenous variables; the University of Toronto's TRACE model, with 187 dependent and 115 independent variables; and the Economic Council of Canada's CANDIDE model, with well over 2400 equations; the Trent model is a relatively small model comprising only 34 behavioural equations, 33 identities, and 32 exogenous variables.

There are several factors to be considered when looking at the size of a model. A large model could be too complicated to manipulate. "The larger the number of equations and the greater the detail shown in the variables, the more complicated it is to derive the individual equations, to manipulate the resulting system, and to see the implications of the model" (D. B. Suits, 1962). It would also be difficult to estimate simultaneously a large system of equations. On the other hand, a small, highly aggregated model has a tendency to condense and simplify an economy, and consequently it would be less accurate. In addition, there is a risk of ignoring key issues or relationships governing institutions.

The small size and level of aggregation in the Trent model help one focus on the main macroeconomic variables without being swamped by a large number of equations and relationships. The model is disaggregated into seven interrelated sectors. Three sectors form the aggregate demand side of the economy, and the four others form the aggregate supply side.

A unique feature of the Trent Model is the separation of the sectors into goods-producing activities and service-producing activities. These activities are grouped on the basis of gross domestic product by industry using the following breakdown:

Goods Producing Activities

1) Agriculture
2) Forestry
3) Fishing and Trapping
4) Mines, Quarries and Oil wells
5) Manufacturing Industries
6) Construction Industry

Service Producing Activities

1) Transport, Communication and Other Utilities
2) Trade

3) Finance, Insurance and Real Estate

4) Community, Business and Personal Service Industry

5) Public Administration and Defence

For instance, the output section has two equations, one for the production of goods and the other for the production of services. An identity is used to combine the two equations for the total output. Hence, the model is designed in a way to enable a researcher to analyse the patterns of structural change occurring in the production, pricing and consumption of goods and services over time. The key motivation to build a model with such features was to provide a scope for analysing inter-structural dynamics of the Canadian economy over the past thirty years.

In an earlier version of the model, (Curtis and Murthy, 1985) the data set was separated into two sub-periods: 1955-66 and 1967-81. The year 1966-67 was chosen as the dividing year since it marked a period of significant change in the Canadian economy. Canada was experiencing a peak in economic activity indicated by a high rate of growth of national income, a low unemployment rate and a stable inflation rate. This period also saw the beginning of major increases in social security programs in Canada. This separation of the sample space thus allows for an independent estimation of the model equations for each of the two sub-periods. The parameters of each sub-period could then be compared for a better understanding of the changes that occurred in the economic relationships. The separation of the sample space could also be used to analyse the strength and weakness of demand management policy in the 1950's as compared to the 1970's.

There are several other possible uses for the model. Since the model is separated in terms of goods and service producing activities, it is possible to study the repercussions of public policy or external shocks on each of these activities in the Canadian economy independently. In addition the design of the model allows for an in-depth study of the patterns of change in the key endogenous variables that may occur due to exogenous intra-sectoral changes or deliberate monetary or fiscal policies. Government policy simulations could also be used to reveal the time-paths of the multiplier effects.

Related to the simulation approach, the model could be used for the purpose of forecasting future patterns of sectoral growth. After the model has been specified and estimated, it is possible to test its reliability by calculating the ex-post forecasts, or historical simulations, of the endogenous variables and comparing them to the actual values.

The version of the Trent model used in this paper appears in a 1986 mimeographed paper (Curtis and Murthy, 1986). They estimated each equation of the model using ordinary least squares method. The sample period for the estimation is 1967:1 to 1984:4. Since preliminary estimates of the individual equations of the model, using the same data set and method were different from the 1986 paper, the entire model is re-estimated. A further step was to estimate the whole model simultaneously as a system of equations, using two stage least squares method. This has not been done previously. This paper does not attempt to alter the model in any way.

The first section of the paper consists of a brief description of the structure of the model, including a complete list of all the variable definitions. The second section is a theoretical specification of each equation and identity used in the model. This is followed by a presentation of the estimated coefficients of all the behavioural equations generated using a simultaneous method. The fourth section is a summary of the simulation study of the model. The last section is the conclusion. The results of the ordinary least squares estimation are shown in Appendix A. In Appendix B, the mathematical formulae required for the correction of autocorrelation and estimation of distributed lags are listed. The root mean square percentage error and the Theil inequality coefficient are also presented in Appendix B.

1. Structure of the Model

The Trent model consists of 34 behavioural equations, 33 identities and 32 exogenous variables. The complete list of all the endogenous and exogenous variables of the model, with references to equation numbers, is provided in Table 1.1. The model is estimated using quarterly data. The specification of the model involves seven sectors that have a considerable degree of interrelationship. This interrelationship can easily be seen on the sectoral structure illustrated in figure 1.2.

The sectors are further divided into an aggregate demand side and an aggregate supply side. Below is a list of all the sectors in the model and next to the name in parenthesis is the number of equations including identities within each sector:

Sectors	Number of Equations
Aggregate Demand Schedule	
1.0 Final Demand Sector	(15)
2.0 Government Sector	(8)
3.0 Monetary Sector	(5)
Aggregate Supply Schedule	
4.0 Output Sector	(7)
5.0 Labour Sector	(6)
6.0 Wages and Prices	(12)
7.0 National Income Component	(14)

Figure 1.2. Trent University Macroeconometric Model-
Sectoral Structure

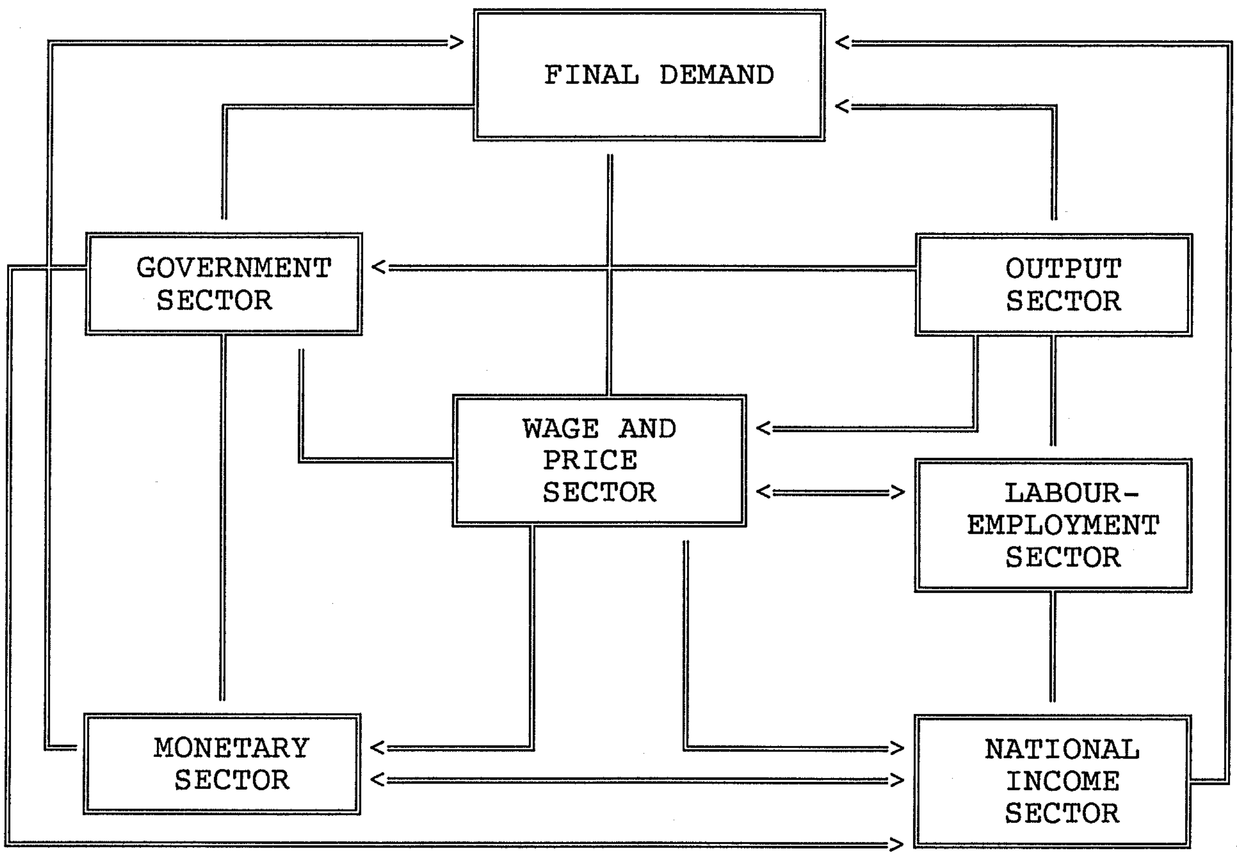


Table 1.1. Glossary of Variable Definitions

Variable Name		Unit	Equation No.	
Endogenous Variables:				
APRT	Average Labour Participation Rate	Ratio	(5.3)	
ECT	Total Employment	Millions	(5.5)	Identity
ECTG	Employment - Goods	Millions	(5.1)	
ECTS	Employment - Services	Millions	(5.2)	
LFTC	Total Labour Force	Millions	(5.4)	Identity
GBT	Government Balance	$ Mill.	(2.8)	Identity
GET	Total Government Expenditure	$ Mill.	(2.7)	Identity
GRT	Total Government Revenue	$ Mill.	(2.6)	Identity
M1	Narrow Money	$ Mill.	(3.1)	
PCEG	Consumer Expenditure Deflator - Goods	1971 = 1	(6.7)	
PCES	Consumer Expenditure Deflator - Services	1971 = 1	(6.8)	
PCET	Consumer Expenditure Deflator - Total	1971 = 1	(6.9)	Identity
PCPI	Consumer Price Index	1971 = 1	(6.10)	
PGDG	Unit GDP Cost Index - Goods	1971 = 1	(6.4)	
PGDP	Unit GDP Cost Index - Total	1971 = 1	(6.6)	Identity
PGDS	Unit GDP Cost Index - Services	1971 = 1	(6.5)	
PGNP	GNP Deflator	1971 = 1	(6.12)	Identity
PIM	Import Price Deflator	1971 = 1	(6.11)	Identity
RG35	3-5 year Government Bond Rate	%	(3.3)	
RRI	Real Rate of Interest	%	(3.4)	Identity
RTB	Treasury Bill Rate	%	(3.2)	

Table 1.1. Glossary of Variable Definitions. Continued..

Variable Name		Unit	Equation No.	
TDRF	Federal Government Tax Revenue - Direct	$ Mill.	(2.1)	
TDRP	Provincial Gov't (includes Municipal) Tax Revenue - Direct	$ Mill.	(2.2)	
TIRF	Federal Government Tax Revenue - Indirect	$ Mill.	(2.3)	
TIRP	Provincial Gov't (includes Municipal) Tax Revenue - Indirect	$ Mill.	(2.4)	
TPTG	Total Direct Taxes on Persons and Other Transfers from Persons	$ Mill.	(2.5)	
UR	Unemployment Rate	%	(5.6)	Identity
WAT	Total Average Weekly Wage Rate	$ Mill.	(6.3)	Identity
WATG	Average Weekly Wage Rate - Goods	$ Mill.	(6.1)	
WATS	Average Weekly Wage Rate - Services	$ Mill.	(6.2)	
XCEG	Consumer Expenditure - Goods	71$ Mill.	(1.1)	
XCES	Consumer Expenditure - Services	71$ Mill.	(1.2)	
XCET	Consumer Expenditure - Total	71$ MIll	(1.3)	Identity
XGDG	Real GDP - Goods	71$ Mill.	(4.1)	
XGDP	Real GDP - Total	71$ Mill.	(4.3)	Identity
XGDS	Real GDP - Services	71$ Mill.	(4.2)	
XGNE	Real GNE - Total	71$ Mill.	(1.13)	Identity
XGNG	Real GNE - Goods	71$ Mill.	(1.14)	Identity
XGNS	Real GNE - Services	71$ Mill.	(1.15)	Identity
XGT	Gov't Expenditure on Goods & Services	71$ Mill.	(1.12)	Identity
XIME	Private Investment (Non-Residential Construction and Mach. & Equip.)	71$ Mill.	(1.4)	

Table 1.1. Glossary of Variable Definitions. Continued..

Variable Name		Unit	Equation No.	
XIPV	Change in Business Inventory Investment	71$ Mill.	(1.6)	
XIRC	Residential Construction	71$ Mill.	(1.5)	
XITP	Total Gross Private Investment	71$ Mill.	(1.7)	Identity
XK	Capital Stock - Total	71$ Mill.	(4.5)	Identity
XKG	Capital Stock - Goods	71$ Mill.	(4.6)	Identity
XKS	Capital Stock - Services	71$ Mill.	(4.7)	Identity
XTM	Imports - Total	71$ Mill.	(1.10)	Identity
XTMG	Imports - Goods	71$ Mill.	(1.8)	
XTMS	Imports - Services	71$ Mill.	(1.9)	
XTX	Exports - Total	71$ Mill.	(1.11)	Identity
YBRI	Other Income (Interest, rent, farm, etc.)	$ Mill.	(7.3)	
YCCA	Capital-Consumption. Allowance - Total	$ Mill.	(7.10)	Identity
YCRP	Corporate Profits	$ Mill.	(7.2)	
YCS	Personal Savings	$ Mill.	(7.14)	Identity
YDIC	Dividends Paid to Canadians	$ Mill.	(7.4)	
YDIS	Personal Disposable Income	$ Mill.	(7.13)	Identity
YFCP	Dividends Paid to Non-Canadians	$ Mill.	(7.5)	
YGDP	Current GDP - Total	$ Mill.	(4.4)	Identity
YGNP	Gross National Product - Total	$ Mill.	(7.12)	Identity
YITA	Indirect Taxes less Subsidies including Capital Consumption Allowance	$ Mill.	(7.11)	Identity
YITS	Indirect Taxes less Subsidies	$ Mill.	(7.9)	Identity
YLI	Total Wage Bill	$ Mill.	(7.8)	Identity

Table 1.1. Glossary of Variable Definitions. Continued..

Variable Name		Unit	Equation No.
YNFA3	Net Private Wealth	$ Mill.	(3.5)
YSLI	Supplementary Labour Income	$ Mill.	(7.1)
YWTG	Wages and Salaries - Goods	$ Mill.	(7.6) Identity
YWTS	Wages and Salaries - Service	$ Mill.	(7.7) Identity

Exogenous Variables:		Unit
DINV	Dummy - Change in Inventory Equation	
DM1	Dummy - Money Aggregate Equation	
DPIM	Dummy - Import Price Equation	
DRESD	Dummy - Residential Construction Equation	
DRTB	Dummy - Treasury Bill Rate Equation	
DWG	Dummy - Wage Rate - Goods Equation	
DWS	Dummy - Wage Rate - Services Equation	
GETR	Government Transfer Payments	$ Mill.
GRNT	Government Non-Tax Revenue	$ Mill.
NPOP	Non-Institutionalised Population (15 years of age & above)	Millions
NP54	Non-Institutionalised Population (Ages 15 to 64)	Millions
PGCE	Government Expenditure Deflator - Current	1971 = 1
PGKE	Government Expenditure Deflator - Capital	1771 = 1
PGUS	U.S. GNP Deflator	1972 = 1
REX	Exchange Rate (Price of 1 U.S. dollar)	Cdn. $
RTBUS	U.S. Treasury Bill Rate	%

Table 1.1. Glossary of Variable Definitions. Continued..

Variable Name		Unit
RXKG	Proportion of Capital Stock in Goods Industry	Ratio
TCNR	Transfer from Persons to Corporations and Non-Residents	$ Mill.
TIME	Time Variable	1 to 72
URN	Natural Rate of Unemployment	%
XGCE	Government Expenditure on Current Expenditure	71$ Mill.
XGDPTR	Real GDP - Total Historical Trend Values	71$ Mill.
XGKE	Government Expenditure on Capital Expenditure	71$ Mill.
XRE	Residual Error	71$ Mill.
XTXG	Exports - Goods	71$ Mill.
XTXS	Exports - Services	71$ Mill.
YCCB	Capital Consumption Allowance - Business	$ Mill.
YCCG	Capital Consumption Allowance - All Gov't	$ Mill.
YIPDR	Interest on Public Debt paid to Persons and other Government Transfers	$ Mill.
YIVA	Inventory Value Adjustments	$ Mill.
YMPA	Military Pay and Allowance	$ Mill.
YRE	Residual Error	$ Mill.

2. Theoretical Specification of the Model by Sector and Equations

FINAL DEMAND SECTOR

The final demand sector of the model is concerned with the calculation of Gross National Expenditure. It follows a very basic Keynesian approach in determining the national expenditure and its components. As with the rest of the Trent model, this sector is disaggregated into goods-consuming activities and service-consuming activities. There are seven behavioural equations in this section: two for consumption, three for investment expenditures, and two for imports. The other final demand variables, government expenditure and total exports, are determined by identities. Eight identities are required to complete this sector.

CONSUMPTION FUNCTION

The consumption function is divided into two separate behavioural equations: one for the expenditures on goods and the other for the expenditures on services.

1.1) PER-CAPITA CONSUMPTION - GOODS

$$XCEG / NPOP = F\,[((YDIS/PCPI)/NPOP,\ PCEG/PCES,\ UR_{-1},\ RG35,\ (YNFA3/PCPI)/NPOP)]$$

It is hypothesised that per-capita personal consumption of goods is a function of per-capita real disposable income and the relative price of goods vis-a-vis services. The cost of finance in terms of the 3-5 year government bond rate is also included as an explanatory variable. To represent a long term consumption pattern, (the life-cycle hypothesis), the per-capita real wealth variable is used. Finally, to capture the effect of the general economic environment on the level of consumer spending, the reciprocal of the unemployment rate is added to the equation. It is assumed that a higher unemployment rate will adversely affect consumer confidence.

1.2) PER-CAPITA CONSUMPTION - SERVICES

XCES / NPOP = F [(YDIS/PCPI, XCEG, YNFA3/PCPI) / NPOP]

The per-capita consumption of services, like the consumption of goods is a function of per-capita real disposable income and per-capita real wealth. It is believed that expenditure on any service product at the retail level is expenditure on a combination or a bundle of both goods and services. Thus, in order to incorporate the interrelationship between the two elements, per-capita expenditure on goods is included in the determination of the consumption of services. The inclusion of the latter variable would indirectly reflect the effects of unemployment and the bond rate, which are omitted from the services equation.

1.3) TOTAL CONSUMPTION (IDENTITY)

$$XCET = (XCEG * NPOP) + (XCES * NPOP)$$

Total consumption is a summation of per-capita consumption of goods and services, multiplied by the current population.

INVESTMENT FUNCTION

The private investment expenditure section within the economy is broken up into three categories: Private Investment (non-residential construction and machinery & equipment), Residential Construction, and Change in Business Inventories (excluding government). Specifying independent equations for each type of investment does help identify the cycles and trends within each category.

1.4) PRIVATE INVESTMENT

$$XIME = F\ [(XGDP/XK)_{-1},\ XGDP/XGDPTR,\ RRI_{-1},\ RRI_{-2},\ RRI_{-3},\ RRI_{-4},\ RRI_{-5}\ ]$$

Private investment is explained by the output to capital ratio and the ratio of real GDP to the trend in real GDP. The latter variable is used to account for the cyclical variations, capacity utilisation and expectations, which would likely affect capital formation. A five quarter lag on the real rate of interest is included to account for the cost of capital.

1.5) RESIDENTIAL CONSTRUCTION

$$XIRC = F\ [\ YDIS/PCPI,\ RG35_{-1},\ RG35_{-2},\ RG35_{-3},\ RG35_{-4},\ DRESD\ ]$$

Expenditures on residential construction is determined by real disposable income and a lagged 3-5 year government bond rate. A dummy variable is used to identify specific government incentive programs during the sample period.

1.6) CHANGE IN INVENTORY

$$XIPV = F\ [\ XGDG/XGNG,\ RG35_{-1},\ DINV]$$

The final investment equation is the change in private inventory. It is a function of the ratio of real GDP in goods to real GNE in goods. This variable captures the relationship between the supply and demand for goods. The cost of holding inventory is reflected by the 3-5 year bond rate. A dummy variable is used to incorporate several extraneous cyclical factors.

1.7) TOTAL GROSS PRIVATE INVESTMENT (IDENTITY)

$$XITP = XIME + XIRC + XIPV$$

Total gross private investment is defined as the sum of the three investment equations.

IMPORT FUNCTION

In the imports section, the model distinguishes between expenditures on imported goods and expenditures on imported services.

1.8) PER-CAPITA IMPORTS - GOODS

$$XTMG / NPOP = F\,[(YDIS/PCPI)/NPOP),\ (PIM*REX)/PGNP,\ XTMG_{-1}/NPOP_{-1}]$$

The per-capita imports of goods is a function of per-capita real disposable income and the domestic price of imports relative to the GNP price deflator. The domestic price of imports is calculated as the product of the import price deflator and the exchange rate. Apparently from equation 6.11, the import price deflator already reflects the exchange rate. Consequently, to avoid double conversion, it may be necessary to re-specify the imports equation.

1.9) PER-CAPITA IMPORTS - SERVICES

$$XTMS / NPOP = F [((YDIS/PCPI)/NPOP), XTMS_{-1}/NPOP_{-1}]$$

The per-capita imports of services is simply a function of the real disposable income. The relative price sensitivity variable from the import of goods equation is not used here, and thus different expenditures on goods and on services are built into the model.

1.10) TOTAL IMPORTS (IDENTITY)

$$XTM = (XTMG * NPOP) + (XTMS * NPOP)$$

1.11) TOTAL EXPORTS (IDENTITY)

$$XTX = XTXG + XTXS$$

The exports identity is the summation of goods and service exports.

1.12) GOVERNMENT EXPENDITURE ON GOODS & SERVICES (IDENTITY)

$$XGT = XGCE + XGKE$$

Government spending variable is split into current and capital expenditures, both of which are exogeneous.

1.13) TOTAL GROSS NATIONAL EXPENDITURE (IDENTITY)

$$XGNE = XCET + XGT + XITP + XTX - XTM + XRE$$

The government expenditure on goods and services (XGT) and total exports (XTX) are exogenous to the model. XRE is the GNE residual error, which is also exogenous. The total consumption on goods and services (XCET), total private investment (XITP) and total imports (XTM) are discussed above.

1.14) GROSS NATIONAL EXPENDITURE - GOODS (IDENTITY)

$$XGNG = XCEG + XITP + (0.50 * XGCE) + XGKE + XTXG - XTMG$$

1.15) GROSS NATIONAL EXPENDITURE - SERVICES (IDENTITY)

$$XGNS = XGNE - XGNG$$

Continuing with the goods and services separation, the GNE is divided into two identities. The GNE on goods is a summation of consumption (XCEG) and net exports of goods (XTXG-XTMG) plus government spending on capital expenditure (XGKE) and 50% of government spending on current expenditure (XGCE). The total private investment is also included. GNE: services is calculated residually as the total GNE minus the portion required by the national expenditure on goods.

GOVERNMENT SECTOR

The government sector of the model is primarily concerned with determining the government budget balance. This sector consists of five behavioural equations explaining government revenue. The expenditure side is exogenous. There are two groups of governments represented, federal and provincial. The provincial level includes the municipal governments. For both levels of government there are two equations, one for the generation of direct tax revenue and the other for indirect tax revenue. The fifth equation explains the total direct tax revenue collected from persons, for all levels of government.

2.1) DIRECT REVENUE - TOTAL FEDERAL GOVERNMENT

TDRF = F [(XGDP*PGDP)]

2.2) DIRECT REVENUE - TOTAL PROVINCIAL GOVERNMENTS

TDRP = F [(XGDP*PGDP)]

Direct tax revenue, for both the federal and the provincial governments, is determined by the total real GDP times the GDP deflator. Both direct revenue functions reflect tax collection from nominal output.

2.3) INDIRECT REVENUE - TOTAL FEDERAL GOVERNMENT

TIRF = F [(XCET*PCET)]

2.4) INDIRECT REVENUE - TOTAL PROVINCIAL GOVERNMENTS

TIRP = F [(XCET*PCET)]

Indirect tax revenue for both levels of government, is generated as a portion of the total nominal consumer expenditure and implies a constant rate of taxation.

2.5) TOTAL DIRECT REVENUE - (ALL GOVT'S)

TPTG = F [(TDRF+TDRP)]

Total government revenue is composed of direct revenue collected from persons and investment income. Since in the model only revenue collected from persons affects disposable income, the total direct revenue equation is a linear function of the sum of the two revenue functions.

2.6) TOTAL GOVERNMENT REVENUE (IDENTITY)

GRT = TDRF + TIRF + TDRP + TIRP + GRNT

Total government revenue is a summation of total direct, indirect and non-tax revenues (GRNT).

2.7) TOTAL GOVERNMENT EXPENDITURE (IDENTITY)

GET = (XGCE * PGCE) + (XGKE * PGKE) + GETR

Government spending is a summation of current and capital expenditures including expenditures on transfer payments, subsidies and capital assistance (GETR). All variables on the right hand side of this identity are exogenous.

2.8) GOVERNMENT BALANCE (IDENTITY)

GBT = GRT + YCCG - GET

The government sector budget balance is the total government revenue including the capital consumption allowances minus the expenditure.

The five revenue equations provide important linkages from the government sector to the other sectors of the model. Total direct tax revenues affect the level of demand through its effect on personal disposable income. Indirect tax revenue has an impact on the consumer expenditure price deflators and through these deflators on the consumer price index, which in turn influences final demand through real disposable income.

On the monetary side of the economy, the government balance affects the long term interest rate (RG35), which further influences the consumption of goods and the investment equations in the Final Demand sector. The interest rate also affects the gross national product through its impact on the investment income portion of the other income equation. The repercussions from the government balance to the investment functions through the interest rate are due to the crowding-out effect.

The disaggregation of the government sector into direct and indirect revenue functions for both the federal and provincial governments provides a variety of combinations of fiscal policy instruments.

MONETARY SECTOR

The monetary sector of the model consists of four behavioural equations: one explaining the real money supply, two equations for interest rates, namely the 90 day treasury bill rate and the 3-5 year government bond rate. The last equation is used to explain net private wealth in the economy.

3.1) MONEY AGGREGATE (M1)

$$M1/PGNP = F\ [(M1/PGNP)_{-1},\ XGNE,\ RTB,\ RTB_{-1},\ RTB_{-2},\ RTB_{-3},\ DM1]$$

The aggregate money, as in the Keynesian LM curve, is defined as a relationship between the rate of nominal interest and the level of real gross national income. A dummy variable is included to account for the effects of postal strikes.

3.2) TREASURY BILL RATE

$$RTB = F\ [\ (M1/PGNP)/((M1/PGNP)_{-1}),\ XGNE,\ RTBUS,\ PGNP_{-1}/PGNP_{-2},\ PGNP_{-2}/PGNP_{-3},\ PGNP_{-3}/PGNP_{-4},\ PGNP_{-4}/PGNP_{-5},\ PGNP_{-5}/PGNP_{-6},\ DRTB\ ]$$

The 90 day treasury bill rate, which is the short term interest rate in the model, is a function of the change in the real money supply and the level of gross national expenditure. Inflationary expectations are incorporated into the treasury bill rate equation through a distributed lag on the rate of change of the GNE price deflator. The U.S treasury bill rate is also included in the equation. It is hypothesised that the American treasury bill rates have a positive impact on the Canadian rate. For example, an increase in the U.S. rate would induce a capital outflow from Canada. This would create downward pressure on the Canadian dollar. It is assumed here that the Bank of Canada would resist exchange rate changes, thus allowing the treasury bill rate to rise with the U.S. rate.

3.3) 3-5 YEAR GOVERNMENT BOND RATE

$$RG35 = F\ [RTB,\ RTB/RTBUS,\ GBT]$$

The government bond rate is a direct function of the short term interest rate (RTB), the ratio of Canadian to the U.S. treasury bill rate and the government budget balance. If the U.S. rate increases relative to the Canadian RTB rate, the local long term rate would increase. A change in the government budget balance is modeled to have an immediate impact on the bond rate.

3.4) REAL RATE OF INTEREST (IDENTITY)

$$RRI = RG35 - [\ (PGNP_{-1} - PGNP_{-5})\ /\ PGNP_{-5}\ ]$$

The real rate of interest is defined as the difference between the rate of interest on the 3-5 year government bond and the annualised rate of change in the gross national product price deflator.

3.5) NET PRIVATE WEALTH

$$YNFA3 = F\ [RTB,\ YNFA3_{-1},\ YGNP,\ YGNP_{-1},\ YGNP_{-2},\ YGNP_{-3}\ ]$$

Net private wealth is measured by the net financial asset holding. It is dependent on the treasury bill rate and on the gross national product.

The monetary sector equations are designed to provide clearly defined monetary policy levers as well as to capture the monetary repercussions of disturbances originating outside the sector. It is possible to manipulate the money supply or the short term interest rate by removing either the equation for the real money supply or the treasury bill rate and making the corresponding variable exogenous.

The monetary sector is linked to the other sectors of the model through the interest rates. On the demand side, the cost of finance influences consumption, and all the investment variables. Private wealth affects both the consumption of goods and of services.

On the supply side of the economy, the long term interest rate determines the investment aspect of the other income equation. Indirectly, however, the levels of output and employment are influenced by the monetary sector variables through their impact on expenditures.

OUTPUT SECTOR

The output sector explains the total volume of goods and services produced within the economy. The stock of capital is also explained in the this sector. The total output and capital stock are disaggregated into the production of goods and the production of services.

4.1) OUTPUT - GOODS

$$\text{Log}(XGDG) = F\ [\text{Log}(XGDG_{-1}),\ \text{Log}(XGNG_{-1}/XGNG_{-2}),$$
$$\text{Log}(XGDS/XGDS_{-1}),\ \text{Log}(XGDG_{-1}/XGNG_{-1})]$$

A log linear specification is used in the output equation. Output of goods is a function of the quarterly change in expenditure on goods, and the change in the output of services. The latter variable reflects the interrelationship between the goods and the service sector. For instance, an increase in services represents an increase in demand for the combination or bundle of goods and services. To incorporate inventory change into the output model, a lagged ratio of the goods output relative to the expenditures on goods is used as an explanatory variable. The inertia in the movement of the endogenous variable is captured by placing a lag of the endogenous variable on the right hand side of the equation.

4.2) OUTPUT - SERVICES

$$\text{Log}(XGDS) = F\ [\text{Log}(XGDS_{-1}),\ \text{Log}(XGNE_{-1}/XGNE_{-2})]$$

The output of services is specified simply by the quarterly change in gross national expenditure. The output of services is thus motivated by the total demand for both goods and services. To eliminate autocorrelation in this equation, a lag of the endogenous variable is placed on the right hand side.

Both the output equations reflect the demand-driven nature of the Trent model, as neither of them include factor costs.

4.3) TOTAL GROSS DOMESTIC PRODUCT (IDENTITY)

$$XGDP = XGDG + XGDS$$

The gross domestic product identity is a sum of the two output equations above.

4.4) CURRENT GROSS DOMESTIC PRODUCT (IDENTITY)

$$YGDP = XGDP * PGDG$$

4.5) TOTAL CAPITAL STOCK (IDENTITY)

$$XK = XK_{-1} + ((XITP_{-1} + XGKE_{-1}) - (YCCA_{-1} / PGNP_{-1})) / 4$$

Capital stock is the previous quarter's capital stock plus the total investment in the economy, both government and private, net of the real total capital consumption allowance.

The total capital stock is further disaggregated into capital stock for the goods and service industries. Capital stock in the goods industry is simply a fraction (RXKG) of the total capital stock. RXKG is exogenously determined, and varies from 29.59% to 30.59%.

4.6) CAPITAL STOCK - GOODS (IDENTITY)

XKG = XK * RXKG

4.7) CAPITAL STOCK - SERVICES (IDENTITY)

XKS = XK * (1 - RXKG)

LABOUR - EMPLOYMENT SECTOR

The labour-employment sector draws together information from the output and the wage and price sectors to determine the level of employment and unemployment in the Canadian economy. This sector consists of three behavioural equations: employment in the goods sector, employment in the service sector and the average labour participation ratio. The rest of the dependent variables are identities assessing the total labour force, total employment, and the unemployment rate.

5.1) EMPLOYMENT - GOODS SECTOR

$$\text{Log(ECTG)} = \text{F [Log(XGDG), Log(XGDG-1/ECTG-1), Log(XKG),}$$
$$\text{Log(WATG/PGDG)]}$$

The level of employment in the goods sector is explained by the volume of output, labour productivity lagged one quarter, capital stock, and the real wage in the goods sector of the economy.

5.2) EMPLOYMENT - SERVICE SECTOR

$$\text{Log(ECTS)} = \text{F [Log(XGDS), Log(}XGDS_{-1}/ECTS_{-1}\text{), Log(XKS),}$$
$$\text{Log(WATS/PGDS)]}$$

The level of employment in the service sector is modeled identically to that of the goods sector, except it uses the service sector data.

5.3) AVERAGE PARTICIPATION RATIO

$$APRT = F\ [APRT_{-1},\ WAT/PCPI,\ TIME]$$

The labour participation rate is defined as the percentage of working age individuals who report that they are in the labour force, either employed or looking for work. In the Trent model, total supply of labour is derived from the non-institutionalised population over fifteen years of age (NP54) and the average labour force participation rate. The non-institutionalised population figure is exogenous, while the participation rate is determined by the real wage rate and a time trend variable.

5.4) TOTAL LABOUR FORCE (IDENTITY)

LFTC = NP54 * APRT

5.5) TOTAL EMPLOYMENT (IDENTITY)

ECT = ECTG + ECTS

5.6) UNEMPLOYMENT RATE (IDENTITY)

UR = ((LFTC - ECT) / LFTC) * 100

The unemployment rate is the total labour force minus the number of people employed expressed as a percentage.

WAGE AND PRICE SECTOR

WAGES

The wage rates within the model are determined using the expectations-augmented Phillips curve approach, with a natural rate of unemployment. Thus the key explanatory variables of the wage rate equations are the unemployment rate, labour productivity and the inflation rate.

Consistent with the other sectors of the Trent model, the disaggregation into the goods-producing and service-producing sectors is carried over into the independent determination of wages in each activity.

6.1) AVERAGE WEEKLY WAGE - GOODS SECTOR

$$\begin{aligned} \mathrm{Log}(WATG/WATG_{-4}) = F\ [\ & \mathrm{Log}((XGDG_{-1}/ECTG_{-1})/(XGDG_{-2}/ECTG_{-2})), \\ & \mathrm{Log}(UR/URN),\ \mathrm{Log}(PCPI\ /PCPI_{-4}), \\ & \mathrm{Log}(PCPI_{-1}\ /PCPI_{-5}),\ \mathrm{Log}(PCPI_{-2}\ /PCPI_{-6}), \\ & \mathrm{Log}(PCPI_{-3}\ /PCPI_{-7}),\ DWG\ ] \end{aligned}$$

An annual rate of change in the weekly wage is used as the dependent variable. The regressors are the annual rate of change in the labour productivity in the goods sector, and the unemployment rate relative to the natural rate of unemployment. Inflationary expectations are modeled into the wage rate determination using a four quarter lag on the change in the annual consumer price index.

6.2) AVERAGE WEEKLY WAGE - SERVICE SECTOR

$$\begin{aligned}\mathrm{Log}(WATS/WATS_{-4}) = F\ [&\mathrm{Log}((XGDS_{-1}/ECTS_{-1})/(XGDS_{-2}/ECTS_{-2})),\\ &\mathrm{Log}(UR/URN),\ \mathrm{Log}(PCPI_{-1}/PCPI_{-5}),\\ &\mathrm{Log}(PCPI_{-2}/PCPI_{-6}),\ \mathrm{Log}(PCPI_{-3}/PCPI_{-7})\\ &\mathrm{Log}(PCPI_{-4}/PCPI_{-8}),\ DWS]\end{aligned}$$

The average weekly wage equation for the service sector is identical to that of the goods sector, except that it is related to service sector variables.

6.3) TOTAL WEEKLY AVERAGE WAGE RATE (IDENTITY)

$$WAT = ((WATG * ECTG) + (WATS * ECTS)) / ECT$$

The total weekly wage rate identity is a weighted average of the two separate rates in the economy, namely the goods sector and the service sector wages.

PRICES

There are three main categories of price deflators and indices in the model. The gross domestic product price deflators, the consumer expenditure price deflators and the price index for imports. Both the GDP and the expenditure deflators are divided into the goods and service sectors.

OUTPUT DEFLATORS

The model employs a basic mark-up pricing approach in assessing the individual price deflators. In other words, output prices are assessed at a certain percentage above their costs. Therefore, the change in sectoral unit labour costs is a significant factor in explaining the price deflator. To reflect the effects of imported inputs on output prices, the quarterly change in the import price index is included in the equation.

6.4) GDP DEFLATOR - GOODS

$$\mathrm{Log(PGDG)} = F\ [\mathrm{Log}(\mathrm{PGDG}_{-1}),\ \mathrm{Log}(\mathrm{PIM}/\mathrm{PIM}_{-1}),\ \mathrm{Log}((\mathrm{YWTG}/\mathrm{XGDG})/(\mathrm{YWTG}_{-1}/\mathrm{XGDG}_{-1}))]$$

6.5) GDP DEFLATOR - SERVICES

$$\mathrm{Log(PGDS)} = F\ [\mathrm{Log}(\mathrm{PGDS}_{-1}),\ \mathrm{Log}(\mathrm{PIM}/\mathrm{PIM}_{-1}),\ \mathrm{Log}((\mathrm{YWTS}/\mathrm{XGDS})/(\mathrm{YWTS}_{-1}/\mathrm{XGDS}_{-1}))]$$

6.6) UNIT GDP COST INDEX - TOTAL (IDENTITY)

$$\mathrm{PGDP} = ((\mathrm{XGDG} * \mathrm{PGDG}) + (\mathrm{XGDS} * \mathrm{PGDS}))\ /\ \mathrm{XGDP}$$

The gross domestic product unit cost index is a weighted average of the GDP deflators from the goods and service sector.

EXPENDITURE DEFLATORS

The consumer expenditure deflators for the goods and services sectors are a function of the change in the proportion of taxes paid on consumption, that is the indirect taxes collected relative to the real consumption expenditure on that sector. The quarterly change in production costs is represented using a distributed lag on the rate of change of output prices. The change in the import price index is also used as an independent variable.

6.7) CONSUMER EXPENDITURE DEFLATOR - GOODS

$$\begin{aligned} Log(PCEG/PCEG_{-1}) = F\ [& \{(YITS/(XCET*PCET))\ /\ (YITS_{-1}/ \\ & ((XCET*PCET)_{-1})\},\ Log(PIM/PIM_{-1}), \\ & Log(PGDG\ /PGDG_{-1}),\ Log(PGDG_{-1}/PGDG_{-2}), \\ & Log(PGDG_{-2}/PGDG_{-3}),\ Log(PGDG_{-3}/PGDG_{-4})\ ] \end{aligned}$$

6.8) CONSUMER EXPENDITURE DEFLATOR - SERVICES

$$\begin{aligned} Log(PCES/PCES_{-1}) = F\ [& \{(YITS/(XCET*PCET))\ /\ (YITS_{-1}/ \\ & ((XCET*PCET)_{-1})\},\ Log(PIM/PIM_{-1}), \\ & Log(PGDS\ /PGDS_{-1}),\ Log(PGDS_{-1}/PGDS_{-2}), \\ & Log(PGDS_{-2}/PGDS_{-3}),\ Log(PGDS_{-3}/PGDS_{-4})] \end{aligned}$$

6.9) CONSUMER EXPENDITURES DEFLATOR (IDENTITY)

$$PCET = ((XCEG * PCEG) + (XCES * PCES)) / XCET$$

Similar to the total output deflator above, the aggregate consumer expenditure deflator is a weighted average of the two sectoral expenditure deflators.

6.10) CONSUMER PRICE INDEX

$$\text{Log}(PCPI/PCPI_{-1}) = F\ [\text{Log}(PCET/PCET_{-1})]$$

The CPI is a direct function of the rate of change of the consumer expenditure deflator.

6.11) IMPORT PRICE INDEX

$$\text{Log}(PIM/PIM_{-1}) = F\ [\text{Log}(PGUS/PGUS\_1), \text{Log}(REX/REX_{-1}), DPIM]$$

Since it is assumed that the U.S. is a major supplier of imports, and that Canada is a price taker, the main determinant of the import price index is the U.S. GNE price index. The other variable is the rate of change in the U.S./Canadian exchange rate.

6.12) GNP DEFLATOR (IDENTITY)

PGNP = YGNP / XGNE

The last variable in the wage and price sector is the gross national product deflator. It is simply the ratio of the total nominal gross national product to the total real gross national expenditure.

NATIONAL INCOME SECTOR

The Trent model employs the basic incomes approach to gross national income accounting. National income is comprised of wages, interest, rental income, corporate profits, dividends, indirect taxes, and capital consumption allowances. Wages and indirect taxes are generated in other sectors of the model, while capital consumption allowances are exogenous. Thus the national income sector generates the remaining components of income required to calculate total gross national product and personal disposable income.

7.1) SUPPLEMENTARY LABOUR INCOME

YSLI = F [(YWTG+YWTS), TIME]

The supplementary labour income is explained as a fraction of total wage and salary income in both the service and goods industries. A time trend is included in the equation to account for the autonomous trend experienced by the dependent variable. The coefficient of the time trend could be interpreted as a measure of autonomous growth.

7.2) CORPORATE PROFITS

$$YCRP = F\ [YCRP_{-1},\ (YWTG+YWTS+YSLI),\ ((YGNP+YGNP_{-1})/2)]$$

Corporate profits before taxes depend on the total wage bill including supplementary income and on the level of national income. The latter variable is an average of the previous two quarters.

7.3) OTHER INCOME

$$YBRI = F\ [YGNP,\ RG35]$$

Other income is an aggregate of several different sources of income. It includes interest and miscellaneous investment income, accrued net income of farm operators from farming, and net income of non-farm unincorporated business including rent. This aggregation can be divided into two components, farm or business and investment income. Thus farm and business income is viewed as dependent on gross national product (YGNP), while investment income is dependent on the long term interest rate (RG35).

7.4) DIVIDENDS TO CANADIANS

$$YDIC = F\ [YDIC_{-1},\ YCRP,\ REX]$$

Dividends received by Canadians include dividend income from foreign investments. This income depends on corporate profits and the exchange rate.

7.5) DIVIDENDS TO NON-CANADIANS

$$YFCP = F\ [YCRP,\ TIME]$$

Dividend payments to non-Canadians are a function of corporate profits and a time trend.

SECTOR WAGE BILLS AND TOTAL WAGE BILL

The wage bills in the goods and service sectors are calculated separately by taking the total number of individuals employed in the sector multiplied by the average weekly sector wage. The result is multiplied by 52 to convert it to an annual figure. For the total wage bill, identity (7.8), the military pay and allowances are added to wages and salaries and supplementary income.

7.6) WAGES & SALARIES - GOODS INDUSTRIES (IDENTITY)

YWTG = ECTG * WATG * 52

7.7) WAGES & SALARIES - ALL SERVICES (IDENTITY)

YWTS = ECTS * WATS * 52

7.8) TOTAL WAGES BILL (IDENTITY)

YLI = YMPA + YWTG + YWTS + YSLI

7.9) INDIRECT TAXES LESS SUBSIDIES (IDENTITY)

YITS = TIRF + TIRP

Indirect taxes are the summation of indirect taxes collected by the federal and provincial governments.

7.10) CAPITAL CONSUMPTION ALLOWANCE (IDENTITY)

YCCA = YCCG + YCCB

Total capital consumption allowance brings together the two exogenous variables, government and business capital consumption allowances.

7.11) INDIRECT TAXES LESS SUBSIDIES, INCLUDING CAPITAL CONSUMPTION ALLOWANCE (IDENTITY)

YITA = YITS + YCCA

7.12) TOTAL GROSS NATIONAL PRODUCT (IDENTITY)

YGNP = YLI + YCRP - YFCP + YBRI + YIVA + YITA + YRE

Summing up the different income components including the inventory adjustments (YIVA) and the residual error (YRE) yields nominal gross national product.

7.13) PERSONAL DISPOSABLE INCOME (IDENTITY)

YDIS = YLI + YBRI + YDIC + YIPDR - TPTG

Disposable income is calculated by adding the total wage bill, other incomes (YBRI), dividends received by Canadians, and interest on public debt paid to persons, as well as other government transfers (YIPDR) net of direct taxes on persons and other transfers from persons (TPTG).

7.14) PERSONAL SAVINGS (IDENTITY)

YCS = YDIS - (XCET * PCET) - TCNR

Savings are disposable income minus real consumption expenditure and the personal transfers to corporations and non-residents.

The national income sector plays a major role in linking the aggregate demand and the aggregate supply side of the economy. Consumption, investment and exports are directly affected by the level of disposable income. The government sector is linked to the income sector through indirect taxes, and to disposable income through direct taxes. The monetary sector influences the level of investment income through the long term interest rate.

Indirectly, the income sector influences aggregate demand through its direct effect on the price deflators and the consumer price index.

It is the income and final demand sectors which combine the various sectors of the model into a cohesive system. In these two sectors, the basic national income accounts approach, which forms the underlying framework of the model, is clearly presented.

3. Estimation of the Trent Model

All the behavioural equations of the model are simultaneously estimated using the two-stage least squares method. Quarterly data over the period 1967:1 to 1984:4 is used, but since the model has an eight quarter lag, estimation only begins in 1969.

For all the equations marked AR1, a correction for first-order serial autocorrelation is used. The other behavioural equations, labeled PDL, are estimated using the Almon Scheme of Polynomial Distributed Lags. A second-degree polynomial with no endpoint restrictions was utilised for all the lag models. The procedure used to correct for autocorrelation, and to estimate the coefficients of the distributed lag variables on individual equations within a system of equations, is reprinted in Appendix B.

In this section of the paper, the list of estimated equations is separated into the demand and the supply side of the economy. The three demand sectors are presented first, followed by the four supply sectors. The t-statistics are listed in parentheses under each coefficient. Also calculated for each function is the coefficient of determination (R^2), the root mean square error of estimate (SEE), and the Durbin Watson statistic (DW). The Durbin Watson h statistic (DW h) is calculated for the regressions containing lagged values of the dependent variable. For equations corrected for autocorrelation, the estimated correlation coefficient (RHO) and its t-statistic, are provided.

FINAL DEMAND SECTOR

1.1) PER-CAPITA CONSUMPTION - GOODS

$$XCEG / NPOP = \underset{(3.38)}{1437.57} + \underset{(13.70)}{0.4823} \left(\frac{YDIS/PCPI}{NPOP}\right) - \underset{(-3.75)}{1407.71} \frac{PCEG}{PCES}$$

$$+ \underset{(5.01)}{1806.1} \left(\frac{1}{UR_{-1}}\right) - \underset{(-7.42)}{20.8624} RG35 - \underset{(-0.84)}{0.02300} \left(\frac{YNFA3/PCPI}{NPOP}\right)$$

$R^2 = 0.9802$ SEE = 32.436 DW = 1.413

1.2) PER-CAPITA CONSUMPTION - SERVICES (AR1)

$$XCES / NPOP = \underset{(2.99)}{554.97} + \underset{(2.76)}{0.13312} \left(\frac{YDIS/PCPI}{NPOP}\right) + \underset{(1.02)}{0.09936} \frac{XCEG}{NPOP}$$

$$+ \underset{(1.79)}{0.07630} \left(\frac{YNFA3/PCPI}{NPOP}\right)$$

$R^2 = 0.9931$ SEE = 12.6716 RHO = 0.95356 (25.53)

The first two equations (1.1) and (1.2) are the estimated consumption functions for goods and services respectively. The per-capita consumption of goods is a function of disposable income, relative price of goods, unemployment rate, interest rate, and net wealth. The per-capita consumption of services is a function of disposable income, net wealth and the level of goods consumption. The estimated marginal propensity to consume out of disposable income is 0.48 for goods and 0.13 for services. The net wealth parameter is negative in the goods equation and positive in the services. However, in the single equation estimation both the coefficients are significant and have the same signs as in the simultaneous estimation. One possible argument for the difference in sign is that, as wealth is increasing, Canadians are changing the composition of total consumption in favour of services.

The model estimates a negative relationship between the nominal interest rate and goods consumption. Thus, individuals perceive nominal rate increases as an incentive to save and postpone present consumption. Not surprisingly, an increase in the goods sector inflation, relative to the service sector, decreases consumption of goods. The significant parameter of the unemployment variable indicates a strong relationship of the rate on individual buying habits.

1.4) PRIVATE INVESTMENT (PDL)

$$XIME = \underset{(0.26)}{1946.84} - \underset{(-17.07)}{67323.71}\,(XGDP/XK)_{-1}$$

$$+ \underset{(6.16)}{43738.14}\,(XGDP/XGDPTR) - \underset{(-0.55)}{81.4008}\,RRI_{-1} - \underset{(-0.49)}{10.35855}\,RRI_{-2}$$

$$+ \underset{(1.01)}{24.1026}\,RRI_{-3} + \underset{(2.11)}{21.98275}\,RRI_{-4} - \underset{(-3.79)}{16.71816}\,RRI_{-5}$$

$R^2 = 0.8689$ SEE = 1303.38 DW = 0.183

The reciprocal of the capital/output ratio is used as an independent variable explaining private investment. It is estimated that an increase in capital stock relative to output would increase the amount of investment. This is consistent with basic theory where, as the capital-output ratio rises, increases in output relative to trend increases investment. Although the lag pattern on the real rate of interest is peculiar, the summation of the coefficients for a polynomial distributed lag yields the long term effect, in this case negative.

1.5) RESIDENTIAL CONSTRUCTION (PDL)

$$\underset{(11.91)}{\text{XIRC} = 2329.34} + \underset{(19.36)}{0.07117}\left(\frac{\text{YDIS}}{\text{PCPI}}\right) - \underset{(-0.34)}{17.6667}\ \text{RG35}_{-1} - \underset{(-0.25)}{149.856}$$

$$\text{RG35}_{-2} - \underset{(-2.98)}{139.365}\ \text{RG35}_{-3} + \underset{(9.35)}{13.8064}\ \text{RG35}_{-4}$$

$$- \underset{(8.70)}{733.72}\ \text{DRESD}$$

$R^2 = 0.8919$ SEE = 278.62 DW = 1.223

The Canadian marginal propensity to invest in residential construction out of disposable income is relatively high at 7%. The government bond rate determines the quantity of housing starts, and is estimated to affect the construction industry adversely.

1.6) CHANGE IN INVENTORY

$$\text{XIPV} = \underset{(4.39)}{3210.91}\ (\text{XGDG}/\text{XGNG}) - \underset{(-3.01)}{118.62}\ \text{RG35}_{-1}$$

$$+ \underset{(7.49)}{1350.51}\ \text{DINV}$$

$R^2 = 0.5753$ SEE = 1042.60 DW = 1.218

The discrepancy between the demand and supply for goods is the major source of inventory change. As expected, when the quantity supplied increases relative to the quantity demanded, inventory stocks increase. The cost of storing inventory is reflected by the interest rate. As rates go up, fewer goods are held.

1.8) IMPORTS - GOODS

$$XTMG / NPOP = \underset{(1.22)}{49.8968} + \underset{(1.03)}{0.03} \left(\frac{YDIS/PCPI}{NPOP}\right) - \underset{(-1.18)}{55.3808} \left(\frac{PIM*REX}{PGNP}\right) + \underset{(11.1)}{0.912} \frac{XTMG_{-1}}{NPOP_{-1}}$$

$R^2 = 0.9296$ SEE = 42.07273 DW h = 1.051

1.9) IMPORTS - SERVICES

$$XTMS / NPOP = \underset{(0.26)}{3.04843} + \underset{(2.07)}{0.02119} \left(\frac{YDIS/PCPI}{NPOP}\right) + \underset{(9.57)}{0.8048} \frac{XTMS_{-1}}{NPOP_{-1}}$$

$R^2 = 0.9542$ SEE = 13.23931 DW h = -1.756

The marginal propensity to import out of disposable income is positive, at 3%. The relative price sensitivity vis-à-vis U.S. goods is negative. Whether the import price index rose or the Canadian dollar depreciated, the volume of imports would decrease.

The services import equation does not contain the price sensitivity variable; however, the proportion of disposable income used for importation of services is less at 2%. This result is consistent with the propensity to consume calculated in the consumption equations, where less is spent on services.

GOVERNMENT REVENUE SECTOR

2.1) DIRECT REVENUE - TOTAL FEDERAL GOVERNMENT (AR1)

$$TDRF = \underset{(0.24)}{683.85} + \underset{(12.15)}{0.13491}\ (XGDP*PGDP)$$

$R^2 = 0.9892$ SEE = 1507.76 RHO = 0.8528 (7.27)

2.2) DIRECT REVENUE - TOTAL PROVINCIAL GOVERNMENTS (AR1)

$$TDRP = -\underset{(-5.02)}{2548.14} + \underset{(39.09)}{0.08386}\ (XGDP*PGDP)$$

$R^2 = 0.9967$ SEE = 512.89 RHO = 0.71525 (5.78)

The direct government revenue variables for the federal and the provincial governments are both positive functions of the total output within the economy. The federal government collects a larger share of taxes on output than do provincial governments.

2.3) INDIRECT REVENUE - TOTAL FEDERAL GOVERNMENT (AR1)

$$TIRF = \underset{(0.05)}{125.94} + \underset{(5.33)}{0.0766}\ (XCET*PCET)$$

$R^2 = 0.9792$ SEE = 731.28 RHO = 0.9185 (13.19)

2.4) INDIRECT REVENUE - TOTAL PROVINCIAL GOVT'S

$$TIRP = \underset{(1.14)}{210.59} + \underset{(112.69)}{0.14534}\ (XCET*PCET)$$

$R^2 = 0.9951$ SEE = 665.82 RHO = 0.8028 (11.83)

Indirect taxes are solely determined by consumption expenditures, and there is a strong positive correlation between these variables. Apparently, the provincial governments receive the bulk of their tax revenue from consumption sales tax.

2.5) TOTAL DIRECT REVENUE - ALL GOVERNMENTS (AR1)

$$TPTG = \underset{(1.76)}{912.44} + \underset{(30.11)}{0.75242}\,(TDRF + TDRP)$$

$R^2 = 0.9976$ SEE = 986.00 RHO = -0.00000673 (-3.79)

The sum of the two separate direct revenue equations form the explanatory variable for total government revenue. The estimate shows that 75% of government revenue is derived from the output of goods.

MONETARY SECTOR

3.1) MONEY AGGREGATE - M1 (PDL)

$$M1/PGNP = \underset{(2.91)}{1032.06} + \underset{(17.58)}{0.8299}\,M1_{-1}/PGNP_{-1} + \underset{(3.56)}{228.23}\,DM1$$

$$+ \underset{(4.03)}{0.01275}\,XGNE - \underset{(-1.09)}{17.2476}\,RTB - \underset{(-0.73)}{49.6460}\,RTB_{-1}$$

$$- \underset{(-3.29)}{36.054}\,RTB_{-2} + \underset{(10.97)}{23.52817}\,RTB_{-3}$$

$R^2 = 0.9718$ SEE = 155.03 DW h = 1.041

The real money demand is determined by the gross national expenditure and the nominal interest rate. The estimated coefficients are consistent with the Keynesian LM curve analysis. The sum of the lag coefficients represents the negative long term effect of interest rates on aggregate money. The GNE on the other hand, exerts a positive influence on the money supply.

3.2) TREASURY BILL RATE (PDL)

$$RTB = \underset{(0.21)}{4.52157} - \underset{(-4.13)}{36.98861}\left(\frac{M1/PGNP}{(M1/PGNP)_{-1}}\right) + \underset{(3.13)}{0.0000329}\ XGNE$$

$$- \underset{(-5.54)}{2.31702}\ DRTB + \underset{(14.55)}{0.97149}\ RTBUS - \underset{(-1.4)}{35.8644}\left(\frac{PGNP_{-1}}{PGNP_{-2}}\right)$$

$$- \underset{(-0.98)}{10.6233}\left(\frac{PGNP_{-2}}{PGNP_{-3}}\right) + \underset{(0.94)}{10.244}\left(\frac{PGNP_{-3}}{PGNP_{-4}}\right) + \underset{(0.28)}{26.738}\left(\frac{PGNP_{-4}}{PGNP_{-5}}\right)$$

$$+ \underset{(2.0)}{38.858}\left(\frac{PGNP_{-5}}{PGNP_{-6}}\right)$$

$R^2 = 0.9429$ SEE = 0.96845 DW = 1.090

The estimate of the treasury bill rate shows that, as the money supply grows, it becomes cheaper to borrow. As the total expenditures in the economy increase, the interest rate is pushed up. Closely related to expenditures is the correlation between interest rates and inflation. Rises in the cost of living increase current spending, which in turn increases the interest rate through a higher demand for cash and credit.

The Canadian interest rate is estimated to move in line with the U.S. rate. This supports the hypothesis stated in section 2 equation (3.2) above.

3.3) 3-5 YEAR GOVERNMENT BOND RATE

$$RG35 = \underset{(11.76)}{4.06907} + \underset{(31.34)}{0.71686}\ RTB - \underset{(-3.94)}{1.2635}\ (RTB/RTBUS)$$

$$- \underset{(-6.46)}{0.0000583}\ GBT$$

$R^2 = 0.9624$ SEE = 0.58212 DW = 1.096

The government bond rate has a direct relationship with the short term interest rate. The ratio of the Canadian to U.S. treasury bill rate had a negative effect on the local long term interest rate. When the governments' expenditures are higher than their revenues, the current bond rate increases.

3.5) NET PRIVATE WEALTH (PDL)

$$
\begin{aligned}
YNFA3 = & \underset{(-1.40)}{-\ 611.94} \underset{(-2.35)}{-\ 211.56}\ RTB + \underset{(50.55)}{1.04003}\ YNFA3_{-1} \\
& + \underset{(0.9)}{0.06123}\ YGNP - \underset{(-0.99)}{0.09561}\ YGNP_{-1} - \underset{(-3.74)}{0.07473}\ YGNP_{-2} \\
& + \underset{(9.15)}{0.12387}\ YGNP_{-3}
\end{aligned}
$$

$R^2 = 0.9988$ SEE = 1306.8 DW h = 0.9976

Wealth is estimated by the level of gross national product and the interest rate. The impact of interest rate changes on net wealth is quite important. When the interest rate rises, individuals holding fixed yield assets will be worse off. According to the sum of the coefficients of the polynomial distributed lag, nominal GNP in the long run is positively related to net wealth. As income rises, society's assets increase over its liabilities. The estimated equation exhibits an odd lag pattern. The coefficient of the current and the previous quarter are insignificant; however, the earlier values seem to have some effect on the endogenous variable.

OUTPUT SECTOR

4.1) OUTPUT IN GOODS SECTOR

$$\underset{}{\text{Log}(XGDG)} = \underset{(0.70)}{0.1694} + \underset{(39.53)}{0.97722}\ \text{Log}(XGDG_{-1}) + \underset{(0.77)}{0.09598}$$

$$\text{Log}(XGNG_{-1}/XGNG_{-2}) + \underset{(6.35)}{2.10391}\ \text{Log}(XGDS/XGDS_{-1})$$

$$- \underset{(-2.18)}{0.08022}\ \text{Log}(XGDG_{-1}/XGNG_{-1})$$

$R^2 = 0.9863$ SEE = 0.01247 DW h = -0.8079

4.2) OUTPUT IN SERVICE SECTOR

$$\text{Log}(XGDS) = \underset{(2.62)}{0.11555} + \underset{(250.54)}{0.99019}\ \text{Log}(XGDS_{-1}) + \underset{(4.87)}{0.3893}$$

$$\text{Log}(XGNE_{-1}/XGNE_{-2})$$

$R^2 = 0.9991$ SEE = 0.00566 DW h = 0.72436

Equations (4.1) and (4.2) are the estimated output functions for goods and services respectively. Since the equations are specified in log linear form, the coefficients are elasticities.

The growth in the demand for goods and in the output of services has a positive impact on goods production. The elasticity of output with respect to the growth in the service sector is higher than that of the growth of national expenditure. This indicates a strong interrelationship between the goods and service sectors. When output of goods rises relative to demand, inventories increase, and production is cut back.

The services output is modeled simply as a function of the growth in the national expenditure. A general rise in demand

(GNE) increases the production of services.

LABOUR-EMPLOYMENT SECTOR

5.1) TOTAL EMPLOYMENT - GOODS SECTOR

$$\underset{}{\text{Log}(ECTG)} = \underset{(-2.39)}{-0.74684} + \underset{(20.62)}{1.07176}\ \text{Log}(XGDG) - \underset{(-10.65)}{0.9204}$$

$$\text{Log}(XGDG_{-1}/ECTG_{-1}) - \underset{(-2.18)}{0.03133}\ \text{Log}(XKG)$$

$$- \underset{(-1.89)}{0.08446}\ \text{Log}(WATG/PGDG)$$

$R^2 = 0.9449$ SEE = 0.01326 DW = 2.149

5.2) TOTAL EMPLOYMENT - SERVICE SECTOR

$$\text{Log}(ECTS) = \underset{(-1.63)}{-1.21884} + \underset{(12.13)}{0.91352}\ \text{Log}(XGDS) - \underset{(-6.54)}{0.80233}$$

$$\text{Log}(XGDS_{-1}/ECTS_{-1}) + \underset{(1.12)}{0.04606}\ \text{Log}(XKS)$$

$$- \underset{(-0.65)}{0.03570}\ \text{Log}(WATS/PGDS)$$

$R^2 = 0.9978$ SEE = 0.00761 DW = 1.613

One of the principal motivating factors for designing this model was to understand the structural shifts, within the economy, in terms of the goods and service activities. The separation of the employment equations into the two sectors reveals two important sectoral differences. The capital stock has a negative effect on the goods sector employment. The effect on employment in services is insignificant, but is positive and significant in the single equation. The gradual, but relative, decline in the output of goods over the years seem to have contributed to diminishing returns on new capital outlay. In addition, the labour productivity variable has a stronger negative impact on employment in the goods sector, as compared to the service sector. The other variable, real wage, has the expected negative elasticity in the goods sector, but is insignificant in the service sector.

5.3) AVERAGE PARTICIPATION RATIO

$$
\begin{aligned}
APRT = \underset{(2.19)}{0.10887} &+ \underset{(10.21)}{0.81445}\, APRT_{-1} + \underset{(1.26)}{0.000076}\, (WAT/PCPI) \\
&+ \underset{(2.20)}{0.000290}\, TIME
\end{aligned}
$$

$R^2 = 0.9875$ SEE = 0.00358 DW h = 0.8209

The labour participation ratio in the model is simply a function of the economy wide real wage, a time trend and inertia. The estimated parameters are positive for the lag of the endogenous variable, and the time trend. The key variable in explaining the participation ratio, the real wage, is insignificant.

WAGE AND PRICE SECTOR

6.1) AVERAGE WEEKLY WAGE IN GOODS PRODUCING SECTOR (PDL)

$$\underset{}{Log\left(\frac{WATG}{WATG_{-4}}\right)} = \underset{(4.8)}{0.05837} + \underset{(2.34)}{0.83853}\ Log\left(\frac{XGDG_{-1}/ECTG_{-1}}{XGDG_{-2}/ECTG_{-2}}\right)$$

$$- \underset{(-4.14)}{0.06023}\ Log(UR/URN) + \underset{(0.98)}{0.62399}\ Log\left(\frac{PCPI}{PCPI_{-4}}\right)$$

$$- \underset{(-0.92)}{0.14284}\ Log\left(\frac{PCPI_{-1}}{PCPI_{-5}}\right) - \underset{(-2.0)}{0.26043}\ Log\left(\frac{PCPI_{-2}}{PCPI_{-6}}\right)$$

$$+ \underset{(4.22)}{0.27122}\ Log\left(\frac{PCPI_{-3}}{PCPI_{-7}}\right) + \underset{(5.66)}{0.05575}\ DWG$$

$R^2 = 0.6060$ SEE = 0.02563 DW = 1.299

6.2) AVERAGE WEEKLY WAGE IN SERVICE PRODUCING SECTOR (PDL)

$$Log\left(\frac{WATS}{WATS_{-4}}\right) = \underset{(7.6)}{0.05997} - \underset{(-6.74)}{0.06511}\ Log(UR/URN) + \underset{(1.52)}{0.76232}$$

$$Log\left(\frac{XGDS_{-1}/ECTS_{-1}}{XGDS_{-2}/ECTS_{-2}}\right) - \underset{(-0.06)}{0.02627}\ Log\left(\frac{PCPI_{-1}}{PCPI_{-5}}\right)$$

$$+ \underset{(0.21)}{0.51047}\ Log\left(\frac{PCPI_{-2}}{PCPI_{-6}}\right) + \underset{(2.32)}{0.36969}\ Log\left(\frac{PCPI_{-3}}{PCPI_{-7}}\right)$$

$$- \underset{(-6.39)}{0.44861}\ Log\left(\frac{PCPI_{-4}}{PCPI_{-8}}\right) + \underset{(7.43)}{0.04221}\ DWS$$

$R^2 = 0.7951$ SEE = 0.01718 DW = 1.561

Consistent with the theory of the short run Phillips curve, the wage equations exhibit positive elasticities vis à vis labour productivity and the inflation rate, and a negative one with the unemployment rate.

6.4) GDP DEFLATOR - GOODS

$$\text{Log}(PGDG) = \underset{(0.94)}{0.006382} + \underset{(137.7)}{1.0}\ \text{Log}(PGDG_{-1}) + \underset{(0.40)}{0.08161}\ \text{Log}\left(\frac{PIM}{PIM_{-1}}\right)$$

$$+ \underset{(2.55)}{0.65563}\ \text{Log}\left(\frac{YWTG/XGDG}{YWTG_{-1}/XGDG_{-1}}\right)$$

$R^2 = 0.9969$ SEE = 0.02571 DW h = 0.1723

6.5) GDP DEFLATOR - SERVICES

$$\text{Log}(PGDS) = \underset{(1.92)}{0.00785} + \underset{(222.99)}{1.002}\ \text{Log}(PGDS_{-1}) + \underset{(2.17)}{0.23643}\ \text{Log}\left(\frac{PIM}{PIM_{-1}}\right)$$

$$+ \underset{(1.98)}{0.30495}\ \text{Log}\left(\frac{YWTS/XGDS}{YWTS_{-1}/XGDS_{-1}}\right)$$

$R^2 = 0.9988$ SEE = 0.01442 DW h = 1.829

Changes in the model's output deflators are a combination of wage push inflation and foreign inflation transferred through the imported inputs. The elasticity of the price deflator with respect to unit labour cost is much higher for goods than for the services index. Thus, the price of goods is more sensitive to changes in this explanatory variable.

6.7) CONSUMER EXPENDITURE DEFLATOR - GOODS (PDL)

$$\text{Log}\left(\frac{PCEG}{PCEG_{-1}}\right) = \underset{(4.09)}{0.00576} + \underset{(1.52)}{0.05583}\ \text{Log}\left(\frac{YITS/(XCET*PCET)}{(YITS_{-1}/(XCET*PCET)_{-1})}\right)$$

$$+ \underset{(4.42)}{0.21536}\ \text{Log}\left(\frac{PIM}{PIM_{-1}}\right) + \underset{(2.09)}{0.09346}\ \text{Log}\left(\frac{PGDG}{PGDG_{-1}}\right)$$

$$+ \underset{(2.17)}{0.06435}\ \text{Log}\left(\frac{PGDG_{-1}}{PGDG_{-2}}\right) + \underset{(3.45)}{0.0693}\ \text{Log}\left(\frac{PGDG_{-2}}{PGDG_{-3}}\right)$$

$$+ \underset{(5.93)}{0.10831}\ \text{Log}\left(\frac{PGDG_{-3}}{PGDG_{-4}}\right)$$

$R^2 = 0.5880$ SEE = 0.006338 DW = 1.458

6.8) CONSUMER EXPENDITURE DEFLATOR - SERVICES (PDL)

$$\underset{}{\mathrm{Log}\left(\frac{PCES}{PCES-1}\right)} = \underset{(1.88)}{0.004269} + \underset{(1.82)}{0.06955}\ \mathrm{Log}\left(\frac{YITS/(XCET*PCET)}{(YITS_{-1}/(XCET*PCET)_{-1})}\right)$$

$$+ \underset{(2.42)}{0.05948}\ \mathrm{Log}\left(\frac{PIM}{PIM_{-1}}\right) + \underset{(3.36)}{0.26019}\ \mathrm{Log}\left(\frac{PGDS}{PGDS_{-1}}\right)$$

$$+ \underset{(3.25)}{0.15241}\ \mathrm{Log}\left(\frac{PGDS_{-1}}{PGDS_{-2}}\right) + \underset{(5.14)}{0.13127}\ \mathrm{Log}\left(\frac{PGDS_{-2}}{PGDS_{-3}}\right)$$

$$+ \underset{(9.03)}{0.19677}\ \mathrm{Log}\left(\frac{PGDS_{-3}}{PGDS_{-4}}\right)$$

$R^2 = 0.4374$ SEE = 0.00639 DW = 1.785

The sector specific consumer price deflators take into consideration the increases in prices due to indirect taxes (tax inflation), foreign inflation, and inflation from the production sector.

6.10) CONSUMER PRICE INDEX

$$\mathrm{Log}\left(\frac{PCPI}{PCPI_{-1}}\right) = \underset{(-17.25)}{-0.92703} + \underset{(17.59)}{0.92845}\ \mathrm{Log}\left(\frac{PCET}{PCET_{-1}}\right)$$

$R^2 = 0.8332$ SEE = 0.00329 DW = 2.281

The CPI is a function of the weighted average of the sector specific deflators (PCET).

6.11) IMPORT PRICE DEFLATOR

$$\mathrm{Log}\left(\frac{PIM}{PIM_{-1}}\right) = \underset{(0.09)}{0.0002943} + \underset{(3.46)}{0.77399}\ \mathrm{Log}\left(\frac{PGUS}{PGUS_{-1}}\right) + \underset{(6.23)}{0.67325}$$

$$\mathrm{Log}\left(\frac{REX}{REX_{-1}}\right) + \underset{(8.36)}{0.2622}\ DPIM$$

$R^2 = 0.7448$ SEE = 0.01017 DW = 1.678

The import deflator is a positive combination of the U.S. national expenditure deflator and the exchange rate.

NATIONAL INCOME COMPONENTS

7.1) SUPPLEMENTARY LABOUR INCOME (AR1)

$$\underset{(-1.25)}{YSLI = -11529.31} + \underset{(0.74)}{0.02757}\,(YWTG+YWTS) + \underset{(2.3)}{393.73}\,TIME$$

$R^2 = 0.9972$ SEE = 377.95   RHO = 0.95233 (23.74)

In the single equation estimation of supplementary income, it is a direct function of wages and salaries received by workers with a negative time trend. Unfortunately, in the simultaneous estimation, wages and salaries have no significant effect. There is also a positive trend as indicated by the coefficient on the time variable.

7.2) CORPORATE PROFITS

$$YCRP = \underset{(0.23)}{119.23} + \underset{(22.04)}{0.9542}\,YCRP_{-1} - \underset{(-3.34)}{0.28869}\,(YWTG+YWTS+YSLI) + \underset{(3.40)}{0.17061}\left(\frac{YGNP+YGNP_{-1}}{2}\right)$$

$R^2 = 0.9749$ SEE = 1706.95   DW h = 4.5881

Business profits decrease as labour income increases, but increases with nominal national product. Movements in corporate profits show a great deal of inertia as expressed in the coefficient of the lagged endogenous variable.

7.3) OTHER INCOME (Rents etc...) (AR1)

$$\underset{(-2.23)}{YBRI = -\ 5370.27} + \underset{(16.31)}{0.13585}\ YGNP + \underset{(1.76)}{354.38}\ RG35$$

$R^2 = 0.9940$ SEE = 1242.65 RHO = 0.81766 (7.63)

Other income, such as miscellaneous investment and non-farm profits, react positively to the level of GNP and the long term interest rate.

7.4) DIVIDENDS TO CANADIANS

$$YDIC = \underset{(-1.9)}{-\ 1782.15} + \underset{(7.28)}{0.66602}\ YDIC_{-1} + \underset{(3.34)}{0.03692}\ YCRP$$

$$+ \underset{(1.81)}{1800.27}\ REX$$

$R^2 = 0.9195$ SEE = 452.3 DW h = -1.1673

Dividends received by Canadians increase with corporate profits, and with a depreciation of the Canadian dollar.

7.5) DIVIDENDS TO NON-CANADIANS

$$YFCP = \underset{(0.24)}{31.82577} + \underset{(1.79)}{0.02133}\ YCRP + \underset{(6.30)}{42.28774}\ TIME$$

$R^2 = 0.8405$ SEE = 439.55 DW = 1.434

Dividends paid out to foreigners are a positive function of corporate profits and a time trend.

This completes the description of the estimated equations of the Trent Model, using the simultaneous approach. Comparing the coefficients from the simultaneous and single equation estimation methods, it is presumed that the two-stage least squares method would produce better results since it reduces the inconsistency introduced by the model's simultaneity.

In general, it was found that the parameters have not appreciably changed. The simultaneous estimation marginally affected the magnitude of several coefficients. For example, in the goods output equation (4.1), the influence of the growth of the total goods expenditure decreased while the impact of the growth in services output increased.

The only disturbing result encountered in the transformation was an equation which had the sign of its parameter change. The time trend on the supplementary labour income equation (7.1), changed from a negative to a positive, implying an increase in supplementary income over time. Several coefficients of distributed lag variables have also changes in the different estimation results. However, the sum of these distributed lag variable coefficients remained the same. In addition, the t-statistics and the Durbin Watson statistics have changed in a few equations. There are more coefficients with lower t-statistics and inferior Durbin Watson statistics in the two stage least square results. This implies that the model efficiency has been reduced in the re-estimation.

However, consider the main uses of an econometric model, namely structural analysis, forecasting and simulation analysis. For these uses is it is extremely important to have a correct theoretical specification of a phenomenon, and also to have a reasonable initial order of magnitude and sign of the coefficients of the individual equations. The statistical tests that are used to judge individual equations and their parameters, and the other statistics to test the underlying assumptions of the model, could be considered of secondary importance, especially when it comes to nonlinear models.

Thus, to test the model's "goodness of fit", it would be appropriate to perform a simulation experiment. This would reveal how successful the model is in representing the real phenomena. The next section deals with the simulation tests and results.

4. Simulation of the Model

Once the coefficients of the equations are estimated, the model then can be simulated as a complete system. Two forms of simulations were performed in order to test the model's ability to trace the historical data. First the static simulation results are shown, followed by a dynamic simulation.

STATIC SIMULATION

In a static simulation, the actual historical values from the input data set are used for the endogenous variables by the lagging functions. It reflects how well the coefficients and the theoretical form reproduce the data set without taking into consideration the errors generated by the previous iteration. The results are summarised in Table 4.1 below. For each of the 65 endogenous variables (variable XTX and XGT are identities totally composed of exogenous elements), the root mean square percentage error and the Theil inequality coefficient is given.[1] In addition, the Theil coefficient is further broken down into three sources of inequality. The first is in the difference in the averages of the actual and the simulated values (U^M). This is a measure of the bias. Next is the measure of the difference in variance (U^S). The third is the covariation difference (U^C), which is a nonsystematic random error. A high value of U^M and/or

[1] The mathematical formulae for root mean square percentage error and the Theil inequality coefficient are provided in Appendix B.

Table 4.1. Results from the Static Simultaneous Simulations.

Variable Name.	RMS % ERROR	THEIL INEQUALITY COEF.	BIAS (U^M)	VAR (U^S)	COVAR (U^C)
XCEG	7.81	0.0305	0.124	0.725	0.153
XCES	2.47	0.0107	0.413	0.079	0.508
XCET	4.19	0.0168	0.043	0.725	0.233
XIME	6.03	0.0339	0.000	0.044	0.956
XIRC	8.82	0.0391	0.115	0.212	0.673
XIPV	182.30	0.3547	0.023	0.141	0.836
XITP	6.68	0.0347	0.035	0.000	0.965
XTMG	4.60	0.0224	0.003	0.007	0.990
XTMS	3.82	0.0173	0.019	0.047	0.934
XTM	3.70	0.0177	0.008	0.029	0.964
XGNE	2.92	0.0125	0.057	0.524	0.419
XGNG	12.14	0.0605	0.817	0.139	0.044
XGNS	19.94	0.1114	0.977	0.020	0.003
TDRF	6.42	0.0294	0.022	0.004	0.973
TDRP	6.15	0.0195	0.010	0.066	0.924
TIRF	11.82	0.0625	0.000	0.038	0.962
TIRP	6.86	0.0216	0.054	0.318	0.628
TPTG	7.26	0.0486	0.349	0.336	0.314
GRT	3.22	0.0122	0.032	0.192	0.776
GET	0.00	0.0000	0.001	0.006	0.993
GBT	5474.23	0.1446	0.032	0.056	0.911
M1	4.14	0.0188	0.105	0.502	0.393
RTB	14.47	0.0523	0.000	0.013	0.987
RG35	8.64	0.0418	0.001	0.045	0.955
RRI	1046.43	0.6286	0.824	0.017	0.159
YNFA3	2.68	0.0106	0.024	0.102	0.874
XGDG	1.54	0.0078	0.000	0.000	1.000
XGDS	0.55	0.0027	0.000	0.000	1.000
XGDP	0.82	0.0041	0.000	0.000	1.000
YGDP	1.33	0.0062	0.030	0.125	0.846
XK	0.00	0.0000	0.000	0.000	1.000
XKG	0.00	0.0000	0.048	0.016	0.936
XKS	0.00	0.0000	0.002	0.000	0.992
ECTG	1.31	0.0065	0.000	0.001	0.999
ECTS	0.64	0.0031	0.000	0.000	1.000
APRT	0.50	0.0025	0.000	0.001	0.999
LFTC	0.50	0.0026	0.002	0.000	0.998
ECT	0.65	0.0033	0.000	0.000	1.000
UR	8.14	0.0343	0.002	0.019	0.979
WATG	2.71	0.0138	0.062	0.104	0.834
WATS	1.70	0.0071	0.001	0.005	0.993
WAT	5.10	0.0285	0.026	0.037	0.937
PGDG	3.15	0.0182	0.016	0.042	0.942
PGDS	1.54	0.0088	0.000	0.006	0.994
PGDP	1.11	0.0058	0.027	0.094	0.879

Table 4.1. Results from the Static Simultaneous Simulations. Continued...

Variable Name.	RMS % ERROR	THEIL INEQUALITY COEF.	BIAS (U^M)	VAR (U^S)	COVAR (U^C)
PCEG	1.05	0.0061	0.414	0.182	0.404
PCES	1.28	0.0080	0.417	0.315	0.267
PCET	1.06	0.0065	0.419	0.284	0.297
PCPI	1.01	0.0063	0.407	0.284	0.310
PIM	0.99	0.0051	0.009	0.088	0.903
PGNP	3.88	0.0183	0.103	0.404	0.492
YSLI	135.27	0.1554	0.583	0.278	0.139
YCRP	14.13	0.0429	0.228	0.005	0.767
YBRI	14.59	0.0408	0.033	0.338	0.628
YFCP	17.71	0.0853	0.003	0.049	0.948
YDIC	16.76	0.0664	0.008	0.013	0.979
YWTG	2.97	0.0148	0.055	0.105	0.840
YWTS	1.72	0.0073	0.003	0.017	0.980
YLI	7.42	0.0147	0.371	0.372	0.258
YITS	19.64	0.1063	0.517	0.428	0.055
YITA	9.29	0.0535	0.517	0.434	0.049
YGNP	5.55	0.0196	0.131	0.729	0.140
YDIS	8.51	0.0198	0.001	0.846	0.153
YCS	84.81	0.0776	0.134	0.468	0.398

U^S would indicate the presence of a systematic error and thereby signal a need to re-specify the structural form of the equation. In addition to the Table 4.1, the actual and simulated values of several selected endogenous variables are graphed in Figures 4.1 to 4.10.

The Trent model does reproduce the historical data set for most of the dependent variables. The root mean square percentage error is less than 10% for most endogenous variables. This is also evident from the graphs of the selected variables. However there are several equations that are extremely poor in representing the actual trends. The government budget balance

Figure 4.1. Gross National Product

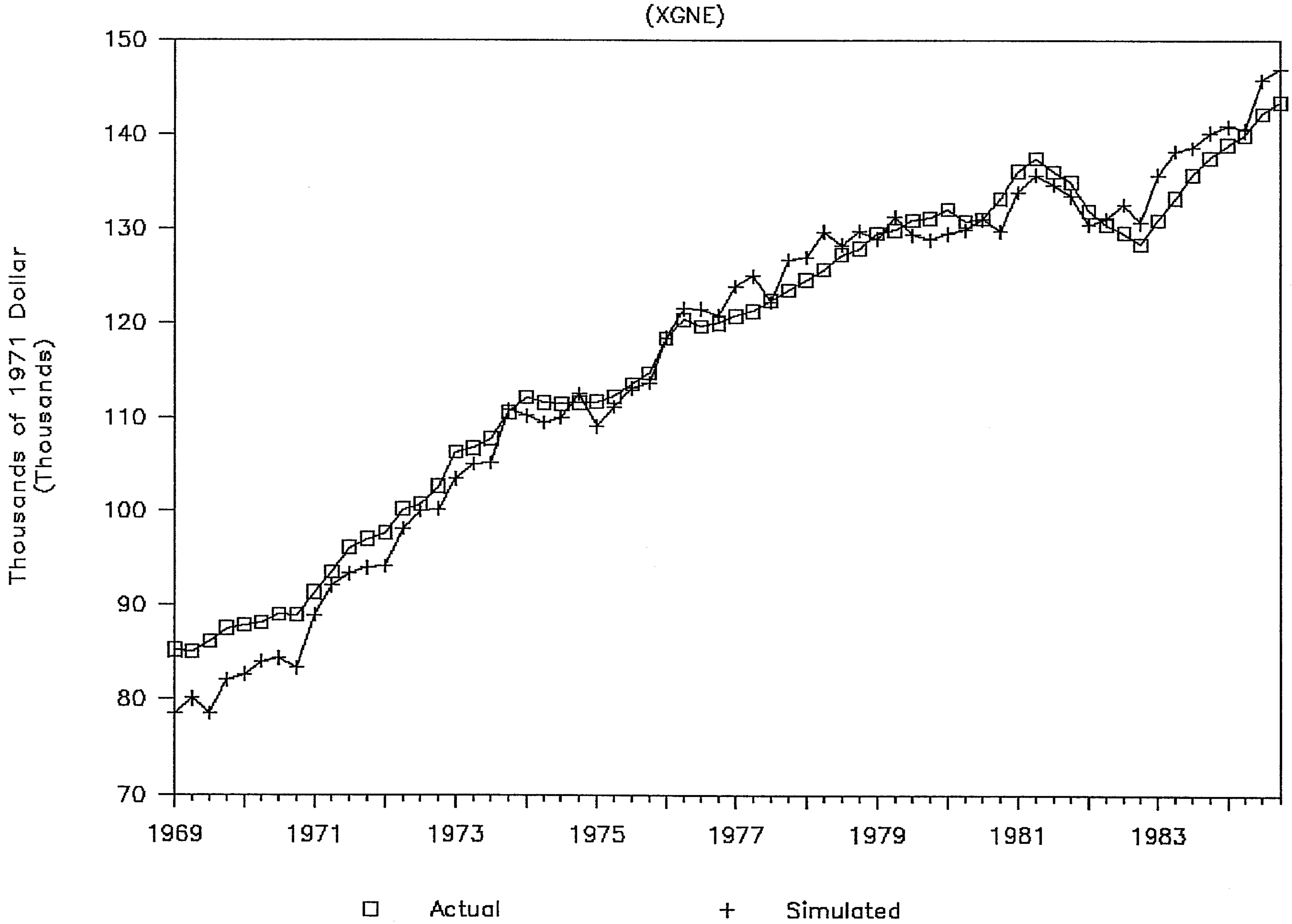


Figure 4.2. Treasury Bill Rate

(RTB)

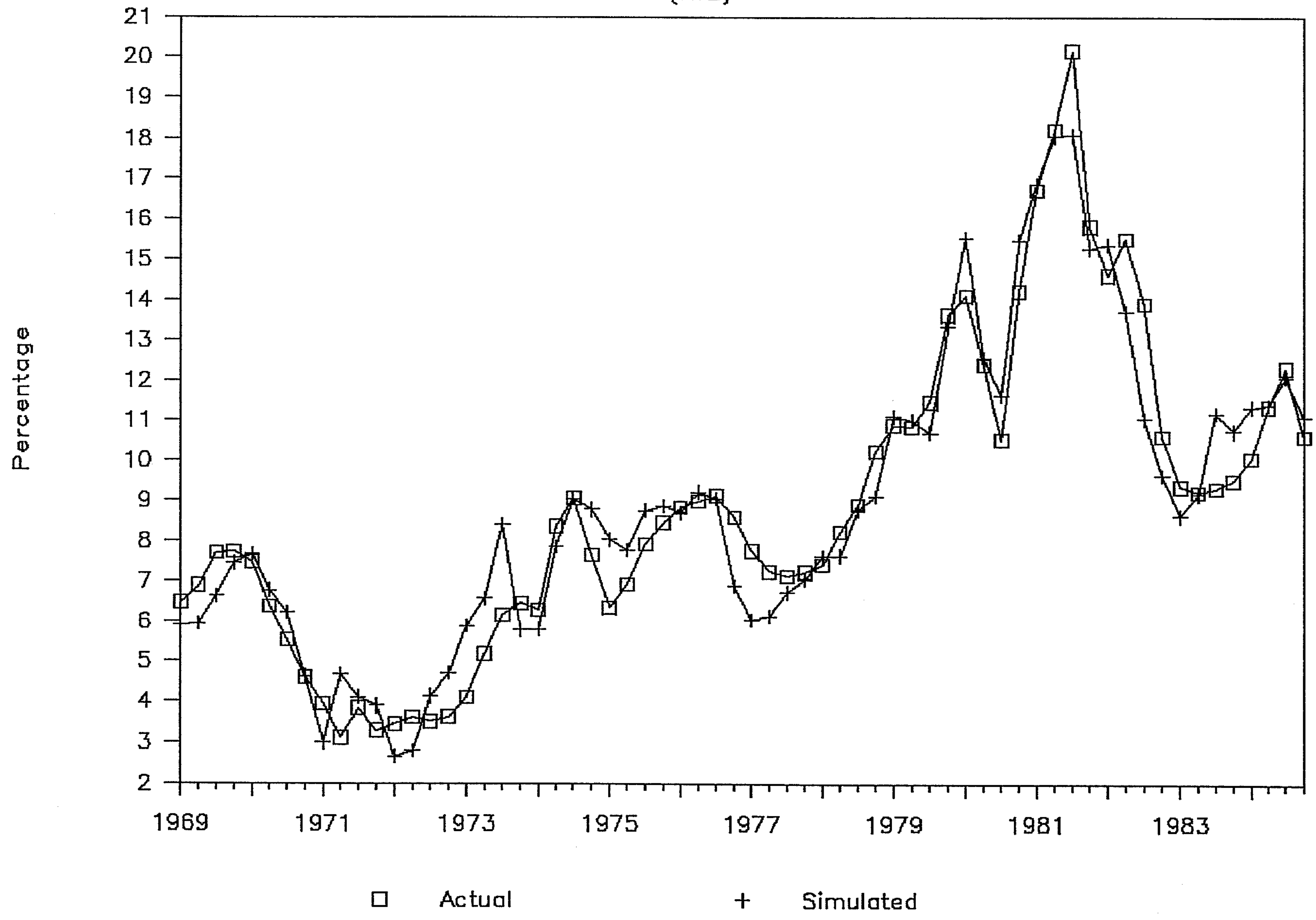


Figure 4.3. Unemployment Rate

(UNR)

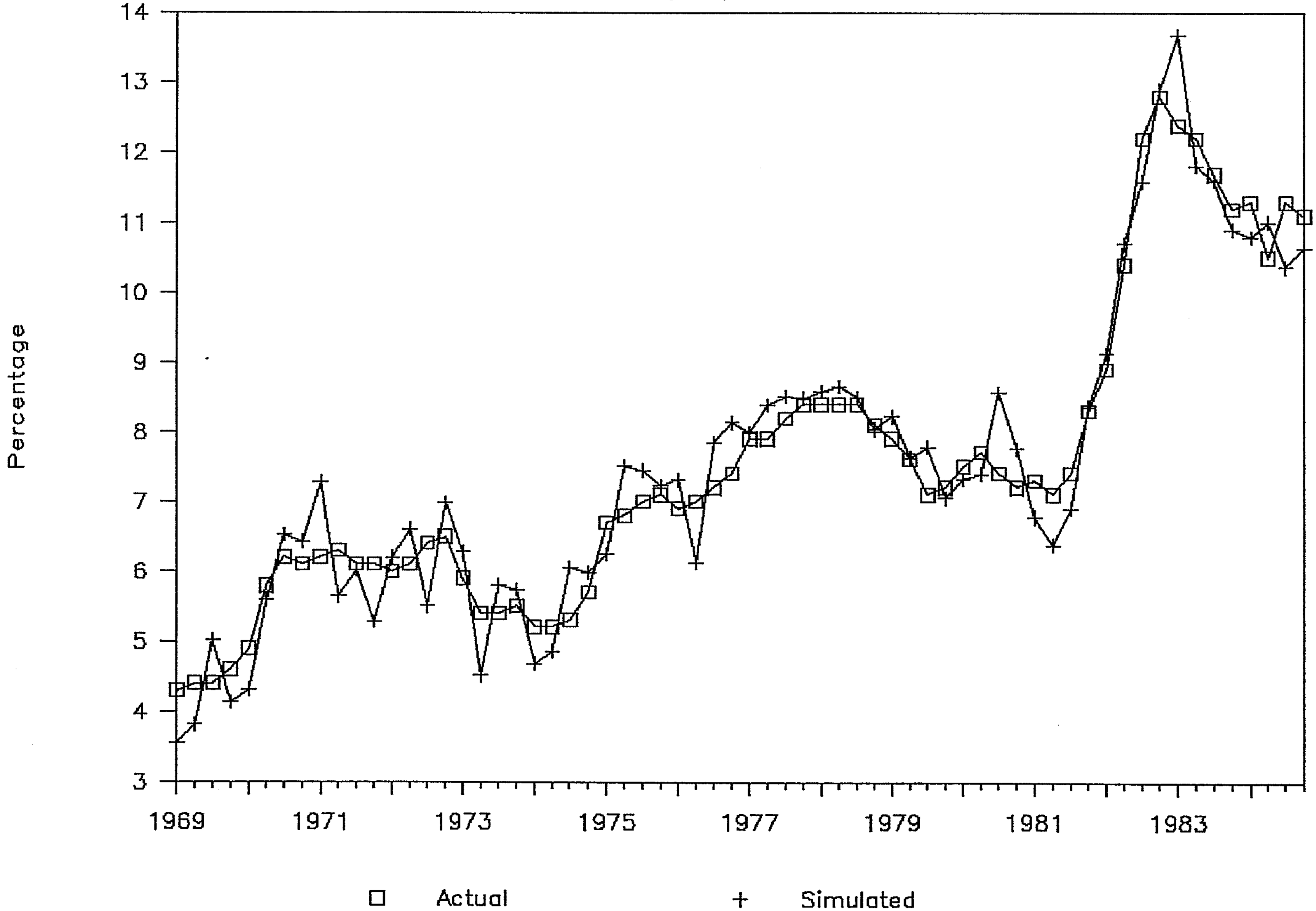


Figure 4.4. Consumer Price Index

(PCPI)

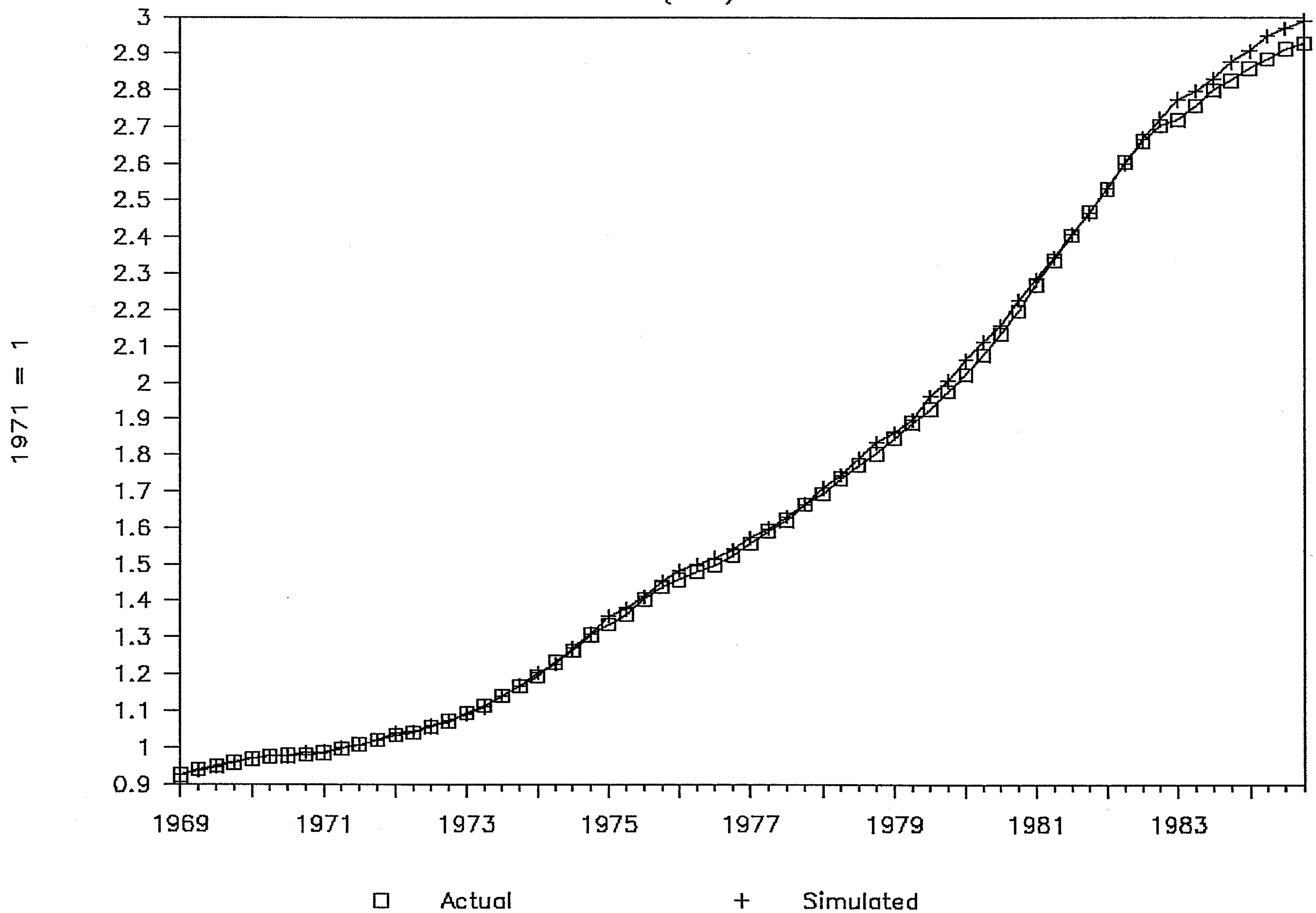


Figure 4.5. Employment: Goods Sector

(ECTG)

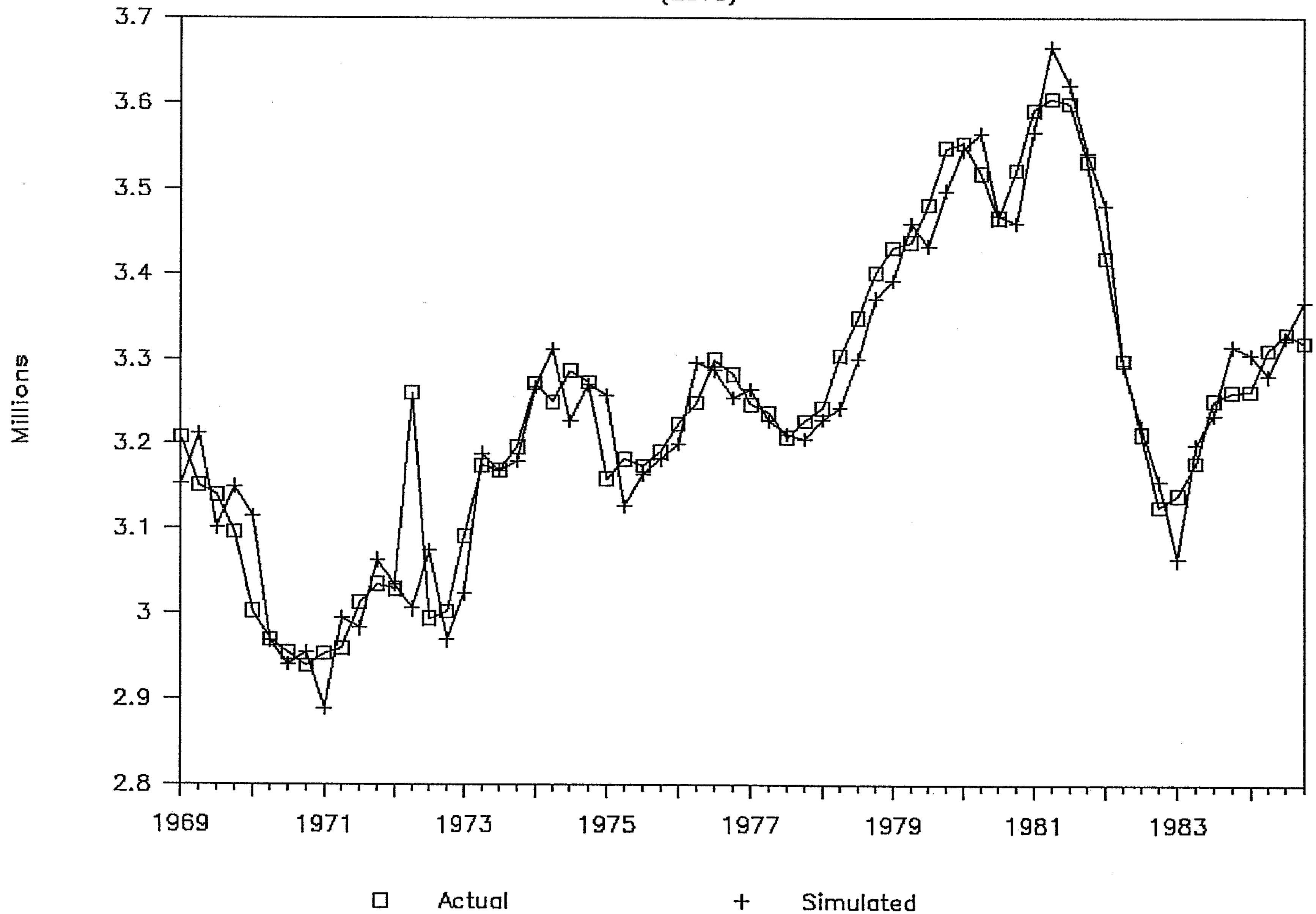


Figure 4.6. Employment: Service Sector

(ECTS)

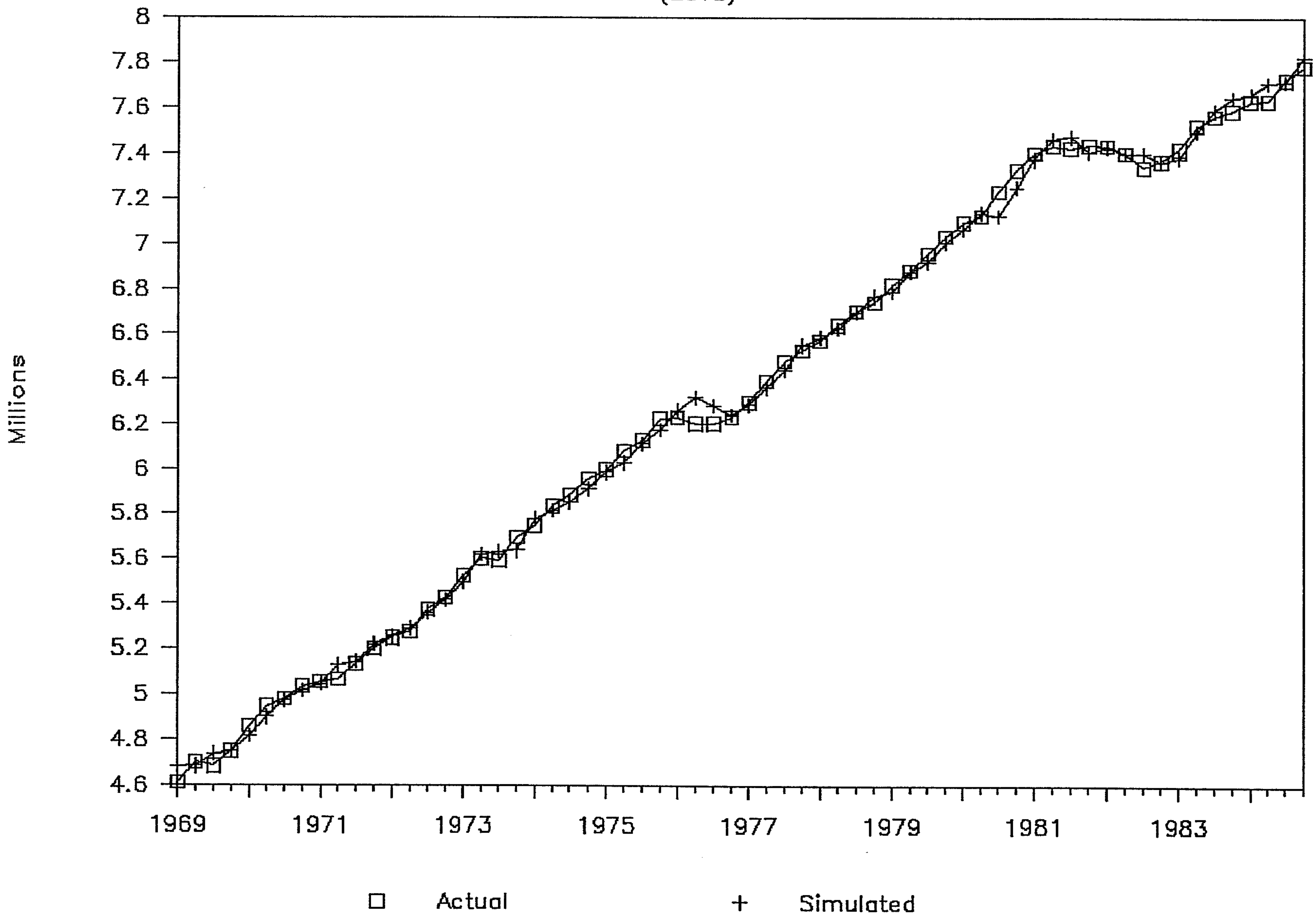


Figure 4.7. Output: Goods Sector

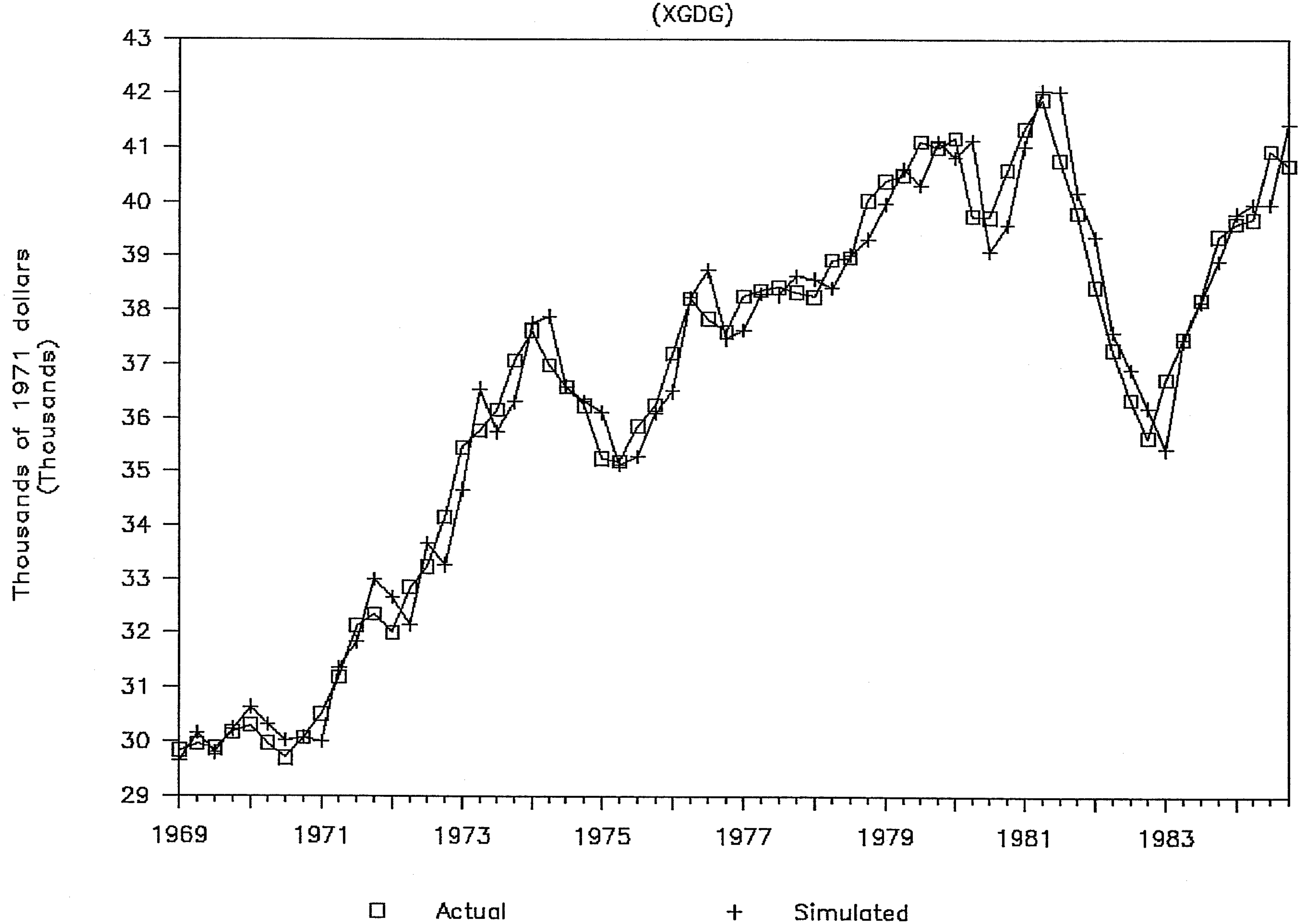


Figure 4.8. Output: Service Sector

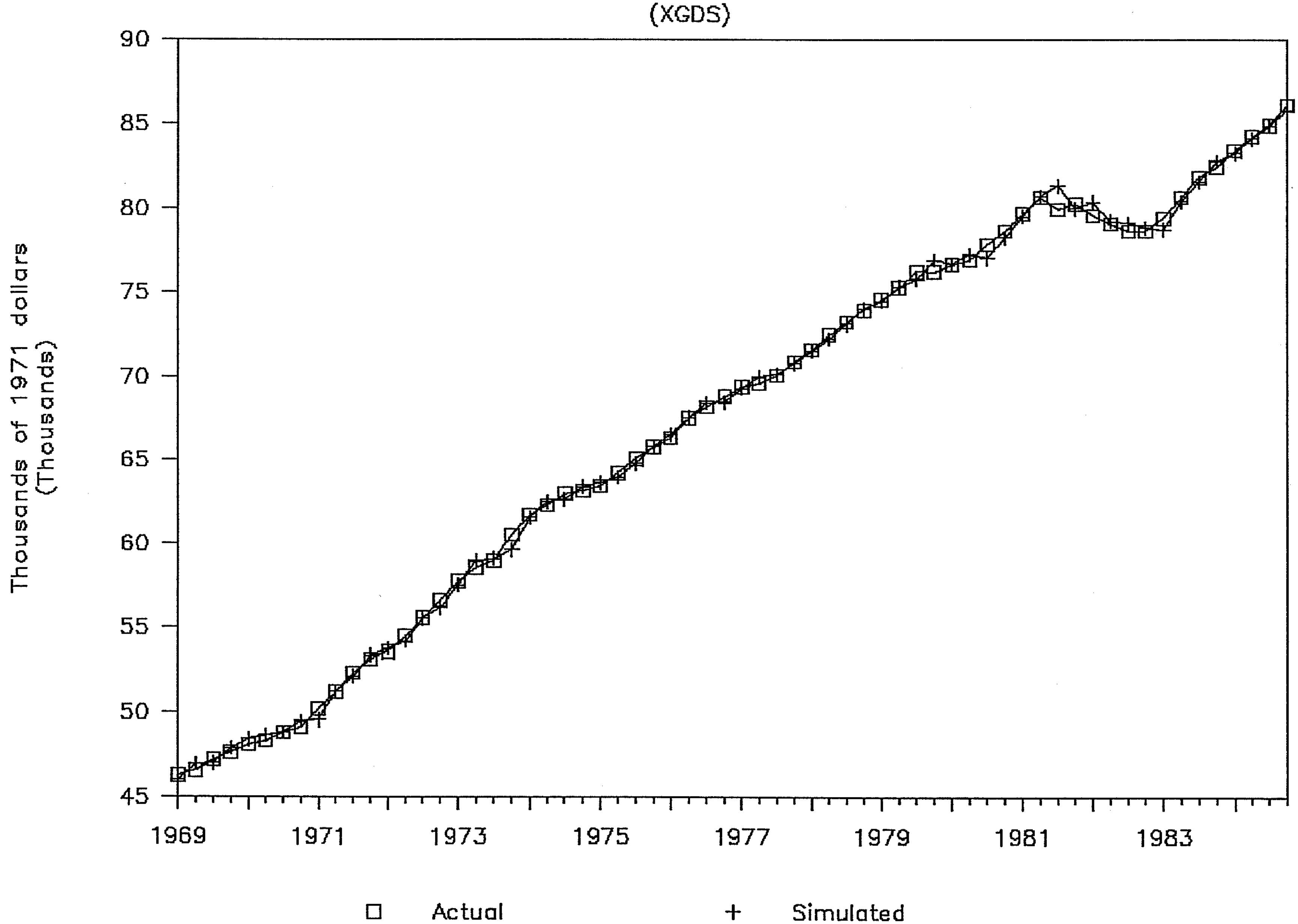


Figure 4.9. Government Balance

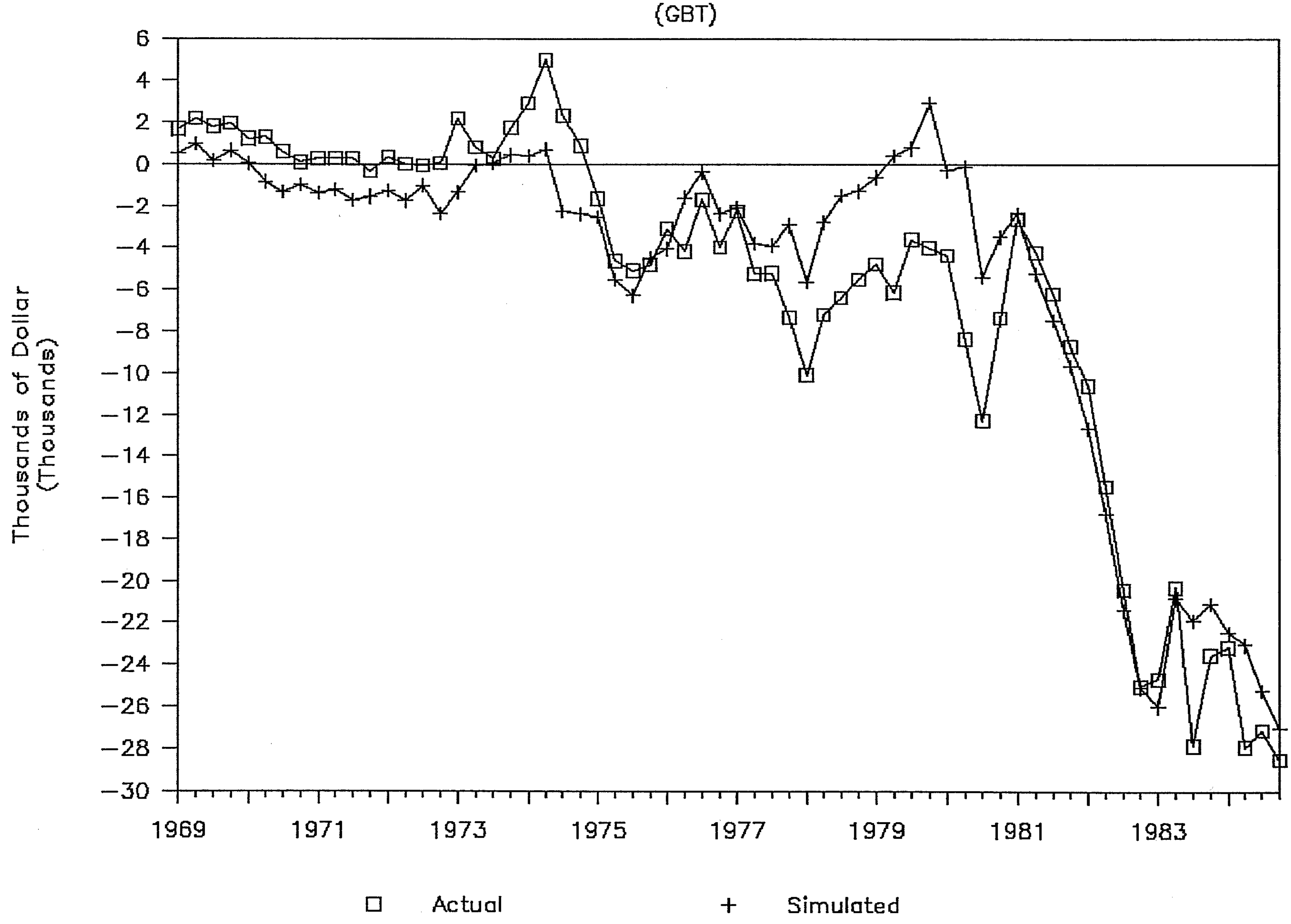
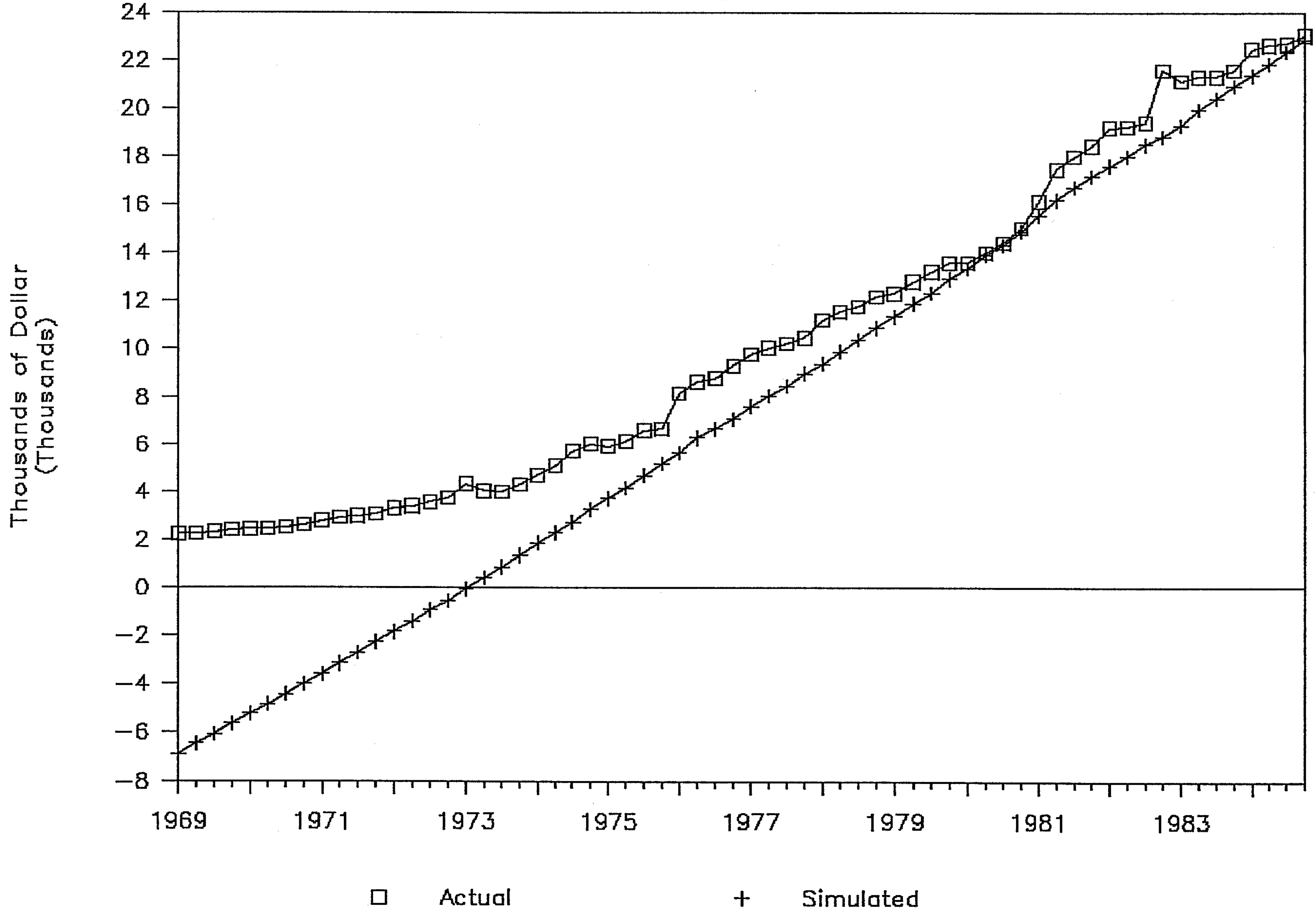


Figure 4.10 Supplementary Income

(YSLI)



and the real rate of interest identities, for instance, cannot closely explain the observed values. Figure 4.9 shows that the model consistently underestimates the government budget deficit, especially during the late 1970's and early 1980's. From the behavioural equations, both the change in inventory (XIPV) and the supplementary labour income (YSLI) have extremly high root mean square errors and Theil inequality coefficients. The bad results on the latter variable could have been expected from the estimation of the parameters of the individual equations. The output and employment rate equations in both the goods and service sectors have extremely good simulation properties. The model does seems to capture the independent behaviour of goods and service sector activities. It appears that in spite of using the actual values of dependent variables, only a few of the equations cannot successfully explain the time series that were used to generate them.

DYNAMIC SIMULATION

In a dynamic simulation, the solved or predicted values are used as input data for the lagged endogenous variables. The actual values are used for lags that extend past the start of the solution range. The Trent model failed to solve all the endogenous variables at the fourteenth iteration. At this iteration the model calculated a negative unemployment rate. Apparently at every observation the demand for labour is growing relatively faster than the supply. Using the single equation estimated coefficients, similar results were found. Positive errors are accumulating in the demand for labour in the goods sector. The demand for labour is made up of the goods and service sector labour requirements. And those requirements are dependent on the consumption demand for goods and services. The supply, on the other hand, is simply a function of the average participation rate times the population over the age of 15. The participation rate is modeled as a function of the real wage; however, the coefficient is only marginally significant in both the single equation estimation and in the system estimation. Thus, it could possibly be argued that the participation rate equation needs a re-specification. In view of the major change in the composition of the Canadian labour force, occurring in the 1970's and still continuing, it may be appropriate to include gender-specific participation rate equations.

5. Conclusion

The version of the Trent model used for this study would require several changes for it to run as a simultaneous system. From the static simulation results, there are a few equations and identities that may require theoretical re-specification since the present version does not reproduce the historical time series. Thus, even if all the individual equations fit the data well, in terms of a high correlation of determination, and are statistically significant, we have no guarantee that the model as a whole, when simulated, will reproduce the historical data set.

A paper recently presented to the International Atlantic Economic Conference in London, by Dr. Curtis and Dr. Murthy, reports on results of a historical simulation with the Trent Model. Their results show the root mean square percentage error for all the endogenous variables to vary between 7% and 0.4 %. However, there are several major differences between the model presented at the conference and the earlier version used for this paper. Certain equations were re-specified; there is greater use of dummy variables; and the treasury bill rate has been made exogenous. Some of these changes seemed to be aimed at correcting the problems encountered in the dynamic simulation attempted in this paper, in particular the error accumulation in the demand for labour in the goods sector. The exercise presented here could well be replicated when a final version of the model has been published.

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APPENDIX A

All the equations in this section are individually estimated using the ordinary least squares method. The equations marked (AR1) are corrected for first order serial correlation, using the Maximum likelihood method. Equations labeled PDL are calculated using the Almon Scheme of Polynomial lags. Under each parameter, in parentheses, the T-Statistics are listed.

FINAL DEMAND SECTOR

A1.1) PRE-CAPITA CONSUMPTION - GOODS

$$XCEG / NPOP = \underset{(3.88)}{1324.173} + \underset{(15.88)}{0.4779} \left(\frac{YDIS/PCPI}{NPOP}\right) - \underset{(-3.90)}{1173.749} \frac{PCEG}{PCES}$$

$$+ \underset{(4.4)}{1279.79} \left(\frac{1}{UR_{-1}}\right) - \underset{(-7.562)}{19.1404}\, RG35 - \underset{(-2.178)}{0.049842} \left(\frac{YNFA3/PCPI}{NPOP}\right)$$

$R^2 = 0.9854$ SEE = 31.543 DW = 1.245 F = 862.357

A1.2) PER-CAPITA CONSUMPTION - SERVICES (AR1)

$$XCES / NPOP = \underset{(4.515)}{597.3719} + \underset{(3.282)}{0.102838} \left(\frac{YDIS/PCPI}{NPOP}\right) + \underset{(1.131)}{0.07235} \frac{XCEG}{NPOP}$$

$$+ \underset{(2.28)}{0.01968} \left(\frac{YNFA3/PCPI}{NPOP}\right)$$

$R^2 = 0.3737$ SEE = 13.571 RHO = 0.9910 (61.97)

A1.4) PRIVATE INVESTMENT (PDL)

$$XIME = \underset{(0.0551)}{3582.407} - \underset{(-6.082)}{49384.271}\,(XGDP/XK)_{-1}$$

$$+ \underset{(5.246)}{34034.636}\,(XGDP/XGDPTR) + \underset{(0.889)}{38.252}\,RRI_{-1} + \underset{(0.152)}{3.709}\,RRI_{-2}$$

$$- \underset{(-0.631)}{19.073}\,RRI_{-3} - \underset{(-1.171)}{29.9944}\,RRI_{-4} - \underset{(-1.663)}{29.0559}\,RRI_{-5}$$

$R^2 = 0.9834$ SEE = 488.9318 F = 704.389

A1.5) RESIDENTIAL CONSTRUCTION (PDL)

$$XIRC = \underset{(11.457)}{2058.39} + \underset{(21.442)}{0.07546}\left(\frac{YDIS}{PCPI}\right) - \underset{(-1.667)}{55.968}\,RG35_{-1} - \underset{(-4.768)}{122.1096}$$

$$RG35_{-2} - \underset{(-4.262)}{109.0337}\,RG35_{-3} - \underset{(-0.515)}{16.740233}\,RG35_{-4}$$

$$- \underset{(8.679)}{739.8677}\,DRESD$$

$R^2 = 0.901$ SEE = 292.244 DW = 0.9648 F = 112.849

A1.6) CHANGE IN INVENTORY

$$XIPV = \underset{(4.335)}{2808.1181}\,(XGDG/XGNG) - \underset{(-2.782)}{100.68328}\,RG35_{-1}$$

$$+ \underset{(7.776)}{1363.03579}\,DINV$$

$R^2 = 0.5954$ SEE = 1014.621 DW = 1.170 F = 32.858

A1.8) IMPORTS - GOODS

$$XTMG / NPOP = \underset{(1.358)}{51.5464} + \underset{(2.014)}{0.0537}\left(\frac{YDIS/PCPI}{NPOP}\right) - \underset{(-1.603)}{67.9359}\left(\frac{PIM*REX}{PGNP}\right)$$

$$+ \underset{(11.262)}{0.837706}\,\frac{XTMG_{-1}}{NPOP_{-1}}$$

$R^2 = 0.9496$ SEE = 40.814 DW h = 1.433 F = 414.197

A1.9) IMPORTS - SERVICES

$$XTMS / NPOP = \underset{(-0.355)}{-3.35978} + \underset{(3.89)}{0.03426} \left(\frac{\underline{YDIS/PCPI}}{NPOP}\right) + \underset{(9.689)}{0.70094} \frac{XTMS_{-1}}{NPOP_{-1}}$$

$R^2 = 0.9668$ SEE = 12.486 DW h = -0.85 F = 974.596

GOVERNMENT REVENUE SECTOR

A2.1) DIRECT REVENUE - TOTAL FEDERAL GOVERNMENT (A1)

$$TDRF = \underset{(0.114)}{98.69447} + \underset{(34.517)}{0.1362549} (XGDP*PGDP)$$

$R^2 = 0.9453$ SEE = 1378.55 RHO = 0.6447 (7.01)

A2.2) DIRECT REVENUE - TOTAL PROVINCIAL GOVERNMENTS (AR1)

$$TDRP = - \underset{(-8.841)}{2334.91396} + \underset{(68.442)}{0.082961} (XGDP*PGDP)$$

$R^2 = 0.9855$ SEE = 483.32 RHO = 0.5883 (5.73)

A2.3) INDIRECT REVENUE - TOTAL FEDERAL GOVERNMENT (AR1)

$$TIRF = \underset{(0.613)}{556.92555} + \underset{(11.74)}{0.07433} (XCET*PCET)$$

$R^2 = 0.6670$ SEE = 684.59 RHO = 0.8438 (13.47)

A2.4) INDIRECT REVENUE - TOTAL PROVINCIAL GOVT'S (AR1)

$$TIRP = \underset{(0.247)}{82.69869} + \underset{(60.798)}{0.146522} (XCET*PCET)$$

$R^2 = 0.9817$ SEE = 466.072 RHO = 0.6855 (7.52)

A2.5) TOTAL DIRECT REVENUE - ALL GOVERNMENTS (AR1)

$$TPTG = \underset{(-2.176)}{-\ 1204.699} + \underset{(73.536)}{0.863416}\ (TDRF + TDRP)$$

$R^2 = 0.9874$ SEE = 676.4599 RHO = 0.7522 (9.37)

<u>MONETARY SECTOR</u>

A3.1) MONEY AGGREGATE - M1 (PDL)

$$M1/PGNP = \underset{(4.090)}{1313.60528} + \underset{(18.740)}{0.808188}\ M1_{-1}/PGNP_{-1} + \underset{(4.211)}{231.577}\ DM1$$

$$+ \underset{(4.7161)}{0.012665}\ XGNE - \underset{(-2.8)}{36.202896}\ RTB - \underset{(-3.317)}{32.99228}\ RTB_{-1}$$

$$- \underset{(-1.846)}{19.19860}\ RTB_{-2} + \underset{(0.358)}{5.17818}\ RTB_{-3}$$

$R^2 = 0.9744$ SEE = 152.0799 DW h = -0.036 F = 387.393

A3.2) TREASURY BILL RATE (PDL)

$$RTB = \underset{(0.128)}{2.52134} - \underset{(-4.438)}{31.583198} \left(\frac{M1/PGNP}{(M1/PGNP)_{-1}}\right) + \underset{(2.716)}{0.0000279}\ XGNE$$

$$- \underset{(-5.528)}{2.35162}\ DRTB + \underset{(15.481)}{1.00331}\ RTBUS - \underset{(-1.784)}{29.26107} \left(\frac{PGNP_{-1}}{PGNP_{-2}}\right)$$

$$- \underset{(-1.211)}{10.83622} \left(\frac{PGNP_{-2}}{PGNP_{-3}}\right) + \underset{(0.529)}{6.43478} \left(\frac{PGNP_{-3}}{PGNP_{-4}}\right) + \underset{(2.673)}{22.55193} \left(\frac{PGNP_{-4}}{PGNP_{-5}}\right)$$

$$+ \underset{(2.083)}{37.515212} \left(\frac{PGNP_{-5}}{PGNP_{-6}}\right)$$

$R^2 = 0.9394$ SEE = 0.9903 DW = 0.9081 F = 128.346

A3.3) 3-5 YEAR GOVERNMENT BOND RATE

$$RG35 = \underset{(12.756)}{4.11154} + \underset{(33.261)}{0.719817}\ RTB - \underset{(-4.54)}{1.35547}\ (RTB/RTBUS) - \underset{(-7.073)}{0.00006057}\ GBT$$

$R^2 = 0.9643$ SEE = 0.56295 DW = 1.054 F = 594.029

A3.5) NET PRIVATE WEALTH (PDL)

$$YNFA3 = -\underset{(-1.442)}{579.51675} - \underset{(-2.498)}{197.40345}\ RTB + \underset{(56.177)}{1.044356}\ YNFA3_{-1} + \underset{(1.415)}{0.075724}\ YGNP - \underset{(-1.87)}{0.96623}\ YGNP_{-1} - \underset{(-1.661)}{0.83133}\ YGNP_{-2} + \underset{(1.976)}{0.116192}\ YGNP_{-3}$$

$R^2 = 0.9988$ SEE = 1273.4 DW h = 1.015 F = 10400.066

OUTPUT SECTOR

A4.1) OUTPUT IN GOODS SECTOR

$$\text{Log}(XGDG) = \underset{(2.173)}{0.405245} + \underset{(49.26)}{0.95434}\ \text{Log}(XGDG_{-1}) + \underset{(1.523)}{0.13497}\ \text{Log}(XGNG_{-1}/XGNG_{-2}) + \underset{(6.912)}{1.74816}\ \text{Log}(XGDS/XGDS_{-1}) - \underset{(-2.698)}{0.092022}\ \text{Log}(XGDG_{-1}/XGNG_{-1})$$

$R^2 = 0.9912$ SEE = 0.0121 DW h = 0.441 F = 1826.602

A4.2) OUTPUT IN SERVICE SECTOR

$$\text{Log}(XGDS) = \underset{(2.956)}{0.102587} + \underset{(317.278)}{0.9913987}\ \text{Log}(XGDS_{-1}) + \underset{(5.09)}{0.3147226}\ \text{Log}(XGNE_{-1}/XGNE_{-2})$$

$R^2 = 0.9994$ SEE = 0.0054 DW h = 0.025 F = 54011.733

LABOUR-EMPLOYMENT SECTOR

A5.1) TOTAL EMPLOYMENT - GOODS SECTOR

$$\text{Log}(ECTG) = \underset{(-4.574)}{-1.02680474} + \underset{(21.824)}{0.9792}\ \text{Log}(XGDG) - \underset{(-10.672)}{0.7449855}\ \text{Log}(XGDG_{-1}/ECTG_{-1}) - \underset{(-2.835)}{0.03732523}\ \text{Log}(XKG) - \underset{(-4.115)}{0.15064316}\ \text{Log}(WATG/PGDG)$$

$R^2 = 0.9496$ SEE = 0.0125 DW = 1.755 F = 306.373

A5.2) TOTAL EMPLOYMENT - SERVICE SECTOR

$$\text{Log}(ECTS) = \underset{(-4.549)}{-2.562653} + \underset{(13.893)}{0.803175}\ \text{Log}(XGDS) - \underset{(-6.409)}{0.58212899}\ \text{Log}(XGDS_{-1}/ECTS_{-1}) + \underset{(3.123)}{0.1012307}\ \text{Log}(XKS) - \underset{(-1.263)}{0.05443419}\ \text{Log}(WATS/PGDS)$$

$R^2 = 0.9985$ SEE = 0.007 DW = 1.429 F = 11055.819

A5.3) AVERAGE PARTICIPATION RATIO

$$APRT = \underset{(2.569)}{0.11249} + \underset{(11.903)}{0.811997}\ APRT_{-1} + \underset{(1.314)}{0.000065735}\ (WAT/PCPI) + \underset{(2.491)}{0.0002791}\ TIME$$

$R^2 = 0.9886$ SEE = 0.1125 DW h = -0.357 F = 1913.486

WAGES AND PRICES SECTOR

A6.1) AVERAGE WEEKLY WAGE IN GOODS PRODUCING SECTOR (PDL)

$$\mathrm{Log}\left(\frac{WATG}{WATG_{-4}}\right) = \underset{(6.222)}{0.065095} + \underset{(1.917)}{0.45044}\ \mathrm{Log}\left(\frac{XGDG_{-1}/ECTG_{-1}}{XGDG_{-2}/ECTG_{-2}}\right) - \underset{(-4.244)}{0.5785}\ \mathrm{Log}(UR/URN) + \underset{(0.733)}{0.3355}\ \mathrm{Log}\left(\frac{PCPI}{PCPI_{-4}}\right)$$

$$+ \underset{(0.173)}{0.06893}\ \mathrm{Log}\left(\frac{PCPI_{-1}}{PCPI_{-5}}\right) - \underset{(-0.076)}{0.030201}\ \mathrm{Log}\left(\frac{PCPI_{-2}}{PCPI_{-6}}\right) + \underset{(0.93)}{0.041195}\ \mathrm{Log}\left(\frac{PCPI_{-3}}{PCPI_{-7}}\right) + \underset{(5.944)}{0.05652}\ DWG$$

$R^2 = 0.6261$ SEE = 0.02283 DW = 1.0820 F = 16.185

A6.2) AVERAGE WEEKLY WAGE IN SERVICE PRODUCING SECTOR (PDL)

$$\mathrm{Log}\left(\frac{WATS}{WATS_{-4}}\right) = \underset{(8.739)}{0.0609182} - \underset{(-7.487)}{0.068079}\ \mathrm{Log}(UR/URN) + \underset{(1.962)}{0.54261}\ \mathrm{Log}\left(\frac{XGDS_{-1}/ECTS_{-1}}{XGDS_{-2}/ECTS_{-2}}\right) + \underset{(0.730)}{0.23444}\ \mathrm{Log}\left(\frac{PCPI_{-1}}{PCPI_{-5}}\right)$$

$$+ \underset{(0.635)}{0.16804}\ \mathrm{Log}\left(\frac{PCPI_{-2}}{PCPI_{-6}}\right) + \underset{(0.247)}{0.067656}\ \mathrm{Log}\left(\frac{PCPI_{-3}}{PCPI_{-7}}\right) - \underset{(-0.225)}{0.06672}\ \mathrm{Log}\left(\frac{PCPI_{-4}}{PCPI_{-8}}\right) + \underset{(7.753)}{0.42747}\ DWS$$

$R^2 = 0.8030$ SEE = 0.0168 DW = 1.4751 F = 38.719

A6.4) GDP DEFLATOR - GOODS

$$\operatorname{Log}(PGDG) = \underset{(1.701)}{0.008816} + \underset{(157)}{1.0007}\operatorname{Log}(PGDG_{-1}) + \underset{(0.238)}{0.03968}\operatorname{Log}\left(\frac{PIM}{PIM_{-1}}\right)$$

$$+ \underset{(2.910)}{0.526354}\operatorname{Log}\left(\frac{YWTG/XGDG}{YWTG_{-1}/XGDG_{-1}}\right)$$

$R^2 = 0.9974$ SEE = 0.02446   DW h = 0.289   F = 8354.262

A6.5) GDP DEFLATOR - SERVICES

$$\operatorname{Log}(PGDS) = \underset{(1.99)}{0.00679} + \underset{(254.6)}{1.0033}\operatorname{Log}(PGDS_{-1}) + \underset{(2.59)}{0.2384}\operatorname{Log}\left(\frac{PIM}{PIM_{-1}}\right)$$

$$+ \underset{(2.58)}{0.3378}\operatorname{Log}\left(\frac{YWTS/XGDS}{YWTS_{-1}/XGDS_{-1}}\right)$$

$R^2 = 0.9990$ SEE = 0.0139   DW h = 1.766   F = 21913.4

A6.7) CONSUMER EXPENDITURE DEFLATOR - GOODS (PDL)

$$\operatorname{Log}\left(\frac{PCEG}{PCEG_{-1}}\right) = \underset{(5.135)}{0.006319} + \underset{(1.844)}{0.044839}\operatorname{Log}\left(\frac{YITS/(XCET*PCET)}{(YITS_{-1}/(XCET*PCET)_{-1})}\right)$$

$$+ \underset{(5.024)}{0.21084}\operatorname{Log}\left(\frac{PIM}{PIM_{-1}}\right) + \underset{(93.091)}{0.089546}\operatorname{Log}\left(\frac{PGDG}{PGDG_{-1}}\right)$$

$$+ \underset{(3.717)}{0.07722}\operatorname{Log}\left(\frac{PGDG_{-1}}{PGDG_{-2}}\right) + \underset{(3.357)}{0.070873}\operatorname{Log}\left(\frac{PGDG_{-2}}{PGDG_{-3}}\right)$$

$$+ \underset{(2.429)}{0.07051}\operatorname{Log}\left(\frac{PGDG_{-3}}{PGDG_{-4}}\right)$$

$R^2 = 0.6117$ SEE = 0.00607   DW = 1.4071   F = 19.532

A6.8) CONSUMER EXPENDITURE DEFLATOR - SERVICES (PDL)

$$\operatorname{Log}\left(\frac{PCES}{PCES-1}\right) = \underset{(3.434)}{0.005957} + \underset{(1.278)}{0.028884} \operatorname{Log}\left(\frac{YITS/(XCET*PCET)}{(YITS_{-1}/(XCET*PCET)_{-1})}\right)$$

$$+ \underset{(2.42)}{0.099073} \operatorname{Log}\left(\frac{PIM}{PIM_{-1}}\right) + \underset{(3.101)}{0.15539} \operatorname{Log}\left(\frac{PGDS}{PGDS_{-1}}\right)$$

$$+ \underset{(4.486)}{0.164843} \operatorname{Log}\left(\frac{PGDS_{-1}}{PGDS_{-2}}\right) + \underset{(4.435)}{0.15617} \operatorname{Log}\left(\frac{PGDS_{-2}}{PGDS_{-3}}\right)$$

$$+ \underset{(2.907)}{0.129358} \operatorname{Log}\left(\frac{PGDS_{-3}}{PGDS_{-4}}\right)$$

$R^2 = 0.5532$ SEE = 0.00565   DW = 1.3414   F = 15.350

A6.10) CONSUMER PRICE INDEX

$$\operatorname{Log}\left(\frac{PCPI}{PCPI_{-1}}\right) = \underset{(2.278)}{0.002026} + \underset{(19.217)}{0.900408} \operatorname{Log}\left(\frac{PCET}{PCET_{-1}}\right)$$

$R^2 = 0.8445$ SEE = 0.0032   DW = 2.200   F = 369.278

A6.11) IMPORT PRICE DEFLATOR

$$\operatorname{Log}\left(\frac{PIM}{PIM_{-1}}\right) = \underset{(1.297)}{0.003448} + \underset{(3.045)}{0.531484} \operatorname{Log}\left(\frac{PGUS}{PGUS_{-1}}\right) + \underset{(7.793)}{0.673836}$$

$$\operatorname{Log}\left(\frac{REX}{REX_{-1}}\right) + \underset{(9.705)}{0.2769}\ DPIM$$

$R^2 = 0.7581$ SEE = 0.0097   DW = 1.573   F = 68.949

NATIONAL INCOME COMPONENTS

A7.1) SUPPLEMENTARY LABOUR INCOME (AR1)

$$YSLI = \underset{(-7.793)}{-2792.64497} + \underset{(10.218)}{0.13297}\ (YWTG+YWTS) - \underset{(-1.177)}{42.6553}\ TIME$$

$R^2 = 0.9605$ SEE = 370.4599   RHO = 0.7732 (10.05)

A7.2) CORPORATE PROFITS

$$YCRP = \underset{(0.014)}{6.164083} + \underset{(23.49)}{0.94638}\ YCRP_{-1} - \underset{(-3.45)}{0.27648}\ (YWTG+YWTS+YSLI)$$

$$+ \underset{(3.533)}{0.164767}\ \frac{(YGNP+YGNP_{-1})}{2}$$

$R^2 = 0.9783$ SEE = 1634.938   DW = 0.909   F = 993.824

A7.3) OTHER INCOMES (Rents etc...) (AR1)

$$YBRI = -\underset{(-3.001)}{3466.97833} + \underset{(27.165)}{0.13336}\ YGNP + \underset{(1.587)}{238.3488}\ RG35$$

$R^2 = 0.9507$ SEE = 1169.44   RHO = 0.7140 (7.91)

A7.4) DIVIDENDS TO CANADIANS

$$YDIC = -\underset{(-2.23)}{1871.8826} + \underset{(7.964)}{0.64431}\ YDIC_{-1} + \underset{(3.972)}{0.039756}\ YCRP$$

$$+ \underset{(2.157)}{1869.2628}\ REX$$

$R^2 = 0.9292$ SEE = 432.7648   DW = 2.138   F = 288.535

A7.5) DIVIDENDS TO NON-CANADIANS

$$YFCP = \underset{(1.519)}{173.6526} + \underset{(2.23)}{0.02555}\ YCRP + \underset{(6.078)}{37.176615}\ TIME$$

$R^2 = 0.8482$ SEE = 435.803   DW = 1.304   F = 187.169

APPENDIX B

Below is the estimation method used for the correction of autocorrelation within the system of equations.

We have the following model;

i) $Y_t = b_o + b_1X_t + e_t$

Where e_t is the error term. Suppose there is autocorrelation of the form

ii) $e_t = p_1e_{t-1} + v_t$ or

iii) $v_t = e_t - p_1e_{t-1}$

where v_t is white noise. The appropriate correction procedure would be to lag the original equation one period, and to premultiply it by the first-order correlation coefficient (p). Then, subtract this out from the original equation (i), there-by leaving the function free of the correlation.

iv) $Y_t - pY_{t-1} = b_o(1-p) + b_1(X_t - pX_{t-1}) + v_t$

We can re-arrange this equation in the following way so as to estimate it only once:

v) $Y_t = b_o + b_1X_t + p_1[\ Y_{t-1} - b_o - b_1X_{t-1}\ ]$

The equations containing a distributed lag structure were estimated using the Almon scheme of polynomial lag. It is a two step method, which is described below.

(x) $Y_t = a_o + b_o X_t + b_1 X_{t-1} + b_2 X_{t-2} + b_3 X_{t-3} + e_t$

Given the above model, we first assume that the coefficients of the lagged variable (b_o-b_3), can be approximated by a function, b = f(A). The function f(A) is assumed to be approximated by a polynomial in A of a suitable degree. Suppose we postulate a 2^{nd} degree polynomial in A, that is;

(xi) $f(A) = s_o + s_1 A + s_2 A^2$

Then we can express the b's as a linear function of the s's where s goes from 0 to 3 (the number of lags in the model)

$$\text{(xii)} \quad \begin{aligned} b_o &= f(0) = s_o \\ b_1 &= f(1) = s_o + s_1 + s_2 \\ b_2 &= f(2) = s_o + 2s_1 + 4s_2 \\ b_3 &= f(3) = s_o + 3s_1 + 9s_2 \end{aligned}$$

Substituting the s's from equation (xii) into the b's in the original equation, (x), and rearranging gives us,

$$\text{(xiii)} \quad \begin{aligned} Y_t = a_o &+ s_o(X_t + X_{t-1} + X_{t-2} + X_{t-3}) \\ &+ s_1(X_{t-1} + 2X_{t-2} + 3X_{t-3}) + s_2(X_{t-1} + 4X_{t-2} + 9X_{t-3}) \\ &+ e_t \end{aligned}$$

Equation (xiii) is then estimated to generate the coefficients. Once the s's are generated we can calculate the b's using equation (xii).

The root mean square percentage error is calculated as follows;

$$\text{RMS\% Error} = \sqrt{\frac{1}{t}\sum_{t=1}^{t}\left[Y_t^s - Y_t^a\right]}$$

Where: Y_t^s = Simulated value of Y_t

Y_t^a = Actual value

t = Number of periods in the simulation

The Theil inequality coefficient and its proprieties are defined as;

$$\text{Theil inequality coef.} = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left[Y_t^s - Y_t^a\right]^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}[Y_t^s]} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}[Y_t^s]}}$$

$$U^m = \frac{[\bar{Y}_s - \bar{Y}_a]^2}{[1/T]\ \Sigma\ [Y_t^s - Y_t^a]^2}$$

$$U^{s} = \frac{[\ \sigma_s - \sigma_a\ ]^2}{[1/T]\ \Sigma\ [\ Y_t^{s} - Y_t^{a}\ ]^2}$$

$$U^{c} = \frac{2\ [\ 1 - p\ ]\ \sigma_s\ \sigma_a}{[1/T]\ \Sigma\ [\ Y_t^{s} - Y_t^{a}\ ]^2}$$

Where: Y_t^{s} = Simulated value of Y_t

Y_t^{a} = Actual value

σ_s = Standard deviation of the series of Y_t^{s}

σ_a = Standard deviation of the series of Y_t^{a}

p = Correlation coefficient of the estimate

T = Total number 0f periods in the simulation

$\overline{Y}_s$ = Mean value for the series of Yt^{s}

$\overline{Y}_a$ = Mean value for the series of Y_t^{a}

t = Index of periods in the simulation