Sectoral Analysis of RDX2 Estimated to 4Q72

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SECTORAL ANALYSIS OF RDX2

ESTIMATED TO 4Q72

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PREFACE AND ACKNOWLEDGEMENTS

This report is an analysis, by sector, of the RDX2 econometric model which has been revised and estimated to the fourth quarter of 1972 and published as Bank of Canada Technical Report 5. This is the fourth version of the RDX2 model and although there have been many changes since the first version was published in 1971, much of the underlying theory and structure remains intact. In this report we have therefore kept the description of the model's structure to a minimum, providing detail only on major differences between this and previous versions. A more complete description of the theoretical basis and the econometric techniques used in the development of RDX2 can be obtained by reading "The Structure of RDX2", Staff Research Study 7, in conjunction with this report.

The results of partial simulations designed to reveal the sectoral dynamics of the revised model are described in detail. In addition to an Introduction and a Conclusion which contain a general overview of the RDX2 project - its evolution, present state, and plans for future development - there are twelve chapters analyzing the structure and dynamics of the twenty-one sectors of RDX2. Each chapter focusses on the dynamic characteristics of a particular sector or subset of equations of the model and can be read independently of the others. Future technical reports will deal with the dynamics of the model as a whole and with the various links between sectors, particularly those between the real and financial sectors. However, the information presented here is considered essential to a proper understanding and interpretation of the simulation results of a model as large and complex as RDX2.

Throughout this report, the mnemonic system of RDX2 is used. The reader who is unfamiliar with this system should refer to Technical Report 5 which contains a complete description of the system together with a list of the variable names and their definitions.

An analysis of the kind presented in this report is an integral part of the RDX2 development program which, over the years, has involved many people. The names of those who have had primary responsibility for the various parts of this report are associated with the individual chapters. There are others whose contributions to this fourth version of RDX2 must also be recognized. Tom Maxwell contributed to the specification of the investment and labour market sectors. William Alexander developed the initial specification and estimation of the import equations, and with Richard Haas constructed the model of the flexible exchange rate. Donald Stephenson and Patrick Grady developed the new personal income tax sector, and Charles Freedman assisted in revisions to the financial sector. Significant contributions to the development of this version were also made by Pierre Duguay and Benjamin Wurzburger. Margaret Bailey and Jill Moxley edited the text which was typed by Yvonne Rowe, and Laurent Tessier and his group prepared the charts.

Jean-Pierre Aubry coordinated the production of this report, with assistance from John Helliwell, Tom Maxwell, and Donald Stephenson.

PREFACE ET REMERCIEMENTS

Ce Rapport technique est une analyse de chaque secteur de la plus récente version du modèle RDX2 présentée dans le Rapport technique N° 5. Les auteurs de cette analyse mettent l'emphase sur les différences entre cette quatrième version du modèle RDX2 et la version originale publiée en 1971. Puisqu'il n'y a aucun changement fondamental entre ces deux versions, la lecture de la description de la version originale [32] est donc fort utile à compréhension du cadre théorique utilisé lors de la construction des différentes versions du modèle RDX2.

Les résultats de simulations partielles qui révèlent la dynamique sectorielle du modèle revisé sont présentés dans les chapitres qui suivent. En plus de l'introduction et de la conclusion qui contiennent une vue d'ensemble du projet RDX2 - son évolution passée, présente et future - il y a dans ce rapport douze chapitres décrivant la structure et la dynamique des vingt et un secteurs de RDX2. Chaque chapitre peut donc être lu indépendamment. D'autres Rapports techniques tenteront de compléter cette information en analysant la dynamique de l'emsenble du modèle, les interrelations entre les différents secteurs, en particulier, entre le secteur financier et le secteur réel. L'information contenue dans ce rapport est essentielle à la compréhension et à l'interprétation de simulations faites avec un modèle de la dimension et de la complexité de RDX2.

Le lecteur qui n'est pas familier avec le système de mnémoniques est invité à consulter le Rapport technique N° 5 qui contient une description complète de ce système ainsi que les définitions des mnémoniques.

L'analyse présentée dans ce rapport fait partie intégrante du programme de développement du modèle RDX2 auquel plusieurs personnes ont participé. Les noms de ceux qui ont directement participé à l'élaboration de ce sixième Rapport technique sont inscrits au début de chaque chapitre. Il nous faut également mentionner la contribution de ceux qui ont participé à l'élaboration de la quatrième version de RDX2 et dont les noms ne figurent pas sur la liste des auteurs de ce Rapport technique. Tom Maxwell a travaillé à la spécification des secteurs de l'investissement et du marché du travail. William Alexander a spécifié et estimé une première ébauche des équations d'importations. Avec Richard Hass, il a également construit le secteur du taux de change flottant. Donald Stephenson et Patrick Grady ont développé le nouveau secteur de l'impôt sur le revenu des particuliers. Charles Freedman a participé à la réestimation du secteur financier. Pierre Duguay et Benjamin Wurzburger ont également contribué au développement de RDX2. Margaret Bailey et Jill Moxley ont édité le texte dactylographié par Yvonne Rowe. Laurent Tessier et son groupe ont préparé les graphiques.

Jean-Pierre Aubry a coordonné l'élaboration de ce rapport avec l'assistance de John Helliwell, Tom Maxwell et Donald Stephenson.

CHAPTER 1

INTRODUCTION

Jean-Pierre Aubry

A. La présentation d'un modèle économétrique

Deux types d'information peuvent être donnés dans la présentation d'un modèle économétrique: d'abord une information descriptive où sont présentées les équations et certaines expériences sur le pouvoir prédictif et sur la réponse du modèle à divers chocs types; ensuite une information analytique où sont étudiés le cadre théorique sous-jacent à la spécification et la dynamique des diverses équations prises individuellement, par sous-ensembles ou globalement.

Avec l'augmentation de la taille des modèles économétriques, les constructeurs ont de plus en plus tendance à ne fournir que le premier type d'information de telle sorte que la dynamique de ces modèles est souvent mal connue. Il est alors impossible d'expliquer clairement l'amplitude et les délais des effets de chocs types sur les principaux agrégats macroéconomiques.

De plus en plus conscients de l'importance du second type d'information, nous désirons, dans cette présentation, décrire non seulement le cadre théorique mais aussi la dynamique sectorielle de cette version de RDX2. Ainsi avant d'étudier la structure globale du modèle, nous avons voulu analyser indépendamment différentes sections du modèle. Pour ce faire nous avons divisé le modèle en 12 sections qui comprennent un ou plusieurs secteurs. A l'exception des chapitres 7 et 13 où les auteurs réfèrent respectivement aux chapitres 6 et 5 pour expliquer les résultats de certaines simulations partielles, les douze textes qui suivent peuvent donc être lus indépendamment. D'autres Rapports techniques qui analysent le modèle dans son ensemble complèteront cette information en décomposant des chocs types, en précisant le rôle des variables financières [19] et en discutant le pouvoir prédictif du modèle [37].

Ce Rapport technique poursuit donc deux objectifs bien précis. Le premier consiste à décrire le cadre théorique utilisé lors de l'élaboration de chaque secteur. Le cadre théorique général du modèle RDX2 ayant relativement peu varié depuis la première publication, nous ferons ressortir tout spécialement, dans ce Rapport technique, les différences entre le cadre théorique de cette version de RDX2 et celui de la première version [32]. Puisque les auteurs de ce Rapport technique ne font qu'un bref resumé de l'approche théorique utilisée lors de l'élaboration de chaque secteur, la lecture de la description de la version originale [32] est nécessaire pour avoir une connaissance plus approfondie et plus globale de la structure du modèle RDX2. Le second objectif est d'expliquer la dynamique de chaque secteur en mesurant l'effet à court, à moyen et à long terme des principales variables explicatives de chaque secteur. Pour ce faire nous utiliserons deux moyens techniques, l'un étant l'utilisation de simulations partielles, l'autre l'agrégation et la solution de différents sous-ensembles d'équations. Nous tenterons donc de résumer, dans la mesure du possible, la dynamique de chaque secteur en un nombre minimum d'équations. Nous croyons que la connaissance de ces équations "clefs" est un atout majeur quant à la compréhension de la dynamique de l'ensemble du modèle.

L'analyse du cadre théorique et de la dynamique sectorielle de chaque secteur va beaucoup plus loin que la phase descriptive. Reflétant le fait que la construction d'un modèle économétrique est un processus continu, sujet à une constante remise en question de sa structure, les auteurs de ce Rapport technique ont inclu, à divers degrés, une critique personnelle de la structure de chaque secteur et ils ont suggéré différentes solutions pour améliorer le modèle. L'ensemble de ces suggestions servira de base à l'élaboration de la prochaine version du modèle RDX2.

B. Les principales caractéristiques de RDX2

Nous en sommes maintenant à la publication de la quatrième version de RDX2 [6]. Il est donc intéressant de se demander comment le modèle a évolué depuis sa conception. Avant de décrire des différences entre les diverses versions du modèle RDX2, il faut d'abord en identifier les points communs. Notons premièrement que, si le nombre total d'équations a augmenté significativement (de 67, passant de 258 à 325), le nombre d'équations de comportement n'a augmenté que de 19 (passant de 142 à 161), de telle sorte que la taille du modèle s'est très peu modifiée. L'augmentation enregistrée s'explique principalement par une plus grande désagrégation des équations d'importations. Il ressort également de la comparaison de ces différentes versions que les objectifs et le cadre théorique général du modèle sont demeurés les mêmes et que l'évolution s'est faite autour de ces deux points majeurs.

RDX2 est un modèle économétrique conçu d'abord pour la simulation à court et à moyen terme de différentes politiques. Un ensemble fort complet d'instruments de politique y sont inclus afin de permettre une grande variété de simulations de politiques monétaires et budgétaires. Les auteurs ont voulu largement développer les secteurs des dépenses, des revenus et du solde budgétaire de l'administration fédérale et des administrations provinciales et municipales. En développant le secteur financier on a tenté d'expliquer l'allocation de portefeuille des agents économiques non financiers, des banques à charte, des sociétés de fiducie et de prêts ainsi que des sociétés d'assurance-vie. On a veillé également à intégrer les besoins de financement de ces sociétés.

Plusieurs variables du secteur public sont définies comme des variables endogènes, et ce dans le but de refléter le fait que l'activité économique (et non seulement les décisions de politiques) influence grandement les variables gouvernementales. D'un autre côté il y a des variables exogènes dont un grand nombre sont des instruments de politique et qui ont une grande influence sur l'activité économique. Il y a finalement des fonctions de réaction qui essaient de modeler le processus décisionnel typique des autorités publiques face aux variations des divers agrégats économiques. Parmi ces fonctions de réaction on retrouve l'équation du taux de rendement moyen des obligations du gouvernement fédéral, d'un à trois ans (RS, éq. 17.1) et l'équation des variations des réserves canadiennes en devises étrangères (FXO, éq. 21.1).

Le modèle RDX2 permet donc de simuler un ensemble de politiques aussi variées que:

- variations de taux d'intérêt
- variations de divers types de dépenses et de taxes gouvernementales

- variations dans les taux de réserve des banques à charte
- variations des prêts hypothécaires consentis par la Société centrale d'hypothèques et de logement.

Le modèle RDX2 nous donne une estimation des effets de ces chocs non seulement sur le secteur privé mais également sur le secteur public.

Une des caractéristiques importantes de l'économie canadienne est son ouverture sur les marchés étrangers. Cette caractéristique se traduit par l'importance accordée aux équations expliquant les importations et les exportations de biens et de services, les entrées et les sorties de capitaux à court et à long terme, la balance commerciale, la balance des paiements et finalement le taux de change. Dans le modèle RDX2 les variables reflétant l'activité économique à l'étranger ont une importance déterminante non seulement sur le commerce extérieur mais aussi sur les prix et les taux d'intérêt.

Les constructeurs du modèle RDX2 ont consacré une grande attention à la quantification de l'effet des pressions de la demande et de l'offre sur les prix, sur les salaires, sur les importations et au développement des liens entres le secteur réel et le secteur financier. Ainsi les variables réelles (consommation, investissement) de RDX2 sont principalement expliquées par des variables de demande; cependant les pressions de l'offre sont surtout introduites par le biais des équations de prix, à l'aide d'un ensemble de concepts économiques qui font la richesse et l'originalité de RDX2.

Un des concepts très utilisés dans le modèle RDX2 est celui de la production brute non agricole du secteur privé (UGPP) qui est obtenu en soustrayant de la production nationale brute (UGNE) la production du secteur agricole, les loyers et la valeur ajoutée par le secteur public et para-public. Une fonction Cobb-Douglas (eq. 3.19) détermine la production du secteur privé non agricole (UGPPS) obtenue par l'utilisation au niveau observé du stock de capital et de l'emploi, ce dernier facteur oeuvrant durant le nombre d'heures de travail observées au niveau de productivité de long terme. Les variations de la productivité observées à court terme par rapport au niveau de long terme et générées par une utilisation plus ou moins intensive du facteur de travail selon les pressions de la demande sur l'appareil de production expliquent la différence entre UGPP et UGPPS. L'utilisation des concepts UGPP et UGPPS dans la spécification de l'équation des variations d'inventaires du secteur privé non agricole (IIB, éq. 3.4) rend possible l'estimation des variations non désirées d'inventaires. Ce dernier concept permet, dans une seconde étape, d'évaluer la demande du secteur privé non agricole (UGPPA, éq. 3.17) en soustrayant de UGPP les variations non désirées d'inventaires.

La substitution, dans la fonction de production, du niveau d'emploi et des heures de travail observés respectivement par un niveau moyen d'emploi de la population active et par la tendance moyenne des heures de travail permet la construction d'une variable (UGPPD) qui représente l'offre du secteur privé non agricole étant donné le stock actuel de capital et une utilisation moyenne de la main-d'oeuvre. La demande de main-d'oeuvre est définie dans une étape subséquente, comme étant le niveau d'emploi (NMMOBD éq. 5.13) requis par la fonction de production, étant donné la tendance moyenne des heures de travail, pour obtenir un niveau de production demandé, UGPPA. Un nouveau concept introduit dans cette dernière version de RDX2 est celui de l'offre maximale de la main-d'oeuvre (pour les secteurs minier, manufacturier et des autres services, NMMOBS, éq. 5.15) qui découle d'une estimation du chômage frictionnel.

Ainsi grâce aux concepts ci-haut mentionnés trois différentes mesures du déséquilibre entre l'offre et la demande peuvent être déduites:

UGPPA/UGPPD	le rapport entre la demande et la production obtenue par le stock de capital actuel et par une utilisation moyenne de la main-d'oeuvre
J12S(UGPP-UGPPA)	l'accumulation des changements non désirées d'inventaires pendant les douze derniers trimestres
NMMOBD-NMMOBS	l'écart entre l'offre et la demande de travail

L'estimation de la rente réelle sur le capital, RHOR, qui est le rendement requis par les investisseurs pour détenir un certain stock de capital est une autre source d'originalité de RDX2. Disons brièvement qu'il a fallu, pour construire cette variable, estimer la valeur du capital en multipliant la valeur comptable du stock de capital par un facteur d'ajustement. Ce facteur d'ajustement a été estimé par le rapport entre la valeur comptable et la valeur en bourse d'un échantillon formé des soixante-six plus importantes sociétés non-financières dont les actions sont quotées sur le marché boursier canadien.

L'ensemble des concepts ci-haut mentionnés est analysé en détail dans la version originale [32]. En plus de dégager les grandes lignes de cette analyse, les textes de ce Rapport technique décrivent l'évolution de ces concepts et de leur emploi.

C. L'évolution du modèle RDX2

L'évolution du modèle RDX2 s'est faite autour du cadre théorique partiellement décrit dans la section précédente. Quatre types bien distincts de facteurs sont à l'origine de l'évolution de RDX2. Ces facteurs sont: le développement de la théorie économique, l'évolution de l'activité économique, l'extension de la période échantillonnale et la dynamique des versions précédentes.

Depuis dix ans, la théorie économique a énormément progressé. Beaucoup de recherches on été faites, par exemple, en vue d'expliquer les relations entre le secteur réel et le secteur financier et, plus récemment, en vue de définir l'impact des contraintes d'offre. Un travail important a été réalisé par les constructeurs de modèles en vue d'intégrer, de vérifier et de quantifier ces nouveaux développements théoriques. Nous n'avons pas échappé à cette tendance. Beaucoup d'efforts ont été entrepris afin de tester différentes approches théoriques dans la plupart des secteurs et en particulier dans les secteurs clefs de la consommation, de l'investissement, de l'emploi, des prix et des salaires.

De façon générale, des critères statistiques ont été utilisés pour discriminer différents modèles théoriques. Nous avons réduit au minimum l'utilisation des contraintes. Dans l'ensemble, les résultats sont décevants car beaucoup de nouveaux modèles théoriques ont été rejetés. Par exemple, dans cette dernière version, nous avions comme objectif d'accroître l'impact de la politique monétaire sur les secteurs de l'investissement et la consommation; malheureusement, dans ces deux secteurs les tests économétriques ont contrecarré cet objectif si bien que l'on se retrouve avec un modèle où l'impact de la politique monétaire est plus faible que dans celui qui avait été estimé dans la version précédente.

L'évolution de l'activité économique des dernières années (1974-1976) a grandement influencé la spécification de la version actuelle. Par exemple, la poussée inflationniste des prix (1971-1975) et la forte hausse du prix du pétrole (1973) nous ont rendu plus conscients de l'importance des prix étrangers sur les prix canadiens et sur l'importance des contraintes d'offre. Certaines décisions de politiques comme l'adoption d'un taux de change flottant et l'indexation des exemptions et des tranches de revenu pour fin d'impôt ont dû être "modelées".

L'addition de nouvelles observations (1T71-4T72) à la précédente période échantillonnale (1T56-4T70) a eu un impact important sur la spécification du modèle. Ainsi le pouvoir explicatif de certains schémas utilisés dans la version précédente s'est effrité, tandis que celui de certains autres s'est raffermi. Lors du travail de spécification de la plupart des équations, il a fallu revérifier l'exclusion de variables explicatives dont la présence était dictée par les schémas théoriques, mais qui avaient été rejetées par les tests statistiques dans les versions précédentes. Au cours de l'estimation, tel que mentionné plus haut, il a également fallu tester l'addition de nouvelles variables explicatives justifiées par de nouveaux schémas théoriques. En plus d'utiliser le test "t" sur chaque coefficient et l'écart type du résidu, nous avons vérifié la stabilité des coefficients (estimation avec différentes périodes échantillonnales) et le pouvoir prédictif (1T73-4T73).

Il y a de grandes différences entre le modèle théorique et le modèle estimé ainsi qu'entre ce que l'on croit être la dynamique d'un modèle et sa véritable dynamique. Ces différences augmentent avec la taille du modèle, et ce n'est qu'en simulant un modèle que l'on découvre ces différences. Les résultats de diverses simulations à court, à moyen et à long terme de la version précédente nous ont donné beaucoup de renseignements sur les faiblesses de cette version et sur les modifications à apporter à la version suivante.

D. Les principaux objectifs

Ainsi, compte tenu des facteurs ci-haut mentionnés, nous avons entrepris la réestimation du modèle avec les objectifs suivants:

1. augmenter l'influence des variables financières sur la consommation, l'investissement et les prix,
2. augmenter, dans les fonctions d'investissement, le pouvoir explicatif de l'écart entre le stock de capital désiré et le stock de capital utilisable,
3. accroître le rôle des contraintes d'offre de main-d'oeuvre sur le marché du travail,
4. augmenter l'impact des heures de travail dans l'équation de revenu trimestriel (WQMMOB),
5. augmenter l'impact des variables mesurant le déséquilibre entre l'offre et la demande dans les équations de prix, de salaires et d'importations,

6. augmenter l'influence et l'impact des prix étrangers sur les prix intérieurs.
7. augmenter l'effet des variables de prix relatifs dans les équations d'importations,
8. endogénéiser la distribution des revenus et les taux moyens de taxation; indexer certaines exemptions et les tranches de revenu,
9. quantifier l'effet de la Loi des banques sur l'allocation des actifs détenus par le public et les institutions financières et sur la structure des taux d'intérêt,
10. reétudier l'équation du taux de change flottant à la lumière des plus récentes observations (1T73-4T75),
11. diminuer, dans l'ensemble du modèle, la longueur des délais d'ajustement.

Les auteurs de ce Rapport technique décrivent les recherches qui ont été entreprises en vue de la réalisation de ces objectifs, évaluent leur degré de réalisation et donnent un aperçu de la direction que devront prendre les recherches ultérieures. A l'exception des objectifs (1) et (2) l'ensemble des autres objectifs a été réalisé à un haut degré. Ainsi donc nous avons une version du modèle RDX2 où les variables de déséquilibre entre l'offre et la demande ont un impact accru dans les fonctions d'emploi, de salaires, de prix et d'importations, où le secteur modelant l'impôt sur le revenu des particuliers est beaucoup plus près de la réalité, où l'écart entre les prix étrangers et les prix domestiques joue un rôle beaucoup plus important et où les cycles produits par différents chocs sont plus courts.

Certes il reste beaucoup de travail à faire. La rédaction de ce Rapport technique et l'élaboration d'autres Rapports techniques sur l'analyse de chocs types, sur le pouvoir prédictif [37] et sur le rôle des variables financières [19] nous ont appris beaucoup sur le modèle et sur les améliorations à y apporter. La conclusion dégage plusieurs perspectives de développement. Ajoutons finalement que tous commentaires sur la structure du modèle et toutes suggestions sur son développement seront bienvenus.

CHAPTER 2

CONSUMER EXPENDITURE: SECTOR 1

Jean-Pierre Aubry

Elisa McFarlane

A. Introduction

Re-estimation of the consumption sector of RDX2 was started with a series of objectives in mind. First, we wanted to improve the definition of income in order to reduce the gap between the definition in RDX2 and the National Accounts definition. Second, we wanted to test the influence on the model of relative prices, price expectation variables, interest rate variables, and a wealth variable. Finally we hoped to estimate an aggregate consumption equation following Modigliani [42]. However, for reasons we will discuss later, we were not entirely successful in meeting these objectives.

This chapter is divided into six parts. In section B the mnemonics and the level of disaggregation currently used in the consumption sector of RDX2 are defined. Our estimation strategy, the general model used, and re-estimation problems are discussed in section C, and in section D the income variables used as explanatory variables are defined. In section E each equation of the final version is analyzed, and in section F we try to give an overall understanding of the sector dynamics by aggregating the consumption equations. Finally, future work on this sector of the model is proposed in section G.

B. Mnemonics and Disaggregation Level

As in the previous version of RDX2 [29], we explain five different types of consumer expenditure:

CNDSD Consumer expenditure on non-durables and semi-durables

CSXR Consumer expenditure on services excluding rent

CRENT Gross rent (imputed and paid) less an estimate of residential property taxes

CMV Consumer expenditure on motor vehicles and parts

CDO Consumer expenditure on other durables.

These expenditure series can be aggregated in different ways:

consumer expenditure on services

CS = CSXR + CRENT + .566 TIPROPM/PRENT

consumer expenditure on non-durables, semi-durables and services

C = CS + CNDSD

consumer expenditure on durables

CD = CDO + CMV

total consumer expenditure

CON = C + CD.

To distinguish between consumer expenditure on goods and services (CON) and the consumption of goods and services we define

CSMVOD Consumer services imputed from the stock of motor vehicles and other consumer durables (equation 1.8)

Therefore total consumption of goods and services is

CONS = CNDSD + CS + CSMVOD.

C. Re-estimation Strategy

During the re-estimation process we made use of the distinction between consumer expenditure (CON) and the consumption of goods and services (CONS). Following Modigliani [42] we estimated an equation for CONS using the model:

$$CONS/NPOPT = a + bYPERM + c(V/((NPOPT)(PCPI))) \qquad (1)$$

where

NPOPT is total population

YPERM is an estimate of real disposable permanent income per capita

V is the market value of private wealth

PCPI is the consumer price index.

We obtained interesting results with this approach, in particular a significant wealth effect; however, when we tried to explain the ratio of each component of consumption to total consumption (CSXR/CONS, CRENT/CONS, CSMVOD/CONS and CNDSD/CONS) by using relative prices the results were disappointing. Introduction of constraints on the price terms in the estimation did not improve the results.

Because of these results we decided to postpone this project and to concentrate on the previous model's framework which used seven variables to explain the components of consumption expenditure:

1) a real wealth variable

   VR = V/((NPOPT)(PCPI))

2) a price expectations variable

   PEX = J4A(PCPICE)/J8A(PCPICE)

3) a real interest rate variable

R = J4A(.01 RHOR)

4) a variable to reflect credit availability

CR = (RABELCD-RABECDD)/(RABELCDD)

5) real government transfers

TR = (J4A(GTPOF+GTPPM+GTPUIBF+GTPCPP+GTPQPP))/((NPOPT)(PCPI))

6) an estimate of real disposable permanent income per capita

YPERM (equation 1.1)

7) a vector of relative prices

RELPR.

A consumption function for consumer expenditure on goods and services (CNDSD, CSXR and CRENT) was then estimated using the general model:

$$C/NPOPT = a + bYPERM + cVR + dPEX + eCR + fTR + g(RELPR)(YPERM) + qR \qquad (2)$$

where

a priori positive signs are expected on the coefficients of the constant, YPERM, VR, TR. A negative sign is expected on the coefficient of CR and R. We have no a priori theories as to the signs of the coefficients on PEX and the RELPR term.

For consumer expenditure on durables (CDO, CMV) we used a stock adjustment model:

$$CD/NPOPT = h(KD/NPOPT-J1L(K/NPOPT)) + k\ J1L(K/NPOPT)$$

where

K is the stock of durables

KD is the desired stock of durables

CD is total consumer expenditure on durables

k is the depreciation rate

Since KD can be explained by the same variables that appear in equation (2), we obtain the following model for CD:

$$CD/NPOPT = a + b\ YPERM + cVR + dPEX + eCR + fTR + qR + g(RELPR)(YPERM) + m\ J1L(K/NPOPT) \quad (3)$$

The equation was re-estimated over four different sample periods: 1Q58-4Q70, 1Q58-4Q71, 1Q58-4Q72, 1Q58-4Q73. This process revealed high instability in most of the coefficients appearing in the general model, (2) and (3), especially the coefficients on interest rate, on price expectations, on credit availability and on lagged stock variables. In certain cases the coefficients had significant perverse signs.

We therefore decided to choose only those specifications that yielded the greatest degree of stability over the various sample periods. Four-quarter differencing was very helpful in reducing multicollinearity among the explanatory variables in these experiments.

Attempts to increase financial links between the consumption sector and the rest of the model were disappointing. The end result of experimentation was a reduction in the existing links. These experiments also revealed that the higher the degree of aggregation the stronger were the financial links.

D. Permanent Income Definition

The definition of permanent income used in the consumption functions has two different components: permanent wage income (JW(YDW)) and permanent nonwage income (YPDNWP), the latter having been constructed independently of the difference between the National Accounts definition of personal income (YP) and disposable wage income (YDW). Permanent wage income is defined as a twelve-quarter polynomial distributed lag (Z2) on disposable wage income (YDW, equation 8.7). Other lag structures were tried but the twelve-quarter distributed lag gave the best empirical results. As in previous versions of the model, permanent nonwage income (YPDNWP) is based on wealth components weighted by imputed real rates of return. More information on these two concepts is given in Helliwell and Maxwell [29], pp 21-30. Even though the theoretical framework is the same, the definitions of YDW and YPDNWP have changed. These changes are discussed below.

1. YDW Disposable wage income

As in the original version, disposable wage income (YDW, [32], equation 8.6) includes wages, salaries, supplementary labour income, military pay and allowances, unemployment insurance benefits, other government-business transfer payments to persons, and the after-tax returns from unincorporated business (YNFNC). This last item has been broken down into two components: wage, approximated by WQMMOB*NEUPB, and nonwage, defined as YNFNC-WQMMOB*NEUPB. Only the wage component is introduced into the YDW equation; the nonwage item appears in the YPDNWP equation. We have assumed that unpaid employees in nonfarm business (NEUPB) receive the same quarterly earnings as paid employees in mining, manufacturing and other business (WQMMOB).

Three variables have also been added to the definition of YDW:

GTPCPP Transfer payments to persons by Canada Pension Plan

GTQPPP Transfer payments to persons by Quebec Pension Plan

.6832J4A(YF) An approximation of farm income that is not re-invested in farms.

We would like our definition of total disposable income (wage and nonwage) to be more compatible with the National Accounts definition of personal disposable income (YDP, equation 8.10). Inclusion of the above items of YDP, omitted from the previous definition of YDW ([29], equation 8.6), has taken us one step closer to this goal.

2. YPDNWP Permanent disposable nonwage income

As mentioned above, YPDNWP is defined as the sum of different wealth components multiplied by their respective imputed real rate of return less the income tax paid by installments and all other direct taxes, with the exception of personal income tax and employer-employee contributions to social insurance and government pension plans.

Instead of using a weighted sum of the stock of single-detached dwellings and multiple dwellings as a proxy for the value of the housing stock, we directly include KRESD in YPDNWP. Another change is the use of EACR and EACRCSB as the nominal return on government bonds and on Canada Savings Bonds respectively instead of RL. Finally the real return on the stock of business fixed-capital and investment (RHOR) approximated in the original version by:

J2A(.01RHO-PCPICE)(J2A(VKB)(1-.01RVB12-.01RVB13)) (4)

is now defined as:

x(1-.01RVB12-.01RVB13) (5)

where

x = J4S(YC-TCA+ECINT+ECINTGBE+YCGBE+YNFNC-(WQMMOB)(NEUPB)) (6)

We use x in order to make the definition of the wealth variables (VKB and V) more consistent with the definition of YPDNWP. By solving equations 18.1 and 18.5, we find that

RHO = [100 (x)/J2A(VKB)] + JW(PGPP)

ie,

x = .01[RHO-JW(PGPP)]J2A(VKB) (8)

By substituting (8) into (5) we obtain for RHOR:

.01[(RHO)-JW(PGPP)]J2A(VKB)(1-.01RVB12-.01RVB13) (9)

The main difference between formulations (4) and (9) for RHOR is the use of product prices (PGPP) in the calculation of the expected annual rate of change in prices instead of the consumer price index. Theoretically, we should have used PCPICE, as in (4), the expected annual rate of change in the consumer price index. Also, as pointed out in the structure of Sector 18, we theoretically should have obtained a value of 1.0 for the sum of the weights on PGPP in the VKB equation and then constructed

PCPICE with those weights. Since the weights did not sum to 1.0 we were obliged to normalize the PGPP weights so that they did sum to 1.0 in the definition of PCPICE.

3. Some points of comparison between the RDX2 permanent income definition and the National Accounts definition

To give us a better idea of how our method of constructing permanent income,

YPER = JW(YDW) + YPDNWP

compares to the usual approach (ie, where permanent disposable income is not split into wage and nonwage components), we derived an estimate of permanent income from the National Accounts definition of disposable income (YDP, equation 8.10), JW(YDP), where the weights (JW) in both definitions are the same as those that appear in the YPERM definition (equation 1.1).

Over the sample period, 1Q58-4Q72, the RDX2 definition is on average 9.2 percent higher than the National Accounts definition. As can be seen from the following regression results, both series follow a very similar pattern.

$$\underset{}{YPER} = -\underset{(4.73)}{130.17} - \underset{(.25)}{3.6459}\ QC1 + \underset{(4.63)}{139.73}\ QC2 - \underset{(6.97)}{101.13}\ QC3 + \underset{(395)}{1.1059}\ JW(YDP)$$

see = 64.8 RB2 = .9996 dw = .51 e = 1.01

where

e is the elasticity between the income variables at their means.

If we subtract the RDX2 definition of permanent disposable wage income JW(YDW) from JW(YDP), we can compare YPDNWP to a National Accounts approximation of permanent disposable nonwage income. With this procedure one should note that the total difference in disposable permanent income between the RDX2 and the National Accounts is attributed to the difference in the definition of personal disposable nonwage income. Over the sample period YPDNWP is on average 89 percent greater than the National Accounts definition JW(YDP-YDW). To explain this important difference we can argue that the YPDNWP takes into account several items not included in the National Accounts definition of personal income - namely, undistributed profits of corporations and imputed income from monetary claims on the government, imputed income from motor vehicles, other consumer durables, and unrealized capital gains on housing. Because of the above differences JW(YDP) and JW(YDW) + YPDNWP do not have the same response to certain shocks, eg, profit shock, and the response of the savings rate defined with National Accounts concepts (YDP-CON)/YDP has to be analyzed very carefully.

Another reason for the large difference in the two approximations of permanent disposable nonwage income is that taxes are underestimated in the definition of YPDNWP. Leo de Bever, in his work on Sector 9 found that by replacing the terms .38427 J4S(TANW) and YWAS in the YPDNWP equation (equation 8.2 where YAS = YWAS + YNWAS) by J4S(TPO) and .8*(YAS) the magnitude of YPDNWP was reduced by approximately 50 percent. The reasoning behind the use of the TPO term rather than TANW is that TANW covers only 50 percent of all tax not collected at source. TPO would thus be the more appropriate variable. The second substitution was made because assessed wage income is approximated better by 80 percent of total assessed income than by YWAS.

In spite of these differences both series follow essentially the same pattern and have a similar growth rate.

$$YPDNWP = -\underset{(4.95)}{198.31} + \underset{(1.14)}{22.509}\, QC1 + \underset{(14.2)}{291.4}\, QC2 - \underset{(10.6)}{213.16}\, QC3 + \underset{(53.0)}{2.0939}\, [JW(YDP) - JW(YDW)]$$

see = 87.2   RB2 = .980   dw = .85   e = 1.11

This equation shows that the elasticity at the points of the means of YPDNWP with respect to [JW(YDP)-JW(YDW)] is slightly over one, implying a growing difference in the two series over time.

E. Analysis of the Consumption Equations

1. CNDSD Consumer expenditure on non-durables and semi-durables (equation 1.1)

We explain the year-over-year change in CNDSD by the year-over-year change in permanent income and the sum of government transfers. All these variables are normalized by the total population variable. For non-durables and semi-durables the marginal propensity to consume attributed to permanent income other than transfers is .31; attributed to income from transfers it is .57 (.31+.26). It should be noted that over the sample period real transfers per capita increase by about $188 and with the estimated marginal propensity to consume (.57) they explain 40 percent of the $269 increase in CNDSD/NPOPT.

2. CS Consumer expenditure on services

We decided to disaggregate consumer expenditure on services into two components, expenditure on rent (CRENT) and expenditure on other services. Figures 1 and 2 confirm the fact that even though both series, CSXR and CRENT, have the same long-term trend, their short- and medium-term behaviour is very different. We then decided to add other supplementary variables to those used in equation (2) and to test the influence of the stock of dwellings on CRENT.

a) CSXR Consumer expenditure on services (excluding rent) (equation 1.2)

The data series on consumer expenditure on services was greatly affected by the transfer in 1961 of hospital and medicare payments from the private to the public sector of the National Accounts. This fact is reflected in the CSXR specification by inclusion of the variables QHOS and EMEDPAY. For example each dollar (constant 1961) paid by the provinces as a medicare payment reduced the consumption of private services (CSXR) by $0.97. The estimation of the marginal propensity to consume services out of permanent income is .166 (=.105/(1-.366)) which is slightly lower than the average propensity to consume (.20).

Figure 1

COMPONENTS OF CONSUMER EXPENDITURE ON SERVICES
(Millions of 1961 Dollars)

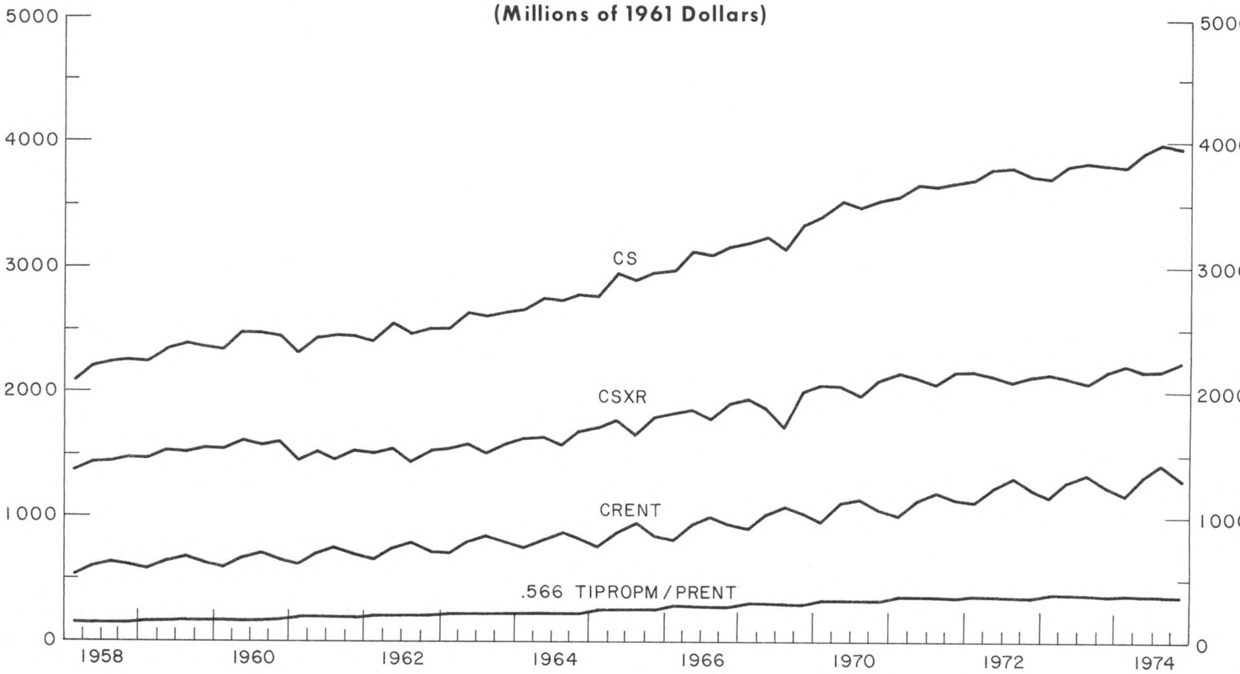
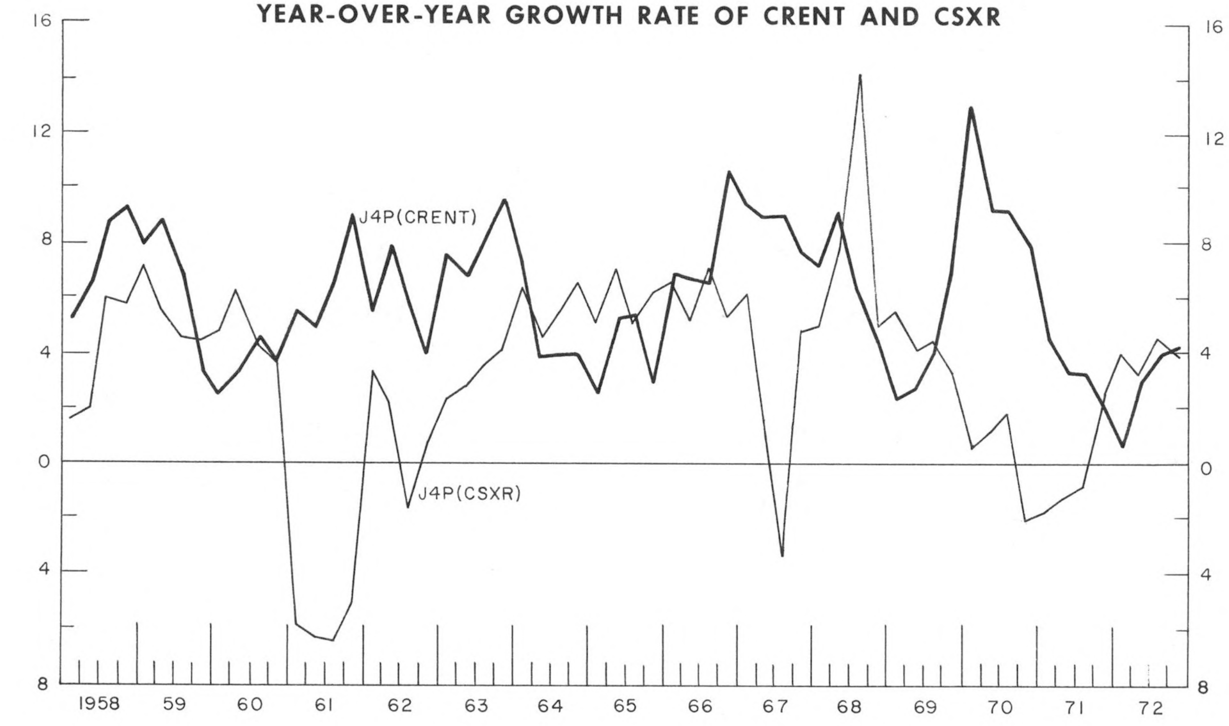


Figure 2

YEAR-OVER-YEAR GROWTH RATE OF CRENT AND CSXR



b) CRENT Consumer expenditure on rent (gross rent paid and imputed less an estimate of residential property taxes)(equation 1.5)

In Table 1 we show how the CRENT series is calculated. The exclusion of consumer expenditure on facilities and on services from gross paid and imputed rent is responsible for the large seasonal movements in the CRENT series. The general model, equation (2), used for all other types of consumer expenditure was rejected by regression experiments.

If we define CRENT as the consumption of services imputed from the stock of dwellings we should obtain the relationship:

$$\text{CRENT} = (\text{RHOR}+d)\text{KRESD} + \text{seasonal adjustments} + \text{short-term economic adjustments} \qquad (10)$$

where

KRESD is the value of the housing stock

RHOR is the average value of the approximation of real supply price of capital (equation 18.4)

d is the depreciation rate of KRESD (equation 2.7).

To explain the short-term economic adjustments we tried different economic variables and different demographic variables without success. A simple constant growth-rate model gave the best results.

$$\text{J1D}(\ln(\text{CRENT})) = \underset{(5.94)}{.015} - \underset{(11.8)}{.016}\ \text{QC1} + \underset{(22.0)}{.094}\ \text{QC2} + \underset{(7.99)}{.034}\ \text{QC3} \qquad (11)$$

see = .023 RB2 = .902 dw = 1.89

Table 1

CALCULATION OF CRENT

Gross contract rent paid		
LESS: Expenses of facilities supplied by landlord and included in rent paid:		
	Amortization of furniture, stoves, and washing machines	
	Heating fuel Janitor services Water Electricity Gas Hot water	supplied by landlord
EQUALS: Gross space rent paid by tenant occupants		
PLUS: Gross space rent imputed to owner occupants		
EQUALS: Gross paid and imputed rent for space		
LESS: Landlord's expenses on tenant- and owner-occupied dwellings		Repair and maintenance Municipal property taxes Depreciation Fire insurance Mortgage interest Real estate commissions on transfers of existing dwellings
EQUALS: Net paid and imputed rents		
LESS: Net rents paid to non-personal sectors		
EQUALS: Net rents, paid and imputed, received by individuals (CRENT)		

Study of the error correlogram revealed that the errors were uncorrelated.

A closer look at the basic series used for the construction of the CRENT series (see Table 1) - namely, the gross contract rent paid series (CGCRP) - revealed that CGCRP followed a dubiously perfect growth-rate model.

$$J1D \ln(CGCRP) = \underset{(20.8)}{.02211} \qquad (12)$$

The fit on the re-normalized error was .99957. This means that, over the sample period, the cycle of economic activity had almost no impact on the CRENT or the CGCRP series. Given these facts we decided to exogenize the CRENT variable. However, we coded into the simulator program, as an option, a simulation rule (equation 1.5) based on the model expressed in equation (10).

3. CMV Consumer expenditure on motor vehicles and parts (equation 1.3)

A special effort was made to introduce a real wealth variable into the CMV equation. Unfortunately econometric tests rejected this variable. The lagged stock coefficient (J1L(KMV)), which was quite sensitive to different specifications and to different sample periods, is very small. This implies a slow speed of adjustment (.134) toward the desired stock equilibrium, such that only 44 percent and 68 percent of the gap between the desired and the actual stock of motor vehicles is closed in four and eight quarters respectively.

On the other hand we have an important relative price effect. One should note that an increase in the price of motor vehicles relative to the price of non-durables, semi-durables and of services induces consumers to save rather than to increase CNDSD and CS. By setting the relative price to its sample average (.875) and by substituting the stock equation into the CMV equation we find the marginal propensity to consume motor vehicles out of permanent income to be .062, which is .01 lower than the average propensity.

4. CDO Consumer expenditure on durables (excluding motor vehicles and parts) (equation 1.4)

Our specification of CDO differs from that of the previous version because we added investment in residential construction (IRC) and the wealth variable (V) and removed the permanent nonwage income variable. The IRC variable reflects the high positive correlation between residential construction and the household expenditure on consumer durables. The regression coefficient on IRC implies that a $1 increase (constant 1961) in residential construction expenditure generates an increase of $0.12 in expenditure on consumer durables. Expressed differently, an average investment of $14,765 in a single-detached dwelling, results in a sale of $1,770 worth of consumer durables.

As in the previous CDO equation the lagged stock coefficient is small, and only 13 percent, 41 percent and 66 percent of the gap between the desired and the actual stock of durables is closed in one, four and eight quarters respectively. By setting the relative price term at its sample average value (.905) and by substituting for KDO in the CDO equation we compute the marginal propensity to consume durables out of permanent wage income to be .07.

F. An Aggregate Consumption Expenditure Equation

If we remove from each of our consumption equations the constant terms, the seasonal variables and the population terms, set the relative price terms to their average values, and substitute the two stock equations (KDO and KMV) in the relation, we can obtain an approximation of the aggregate consumption expenditure equation. This approximation is presented in Table 2 from which it can be seen that the marginal propensity to consume out of wage income and nonwage income is .61 and .49 respectively.

Table 2

AN APPROXIMATION OF THE AGGREGATE CONSUMPTION EQUATION

$$CON \cong J1W\left(\frac{YDW}{PCPI}\right) + J2W\left(\frac{YPDNWP}{PCPI}\right) + J3W(IRC) + J4W\left(\frac{V}{PCPI}\right) + .26378\ J4A\left(\frac{TR}{PCPI}\right) + CRENT$$

	J1W	%*	J2W	%	J3W	%	J4W	%
t= 0	.15485	(25)	.42006	(88)	.02997	(60)	.00248	(223)
-1	.13433	(47)	.03770	(96)	.02790	(108)	-.00017	(208)
-2	.11045	(66)	.01300	(99)	.02608	(157)	-.00015	(194)
-3	.08738	(80)	.00472	(99)	.02449	(202)	-.00013	(183)
-4	.06655	(91)	.00157	(100)	-.00687	(189)	-.00011	(173)
-5	.04837	(99)	.00046	(100)	-.00601	(179)	-.00010	(164)
-6	.03294	(104)	.00009	(100)	-.00525	(169)	-.00009	(156)
-7	.02017	(108)	-.00001	(100)	-.00460	(159)	-.00008	(149)
-8	.01002	(109)	-.00003	(100)	-.00402	(152)	-.00007	(142)
-9	.00238	(110)	-.00001	(100)	-.00352	(145)	-.00006	(137)
-10	-.00281	(109)	.00001	(100)	-.00308	(140)	-.00005	(132)
-11	-.00564	(108)	.00002	(100)	-.00269	(135)	-.00004	(129)
-12	-.00618	(106)	.00003	(100)	-.00235	(130)	-.00003	(126)
-13	-.00555	(105)	.00004	(100)	-.00206	(126)	-.00003	(123)
-14	-.00489	(105)	.00005	(100)	-.00180	(123)	-.00003	(121)
-15	-.00428	(104)	.00006	(100)	-.00158	(120)	-.00002	(119)
-16	-.00374	(104)	.00006	(100)	-.00138	(118)	-.00002	(117)
-17	-.00326	(103)	.00006	(100)	-.00121	(116)	-.00002	(115)
-18	-.00284	(103)	.00006	(100)	-.00105	(114)	-.00002	(113)
-19	-.00248	(103)	.00006	(100)	-.00092	(112)	-.00001	(112)
Sum	.62577		.48753		.06005		.00122	
Steady state	.609		.48829		.05361		.00111	

* Percentage cumulant

These two numbers are fairly low compared to the average propensity to consume out of permanent income (.9).

We have to be very cautious, however, when comparing these estimated marginal propensities to consume with the average propensity to consume. There are other endogenous terms in this aggregate equation that cannot be neglected, such as IRC, V/PCPI, J4A(TR). To obtain a rough estimate of the impact of these terms their average behaviour over the sample period can be used as a simulation rule.

TR = .11 YPERM

IRC = .06 YPERM

V = 14 YPERM

If we substitute these average relations into the aggregate consumption equation, the marginal propensity to consume out of wage income increases from .61 to .66, which still leaves a discrepancy between it and the average propensity to consume. However, if we take into account the fact that CRENT is exogenously defined and if we add its average propensity to consume, CRENT = .10 YPERM, to the aggregate consumption relationship, we obtain a more reasonable difference between the average and the marginal propensity to consume out of permanent income.

G. Looking Ahead

In the near future, when the data base is updated to the end of 1975, we would like to continue our research on the impact of financial variables on consumption expenditure. First, we plan to study the effect of different factors such as institutional saving (eg, pension plans) and age distribution (through the life-cycle hypothesis) on the saving rate. Second, we would like to examine more closely the effect on consumption expenditure of income distribution and of the increasing growth in the number of households with more than one 'bread-winner'. Finally, we will again try to incorporate the Modigliani [42] approach.

CHAPTER 3

RESIDENTIAL CONSTRUCTION: SECTOR 2

Jean-Pierre Aubry

A. Introduction

In this version of RDX2 we have made an important conceptual change in the modelling of residential construction from that adopted in the first version of RDX2 [32]. There, housing starts were explained in a reduced form equation by real disposable income per household and by credit conditions. No direct link existed between housing starts and mortgage approvals. The latter were defined in Sector 17 by a stock adjustment model - equations 17.9 and 17.10. The main but indirect link between the real and the financial sector was the mortgage interest rate. This lack of a direct link led to inconsistent simulation results.

In the present version of RDX2 housing starts are directly linked to mortgage loans so as to reflect the fact that most residential construction is financed by mortgage loans. This change virtually ensures consistent simulation behaviour between mortgage loans and business investment in residential construction, allows direct estimation of the lags between mortgage approvals and housing starts, and makes the estimation of the impact of CMHC mortgage approvals easier. The new approach involves three steps. First, mortgage loans for new residential construction approved by life insurance companies, trust and mortgage loan companies, and chartered banks (HAPNRESD) are isolated from total mortgage loans for new residential construction, existing houses, and commercial construction approved by these three groups of institutions (HAPB+HAPTL+HAPLI). Second, HAPNRESD directly determines housing starts. Third, housing starts in turn determine investment in residential construction and changes in the stock of dwellings.

B. Mortgage Approvals for New Residential Construction

The variable HAPNRESD, equation 2.5, is principally explained by the sum of mortgage approvals made by life insurance companies, trust and mortgage loan companies, and chartered banks (HAPLI+HAPTL+HAPB). For each additional dollar invested, $0.49 will be allocated, ceteris paribus, to new residential construction. This marginal propensity is close to the average ratio of HAPNRESD/(HAPTL+HAPLI+HAPB), .52, calculated over the estimation period.

As shown in equation 2.5, an increase in the number of families (representing an increase in demand) and a decrease in investment in non-residential construction (representing a substitution effect) increase the propensity to allocate mortgage loans to new residential construction.

The introduction of mortgage approvals by Central Mortgage and Housing Corporation, HAPCMHCS and HAPCMHCM, into the specification allows us to measure the substitution effect between these government loans and private business loans. The small estimated substitution effect, .0845, reflects the fact that Central Mortgage and Housing Corporation makes mortgage loans to specific groups, such as people with low incomes, who cannot borrow in the private market, and for certain projects that cannot be financed through the private market. We tried without success to introduce the mortgage approvals of other lending companies (HAPNROT) separately but we were forced to constrain the substitution effect of such approvals to that of CMHC loans. At present HAPNROT includes only Quebec savings banks, mutual benefit societies, and fraternal societies. Research is underway to add to HAPNROT approvals by credit unions, pension funds, and personal sector lenders. We hope this work will improve the quality of the series.

C. Housing Starts: Single-Detached (HSTS) and Multiple (HSTM), Equations 2.2 and 2.6

One of the problems encountered in explaining housing starts by means of mortgage approvals is that dwelling units are regressed against dollars, which makes the interpretation of the estimated coefficients difficult. We solved the problem in the present version of RDX2 by multiplying housing starts - single-detached (HSTS) and multiple (HSTM) - by their respective estimated prices. This weighted sum was then regressed against the sum of mortgage approvals of new residential construction:

$$(14.765\ PIRC)HSTS + (9.843\ PIRC)HSTM = JW(HAPNRESD+HAPCMHCS\ \ HAPCMHCM+HAPNROT)$$

where

14.765 is the average cost for a single-detached dwelling under the National Housing Act in 1961,

9.843 is the average cost of a multiple dwelling, (2/3)*14.765.

The length and the degree of the polynomial followed by the lag structure are constrained by monthly information available on the lags between mortgage approvals and mortgage loan disbursements. An additional dollar of mortgage loans for new residential construction (measured in 1961 prices) increases the aggregate value of new dwelling starts by $1.07. This difference of 7.184 percent is explained by the fact that mortgage loans are only a portion of housing starts costs, that some proposed construction projects are cancelled, and that mortgage activity is not completely covered by the mortgage term. Further research will be undertaken in an attempt to extend our mortgage market coverage.

Since equation 2.2 explains a weighted sum of two endogenous variables (HSTS and HSTM), another equation is required to determine the division of housing starts between single-detached and multiple housing starts. We tried, with little success, to explain the ratio of HSTM/(HSTM+HSTS) principally by demographic variables. This was the approach used in Helliwell and Maxwell [29]. The results were reasonable (RB2=.85) for the sample period 1956-1970, but we could not explain the downward shift observed since 1970. As well, because all the explanatory variables were exogenous there was no obvious advantage in using such a specification and so we decided to exogenize the ratio. This subject will be studied further, especially for purposes of forecasting.

D. Business Investment in Residential Construction (IRC), Equation 2.1

Business investment in residential construction (IRC) has three components: investment generated by the construction of new dwellings, building alterations, and supplementary housing stock costs. The first component is consistently estimated by constraining the sum of the weights on housing starts (HSTS, HSTM) to their respective 1961-dollar values. The length of both lag structures is constrained to the length of lags used at Statistics Canada on the weights on units-put-in-place. The second and third components are captured by adding the lagged value of housing stock (KRESD).

E. The Stock of Single-Detached Dwellings (SHS) and of Multiple Dwellings (SHM), Equations 2.3 and 2.4

The stock of dwellings (SHS+SHM) is constructed from the cumulation of the quarterly completions pre-multiplied by a constant term so that the stock series are consistent with the 1951, 1961, and 1971 census benchmarks. According to the implicit hypothesis, demolitions and conversions are proportional to housing activity measured by completions. Our specification of SHS and SHM is consistent with this methodology - completions are replaced by a lag structure on housing starts of the same length as that in the IRC equation. The sum of the weights on HSTS is .82928 and on HSTM is 1.02509. The difference reflects the relative extent of the conversion of single-detached dwellings into multiple dwellings.

F. The Dynamic Response

By excluding seasonal variables and constant terms and setting the ratio of multiple starts to total housing starts equal to its average value (.56) one can summarize the dynamics of the entire sector by the following equation:

$$IRC = JW[.49172 \left(\frac{HAPT}{PIRC}\right) - .06041 \left(\frac{INRC*PINRC}{PIRC}\right) + .41003 \frac{J4P(NHH)}{PIRC} + .9154 \left(\frac{HOT}{PIRC}\right)]$$

where

HAPT = HAPB + HAPTL + HAPLI
HOT = (HAPCMHCS + HAPCMHCM + HAPNROT)

	JW
t = 0	.17550
-1	.26877
-2	.26601
-3	.18149
-4	.09899
-5	.04979
-6	.02666
-7	.01704
-8	.01101
-9	.00698
-10	.00524
-11	.00473
-12	.00472
-13	.00472
-14	.00471
-15	.00470
-16	.00470
-17	.00469
-18	.00469
-19	.00468
Sum	1.1518

Steady state 4.64
Steady state without the lagged stock effect is 1.07184

This equation shows that an additional 1961 dollar invested by a major lending institution will result in an increase of \$4.64 (measured in 1961 prices) at the steady state. Most of this response (\$3.57) is produced by expenditure on alterations spread over the life of a house. In the medium-run, the lagged stock effect can be neglected since it accounts for only 7 percent of the total response after twenty quarters. In this context a 1961 dollar invested in the mortgage market by any of the main lending institutions would have generated, ceteris paribus, an investment of $0.53 (= .49172 x 1.07184) in residential construction. On the other hand the same dollar invested by CMHC would have increased business investment in residential construction by $0.9812 (= .9154 x 1.07184). In both cases 78 percent and 95 percent of the shock response is completed at the end of the first year and at the end of the second year, respectively.

CHAPTER 4

BUSINESS INVESTMENT AND OUTPUT: SECTOR 3

Lloyd Kenward

A. Introduction

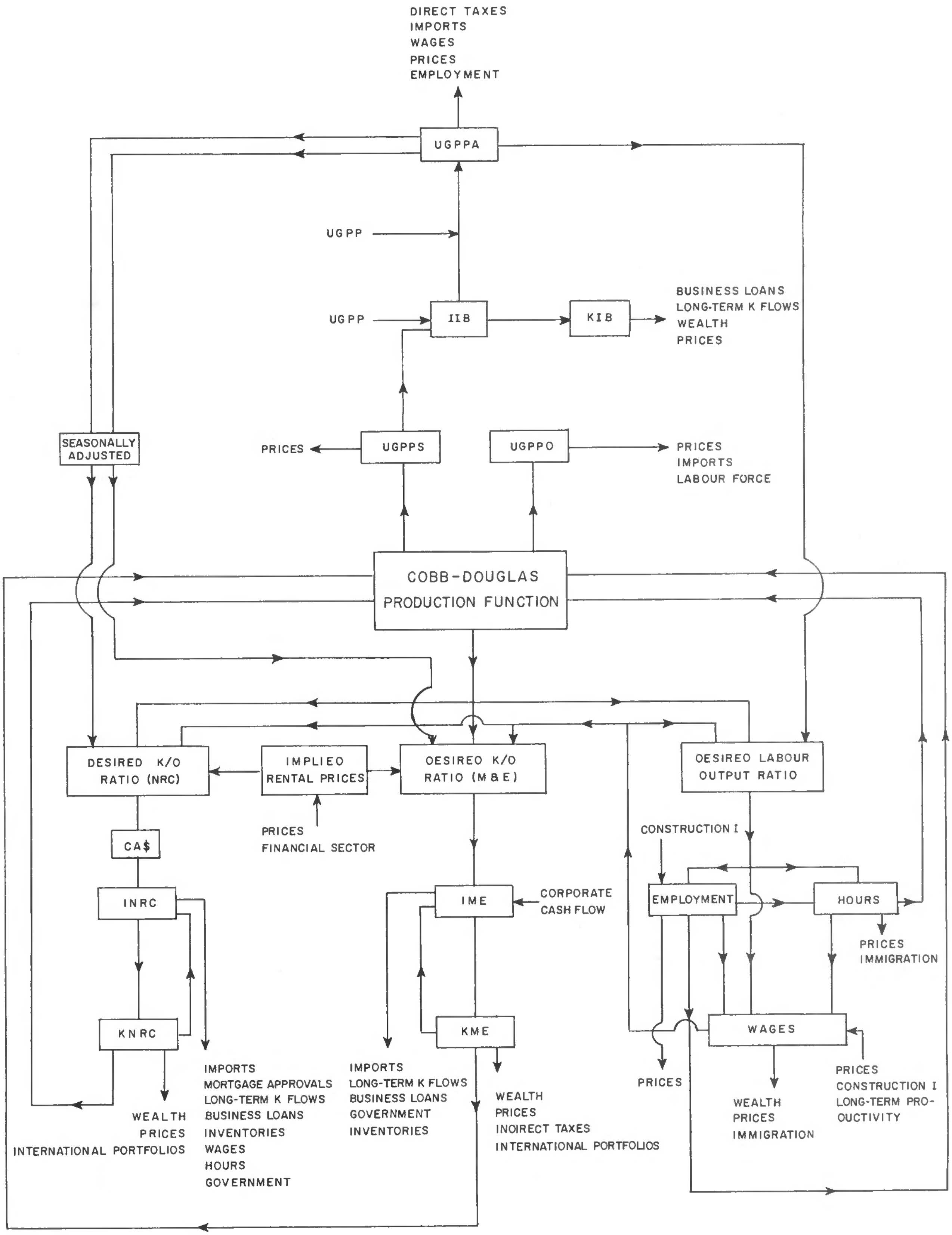
Although we have made numerous modifications in Sector 3, the basic structure of this portion of the model is unchanged from its original form. Because many of the links in RDX2 flow through Sector 3, a brief overview of the sector is provided in section B with a detailed description reserved for those parts of the sector requiring explanation supplementary to that given in Helliwell et al. [32]. Major changes in the sector are reported in section C and minor changes in section D. Several notable research failures are included in section E; some lag structures are described in section F.

B. Overview

Two fundamental concepts underlie Sector 3: interrelated derived factor demands and forward-looking investment behaviour. Our approach to the former is related to the work of Nadiri and Rosen [46] and Coen and Hickman [15] although there are important differences in our approach to expectations, the degree of exogeneity, and imposed constraints. Helliwell and Glorieux [27] describe the theoretical basis for our forward-looking investment specification.

The essence of Sector 3 and its links with the rest of the model are captured in Figure 3. At the centre of the system lies a three-factor (man-hours and two types of capital) Cobb-Douglas production function with constant returns to scale. Its main

Figure 3
INTERRELATED FACTOR DEMAND NETWORK



thrusts are downward in Figure 3 into the derived factor demand network and upward as the supply function.

The interrelated factor demand network implicitly models a hierarchy in the speeds of adjustment of the factor inputs in response to a change in demand. The hierarchy, working from fastest to slowest, is: short-run productivity, hours, labour, capital in the form of machinery and equipment and capital in the form of non-residential construction. The implications of this hierarchy for the dynamic response of RDX2 is extensively discussed in Helliwell and Higgins [28].

In the derived factor demand portion of Figure 3, under a hypothesis of cost minimization, the production function is inverted to obtain two desired capital/output ratios, KMEY (3.10) and KNRY (3.11). The ratio KMEY is associated with the capital factor KME (3.7) and the ratio KNRY is associated with the capital factor KNRC (3.8). The same procedure is followed to obtain a desired labour/output ratio (see the description of Sector 5). Given these desired capital/output ratios and expected output, that is JW(UGPPASA) in equations 3.1 and 3.2, the desired level of capital stock can be obtained for use in a flexible accelerator model.

In considering the origin of factor prices, particularly those of capital, and the estimation of the coefficients in the production function, we take the position that the production function represents the long-term equilibrium relationship between output and desired inputs but that these are not the quantities measured by our data. Hence the parameters on the production function are estimated indirectly through the factor markets. The coefficient on labour (man-hours worked measured in efficiency units) in the production function is determined by the historical average of labour's share of income over the estimation period. The split between the remaining two factors of production (KME and KNRC) is determined on the basis of criteria outlined in Section E.

The factor prices for KME and KNRC are implied rental prices after corporate income tax (see equations 3.12 and 3.13). Unfortunately there is a bracket misplaced in the equations 3.12 and 3.13. The correct expression for the first terms in the RCME equation is

$$RCME = JW(PIME) \frac{[1-(CPVME)(.01\ RTCA)]}{.50}$$

An analogous expression is correct for RCNR.

The origin of the factor prices may be considered Jorgensonian having been derived from the equality between the price of a new capital good and the discounted value of all future services derived from that capital good. See Hall and Jorgenson [24]. Jorgenson's expression (with k = 0) is:

$$c = q(\gamma+\delta)\ \frac{(1 - uz)}{1 - u}$$

where

c is the cost of capital services

q is the price of capital goods

δ is the rate of replacement

u is the tax rate

z is the present value of depreciation deduction

γ is the discount rate

The counterparts in equation 3.12 are:

c = RCME

q = JW(PIME)

δ = .02035

u = .01 RTCA

z = CPVME

$$\gamma = \{[(1 + \alpha RHOR2 + (1-\alpha)RHOR)]^{.25} - 1\}\ [1 - u\ TAXADJ]$$

where

$$\alpha = \frac{LDIRV12}{KB\$}$$

$$TAXADJ = \frac{J4S(ECINT)}{J4S(ECINT+YC)}$$

All the above variables are straightforward interpretations of the Jorgenson variables except those for q, u and γ . Our JW(PIME) interpretation of q is an attempt to capture expected future prices rather than static price expectations. The 1-u term is included in our definition of the desired capital/output ratios therefore we exclude it from the rental prices. Interpretation of the rental prices could be improved by moving the 1-u term to the rental prices in future versions of the model. The complicated expression for γ represents an average, with weights α and $1 - \alpha$, of the U.S. (RHOR2) and Canadian (RHOR) real supply price of capital including an adjustment (TAXADJ) for the tax deduction of interest payments (ECINT) vis-à-vis the other return to capital, corporate profits (YC). Having completed an excursion into the estimation of the production function and rental prices we return to our description of the interrelated factor demand system and its importance in the investment sector.

From the implied rental prices and the production function, we have obtained the desired capital/output ratios under a hypothesis of cost minimization. The desired capital/output ratio is then multiplied by the expected minus the preferred level of output of the existing capital stock to ascertain the gap between desired and actual capital stock. Thus, in the IME equation, for example, we define

$$UGAPME = KMEY(JW(UGPPASA)-(.97965)^{8}UGPPAMP)$$

where

UGAPME is desired minus actual capital stock,

KMEY is the desired capital/output ratio,

JW(UGPPASA) is the expected output eight periods ahead with allowance for some seasonal adjustment, and

$(.97965)^{8}$UGPPAMP is the output that will be preferred eight periods ahead, after allowing for depreciation, according to a vintage approach to capital stock.

This gap variable is the main driving variable for the flexible accelerator specification of the fixed business investment equations. The specification is supplemented by the lagged capital stock, a corporate cash flow variable (comprising profits plus capital consumption allowances) that alters the timing of investment expenditure, and by seasonal dummy variables. In the case of machinery and equipment the gap variable enters as a distributed lag with weights (JW(UGAPME), after equation 3.1) specified a priori that represent the rate at which perceived gaps in the capital stock are turned into actual investment expenditure. In the case of non-residential construction these putting-in-place weights are now estimated by the procedure described below. This completes the description of the links in the bottom of Figure 3 as they pertain to the investment sector.

In the top of Figure 3 we illustrate two concepts of supply that emerge from the production function: short-term supply (UGPPS, equation 3.19) and long-term desired supply (UGPPD, equation 3.18). In both concepts we employ the indirectly estimated production function but with different factor inputs. In equation 3.19 we use actual factor levels, excluding short-run productivity. In equation 3.18 we use actual levels of capital stock but the average employment rate of labour and trended hours worked.

As well as being the normalizing element in normal unit labour costs in the price sector, UGPPS feeds directly into the change in business inventories (equation 3.4). Here UGPPS helps to define the buffering role of inventories against unexpected increases in aggregate business demand. The aggregate business demand variable (UGPP, equation 3.16) is gross national expenditure less agricultural and non-commercial expenditure in constant dollars. The buffer variable is defined as UGPPS - (UGPP-IIB) so that any increase in final business demand that cannot be supplied from existing factors of production draws down inventories. This buffer variable, seasonal dummies, lagged stock of inventories, and two distributed lags (one on imports and the other on the remainder of aggregate demand) define the equation for IIB.

The variable UGPPA is the other measure of aggregate demand in Sector 3. That is, UGPP is adjusted to remove unintended inventory changes. We define unintended inventory changes as

β_1 [UGPPS- β_2-(UGPP-IIB)]

where

β_1 is the estimated buffer stock coefficient in the IIB equation and

β_2 is the mean of UGPPS - UGPP + IIB.

We include β_2 so that on average over the sample UGPPA equals UGPP, ie, unintended inventory changes equal zero.

Expectations about future values of variables enter four equations in Sector 3: (3.1), (3.2), (3.12), and (3.13). In (3.1) and (3.2) they form the basis for the concept of forward-looking investment behaviour by determining expected output. In (3.12) and (3.13) the expectations procedure is used to determine expected prices for the two types of investment goods. We refer the reader to Helliwell and Glorieux [27] for the algebraic details.

Investment expectations are assumed to be made eight quarters ahead for IME and twelve quarters ahead for INRC. In both cases experience over the past twelve quarters is used to form expectations about future output. Having searched over a grid of parameter values we use the combination of regressive, extrapolative, and trend expectations that maximizes the fit of the relevent investment equation to identify the parameters in the twelve-quarter lag (see JW(UGPPASA) after equations 3.1 and 3.2) that determines expected output eight or twelve quarters ahead. For both fixed investment equations a dynamic simulation of JW(UGPPASA) alone indicates an expected output dominated by trend with gentle cycles around the trend line.

C. Major Changes

Three changes have taken place in Sector 3 that may be considered major. First, the former equation for investment in non-residential construction has been split into two: a decision function (equation 3.2) and a realization function (equation 3.3). Second, capital consumption allowances have been endogenized. Third, an inflationary bias has been removed from rental prices and from desired capital/output ratios.

In section B we note that for IME a set of distributed lag weights, which describe the rate at which machinery and equipment are put in place, is specified a priori. For INRC these weights are estimated by the use of CA$: commercial, industrial and engineering contract awards (equation 3.2). We think of the decision to award a contract as corresponding closely to the perception of a gap between desired and actual capital stock with the lag structure on the gap to be decided by the data. Only the immediate impact is significant. The dummy variable QGT is designed to pick up three quarters when contract awards were exceptionally high - 2Q60, 2Q65, and 3Q65. The gap variable simply cannot capture these quarters. As data for contract awards are available only in current dollars we deflate by the price index for non-residential construction knowing that the result will be wrong if builders bid for contracts on the basis of expected prices. Experiments with various mechanisms for determining expectations over different time horizons lead to more complicated specifications that generally do not fit the data as well as the existing specification and that are unstable outside the fitting period. In contrast the present specification of the decision function is stable outside the estimation period and forecasts, on a single-equation basis, consistently with its standard error throughout 1973 and well into 1974. For an eight-quarter simulation using the entire model, the forecasts of the decision function were accurate during 1973 but deteriorated during 1974.

Equation 3.3 represents the realizations function or the transformation of a contract award into INRC. A similar specification and other possibilities are discussed in detail in Kenward [38]. The use of CA$ as an explanatory variable for INRC is preferred to the use of building permits, another leading indicator, on the ground that CA$ provides somewhat better coverage of INRC, although outside the context of a large-scale model there are excellent reasons for using both. See Hodgins and Tanner [35] p 82. A variable distributed lag similar to that used in Tanner [50] was tried in the realization function with seasonal dummies, foreign direct investment, and the capacity utilization variable J4A(UGPPA/UGPPD) varying the profile of the lag. This specification exhibited a high degree of autocorrelation and was unstable outside the fitting period.

Two equations have been added to Sector 3 in order to make capital consumption allowances endogenous. Both are elementary regressions of different capital consumption allowances on a lagged nominal capital stock. In the case of capital consumption allowances for corporations (equation 3.6) the explanatory variable, apart from seasonal dummies, is the lagged depreciated portion of the business stock of capital converted to nominal terms by a long moving average of the appropriate price index. In total capital consumption allowances (equation 3.5) we use the same specification but with the stock of capital expanded to include residential construction and non-residential government construction.

The final major change in Sector 3 results from our attempt to remove an inflationary bias from rental prices and from desired capital/output ratios. In earlier versions of RDX2 the nominal rental prices expected to prevail halfway through the construction period are compared with the expected nominal labour cost at the half-life of the equipment - currently 47 and 105 quarters for IME and INRC, respectively. These costs are minimized. The inflationary bias resulted from earlier modelling of expected nominal labour cost in terms of the change in nominal wages. Thus the potential investor was extrapolating the current rate of change of wages far into the future. This induced a strong upward bias in the capital/output ratios towards the end of our estimation period. In this version of RDX2 the cost minimization is based on a comparison of the expected real efficiency wage and the expected real rental price, with the weights of future periods declining as the value of the asset depreciates. More specifically, we define WEFFH to be the nominal efficiency wage WEFFH = WQMMOB/13HAWMM*ELEFF and WEFFH/PGPP to be the real efficiency wage expected to grow at a quarterly rate of 1 + g. Thus the real discounted present value of after-tax labour payments n periods ahead is:

$$\frac{(1-.01RTCA)(WEFFH/PGPP)(1+g)^{n}}{(1+\overline{RHOR})^{n}}$$

where

$\overline{RHOR}$ is the average value of RHOR.

If one converts to nominal terms and assumes that capital goods prices are considered to be fixed at the time of purchase so that one can ignore intertemporal differences between rental prices and the above expression, then the relative prices for labour and KME at t+n are

$$\frac{(1-.01RTCA)(WEFFH)(1+g)^{n}}{(1+\overline{RHOR})^{n} \quad RCME}$$

Since equipment is assumed to decay at rate δ, relative prices at period n are weighted by $(1-\delta)^{n}$. Summing over n to infinity, normalizing, and making some algebraic transformations one gets the following expression for relative prices of labour and KME

$$\frac{(1-.01RTCA)WEFFH}{RCME}\left(\frac{\overline{RHOR}+\delta}{\overline{RHOR}-g+\delta(1+g)}\right)$$

where

$$g = \frac{J12A[WEFFH/PGPP]}{J1L(J12A[WEFFH/PGPP])} \quad \text{and}$$

$\overline{RHOR} = .01785.$

Although we have avoided the problem of comparing relative costs at the half-life of the equipment, we do so at the expense of introducing expectations which are inelastic except for the effect of g.

D. Minor Changes

The release by Statistics Canada of new annual estimates of fixed capital flows and stocks provides us with the opportunity of improving several aspects of the model associated with our capital stock variables.

To demonstrate our new estimates of depreciation rates consider the identity

$$K_t^n = K_{t-1}^n + I_t - D_t$$

where

K_t^n is the net capital stock at the end of period t,

I_t is gross investment in period t, and

D_t is depreciation in period t.

In RDX2 we assume depreciation at a fixed constant rate to obtain

$$K_t^n = (1-\delta)K_{t-1}^n + I_t$$

Statistics Canada uses depreciation calculated as

$$D_t = \frac{1}{2\gamma}(K_t^g - K_{t-1}^g)$$

where

γ is the economic life of capital goods and the remainder of the expression on the right is the mid-year gross capital stocks.

Hence,

$$K_t^n = K_{t-1}^n + I_t - \frac{1}{2\gamma}(K_t^g + K_{t-1}^g)$$

which implies that in RDX2 we should set

$$\delta = \frac{1}{2\gamma}\frac{(K_t^g + K_{t-1}^g)}{K_{t-1}^n}$$

This expression is not constant over time because the ratio of mid-year gross stock to year-end net stock varies over time. We estimate δ as the geometric mean of the right side of the above expression. Our new depreciation rates, so estimated, are considerably different from the rates in the earlier versions of the model. For KME we now use an annual depreciation rate of 7.89 percent compared with 20 percent in the previous model. For KNRC the new and old rates are 3.45 percent and 4 percent, respectively. These annual rates of depreciation are then converted into quarterly rates for inclusion in RDX2 by solving

$$\delta^A = \delta^Q \{1 + (1-\delta^Q) + (1-\delta^Q)^2 + (1-\delta^Q)^3\}$$

where

δ^A is the annual rate of depreciation, and

δ^Q is the quarterly depreciation rate.

Our capital stock definitions are also changed from the earlier definitions because capital stock is now computed net of agriculture. Since the agricultural component is only available annually we interpolate with the seasonal component derived from an unpublished series of current-dollar investments in farm implements provided by Statistics Canada.

Changes in our estimates of capital stock have prompted some minor re-specification of the business fixed investment equations. The dependent variable in both investment equations in the original version of the model was defined to be net investment, that is the estimate of depreciation was subtracted from gross investment. The dependent variable is now defined to be gross investment excluding agriculture. Consequently we include lagged capital stock as a variable to explain replacement investment.

In the original version of RDX2 several financial variables entered the specification of the fixed investment equations in a manner that altered the timing of investment decisions. Corporate cash flow, direct foreign investment, the long-term rate of interest, and changes in chartered bank business loans were all included originally. Now only the corporate cash flow variable remains. In general these index variables are very sensitive to the estimation period and influence the cyclical properties of the model excessively. By removing most of them from the specification we have improved the stability of the model, but the response of the specification to a monetary shock is notably reduced.

Expectations of future output for use in the investment equation were previously formed on UGPPA. Hypothesizing that entrepreneurs exclude seasonality from expectations determining their fixed investment decisions, we have made some elementary seasonal adjustments to UGPPA in order to create UGPPASA. See the definition of UGPPASA in [6] p 91. This seasonally adjusted version of expected output enters the investment equations exactly as UGPPA does in the original RDX2 [32].

Whereas the gap variable in the investment equations used to be defined in net terms, we now define the gap in gross terms. For example, in the IME equation we used to define the gap as the desired capital stock eight periods in the future less actual output today based upon a vintage capital stock, ie, UGPPAMP. We have modified the IME gap variable to desired capital stock eight periods ahead less actual output eight periods ahead if no investment is made in the meantime. Thus we now scale UGPPAMP by $(1-\delta)^8$ in an attempt to capture the loss of output that will occur over the next eight periods due to depreciation of the capital stock.

The UGPPAMP equation (3.14) and the UGPPANP equation (3.15) represent attempts to capture the concept of output according to a vintage stock of machinery and equipment and non-residential construction. In the first version of RDX2 [32] investment was cumulated into the vintage concept of output with a lag that was about half the length of the expenditure lag. We now take the position that UGPPAMP and UGPPANP represent the amount produced if each part of the capital stock is employed using factor proportions governing investment decisions at the time the gap was perceived. The weights on KMEY, for example, that cumulate IME into UGPPAMP are exactly the weights that describe the rate at which perceived gaps are converted into investment. For example, if

$$I_t = .1\ GAP_t + .9\ GAP_{t-1}$$

and the capital/output ratio becomes fixed when the gap is seen to exist, then 10 percent of all investment taking place at time t is associated with the desired capital/output ratio in this period and 90 percent with the desired capital/output ratio in the last period. In equations 3.14 and 3.15 we therefore cumulate investment using a distributed lag on the desired capital/output ratios consistent with the putting-in-place lags in equations 3.1 and 3.2. In the case of equation 3.1 these weights are given by JW(UGAPME). To obtain the weights from equation 3.3, we write the equation in final form (see Theil [51] p 464) and re-normalize the sum of the weights to equal unity. Because the lag structure on CA$/PINRC implied by equation 3.3 is of infinite length and only nineteen lags are available in the Simulator program [7], the infinite lag structure was truncated at nineteen lags before it was re-normalized.

A further minor point to be noted in Sector 3 is that there are now fewer lags in the change-in-inventories equation (3.4) than was previously the case. Originally consumption plus exports plus government expenditure on goods entered the equation with the same lag but imports and investment each entered with a separate lag. The investment lag has now been combined with the consumption plus exports plus government expenditure lag. Imports still enter with a separate lag.

Finally the definition of UGPP (equation 3.16) has undergone a minor change. The variable UGPP is UGNE minus agriculture and non-commercial services. Data for agriculture and non-commercial services are not available in real terms. In the original version of the model we subtracted from UGNE all variables to the right of (YGNE/PGNE) in equation 3.16 using average 1961 values as a wage index. In the definition of YGPP we now subtract other variables (TILGS + CCAGF$ + CCAGPM$ + CCAGH$) to convert YGNE at market prices into UGPP at factor cost. We assume that PGNE is an appropriate proxy for the price deflator for TILGS + CCAGF$ + CCAGPM$ + CCAGH$ and reduce UGNE by EPGPPADJ = (TILGS + CCAGF$ + CCAGPM$ + CCAGH$)/YGNE. The constants in the definition of UGPP are different from the constants in equation 7.22 in the original version of the model because the average 1961 values of each wage has since been redefined to include supplementary wage payments.

E. Noteworthy Failures

Here we discuss our unsuccessful efforts to improve the state of the investment sector of RDX2. The discussion is organized into three parts: the inventories equation, the production function, and the investment equations.

We attempted to improve the role of financial variables in the inventories equation. Currently financial variables affect inventories indirectly through investment, caused by changes in the desired capital/output ratio, and through the consumption of durables, caused by changes in wealth. We thought the cost of holding inventories should play a more direct role than it does. The following financial variables are examples of variables unsuccessfully included as explanatory variables: RPRIME, R90, RPRIME-J4P(PGPP), R90-J4P(PGPP), R90-PCPICE, RPRIME-PCPICE, and (RABEL-RABELD)/RABEL. With i as an index for each of these variables, the following specifications were tried for the financial variable: i, i/J12A(i), i*sales, [i/J12A(i)]*sales.

The structural importance of the RDX2 interrelated factor demand network led us to try to exploit that network to estimate the production function. For various combinations of production function parameters, we simulated the fixed investment equations thereby obtaining simulated series for each of the capital stocks. We hoped that by using computed values of factor inputs in UGPPS we could search across a grid of parameters and choose the set that maximized the fit between computed and actual UGPPS. Unfortunately, the fit changed trivially in response to changes in the production function parameters. Also, there was a disturbing tendency for the gap variable in the INRC equation to take on negative values, implying attempts to disinvest faster than the rate of depreciation. Ultimately, we arrived at the existing combination of production function parameters by the unconventional method of choosing the combination of parameters that minimizes the number of negative gaps in the INRC equation and creates KMEY and KNRY series whose means are closest to the mean of the envelope curve fitted through the extreme aggregate capital/output ratios.

Unease with a production function that implies a unit elasticity of substitution among all factors of production led us to experiment with more flexible functional forms - eg, those used by Christensen, Jorgenson and Lau [13]. The basic difficulty here was that the estimation procedures used were not powerful enough to enable us to discriminate among various functional forms and to identify uniquely the estimates of all the parameters within our framework of the hierarchical adjustment of factor inputs.

The forward-looking investment behaviour concept used in specifying our investment equation is based on a further search across a grid of parameter values in order to choose the combination of extrapolative and regressive expectations that will maximize the fit of each investment equation. An attempt was made to formalize this procedure by using a nonlinear maximizing algorithm to search for the maximum likelihood set of parameter values. A slightly modified specification of the original model's investment equations [32] was used in this exercise with and without the putting-in-place weights specified a priori. The results were particularly disturbing in that end-point solutions were common, multiple maxima occurred, and the algorithm often failed to converge. We concluded that all the parameters in the original set of investment equations and for that matter the current IME equation cannot be uniquely identified by the data. At least one set of weights (JW(UGAPME)) must be specified a priori or else the equation specification must change - hence the use of CA$/PINRC.

Apart from formal maximum likelihood estimation, several unsuccessful efforts were made to estimate lag structures, particularly for IME. Numerous specifications of Almon lags on the gap variable were tried in a blatantly data-mining fashion so as to replace the JW(GAPIME) weights specified a priori. Nothing proved to be satisfactory. The best results under estimation were obtained when we used the gap variable with lagged dependent variables at lags of one, four, and five quarters. However, under simulation and a government shock the performance of the equation was rated inadequate. New orders for machinery and equipment were used in the same role as CA$ but again the results were poor because the coverage of IME by new orders is not good particularly with respect to imports.

The role of lagged capital stock in the investment equations also received attention. Traditionally, the lagged capital stock has been regarded as generating non-accelerator-induced investment. The specification of the investment equations implies that accelerator-induced investment is carried out according to a vintage concept but that investment from lagged capital stock is not. Various modifications were made in lagged capital stock according to various vintage assumptions. In every case the fit of the equation fell slightly, with the source of investment expenditure shifting from lagged capital stock to the gap variable. The best of these equations did not respond any differently than do the original equations to either a monetary or fiscal shock.

Experiments were also made with the variable VKB/KB$ - the RDX2 equivalent of Tobin's Q - in an attempt to obtain a greater impact from financial variables on investment (see Tobin [53] p 223). The variable was marginally insignificant when added as an explanatory variable to equation 3.2 but did not contribute enough to the shock response of the model to justify inclusion. It was never significant in equation 3.1.

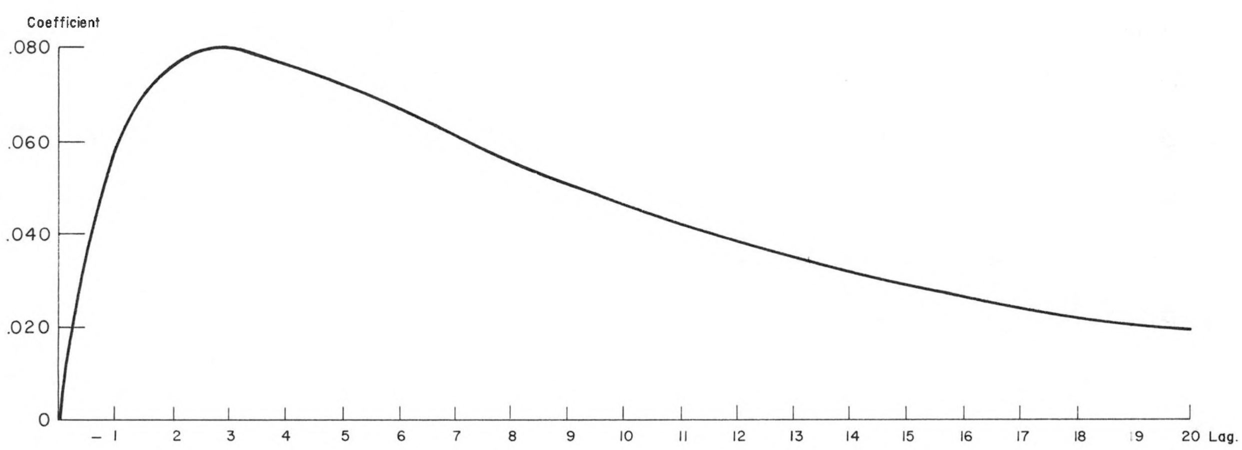
F. Comment on Lag Structures

Three different lag structures are described in an attempt to provide insight into the dynamics at work in Sector 3. The first lag structure concerns the rate at which CA$/PINRC feeds into INRC. The second and third are convolutions of a series of lags that display IME and INRC, respectively, as a function of UGPPA.

In order to examine the relationship between INRC and CA$/PINRC, we rewrote equation 3.2 in final form. The lag on CA$/PINRC resulting from this transformation is plotted in Figure 4.

Figure 4

TIME PROFILE OF THE LAG ON CA$/PINRC IN EQUATION 3.3



It is considerably longer than the lag specified a priori in the original version of the model but highly plausible, with zero initial impact and peak impact at lag three. We must add that these lags were not specified a priori but were estimated in the manner described by Hendry in Section 3 of [33] using a first order autoregressive error. The asymptotic test for first order autocorrelation given by Hendry in equation 8 [33] fails to reject the hypothesis of a white noise error in equation 3.3. The steady-state coefficient on CA$/PINRC is 1.13 with 83 percent of this effect passed after the first twenty quarters.

To understand the complicated lag structures in the investment equations, consider the following manipulations that focus on the IME equation and abstract from variations in KMEY, the timing index, the dummy variables, and the agricultural component of IME. Equation 3.1 may be written as

$$IME_t = \alpha_1 \, J1W(UGAPME) + \alpha_2 \, KME_{t-1} \qquad (1)$$

where

$\alpha_1 = .05629$

$\alpha_2 = .03147$

$UGAPME = \overline{KMEY} \, J2W(UGPPA) - \alpha_3^{\,8} \, UGPPAMP$

$\overline{KMEY}$ is the average value of KMEY over the data series,

$\alpha_3 = .97965$

J1W is the set of lag weights given below JW(UGAPME) after equation 3.1, and

J2W is the set of lag weights given below JW(UGPPASA) after equation 3.1.

From equation 3.7

$$KME_t = \alpha_3 \; KME_{t-1} + I_t \tag{2}$$

And from equation 3.14

$$UGPPAMP_t = \alpha_3 \; UGPPAMP_{t-1} + \frac{I_t}{KMEY} \tag{3}$$

Writing these in terms of the lag operator, L, and substituting (2) and (3) into (1), we obtain

$$IME_t = \alpha_1 \; J1W(J2W(UGPPA)) \; \overline{KMEY} - \alpha_1 \; J1W(\alpha_3{}^8 \frac{IME_t}{1-\alpha_3 L}) + \alpha_2 \frac{L(IME_t)}{1-\alpha_3 L}$$

and solve to obtain

$$IME_t = \frac{\alpha_1 \; \overline{KMEY} \; J3W(UGPPA)}{(1-(\alpha_3+\alpha_2)L + \alpha_1\alpha_3{}^8 J1W/(1-\alpha_3 L)}$$

where

J3W = J1W*J2W

This expression implies a lag on UGPPA as shown in Figure 5. The steady-state coefficient is about .09 with the sum of weights approaching this very slowly. The combination of positive and negative weights in the lag structure results from our use of both extrapolative and regressive expectations.

In Figure 6 the same results are presented for INRC. The profile in Figure 6 is dominated by the lag shown in Figure 4 although there are some small negative weights after lag twenty-two. The other sources of difference in the lag in Figures 5 and

Figure 5

TIME PROFILE OF THE LAG ON UGPPA IN EQUATION 3.1

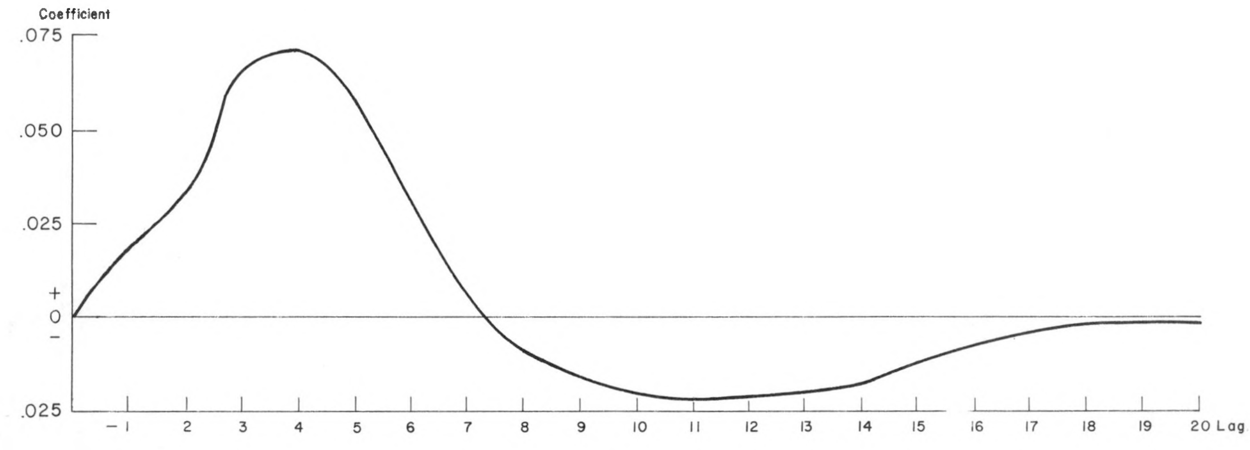


Figure 6

TIME PROFILE OF THE LAG ON UGPPA IN EQUATIONS 3.2 AND 3.3

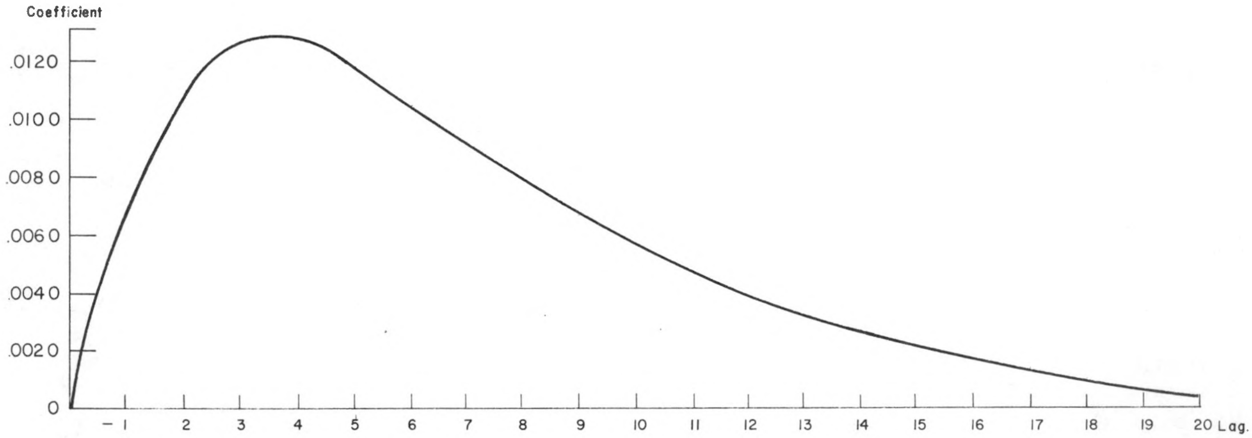


Figure 7

ADJUSTMENT OF KME TO DESIRED LEVEL

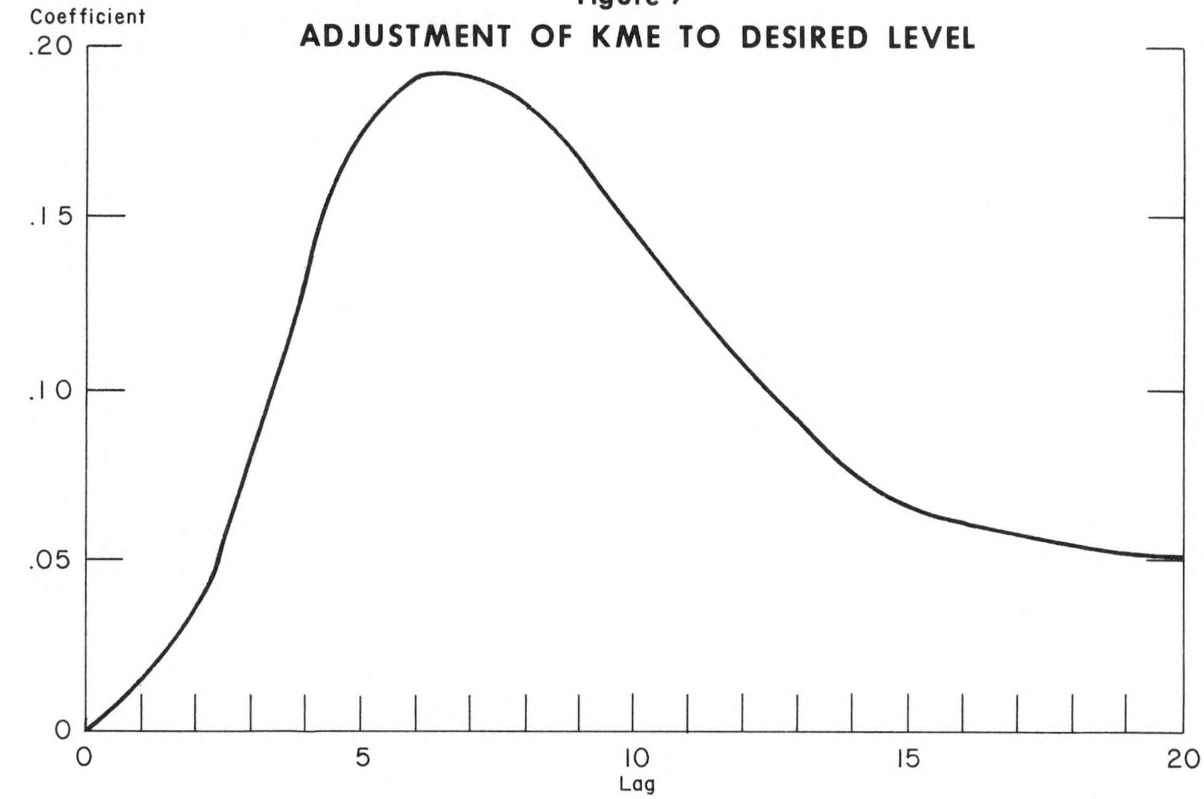
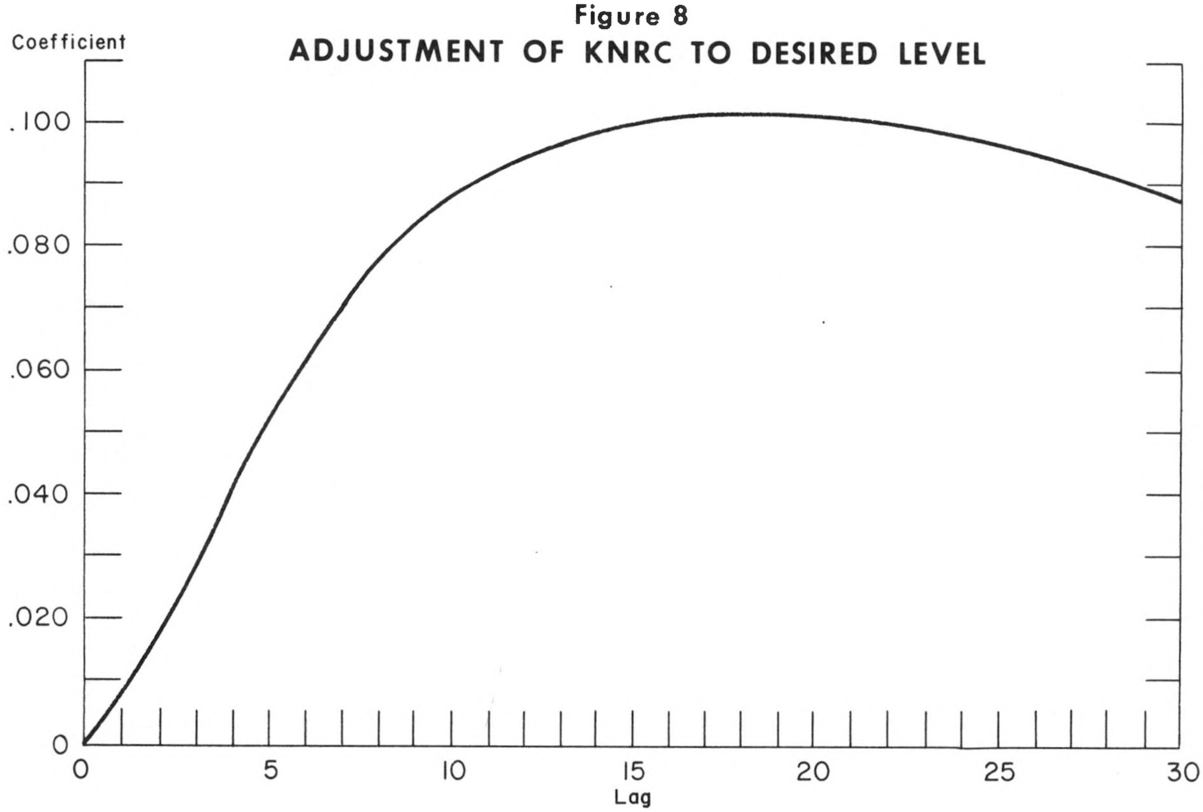


Figure 8

ADJUSTMENT OF KNRC TO DESIRED LEVEL



6 are different combinations of extrapolative and regressive expectations and different depreciation rates for the two types of capital goods.

In Figures 7 and 8 we show how each capital stock adjusts to desired levels as a function of UGPPA. To obtain these two profiles we divide the appropriate lag in Figures 5 and 6 by $(1-\delta L)$. The variable KNRC clearly adjusts much more slowly than KME. Because Figures 7 and 8 may be thought of as the integrals of Figures 5 and 6, respectively, the sources of difference between the two adjustment processes are the same as those noted in the previous paragraph.

CHAPTER 5

FOREIGN TRADE: SECTOR 4

Ulrich Kohli

A. Introduction

The only major change in this version of the trade sector of RDX2 compared with previous versions is the respecification of the commodity import equations by Alexander [3]. The number of import equations has increased substantially as commodities have been further disaggregated on the basis of the Standard International Trade Classification, Revised (SITC)[54], but maintaining the distinction between imports from the United States (U.S.) and imports from the rest of the world (ROW).

One characteristic of the new commodity import model, is that an attempt has been made to estimate jointly the equations for imports from the United States and from the rest of the world by SITC category and to make use of prior theoretical knowledge about the properties of demand systems, such as symmetry and homogeneity, in order to deal with the problem of collinearity which might result from the use of disaggregated data. Except in the case of equation 4.17 for imports of motor vehicles and parts from the United States (MMVP12), all commodity import equations are expressed in loglinear form and are almost identically specified. Each equation typically contains an activity variable and three price variables: domestic, U.S., and ROW.

For each SITC category, the pair of import equations can be written as follows:

$$\ln M_{12} = a_0 + a_1 \ln PD + a_2 \ln PM_{12} + a_3 \ln PM_{13} + a_4 \ln ACT$$

$$\ln M_{13} = b_0 + b_1 \ln PD + b_2 \ln PM_{12} + b_3 \ln PM_{13} + b_4 \ln ACT$$

where

the subscript $_{12}$ refers to Canadian imports from the United States, the subscript $_{13}$ refers to Canadian imports from the rest of the world,

M is the import quantity,

PM is the import price,

PD is the domestic price (the proxy for the price of domestic substitutes), and

ACT is activity (the proxy for total expenditure).

Homogeneity implies that

$$a_1 + a_2 + a_3 + a_4 = 0 \text{ and } b_1 + b_2 + b_3 + b_4 = 0$$

and symmetry requires that

$$a_3/w_{13} + a_4 = b_2/w_{12} + b_4$$

where

$w_{12} = M_{12}PM_{12}/ACT$, and $w_{13} = M_{13}PM_{13}/ACT$

Only a few modifications have been made in the remainder of the model. The number of export equations remains unchanged at three and the thirteen equations for imports and exports of services are estimated as previously in current dollars. Finally the number of technical relationships has been increased by defining imports of goods from the United States and the rest of the world in constant and current dollars.

The remainder of this chapter is divided as follows: Part B is a detailed description of the new import equations. Part C is a report on minor changes in the rest of the sector, and part D is a short conclusion that includes some thoughts about future research.

B. Imports of Goods

1. Equations 4.1 to 4.16

The Standard International Trade Classification, Revised (SITC) is used at the one-digit level of aggregation. Small quantities of goods are, however, exogenized and imports of motor vehicles and parts from the United States are treated separately. The disaggregation scheme thus includes eight categories and is more detailed than, although consistent with, the classification adopted for Project LINK [8]. In previous versions of RDX2 this latter classification, which distinguishes among four categories of goods, was followed for imports from the United States, but imports from the rest of the world were represented by only one equation. In this version of RDX2, both regions are treated symmetrically in eight equations each. The larger number of categories found here compared with the number in the LINK classification results from the division of imports of manufactured goods into four classes: SITC 5, 6, 7, and 8; and from the division of imports of food and beverages into two categories: SITC 0 and 1.

The import demand model is derived from traditional consumer theory by assuming that the demand for imported goods is determined simultaneously with the demand for domestic goods as the solution of a utility maximization problem. Thus the utility of each consumer is maximized as income is allocated between available domestic or imported commodities. It is well known that if the utility function satisfies certain regularity conditions, the solution of this problem yields a system of commodity demand equations where the demand for each commodity (imported or domestic) is a function of the consumer's income and of all the prices in the model. In addition, this system of demand equations also satisfies a number of properties well known in the literature, such as symmetry, homogeneity, additivity, and integrability.

If one considers eight types of goods and distinguishes between three origins: domestic, U.S., and ROW, each demand equation becomes a function of income and of twenty-four price variables. In order to limit the number of exogenous variables in each equation the utility function is assumed to be weakly separable in each type of good. It is also assumed that optimization takes place in two steps. First, total income is allocated between the eight types of good. Second, for each type of good, given expenditure, the shares of purchases from domestic, U.S., and ROW suppliers are determined. The second step can be characterized by a three-equation subsystem in which each equation contains only four arguments: three prices corresponding to the three regions of origin for the goods under consideration and total expenditure on these goods. This subsystem again satisfies the usual properties of demand systems. One should note however that the assumption of a two step optimization process is only valid if the subaggregator functions are homothetic. Homotheticity, however, is not imposed here. Finally it is assumed that aggregation over individuals is possible with only negligible effect on the extension of the model to a system of market demand functions.

The full system can thus be decomposed into eight subsets of three equations, and each subset can be estimated in turn. Ideally one would like to estimate all three equations of each subsystem jointly subject to symmetry and zero degree price homogeneity. Unfortunately the necessary data are not available because expenditure on domestic goods is, in general, unknown. Therefore only the two import equations are estimated using proxies for total expenditure on each type of commodity. The estimation of an incomplete demand system allows for the use of a large variety of functional forms for each demand equation, if one is willing to assume that the missing equation is such that the additivity conditions are satisfied.

The activity variables, as in previous versions of RDX2, are constructed as a weighted sum of the major components of gross national expenditure (see [3] or [6] for more details). For each category of goods the weights are the relative import content of final expenditure components and they are derived from the 1961 Canadian input-output tables [11]. This procedure raises some problems, for while the activity variables can be considered as linear indexes of expenditure on imports, they will not, in general, be equal, or even proportional, to a linear approximation of total expenditure on any commodity group. This implies that the symmetry restrictions cannot be imposed correctly. A correct application of the restrictions would require a concordance between SITC "commodities" (from domestic and foreign sources) and final expenditure components which, in contrast to the previously described method, would allow a complete distribution of the final expenditure components across the SITC activity variables. It can be shown that under this scheme, the correct final expenditure weights would be equal to the quotient of the average propensity to import SITC commodities out of each final expenditure category and the market share of each SITC import in each component of final expenditure. Unfortunately, although the average propensities to import can be derived from the input-output tables, the required market share information is generally unavailable. The distribution of final expenditure between SITC commodities would therefore necessarily require arbitrary assumptions regarding the market shares. One could assume for instance that, for each category of expenditures, these shares are equal to the observed average of imports in the corresponding category of expenditure. Such an approach although arbitrary might be preferable to the one presently used in RDX2: the activity variables would at least add up to the sum of the expenditure variables, although there is obviously no guarantee that the individual expenditure variables will be equal or even proportional to actual expenditure on any commodity group.

The domestic price variables are derived from the deflators of the same GNE components as those used to construct the activity variables and using the same weighting matrix. This leads to additional difficulties. One would typically like to use the prices of the domestic goods competing with imports. Unfortunately these domestic prices cannot be observed. Furthermore they cannot be determined unambiguously by the deflators of the final expenditure components as the number of SITC commodities here is larger than the number of final expenditure components. If those two numbers were the same, the correct procedure would be to solve for the domestic prices the system of linear price equations implied by the (transpose of) the input-output matrix which is used. The domestic prices could then indeed be written as a function of the GNE deflators, but they would be a function of import prices as well. Simply using the same weights as those used for the activity variables would thus not be correct and therefore can hardly be viewed as an appropriate method for the general case where the number of domestic commodities is larger than the number of expenditure components. It might have been preferable to arbitrarily reduce to six the number of independent domestic commodities; the number of imports would not necessarily have to be reduced simultaneously, but one might choose to do so. The appropriateness of imposing symmetry in the present conditions is therefore again questionable.

The estimation procedure is referred to in Bank of Canada Technical Report 5 [6] as joint least squares (JLS) and is described in detail in Alexander [3]. Thus for each subsystem, the two import equations are first estimated by ordinary least squares in order to obtain an approximation of the standard error of estimate of each equation and to test for autocorrelation or other lag structures. The two equations are next stacked, after the variables are transformed using the OLS estimate of the standard errors and of the autocorrelation coefficients, and then estimated as a single equation with the symmetry condition imposed at the mean of the sample as an additional observation. Homogeneity is imposed directly by dividing foreign prices and activity by the domestic price.

The domestic price variables are further multiplied by the ratio of actual output to desired output in an attempt to capture the idea that the effective price of domestic commodities may be higher than the observed price in periods of high capacity utilization when delivery lags may increase substantially. The markup between the effective price, ie, the shadow price, and the observed price should, however, be determined endogenously; the presumption that this markup is equal to the ratio of actual to desired output (minus one) is unduly restrictive.

New price series of imports from the rest of the world are used. These are Laspeyres price indexes rather than the residual deflators previously used. Finally time series of ad valorem Canadian import tariffs were constructed on the SITC basis and used to inflate prices of imports from the United States and the rest of the world.

The functional form selected to estimate the import demand equations is the loglinear specification (ie, a first order approximation in logarithms). Initially the model was estimated in linear form, but this specification was subsequently abandoned because it resulted in a continuous fall over time in all import price elasticities. By using the loglinear form the price and activity elasticities, rather than the corresponding propensities, are held constant for each commodity and hence the aggregate elasticities are fairly stable over time. For either the linear or the loglinear functional form the symmetry conditions result in nonlinear restrictions on the parameters. Other functional forms could be used such as the differentials of the translog (Christensen, Jorgenson and Lau [13]) or of the generalized Leontief (Diewert [18]) that yield linear symmetry restrictions. These functions were, however, developed for complete demand or production systems and could not be applied meaningfully to incomplete systems. The procedure adopted here, devised by Court [17], is to take a first order approximation of the restriction at the mean point. The symmetry constraint is thus replaced by a linear restriction on the activity and import price elasticities.

In estimating the import systems, allowance has been made in some instances for a structural change in the parameters. Such a change could be attributed to a variety of factors, one factor being the somewhat questionable quality of the data prior to 1965. Usually this hypothesis was investigated in the presence of strong autocorrelation and subjected to a Chow test. As well, in the presence of autocorrelation, alternative lag specifications were tested for but all of them were rejected in the case of the loglinear model. All equations, except those for imports of energy fuels (4.7 and 4.8), are expressed in per capita terms. Finally, in equations 4.15 and 4.16 for the period 1958-1964 the cross import prices were dropped since they were highly insignificant.

In Table 3 the estimated activity and price elasticities of all equations are reported. The activity and import price elasticities can be read directly from each equation, and the domestic price elasticity can be calculated as the negative of the sum of the activity and the import price elasticities. The activity elasticity varies widely from category to category, with manufactured goods being, in general, more activity elastic than other goods. In some instances the activity elasticity varies according to the origin of the commodity. Thus imports of beverages and tobacco from the rest of the world are, not surprisingly, much more elastic (2.528) than are imports of the same commodities from the United States (0.413). Similarly imports of miscellaneous manufactured articles from the rest of the world are more elastic in the period 1965-1972 than are these imports from the United States, whereas the reverse is true for imports of energy fuels. The aggregate activity elasticity of imports (equations 4.1-4.16) is in the neighbourhood of unity. It increases slightly, from 0.96 in 1Q65 to 1.08 in 1Q72 as a result of the increasing import share of the more elastic goods.

Table 3

PRICE AND ACTIVITY ELASTICITIES OF IMPORT COMPONENTS BY SITC CATEGORY*

Equation		SITC	PM_{12}	PM_{13}	PD	ACT
MFA12		0	-0.668	0.180	-0.081	0.569
MFA13		0	0.186	-0.590	-0.459	0.863
MBT12		1	-1.067	0.358	0.296	0.413
MBT13		1	0.085	-0.116	-2.497	2.528
MCM12A		2	-1.054	0.239	0.646	0.169
MCM13A		2	0.484	-0.868	0.120	0.264
MEF12		3	-1.246	1.220	-2.194	2.220
MEF13A		3	0.471	-0.548	-0.744	0.821
MCH12		5	-0.934	-0.102	0.077	0.959
MCH13		5	-0.424	-1.516	0.872	1.068
MMM12		6	-0.744	0.045	-0.070	0.769
MMM13		6	0.089	-2.476	1.772	0.615
MOM12A	1958-64	7	-0.776	0.059	-0.298	1.015
MOM13A	1958-64	7	0.467	-0.791	-0.321	0.645
MOM12A	1965-72	7	-1.322	-0.099	0.189	1.232
MOM13A	1965-72	7	-0.573	-2.042	-0.937	1.678
MIM12	1958-64	8	-1.673	0	-0.395	1.278
MIM13	1958-64	8	0	-0.771	-0.507	1.278
MIM12	1965-72	8	-0.190	-0.351	-0.305	0.846
MIM13	1965-72	8	-0.569	-1.843	-0.052	2.464

*PM is the import price, PD the domestic price, and ACT is activity.

Table 4

IMPORT PROPENSITIES OF MAJOR FINAL EXPENDITURE COMPONENTS BY SITC CATEGORY (1Q68 values)

SITC	CON$	COND$	GOV$	KAP$	CONST$	EXPT$
0	0.01142	0	0.00204	0.00058	0.00001	0.00450
1	0.00155	0	0.00014	0.00005	0.000001	0.00016
2	0.00199	0	0.00058	0.00152	0.00001	0.00276
3	0.00970	0	0.00587	0.00600	0.00561	0.01485
5	0.01130	0	0.00939	0.00658	0.00007	0.01444
6	0.01364	0.01065	0.00793	0.02841	0.00008	0.03299
7	0.00107	0.02069	0.01715	0.41078	0.00024	0.03455
8	0.01632	0.02432	0.01987	0.05634	0.00011	0.01906
Total	0.06698	0.05566	0.06297	0.51025	0.00612	0.12332

In Table 4 we report the import quantity propensities of the major final expenditure components (these are the same as those used to compile the activity variables) arranged by SITC category. The total import propensities, calculated for 1Q68, are shown in the last row of figures. When the last row is multiplied by 1.07 (the 1Q68 value of the price deflator of the sixteen import components) one obtains an indication of the marginal import content of final expenditure components or the impact of changes in import prices on prices of output components. It appears that the import propensity of final expenditure on machinery and equipment is very high. Thus a change in aggregate demand will have, through its derived effect on investment in machinery and equipment, a marked impact on the volume of imports, especially machinery imports. In other words the multiplier effect and the accelerator effect are both substantially reduced through import leakages. The import propensity of the consumption and export components of final expenditure may appear somewhat low. One must, however, recall that those figures do not include imports of motor vehicles and parts, which are treated separately.

The own price elasticiy of imports varies considerably as well. It is as low as 0.116 in absolute value for imports of beverages and tobacco from the rest of the world and as high as 2.476 in absolute value for imports of manufactured goods classified by material (SITC 6) from the rest of the world. As far as the cross-import-price effects are concerned, there is evidence of complementarity between imports from the United States and the rest of the world for SITC 5, SITC 7 (1965-1972), and SITC 8 (1965-1972). For SITC 8 (1958-1964) imports from the United States and the rest of the world are substitutes for each other as indicated by the positive activity elasticity. Indeed, although the total cross price elasticities are zero, the partial (Allen-Hicks) cross price elasticities are positive. For the same reason domestic goods always appear to be substitutes for imported goods. This can be verified by calculating the elasticities of substitution or the partial price elasticities even though in some instances the total elasticity may be negative as in SITC 0, SITC 3, and SITC 8. The aggregate price elasticity of the sixteen import components considered in this section increases slightly in absolute value from 1.06 in 1Q65 to 1.17 in 1Q72. The domestic price elasticity falls from .10 to .09 during the same period. As in the case of the aggregate activity elasticity reported earlier, these price elasticities are calculated directly from the coefficients of the import model and hence do not allow for interactions with other sectors of the model.

2. Imports of motor vehicles and parts from the United States, equation 4.17

Imports of motor vehicles and parts from the United States (MMVP12) are the largest single import component in the model. Their share of total imports of goods (MGA) increased from 16.1 percent in 1Q65 to 27.7 percent in 1Q72. Compared to previous versions of this equation, equation 4.17 has been altered in two major ways. The estimation period has been divided into two subperiods in an attempt to model the impact of the Canadian-U.S. Agreement on Trade in Automotive Products (Autopact), which took effect in 1965, and the definition of imports of motor vehicles and parts has been broadened to include imports of internal combustion engines, a non-trivial component of Autopact-related trade. For the subperiod 1958-1964 the equation is essentially unchanged from its predecessors. For the estimation period 1965-1972, however, the equation has been estimated in share form, since, as a result of the Autopact, one would expect imports of motor vehicles and parts from the United States to account for a fairly stable share of consumption (see Alexander [2]). The fact that relative prices have a significant effect on the ratio of imports to consumption indicates, however, that market forces are still very much at work, in spite of the constraints that may have been instituted through the Autopact. The different specification of the equation for the two subperiods results in a dramatic increase of the import price elasticity at the passage from the early subperiod to the late one. The own price elasticity of imports of motor vehicles and parts, which is zero prior to 1965, becomes a high 5.06 (absolute value) in 1Q65 and eventually falls to 2.06 (absolute value) in 1Q72. Such discontinuity in the price elasticity of imports of motor vehicles and parts may produce, for some simulations, undesirable effects on the balance of trade. This property of the model should thus be kept in mind when the simulation period begins prior to 1Q65 (see Chapter 13, Section D).

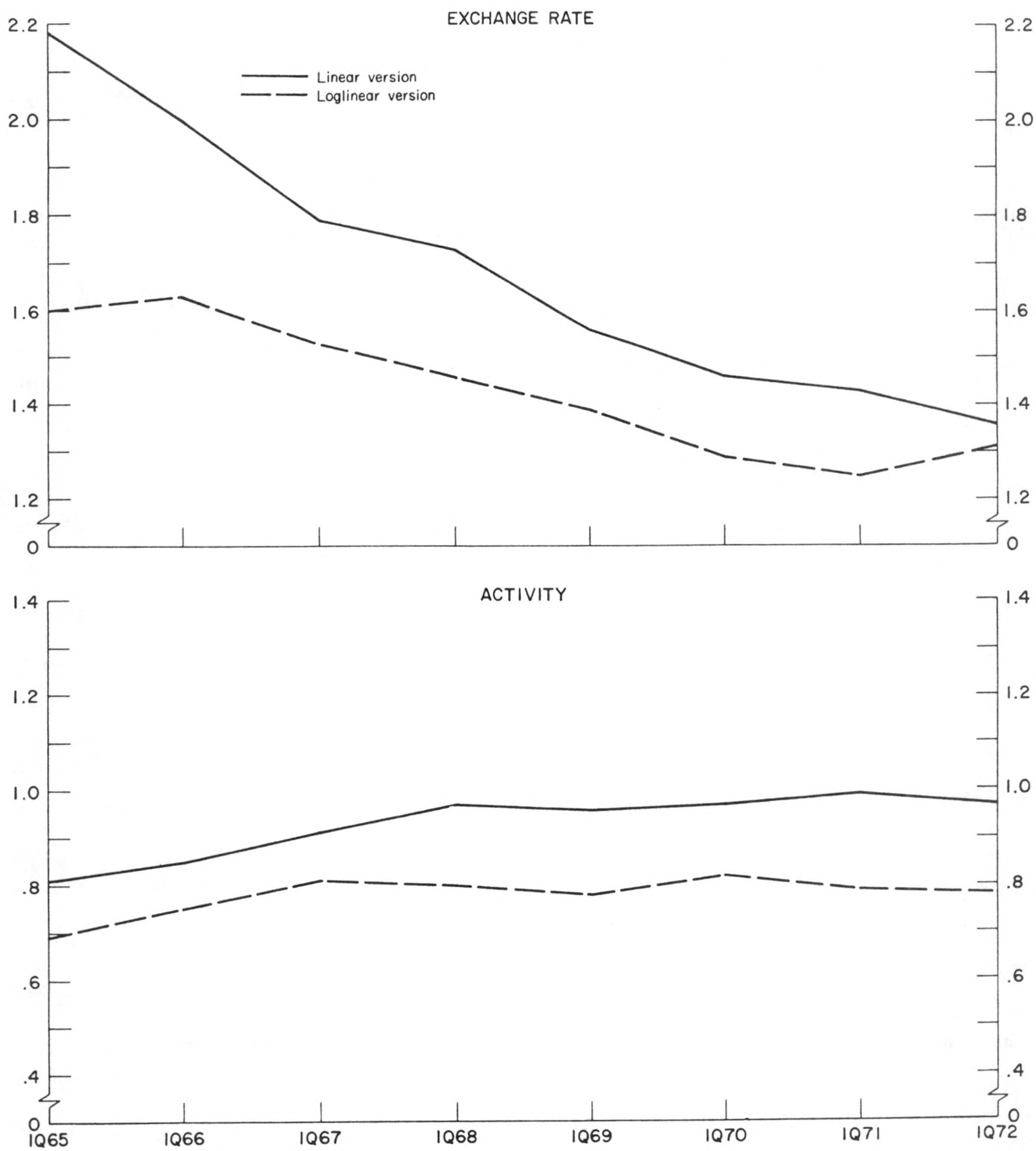
Equation 4.17 is responsible for most of the fluctuations in the price and activity elasticities of aggregate imports (see Figure 9). Indeed the other components, because of the loglinear formulation, can only affect the aggregate elasticities to the extent that their relative importance varies over time. The import price or exchange rate elasticity falls from 1.6 in 1Q65 to 1.31 in 1Q72 in absolute terms, while the activity elasticity fluctuates around .8. In Figure 9 we also show the changes that occur in the estimated elasticities when the linear rather than the loglinear functional form is used for equations 4.1-4.16. In particular, we illustrate in Figure 9 the steady fall in the exchange rate elasticity of aggregate imports implied by the linear specification.

C. Minor Changes

The remainder of Sector 4 is essentially unchanged and only a few explanations in addition to those in Helliwell et al. [32] are necessary.

Figure 9

EXCHANGE RATE AND ACTIVITY ELASTICITIES OF AGGREGATE IMPORTS (MGA)



1. Exports of goods, equations 4.18-4.20

The export side of the model still consists of three equations, two for the U.S. demand and one for the ROW demand for Canadian exports. Equation 4.18, exports of motor vehicles and parts, has been left unchanged and simply estimated over the extended time period. Some research was carried out in an attempt to model the institutional constraints resulting from the Autopact. A new export equation proposed by Alexander [2] has not yet been included in the model. Equation 4.19, exports of other goods to the United States, has been modified in four ways. Exports of uranium, aircraft and parts have been exogenized. The U.S. and Canadian capacity utilization variables have been left out. The lag structures on the activity and price variables were abandoned and replaced by moving averages of these variables. Equation 4.19 is now specified in loglinear form, which implies a constant total long-term price elasticity. Its estimated absolute value is 1.25, which may be fairly high compared to previous estimates, but a considerable amount of time must elapse before this value takes full effect.

The last export equation (4.20) - exports of goods (excluding wheat, uranium, aircraft and parts) to the rest of the world - is estimated as previously in loglinear form. The capacity utilization variables are now left out, and two new variables are included: the rate of change in world trade and a dummy variable reflecting strikes in the iron mines that occurred toward the end of the estimation period. The lag structure of the relative price variable has been abandoned and replaced, as in equation 4.19, by a sixteen-quarter moving average. The loglinear specification constrains the long-term price elasticity of the ROW demand for Canadian goods to be a constant. The estimation yields a low .62.

2. Imports and exports of services, equations 4.21-4.33

Services account for a significant share of Canadian foreign trade, although this share fell slightly in the early 1970s. Thus imports of services, which accounted in 1970 for 33 percent of the value of imports, amounted to 28 percent of imports in 1972. On the export side proceeds from exports of services fell from 22 percent to 20 percent over the same period. The importance of this component of Canada's balance of trade has already been recognized in Helliwell et al. [32] where thirteen equations are devoted to imports and exports of services. A few minor changes have been made in these equations: the inclusion in equations 4.27 and 4.31 of a constant term, the omission of seasonal variables in equation 4.26 and of the lagged dependent variable in equation 4.28. Otherwise the equations were simply re-estimated over the extended time period.

3. Technical relationships, equations 4.34-4.47

Fourteen technical relationships complete the model. Because of the new disaggregation scheme of imports, five new equations (4.34-4.38) have been added to Sector 4. Equations 4.34 and 4.35 indicate in current dollars the value of imports from the United States and the rest of the world and are straight identities. Equations 4.36 and 4.38 are Laspeyres aggregator functions and indicate, in constant dollars, the quantity of goods imported from the United States, the rest of the world, and the entire world. It is in this section of the model as well, that the exogenous import and export components are entered: MMIS12A, MMIS13A, and MMVP13 for imports; XMIS12, XMIS13, and XW13 for the exports.

D. Concluding Comments

Most of the efforts devoted to Sector 4 were directed toward the development of new import equations. The emphasis was put on a higher level of disaggregation particularly for imports from the rest of the world and, at the same time, more attention was paid to the micro-foundations of demand systems. This exercise, however, is only a first step in view of some of the serious shortcomings mentioned above, especially regarding the concept of the activity and domestic price variables. It would be useful to experiment with alternative disaggregation schemes, as well as with alternative functional forms and to pay special attention to the homogeneity and symmetry restrictions. Since most import decisions are made by producers it might be appropriate to derive the system of import demand equations from production theory rather than from consumer theory, even though, as already mentioned by Alexander [3], this may only have little bearing on the results. This is especially true since the activity variables are derived from the GNE components rather than from consumption expenditure or disposable income as consumer theory would suggest. It also seems desirable to employ a more familiar estimation technique than the one used here, such as Zellner [56], in order to estimate import demand equations for various commodities jointly. Finally, it is desirable to achieve a higher level of disaggregation of exports, and to include export supply functions in Sector 4 directly by either estimating export supply functions alone, leaving the price of exports exogenous, or by estimating the export supply functions simultaneously with foreign demand functions. At present, export quantities are determined by foreign demand functions alone which is tenable only if the Canadian export supply functions are infinitly price elastic (the U.S. and ROW would then have to be viewed as small open economies relative to Canada). The export price equations in Sector 7 can indeed hardly be accepted as inverse supply functions or reduced form price equations.

CHAPTER 6

BUSINESS EMPLOYMENT, HOURS, LABOUR FORCE, POPULATION, AND WAGES: SECTORS 5-6

Lloyd Kenward

A. Introduction

Sectors 5 and 6, together with Sector 3, provide the main interactions among sectors on the real side of RDX2 as well as the principal channels from real output to prices. Hence we begin with a supplement to the description of Sectors 5 and 6 given in the 1971 version of RDX2 [32] using Figure 3 (p 42). In sections B and C we describe the numerous modifications of Sectors 5 and 6, respectively.

The links among Sectors 5 and 6 and the other sectors of the model are portrayed at the lower right of Figure 3. From the inverted production function we obtain the desired quantity of labour (NMMOBD) for the production of the given output, given long-run hours. We use the difference between NMMOBD and the quantity of labour actually employed last quarter as the partial adjustment structure in the basic employment equation, NMMOB. The desired quantity of labour minus labour supply enters the wage equation as the labour market tightness variable. The deviation of actual hours worked from trend hours worked as a proportion of trend hours worked is explained by equation 5.4, with the excess demand for labour as a proportion of total demand being the principal explanatory variable. Numerous other feedbacks into the rest of the model are shown in Figure 3.

B. Business Employment, Hours, Labour Force, and Population (Sector 5)

In the original version of RDX2 [32] there are two endogenous business employment equations. In this version there are three: NMMOB: Paid employees in mining, manufacturing, and other business (5.1), NC: Paid employees in construction (5.2), and NEUPB: Unpaid employees in nonfarm business (5.3). We begin the discussion of Sector 5 with a description of each of these employment equations.

Paid employees in mining, manufacturing, and other business (NMMOB) adjusts to constrained desired labour (NMMOBD*), which is a modification of NMMOBD using the potential supply of labour in mining, manufacturing, and other business (NMMOBS). We define NMMOBS as the unemployed plus NMMOB less an allowance for structural unemployment (ERNUMIN+.5). Given this concept of NMMOBS, we modify NMMOBD according to the following rule:

$$NMMOBD^* = NMMOBD, \text{ if } NMMOBD \leq NMMOBS$$

$$NMMOBD^* = NMMOBS(NMMOBD/NMMOBS)^{.3}, \text{ if } NMMOBD > NMMOBS$$

Thus when desired labour is greater than the supply of labour we modify demand in order to obtain a greater response to the supply constraints in the model. This rule amounts to a imposing a threshhold effect that speeds up the adjustment of hours in the system of interrelated factor demand. We explored several alternatives to NMMOBD*, concentrating upon variable speeds of labour adjustment, with a specification that makes the rate of labour adjustment proportional to some measure of capacity utilization. None of the alternatives fitted the data as well as

NMMOBD* or provided the kind of shocked response that we considered appropriate. In contrast to the treatment of desired capital/output ratios in Sector 3, neither NMMOBD nor NMMOBD* is directly affected by the relative prices of the factors of production.

The variable ERNUMIN, with which we attempt to capture structural or frictional unemployment, is constructed by assuming that 1966 was a year of zero cyclical unemployment as measured by the unemployment rate of Canadian prime-age males (twenty-five to fifty-four years of age) and that there has since been no shift in that structural unemployment rate. In order to calculate the frictional unemployment rate for individual groups of males under and over the prime age, these unemployment rates were regressed against the unemployment rate of males aged twenty-five to fifty-four (a cyclical variable), seasonal dummies, unemployment insurance shift dummies, and various demographic labour-force variables thought to influence the structural unemployment rate for the group. The minimum unemployment rate was obtained by solving each regression with the unemployment rate of prime-age males for the relevant quarter in 1966 and then taking a weighted sum over the various groups where each weight represents each group's share of the total labour force.

The second employment equation, NC, was originally driven by the unemployment rate, the trend of residential and non-residential construction, and deviations from this trend. We modified this specification to make it analogous to the NMMOB equation. Changes in NC are the result of adjustment toward a desired level of construction employment (NCD). To obtain NCD we assume a Leontief production function and impose a fixed ratio of total investment to total man hours in efficiency units. We find this ratio to have been .10388 over the sample and, using this quantity, we solve for NCD.

Changes in the third endogenous employment variable, NEUPB, are explained by changes in paid nonfarm employment.

The employment equations, apart from seasonality, may be summarized by substituting the equations for NMMOB, NC, and NEUPB into the equation for NE to obtain the following expression for the adjustment of total employment to describe levels of employment.

$$NE = 1.104\ [J1W(NMMOBD^*) + J2W(NCD^*) + NIS + NGPAF + NGPAPM + NIOS + NX] + NFP + NEUPF$$

	J1W	%*	J2W	%
t=0	.097	(10)	.124	(12)
-1	.088	(19)	.109	(23)
-2	.079	(26)	.095	(33)
-3	.072	(34)	.083	(41)
-4	.065	(40)	.073	(48)
-5	.058	(46)	.064	(55)
-6	.053	(51)	.056	(60)
-7	.048	(56)	.049	(65)
-8	.043	(60)	.043	(70)
-9	.039	(64)	.038	(73)
-10	.035	(68)	.033	(77)
-11	.032	(71)	.029	(80)
-12	.028	(74)	.025	(82)
-	-		-	
-	-		-	
-	-		-	
Steady state	1.00		1.00	

* Percentage cumulant.

This rate of adjustment seems slow. It requires about three years for NE to adjust to 75 percent of its long-term value in response to changes in desired quantities of labour. It should be noted that this is adjustment of labour, not labour input into the production function. Labour input into the production function includes labour, hours and short-run productivity and adjustment by hours and short-run productivity is much faster than labour alone. Government employment is held constant in this exercise.

As in the earlier versions of RDX2 there are two 'hours worked' equations. The first, HAWMM: average weekly hours worked in mining and manufacturing, has the same specification as the original equation. The second, HAWC: average weekly hours worked in construction, has been structurally re-specified. The dependent variable for both equations is now the deviation of hours from the long-term trend as a proportion of the long-term trend. In the case of HAWMM the long-term rate of reduction in hours worked was chosen to ensure that there is no trend remaining in the definition of the dependent variable.

Apart from short-run productivity, hours is the fastest adjusting factor of production. In spite of the fact that employment and hours enter the production function together as man-hours, we are able to achieve faster adjustment by hours because of our specification of the HAWMM and NMMOBD equations. First, we solve the production function for man-hours, then set hours on a trend value that represents long-run normal hours and so obtain the desired quantity of labour (NMMOBD). Hours worked then deviates from the same trend value so as to chose the gap between desired and actual employment. Remaining short-term variations in aggregate demand are assumed to be accommodated by short-run productivity.

The constrained desired labour variable is used as the principal explanatory variable for HAWMM. When labour supply is greater than demand, the last term in equation 5.4 vanishes and hours worked adjusts so that part of the labour requirement for mining, manufacturing, and other business not met by current employment is met by changes in hours worked. When labour demand exceeds supply the last term in equation 5.4 increases the rate at which hours adjust. For example, when we simulate a sustained 10 percent increase in labour demand (NMMOBD) for Sector 5 alone, with labour supply greater than demand (ie, $\beta = 1$ in equation 5.16), we find that 46 percent of the increase in the supply of man hours in the first quarter comes from HAWMM. By the fourth quarter the contribution of HAWMM falls to 18 percent and by the twelfth quarter to 5 percent. If labour demand is greater than supply (ie, $\beta = .3$ in equation 5.16), the contribution of HAWMM becomes 90 percent, 70 percent, and 51 percent for the first, fourth, and twelfth quarters, respectively.

The specification for average hours worked in construction (HAWC) is now analogous to HAWMM. In addition, we use all categories of construction investment as explanatory variables rather than just investment in non-residential construction, as is the case in all previous versions of the model. The contribution of HAWC, because of an increase in labour demand, is about 33 percent of total man hours in construction supplied during the first quarter. It falls to zero by the twelfth quarter.

The remaining three equations in Sector 5 - NL: Labour force (5.6), NIMS: Immigrants (5.7), and NEMS: Emigrants (5.8) - have changed little from the original specifications. In the NL equation the participation rate is explained by net immigration, noninstitutional population fourteen years of age and over, and the degree of capacity utilization. The capacity utilization variable (UGPPA/UGPPD) replaces the real disposable income variable originally in the equation and, although not significant (the t-statistic equals 1.21), plays an important role in the response of the model under simulations involving low rates of excess capacity in the economy.

In the equation for immigrants the role of the non-institutional population fourteen years of age and over (NPOP) has changed. Originally, increases in the level of NPOP had a small negative effect on NIMS as a proportion of NPOP after a long lag. In the second version of RDX2 [29] changes in the rate of growth of NPOP alter only the timing of immigration.

The specification of the equation for emigrants is unchanged from that of earlier versions and the only notable coefficient change is the fall in the coefficient on the unemployment variable. This has declined with each extension of the estimation period until it is now less than one-third of its original value. The shocked response of emigration to changes in the unemployment rate has also declined markedly. Although the long-term coefficients on the unemployment variable for NIMS and NEMS are virtually similar, the responses of these variables to a change in the unemployment rate are very different. Because the unemployment rate affects NIMS and the inverse of the unemployment rate affects NEMS, the response of NEMS to changes in the unemployment rate will be less than the response of NIMS by a factor of approximately $1/RNU^2$.

The asymmetrical effect of RNU on NIMS and NEMS may be interpreted as resulting from different roles assigned to immigration and emigration in RDX2. Immigration is partly modelled as a behavioural relationship and partly as a policy reaction function. Policy makers are assumed to encourage immigration during periods of low unemployment and reductions in the growth rate of population. The behavioural aspect of NIMS arises from increases in immigration in response to increases in Canadian real wage relative to European and American real wages. Emigrant's behaviour is determined non-linearly by Canadian and American unemployment rates.

In Figures 10a and 10b we present the response of three variables in Sector 5, with all other sectors exogenous, to two different demographic shocks. These variables are: total population (NPOPT), noninstitutional population fourteen years of age and over (NPOP), and labour force (NL). The response of these variables to an increase of one million births is shown in Figure 10a; their response to an increase of one million immigrants is presented in Figure 10b. Both demographic shocks have an identical effect on NPOPT and NPOP. However, because equation 5.6 models a higher participation rate for immigrants than for native Canadians, the NL response is greater for the immigration shock than for the birth shock. The higher participation rate of immigrants lasts for nineteen quarters after entry into Canada - the eligibility period for Canadian citizenship. During these nineteen quarters the increase in the labour force is actually greater than the increase in the population fourteen and over. This result occurs because the estimated coefficient on the net immigration variable in the NL

Figure 10a

THE RESPONSE OF POPULATION AND LABOUR FORCE TO AN INCREASE OF 1 MILLION BIRTHS

Millions of Persons
(Shock — Control)

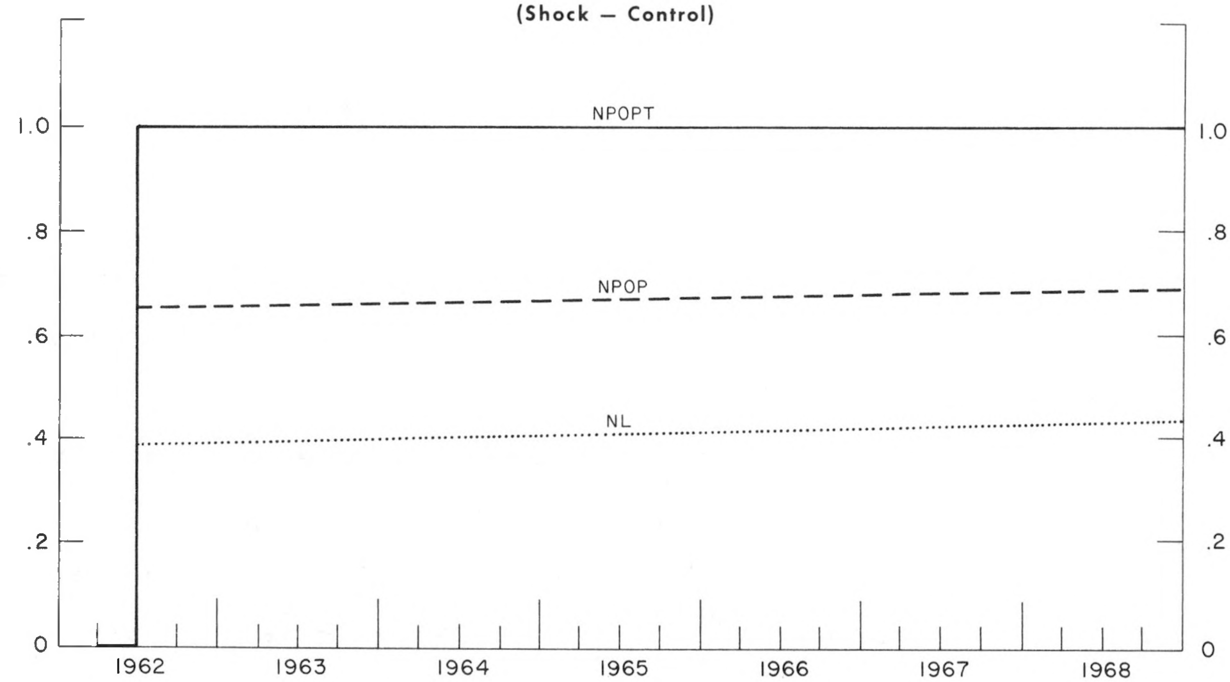
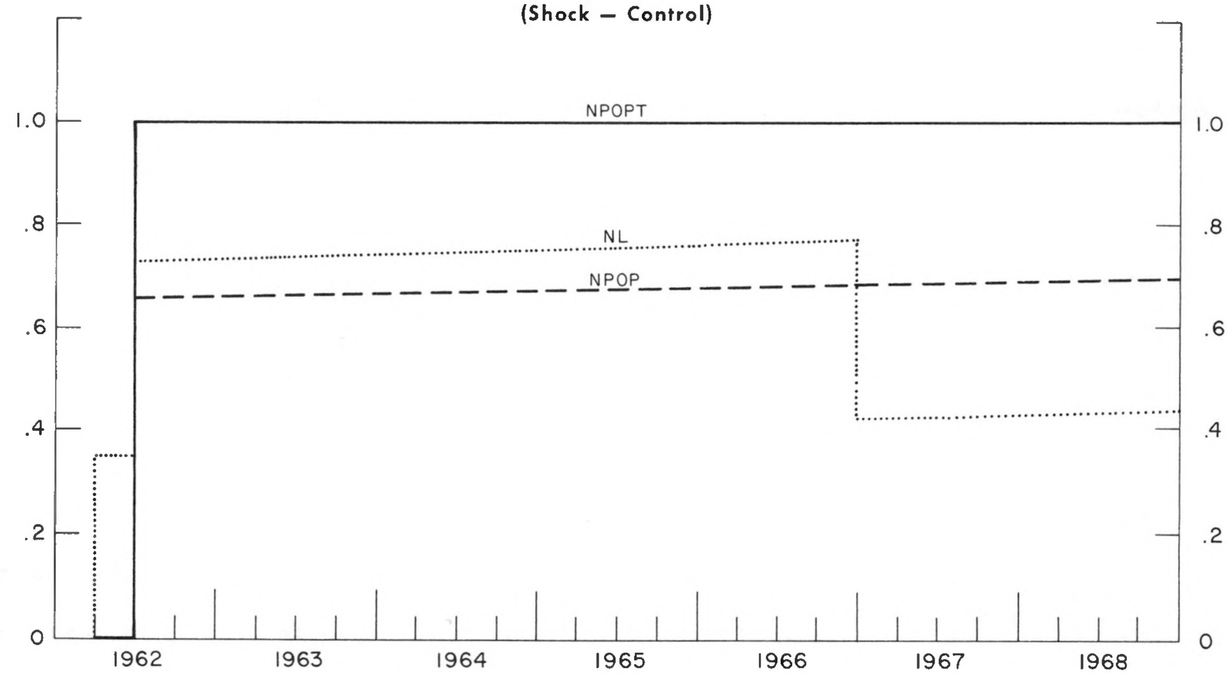


Figure 10b

THE RESPONSE OF POPULATION AND LABOUR FORCE TO AN INCREASE OF 1 MILLION IMMIGRANTS

Millions of Persons
(Shock — Control)



equation generates a greater response than the response implied by the exogenous variable EPOP that converts NPOPT into NPOP. A more realistic response could be obtained by also shocking the exogenous variable EPOP such that it respects the age structure of native Canadians and of immigrants.

The responses of the labour force to the shocks imply a participation rate of about .71 for immigrants and .49 for native Canadians. Native-born Canadians do, however, enter the labour force one quarter after birth. Because RDX2 has a higher participation rate for immigrants than for native Canadians, the more serious implication in RDX2 is that an immigration-induced labour force increase leads to a higher unemployment rate than a birth-rate-induced increase in the population, given constant labour demand.

The unusual response of RDX2 to these shocks has resulted in our dedication of resources to improving the role of demographic variables in the model. We hope to provide more reasonable response to similar shocks in future versions of RDX2.

C. Wages (Sector 6)

As in previous versions of RDX2 [32] and [29], we have two earnings equations - WQMMOB: Mining, manufacturing, and other business (6.1) and WQC: Construction (6.2). The former in particular has been considerably re-specified by Benjamin Wurzburger. We first turn our attention to it, with comments on WQC presented near the end of this part of the study. At the end of the next chapter some of the interactions between wages and prices are discussed in detail.

The WQMMOB equation can be interpreted as either a factor-share equation or as a Phillips curve equation with some institutional refinements. In referring to the WQMMOB specification as a factor-share equation we have in mind collective bargaining toward a fixed share of nominal output per worker so that, in equilibrium, the wage bill is some fixed proportion, b, of nominal output. Thus,

WQMMOB*NMMOB = b*P*UGPPA

where

P is some price index. Then,

ln(WQMMOB/P) = constant + ln(UGPPA/NMMOB). (1)

This approach is our preferred one since it has the desirable property of being consistent with our Cobb-Douglas production function. We use two measures of output per worker in trying to capture the term on the right of (1). The first measure is based on the assumption that labour bargains toward an equilibrium real per capita output in proportion to the rate of technological change - that is toward ELEFF. This approach is appropriate only if, in the long term, variations in the capital/output ratio are not substantial. The second measure is UGPPA/NMMOBD. This is used because we derive NMMOBD from the inversion of the production function and thereby take some account of variations in the ratio of capital to output.

We obtain the basic specification of the WQMMOB equation by assuming that nominal wages adjust in each quarter so as to remove part of the disequilibrium in the previous quarter. Since we believe that nominal wages are affected by supply and demand conditions in the labour market we add the term (NMMOBD-NMMOBS)/NMMOBS. We comment on the HAWMM and NMMOB terms below.

The alternative Phillips curve interpretation of the WQMMOB equation begins with the Lipsey approach [39] in which Lipsey specifies that wages adjust to some measure of excess demand in the labour market. In our case

$$J1P(WQMMOB) = f(NMMOBD-NMMOBS)/NMMOBS. \quad (2)$$

McCallum [40] uses a different approach to measuring excess demand. He specifies labour demand per unit of aggregate output (D/Q) and labour supply - a proportion of population (S/N) - as functions of time (t) and the real wage (w): $D/Q = g(w, t)$ $S/N = h(w, t)$ to obtain

$$J1P(W) = a + b \log J1L(q) - c \log J1L(w) + dt.$$

Combining the McCallum approach with (2) we obtain the basic specification for W = WQMMOB, q = UGPPA/NMMOBD, w = WQMMOB/PCPI, and t = ELEFF. To both interpretations of the WQMMOB equation we add two institutional terms, J1P(HAWMM) and J1P(NMMOB). Since this equation is an earnings equation and not a wage rate equation, an increase in hours worked will have a direct impact on WQMMOB. The estimated coefficient on the hours variable is about .30 - a little lower than expected in view of the fact that WQMMOB includes both hourly and salaried workers.

If newly hired (inexperienced) workers tend to receive lower average wages than established workers, an increase in employment will lower the average wage. We achieve this result by adding

NMMOB as an explanatory variable to the WQMMOB equation. Because the use in RDX2 of an aggregate production function implies homogeneous labour, we prefer to interpret the NMMOB term as being the result of institutional considerations rather than the idea that inexperienced workers are less productive than established workers. The coefficient on J1P(NMMOB) is -.45, which implies that inexperienced workers receive on average only 55 percent of the remuneration of the average established worker. This may be a little low.

The concept of workers bargaining for a share of national output implies that in the WQMMOB equation one ought to use the price deflator appropriate for the output being shared; ie, PGPP or possibly PGNE. On the other hand, if workers bargain for a real standard of living, then one ought to consider the consumer price index. Preliminary experimentation with the WQMMOB equation revealed the best fit when the consumer price index was used. That is our final choice for a price variable in both the wage equations.

Although there is not a great deal of difference between PCPI and PGNE in the WQMMOB equation under estimation, there is an important difference under certain policy shocks. PCPI reacts much more than PGNE in response to a change in the exchange rate (see Figure 13). Thus our choice of a price index in the WQMMOB equation ensures that our principal wage variable reacts more strongly to a foreign price shock than it would have reacted if we had used a different price deflator.

The original version of RDX2 [32] has an inflationary expectations term in both of the wage equations, but as the estimation period is extended the variable begins to become insignificant. In this version of RDX2 when our standard measure of the expected annual rate of inflation (PCPICE) is added as an explanatory variable the term is insignificant and has a negative sign. When the year-over-year rate of consumer-price-index change is added the coefficient is insignificant.

Although, apart from dummy variables, only one of the original variables in the WQC equation remains, we have not yet re-specified this equation as fully as we have the WQMMOB equation. Clearly ELEFFC, WQC/PCPI, and HAWC are strictly analogous to ELEFF, WQMMOB/PCPI, and HAWMM. In addition, the coefficients on the variables in the WQC equation are of the same magnitude as the coefficient on the equivalent variable in the WQMMOB equation. Furthermore, the variable IRC + INRC .../ELEFFC is roughly comparable to UGPPA/NMMOBD. Since these variables are the basis of the factor-share interpretation of the WQMMOB equation, we can clearly give this interpretation to WQC. Although we tried several possibilities, we were unable to incorporate a labour market tightness variable in the WQC equation and so the Phillips curve interpretation cannot be given to the WQC equation. The J4L(J1P(WQC)) variable picks up seasonality not captured by the intercept dummies, probably because the seasonality in WQC has been increasing over time.

For analytical purposes the two wage equations may be approximated by logarithms and in stationary state written as:

$$\ln WQMMOB = \ln PCPI + .76 \ln ELEFF + .27 \ln(UGPPA/NMMOBD) \text{ and}$$

$$\ln WQC = \ln PCPI + 1.46 \ln ELEFFC$$

Thus in the long run both wage equations are neutral with respect to a sustained increase in prices. For WQMMOB and WQC, 9 percent of a 10 percent increase in PCPI is recovered after eight quarters. The full 10 percent is made up after twenty quarters for WQMMOB and after ten quarters for WQC. A unit increase in ln(ELEFF) eventually raises ln(UGPPA/NMMOBD) by one unit that, together with the original increase in ln(ELEFF), raises ln(WQMMOB) by 1.03. A unit increase in ln(ELEFFC) raises ln(WQC) by 1.47 in the long run. Although the response in ln(WQMMOB) is approximately correct, the response in ln(WQC) is a little high.

Comparing the present WQC equation to the original we note that, with the extension of the estimation period, there has been a considerable deterioration in the fit of the equation. The strongest coefficient, that on J1P(HAWC), has fallen in value by more than one third. Also the other two main driving variables - PCPICE and the inverse of the unemployment rate - have dropped out. The original specification was unstable outside the estimation period and although the present specification is acceptable we shall attempt to improve the WQC equation.

CHAPTER 7

PRICES: SECTOR 7

Jean-Pierre Aubry

A. The Theoretical Approach[1]

One of the key sectors of the RDX2 model is the price sector. The disaggregation level of its eighteen stochastic equations is in line with the disaggregation level of the stochastic equations in the consumption, investment, and government sectors.

The theoretical approach used in the price sector is identical with that used in the price sectors of the two previous versions of RDX2 [32] and [29]. In the medium and long run the application of a mark-up theory to varying costs explains price behaviour. In the short run, however, the imbalance of supply and demand is a determining factor.

The most important explanatory variable in the price equations is normal unit labour cost, which is the ratio of labour cost to the amount of output produced by existing capital stock, employees, and average weekly hours as fixed by the production function: (NMMOB)(WQMMOB)/UGPPS. Normal unit capital cost, also a price determinant, is evaluated by using imputed rental prices: (.01(RCNR)(KNRC)+.01(RCME)(KME))/UGPPS. The introduction of foreign prices into the domestic price equation captures the cost of imported inputs and the short-term demand pressure on exports. All foreign prices are pre-multiplied by the exchange rate (PFX) so that domestic prices have the same elasticity with respect to foreign prices expressed in U.S. dollars as they have with respect to the exchange rate.

Econometric and theoretical criteria were used to discriminate between the flow and stock dimensions of the demand and supply imbalance. The flow dimension is approximated by the ratio of aggregate demand less unintended inventory changes (UGPPA) to desired output (UGPPD). On the other hand the stock measure of imbalance between supply and demand is defined as:

(J1L(KIB)-J12S(UGPP-UGPPA))/J1L(KIB)

where

J12S(UGPP-UGPPA) is a three-year cumulation of unintended inventory changes.

Downward pressure will then be exerted on prices as long as excess inventories exist.

During the specification process the sales tax rate was introduced as an independent explanatory variable in order to test whether changes in demand generated by sales tax rate variations would affect producers' prices or not. With the exception of the price deflator equation for business investment in machinery and equipment (PIME), the sales tax rate had no significant impact, implying a full and immediate pass through of any change in the sales tax rate to the final price.

Because the Cobb-Douglas production function implies constant elasticities of domestic prices with respect to the explanatory variables, the price equations are estimated in logarithmic form. The typical structural form of the price equation is thus

$$\ln(P/(1+.01R)) = a + b\ \ln[(WQMMOB)(NMMOB)/UGPPS]$$
$$+ c\ \ln[(.01(RCNR)(INRC) + .01(RCME)(KME))/UGPPS]$$
$$+ d\ \ln[(PFX)(PF)]$$
$$+ e\ \ln[J4A(UGPPA/UGPPD)]$$
$$+ f\ \ln[(J1L(KIB) - J12S(UGPP-UGPPA))/J1L(KIB)]$$

where

P is a domestic price deflator,

PF is a foreign price deflator, and

R is an indirect sales tax rate.

We had two major problems with the original version of the price sector [32]: the rapidly declining elasticity of the explanatory variables over the sample period and the small impact of supply-demand imbalance. The first problem was solved in the next version of the price sector, [29], by adopting a loglinear form. Unfortunately, this change not only failed to solve the second problem but also reduced the impact of foreign prices.

B. Improvement Strategy

In the re-specification process we tried to improve four aspects of the specification in [29]: the quality and effect of the supply-demand imbalance variable, the transmission of foreign inflation, the possibility of adding some measure of money market disequilibrium, and the problem of high levels of autocorrelation.

Our capacity measure, J4A(UGPPA/UGPPD) re-normalized to 100, was compared with another calculated by Glorieux and Jenkins [21]:

PJCAP = actual output/capacity

where

output is the quarterly real domestic product seasonally adjusted, and

capacity is determined by trend through troughs in capital/output ratios.

As shown in Figure 11 both measures have essentially the same pattern. Even though the J4A(UGPPA/UGPPD) series has a smaller variance than PJCAP, the timing of the peaks and troughs is virtually the same. With the introduction of PJCAP instead of J4A(UGPPA/UGPPD) no notable change appeared.

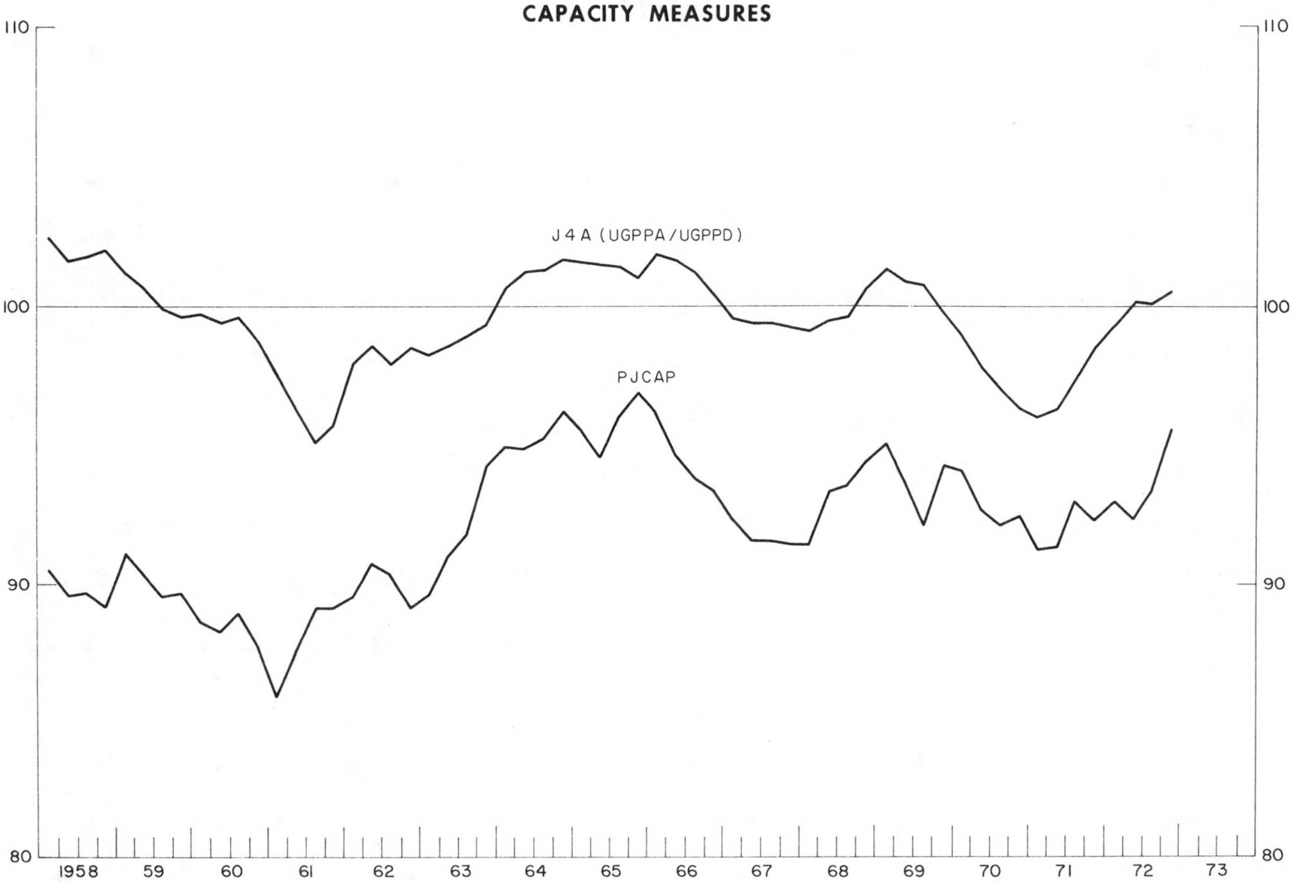
We tried, without success, to use an alternative to the four-quarter moving average, namely, the ratio UGPPA/UGPPD with the seasonal variations removed:

$$.25(UGPPA/UGPPD)/(.233Q1+.257Q2+.255Q3+.256Q4)$$

Special attention was paid to the estimation of domestic price elasticity with respect to foreign prices. In the previous version of RDX2 [29] the consumer price index had a low partial equilibrium long-run elasticity of .07 with respect to foreign prices. Using the price model based on input-output tables issued by Statistics Canada [36] one should obtain partial long-run elasticities for domestic prices and the CPI with respect to foreign prices of the following magnitudes:

Consumer price index	.156
Prices for machinery and equipment	.439

Figure 11
CAPACITY MEASURES



Construction prices	.133
Price for final demand	.174

As noted below, our estimates are close to these numbers, but it takes from six to eight quarters to get close to the partial equilibrium response.

Experiments were also run to test the addition of money market disequilibrium variables into the specification. The two variables used were the liquidity variables: J4A(M^L/UGPPS), where M^L = ANFCUR + DDB, a four-quarter moving average on the ratio of M^L to the aggregate normal supply derived from the production function; and J8A(RABELCD/RABELCDD), an eight-quarter moving average of the chartered bank ratio of actual Canadian dollar earning liquid assets to the desired ratio of earning liquid assets. No significant impact was observed except in the price index equation for residential construction materials (PRM).

Nearly all the estimated equations in the price sector had a low Durbin-Watson statistic - a situation that may have been produced by the existence of an autocorrelated error or by dynamic mis-specification. In order to detect the exact problem in each equation we ran the general instrumental variable estimation (GIVE) program developed by David Hendry [33] and [34] in which the validity of the autoregressive restrictions is determined by a maximum likelihood ratio test. Eleven of the sixteen stochastic equations in the previous version of the model rejected the existence of an autocorrelated error in favour of dynamic mis-specification. Autocorrelation appeared in the PINRC, PGCNWC, PINRCG, PIMEG, and PRENT equations where the explanatory variables are mainly other domestic prices: PNRM, PCS, PINRC, PIME, and PIRC. For each of the other stochastic equations, except the PCMV equation, the specification was greatly improved by the addition of a lagged dependent variable. The dynamic implication of this addition is that geometrically declining weights should be distributed in the same way on all the explanatory variables. However, the introduction of a lag structure on an explanatory variable in conjunction with a lagged dependent variable generates weights distributed so as to produce different speeds of adjustment. Figure 12 is an illustration of the lag patterns obtained by simultaneous use of an Almon variable (Z2) and a lagged dependent variable - the case of lag structures on a unit labour cost variable.

Each price equation was estimated over the sample periods 1Q58-4Q70 and 1Q58-4Q72. The robustness of the coefficients and their tracking ability during the periods 1Q71-1Q72 and 1Q72-4Q73 were important criteria applied in the specification process.

C. Description of the Equations

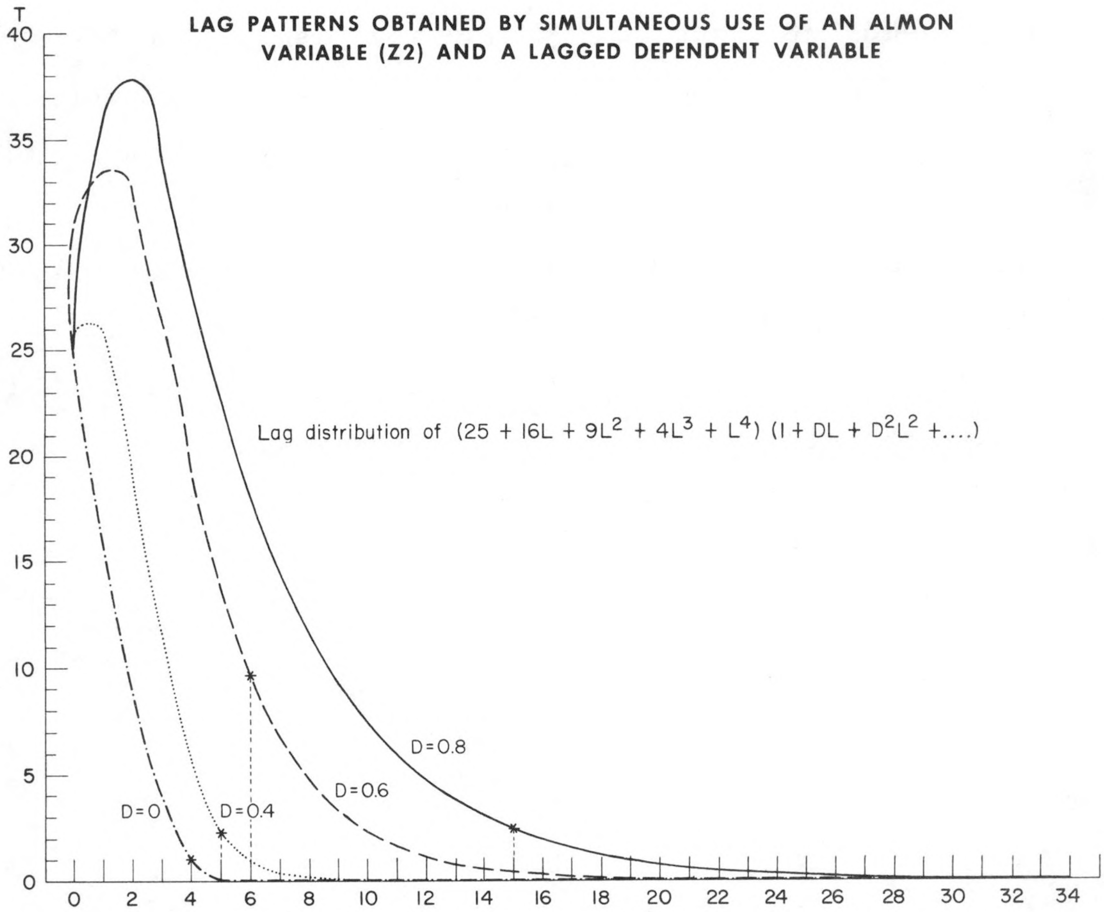
1. The components of the consumer price index

PCNDSD Price of consumer non-durables and semi-durables (equation 7.1)

The major price variable is PCNDSD because it explains more than half the consumer price index. The consumption of non-durables and semi-durables represented 51.9 percent of the 1957 consumption basket (see equation 7.18). Equation 7.1 is also a good illustration of the effect of including the lagged dependent variable. Acting on the results of the GIVE program we added the lagged dependent variable and dropped the lags on import prices.

Figure 12

LAG PATTERNS OBTAINED BY SIMULTANEOUS USE OF AN ALMON VARIABLE (Z2) AND A LAGGED DEPENDENT VARIABLE



* Indicates the quarter in which 95 percent of equilibrium is obtained

The elasticity of PCNDSD with respect to WQMMOB*NMMOB/UGPPS, ie, labour cost, decreased from .765 in Hendry [33] to .569. On the other hand, the elasticities with respect to the flow measure of the imbalance between demand and supply, and especially with respect to the weighted price of imports, increased to .354 and .290, respectively. The long-term elasticity of .290 in the latter case is much more plausible than the .023 estimated for equation 7.1 in Helliwell and Maxwell [29], where the impact response is practically the same. In Table 5 we present the dynamic response of the previous specification in [29] and of the present specification.

PCSXR Price of consumer services excluding rent and property taxes (equation 7.2)

The addition of the lagged dependent variable is the only change made to the original specification. The long-run elasticity of the earnings variable (WQMMOB) increases slightly from .927 to .982 and the elasticity of the flow measure of supply-demand imbalance takes a big jump from .135 to .386. In replacing the normal unit labour cost variable by the earnings variable we assume that an increase in the normal productivity of the economy (UGPPS/NMMOB) involves no downward pressure on PCSXR and that producers retain all the productivity gains realized in this sector not absorbed by the workers.

PCMV Price of consumer durables - motor vehicles (equation 7.3)

This equation differs markedly from the original version in Helliwell et al. [32]. Since the seasonal pattern is not the same throughout the sample period, a particular seasonal pattern

Table 5

CUMULANTS OF THE LAG DISTRIBUTIONS IN THE PCNDSD EQUATION IN THE PREVIOUS [29] AND THE PRESENT VERSION OF RDX2

	Labour Cost		Import Cost		Supply/Demand	
	Previous	Present	Previous	Present	Previous	Present
t = 0	.34788(45)	.09716(17)*	.12341(527)	.10901(38)	.19427(100)	.13310(38)
-1	.57052(74)	.22000(39)	.15278(652)	.17708(61)	" "	.21621(61)
-2	.69579(91)	.33170(58)	.12278(524)	.21958(76)	" "	.26811(76)
-3	.75142(98)	.41698(73)	.06810(291)	.24612(85)	" "	.30051(85)
-4	.76534(100)	.47698(83)	.02342(100)	.26269(91)	" "	.32074(91)
-5	" "	.50980(90)	" "	.27304(94)	" "	.33370(94)
-6	" "	.53208(93)	" "	.27950(96)	" "	.34126(96)
-7	" "	.54599(96)	" "	.28353(98)	" "	.34619(98)
-8	" "	.55460(97)	" "	.28605(99)	" "	.34927(99)
-9	" "	.56010(98)	" "	.28762(99)	" "	.35119(99)
-10	" "	.56349(99)	" "	.28860(99)	" "	.35239(99)
Steady state	.76534(100)	.56912(100)	.02342(100)	.29024(100)	.19427(100)	.35439(100)

* The cumulants as a percentage of the steady state are in parentheses.

is estimated for the first three years by multiplying the trended seasonal variable by the dummy variable QSEAPCMV, which equals 1 from 1Q58 to 4Q60 and zero elsewhere. For the remainder of the sample period the seasonality of the explanatory variables explains the seasonal variations of PCMV and therefore the three additional trended seasonal variables are not required.

Compared with the previous estimation, the coefficient on the stock measure of supply-demand imbalance drops and the elasticity of labour cost and of the labour efficiency factor (ELEFF) double. A short-term productivity variable defined as the reciprocal of the ratio of the actual man-hours (NMMOB*HAWMM) to the equilibrium man-hours (NMMOBD*[41.372-.0133 QTIME]) is introduced, as in previous versions, into the PCMV specification. This term implies that any increase in short-term productivity puts downward pressure on PCMV. Because there is no longer a supply-demand imbalance term in the PCMV equation, an expansionary shock has the short-run effect of reducing PCMV.

The addition of monetary variables did not solve the problem of unstable coefficients. In this version of the equation labour cost has a high long-run elasticity (1.228) partially offset by the labour efficiency factor, which has an elasticity of -1.54. But, because ELEFF is an exogenous variable, this offset mechanism did not operate during the simulation experiments. Different Almon lag constraints were tested in the estimation of the impact of the implicit price deflator for U.S. consumer expenditure on durables (PC2) multiplied by the exchange rate (PFX). The coefficients are constrained in the present equation to follow a second-degree polynomial passing through zero at t+1 and having a zero slope at the distribution end-point. The estimated elasticity of PC2 and PFX is .281. This is certainly too low. In subsequent experiments we plan to use a U.S. price deflator for consumer expenditure on motor vehicles.

PCDO Price of other consumer durables (equation 7.4)

The price of other durables is explained by current labour cost and by the stock measure of demand-supply imbalance with long-run elasticities of .287 and .268, respectively. The normal unit capital cost is not included because its coefficient is not significantly different from zero. We also tried without success to include the foreign price variable, monetary variables, and a proxy for expected inflation. The GIVE program suggested the inclusion of a lagged dependent variable and the use of the current value of the normal unit labour cost.

PRENT Price deflator for gross rent (paid and imputed), (equation 7.17)

Three components explain PRENT: a first difference of the percentage of the total population living in urban areas, an Almon variable on the price index of residential construction, and another Almon variable on the average mortgage rate. These three variables have long-run elasticities of 33.26, .812, and .656, respectively. The high coefficient (.95791) in front of the lagged dependent variable implies a slow response to any shock. As an extension to our comments on CRENT in Chapter 2, 99.7 percent of the variance of PRENT is explained by a constant growth rate model. This fact casts doubt on the data series.

PCPI The consumer price index (Laspeyres base), (equation 7.18)

The consumer price index is explained here, as in equation 7.18 in [29], by a weighted sum of the implicit consumption price deflators explained above: PCNDSD, PCSXR, PCMV, PCDO, and PRENT. In the two previous versions of equation 7.18 the elasticity of PCPI with respect to the weighted sum of the deflator was greater than 1: 1.092 and 1.084. A better choice of weights and the addition of two variables bring this elasticity down to the more desirable level of 1.

The variable PCPI is a Laspeyres price index. The 1957 base-weighted index was linked to the 1947 base-weighted index in January 1961; the 1967 base-weighted index was linked to the 1957 base-weighted index in April 1973. See Canadian Statistical Review, 1961 [10] and the Consumer Price Index for Canada 1973 [12]. Thus during the period of the estimation process (1961-1972) the consumer price index is a Laspeyres price index with fixed 1957 weights. The weights used in the previous versions of this equation, which represent the average shares of the five consumption categories CNDSD, CMV, CDO, CSXR, and CRENT over the estimation period, are replaced here by the 1957 weights.

We added two variables to the equation in order to solve the problem raised in explaining a Laspeyres index by means of a Paasche deflator. Faced with a price variation evident since the base period, consumers will switch their expenditures to the relatively cheaper subaggregates of the five main aggregates. According to the hypothesis that such price variations, observed at a lower level of disaggregation, are subject to economic cycles and trends, we can justify the introduction of the variables J4A(UGPPA/UGPPD) and QTIME. The inclusion of these variables and the use of the 1957 weights give a long-run elasticity of PCPI with respect to the weighted sum of the consumption deflators of 1.009 - a number that is not significantly different from 1.

2. The investment price equations

PIME Price deflator for business investment in machinery and equipment (equation 7.5)

When the lagged dependent variable is excluded the new equation is the same as that in the previous version of RDX2 [29]. The normal unit labour cost and the corresponding U.S. price (PPD2) multiplied by the exchange rate now have elasticities of .520 and .480, respectively, compared with .494, and .473 in (7.5) in [29]. The PIME equation is the only equation in which the whole of a tax increase is not passed on in higher prices, a proportion being absorbed by the sellers. The degree of absorption is 40 percent initially, and increases to 66 percent in the long run.

PKIB Price index for nonfarm business inventory stock (equation 7.8)

Substantial changes have been made to the PKIB equation in [29]. We have replaced the consumer price index and the flow measure of stock-demand imbalance with the price deflator for gross private business, purged of service cost, and with the stock measure of supply-demand imbalance. The price of imported goods and a lagged dependent variable were added; the productivity variable was dropped. Note that the long-run elasticity of foreign prices is in line with the import share of GNE. The dynamic impact of domestic and foreign prices is shown in Table 6.

Table 6

THE DYNAMIC IMPACT OF DOMESTIC AND FOREIGN PRICES IN THE PKIB EQUATION

	JW(PGPPXS)	%*	JW(PMG)	%
t = 0	.106	(13)	.073	(28)
-1	.135	(29)	.052	(48)
-2	.155	(48)	.038	(63)
-3	.170	(68)	.027	(73)
-4	.075	(77)	.019	(81)
-5	.054	(83)	.014	(86)
-6	.039	(88)	.010	(90)
-7	.028	(91)	.007	(93)
-8	.020	(94)	.005	(95)
-9	.014	(96)	.004	(96)
-10	.010	(97)	.003	(97)
-11	.007	(98)	.002	(98)
-12	.004	(99)	.001	(99)
-13	.004	(99)	.001	(99)
-14	.003	(100)	.001	(99)
-15	.002	(100)	.001	(99)
-16	.001	(100)	.000	(100)
-17	.001	(100)	.000	(100)
-18	.001	(100)	.000	(100)
-19	.001	(100)	.000	(100)
Steady state	.831	(100)	.259	(100)

* Percentage cumulant.

3. The equations for construction prices

The specification of the next four construction price equations PIRC, PINRC, PRM, and PNRM should be viewed as a whole. The price indices for construction materials (PRM) and (PNRM) are explained by the normal unit labour cost, unit capital cost, foreign prices, and the flow measure of demand-supply imbalance. We explain the price deflators for business investment in construction (PIRC) and (PINRC) by the construction wage (WQC), the price of construction materials, and the percentage change in unit capital costs. When the PRM and PNRM equations are substituted into the PIRC and PINRC equations, respectively, one obtains the dynamic response presented in Table 7. As is evident in Table 7, the labour cost variables are the key variables. They have total elasticities of .547 (.233+.314) and .943 (.143+.800) with respect to PIRC and PINRC. This large difference in the labour cost impact is mainly attributable to the inclusion in the PRM equation of the foreign price variable (PFX*PCH2) and of the monetary variable (J4A(M1/UGPPS)). Both variables have large, significant coefficients. In fact, the PRM equation is the only price sector equation in which the monetary variable appears. When the elasticities of PFX*PCH2 and J4A(M1/UGPPS) are added to labour cost elasticity one obtains a total elasticity of .921, which is of the same magnitude as that obtained in the PINRC equation. The foreign price variable and the liquidity variables were introduced without success into the PINRC equation.

Table 7

DYNAMICS OF THE PIRC AND THE PINRC EQUATIONS

$$\ln(\text{PIRC}) = \text{J1W}(\ln(.001\ \text{WQC})) + \text{J2W}(\ln[(\text{NMMOB})(\text{WQMMOB})/\text{UGPPS}]) + \text{J3W}(\ln[\text{J4A}(\text{UGPPA}/\text{UGPPD})])$$

$$+ \text{J4W}(\ln(\text{PFX}*\text{PHC2})) + \text{J5W}(\ln(\text{M1}/\text{UGPPS})) + \text{J6W}(\ln[(.01(\text{RCME})(\text{KME}) + .01(\text{RCNR})*(\text{KNRC}))/\text{UGPPS}])$$

$$\ln(\text{PINRC}) = \text{J7W}(\ln(.001\ \text{WQC})) + \text{J8W}(\ln[(\text{NMMOB})(\text{WQMMOB})/\text{UGPPS}]) + \text{J9W}(\ln(\text{J4A}(\text{UGPPA}/\text{UGPPD})))$$

$$+ \text{J10W}(\ln[(.01(\text{RCME})(\text{KME}) + .01(\text{RCNR})(\text{KNRC}))/\text{UGPPS}])$$

	J1W	J2W	J3W	J4W	J5W	J6W	J7W	J8W	J9W	J10W
t = 0	.04830	.03251	.08019	.03246	.05270	.00280	.02078	.3229	.04262	.163
-1	.05720	.05474	.08372	.03389	.05501	.05670	.02743	.06595	.05979	.03583
-2	.04853	.06001	.06559	.02655	.04310	.03341	.02613	.08670	.06291	.02683
-3	.03415	.04906	.04570	.01850	.03003	.01990	.02109	.04437	.05887	.02032
-4	.02052	.03490	.02987	.01209	.01963	.01181	.01517	.09105	.05166	.01539
-5	.01117	.02304	.01876	.00759	.01233	-.04521	.01031	.08134	.04353	-.02047
-6	.00608*	.01461*	.01149*	.00464*	.00753*	-.02430	.00701	.06936	.03567	-.01309
-7	.00331	.00898	.00686	.00278	.00451	-.01315	.04770	.05731	.02865	-.00831
-8	.00180	.0540	.00405	.00164	.00266	-.00710	.00324*	.04630	.02265	-.00522
-9	.00098	.00319	.00236	.00095	.00155	-.00384	.00220	.03679	.01770	-.00323
-10	.00053	.00187	.00136	.00055	.00089	-.00208	.00150	.02885	.01369	-.00197
-11	.00029	.00108	.00078	.00032	.00051	-.00112	.00102	.02238	.01051	-.00118
-12	.00016	.00062	.00044	.00018	.00029	-.00061	.00069	.01722	.00801	-.00068
-13	.00009	.00035	.00025	.00010	.00017	-.00033	.00047	.01316*	.00607*	-.00038
-14	.00005	.00020	.00014	.00006	.00009	-.00018	.00032	.00999	.00458	-.00020
-15	.00003	.00011	.00008	.00003	.00005	-.00010	.00022	.00755	.00344	-.00009
-16	.00001	.00006	.00004	.00002	.00003	-.00005	.00015	.00568	.00258	-.00003
-17	.00001	.00004	.00002	.00001	.00002	-.00003	.00010	.00426	.00192	.00000
-18	.00000	.00002	.00001	.00001	.00001	-.00002	.00007	.00318	.00143	.00002
-19	.00000	.00000	.00001	.00000	.00001	-.00001	.00005	.00176	.00106	.00003
Steady state	.233	.314	.3516	.143	.231	.027	.143	.800	.481	.046

* Asterisks indicate that 95% of the steady-state impact is obtained.

4. The export price equations

The price indices for goods exported (see Chapter 5, section C) to the United States and to other countries (PXNMV12) and (PXNW13), respectively, are functions of a domestic price (PGPP), foreign prices (PFX*PXBNF2, PFX*PXWG), and the lagged dependent variable. The .17 long-term elasticity of PXNMV12 with respect to foreign prices is unfortunatly too low. The price index for exports of motor vehicles and parts to the United States (PXMV12) remains exogenous. Given the strong link between the Canadian and U.S. automotive markets, PXMV12 can be endogenized by a simulation rule that ties PXMV12 to the import price (PMMV12). Further research is currently being done by Benjamin Wurtzburger to see whether this impact can be increased. With more appropriate foreign price variables he obtains a foreign price elasticity close to one and a domestic price elasticity not significantly different from zero. These results reinforce the assumption that Canada is closer to a situation of a price taker. As mentioned in the concluding comment of Chapter 5, research is required on the rate of supply conditions in the export volume equations.

5. The government price equations

PGCNWG Price deflator for current nonwage government expenditure (equation 7.14)

This equation contains a lagged dependent variable, three trended seasonal variables, an Almon variable on the price of manufactured products from the United States (PMMP12), and another Almon variable on the Canadian price of consumer services

(PCS). These two Almon variables are weighted by the ratio of current defence expenditure, excluding military pay and allowances, to total government nonwage current expenditure, and to 1 minus this ratio, respectively. Given the downward trend in the ratio (GCSDD-GMPF)/(GCNWF+GCNWPM+GGGSH) the elasticity of the foreign price drops from .5 at the beginning of the estimation period to .1 at the end.

PINRCG Price deflator for government investment in non-residential construction (equation 7.15)

PIMEG Price deflator for government investment in machinery and equipment (equation 7.16)

The variables PINRCG and PIMEG are explained by a geometrically declining lag distribution on their corresponding price deflators for business investment, PINRC, and PIME. The low long-run elasticity obtained in the PIMEG equation (.640) reflects an important difference in the PIMEG and PIME growth rates, and also casts doubt on the quality of the PIMEG series.

6. The import price equations

Import prices expressed in Canadian currency (equations 7.24-7.40) are endogenized by technical relationships that constrain the import price to have a unit elasticity with respect to the exchange rate and with respect to the foreign price expressed in a foreign currency.

D. Dynamic Links Between the Price and Wage Sectors: A Three-Equation Simplified Model

In RDX2 the simulation responses of the price and wage sectors can be schematized at the steady state by a three-equation system. The consumer price index is basically a function of wages, labour, productivity, and foreign prices. On the other hand, wages (WQMMOB) and (WQC) are a function of productivity and of the consumer price index.

1. The simulation response of the consumer price index

By aggregating the equations of the five components of the consumer price index and then dropping the constant terms, the seasonal variables, and the supply-demand imbalance variables we obtained the equilibrium relationship:

$$\begin{aligned} \ln(PCPI) = {} & .667 \ln(WQMMOB) - .430 \ln(PRO*) \\ & + .184 \ln(PF) + .019 \ln(WQC) \\ & - .1073 \ln(ELEFF) \end{aligned} \qquad (1)$$

where

PRO* = UGPPS/NMMOB

PF = foreign prices

The long-term elasticity of PCPI with respect to wages is .686 and with respect to foreign prices is .184. Seventy-eight percent of the wage impact comes via the PCNDSD and PCSXR equations whereas 83 percent and 11 percent of the foreign price impact come via the PCNDSD and PCMV equations, respectively. The .237 difference between the WQMMOB coefficient and the PRO* coefficient is explained by the PCSXR equation, which has no productivity term. The elasticity of PCPI with respect to foreign prices is slightly greater than the input-output estimate of .156. However, the wage pressures are not large enough to bring the elasticity of PCPI with respect to total cost - wages and foreign prices - close enough to the preferred level of 1. The long-run elasticity of PCPI is .667 + .019 + .184 = .87. The productivity impact, with a long-run elasticity of -.537, is far from the minus 1 level preferred. In a partial simulation context this means that profits absorb the residual impact produced by a wage and a productivity increase of .13 and -.463, respectively. The partial simulation results presented in Figure 13 provide information about the speed of adjustment. Clearly most of the adjustment occurs in the first sixteen quarters. In the three cases, over 60 percent and 80 percent of long-term equilibrium is realized at the end of the first year or at the end of the second year.

2. The simulation response of the wage equation

The two wage equations (WQMMOB) and (WQC) explained in the previous section of this report can be represented at the equilibrium by the following equations:

$$\ln(WQMMOB) = \ln(PCPI) + .75 \ln(ELEFF) + .48 \ln(PRO^{**}) \qquad (2)$$

$$\ln(WQC) = \ln(PCPI) + 1.38 \ln(ELEFFC) \qquad (3)$$

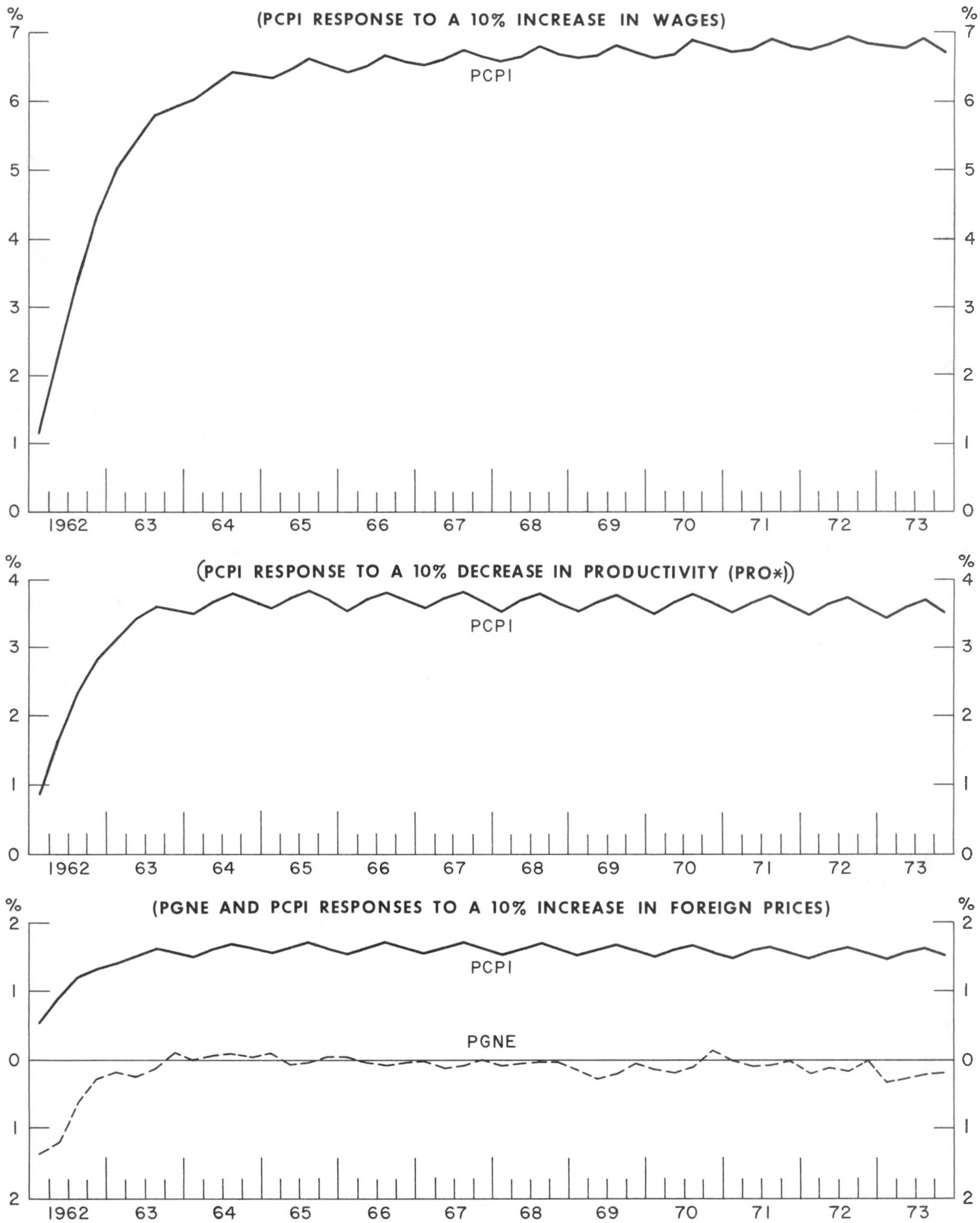
where

$PRO^{**} = UGPPA/NMMOBD$

In Figure 14 we focus on the speed of adjustment toward this equilibrium.

Figure 13

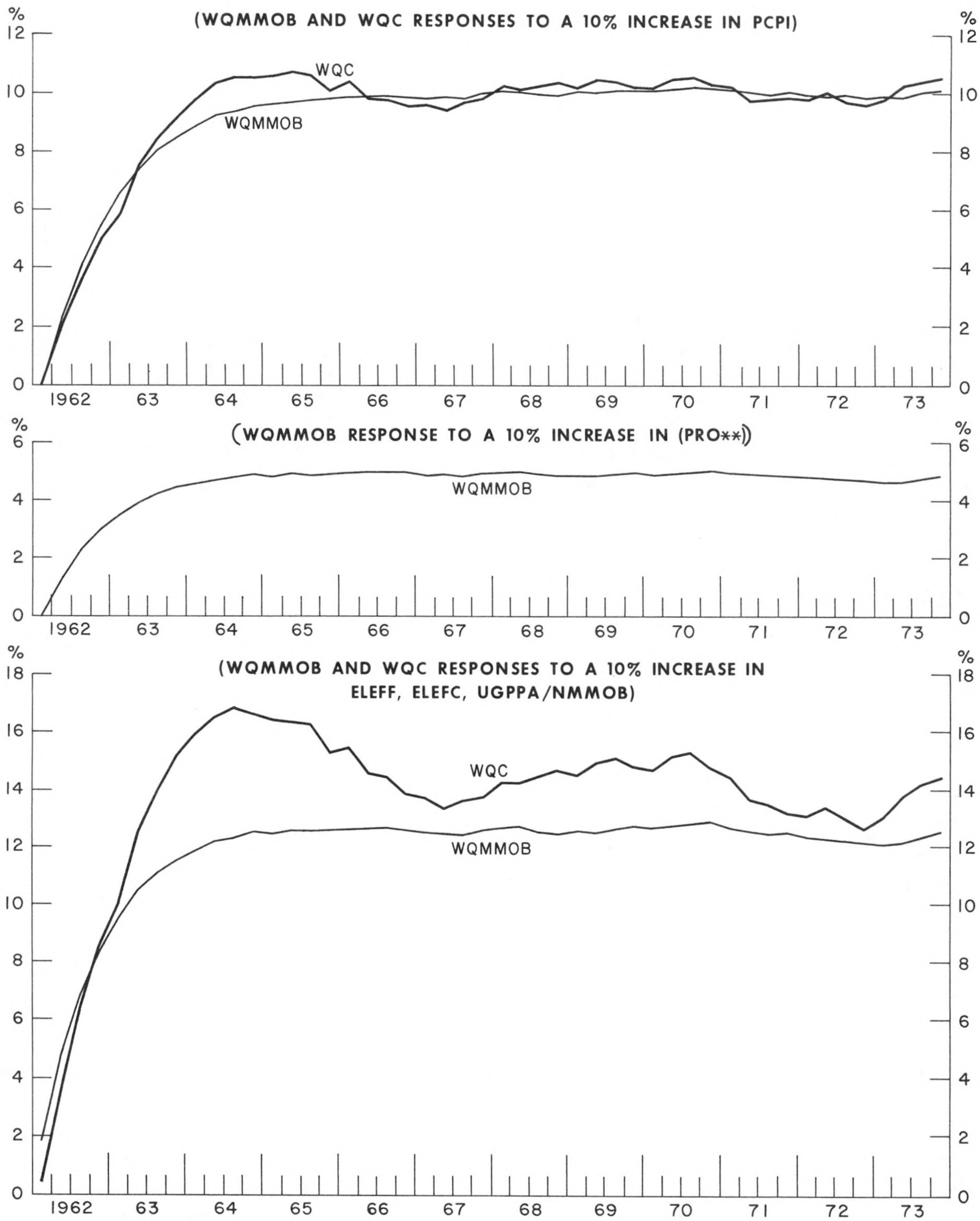
PRICE EQUATIONS†: SIMULATION RESULTS



† The price sector is Sector 7 plus the RCME and RCNR equations.

Figure 14

PRIVATE SECTOR WAGE EQUATIONS : SIMULATION RESULTS



By solving the above three-equation system with the assumption that PRO = PRO* = PRO** we obtain the following:

$$\ln(WQMMOB) = .13\ \ln(PRO) + .586\ \ln(PF) + 2.0\ \ln(ELEFF) + .084\ \ln(ELEFFC) \quad (4)$$

$$\ln(WQC) = -\ .35\ \ln(PRO) + .586\ \ln(PF) + 1.25\ \ln(ELEFF) + 1.464\ \ln(ELEFC) \quad (5)$$

$$\ln(PCPI) = -\ .35\ \ln(PRO) + .586\ \ln(PF) + 1.25\ \ln(ELEFF) + .084\ \ln(ELEFFC) \quad (6)$$

By subtracting (6) from (4) we obtain the following real-wage equations:

$$\ln(WQMMOB/PCPI) = .48\ \ln(PRO) + .75\ \ln(ELEFF) \quad (7)$$

$$\ln(WQC/PCPI) = 1.38\ \ln(ELEFFC) \quad (8)$$

These reduced form equations show that, if foreign prices increase by 1 percent and if there are no real changes in the economy, nominal wages and consumer prices will increase in the long term by around .6 percent. This result is important in the interpretation of foreign price shocks in RDX2 - see Aubry and Kierzkowski [4]. It also shows that, if there is a 1 percent increase in productivity, nominal wages (WQMMOB) will eventually increase by 2.214 (2.0+.13+.084) percent and consumer prices by .984 (-.35+1.25+.084) percent. Thus the real-wage increase will be 1.23 percent. This result can be explained by the wage equations. They imply an elasticity of wages in mining, manufacturing, and other business and in construction with respect to productivity greater than 1 (1.23 and 1.38, respectively). Because ELEFF and ELEFFC are exogenous variables in RDX2, only the endogenous productivity variable PRO will move under a shock other than an ELEFF or an ELEFFC shock. Thus, if a shock increases endogenous productivity (PRO) by 1 percent in the medium term, nominal wages will eventually increase by .13 percent and consumer prices will decrease by .35 percent, ceteris paribus, so that the increase in real wages will be .48 percent.

3. The simulation response of the price and wage equations

According to the simulation results presented in Figures 13 and 14 one can approximate the PCPI and WQMMOB relationships for purposes of exposition as follows, if one neglects ELEFF:

$$\ln(PCPI) = .183 \ln(WQMMOB) + .049 \ln(PF) - .111 \ln(PRO) + .7\ J1L(\ln(PCPI)) \quad (9)$$

$$\ln(WQMMOB) = .3 \ln(PCPI) + .225 \ln(ELEFF) + .144 \ln(PRO) + .7\ J1L(\ln(WQMMOB)) \quad (10)$$

The reduced form of this structural model is:

$$\ln(PCPI) = J1W \ln(PF) + J2W \ln(PRO) \quad (11)$$

$$\ln(WQMMOB) = J3W \ln(PF) + J4W \ln(PRO) \quad (12)$$

	J1W	%*	J2W	%	J3W	%	J4W	%
t = 0	.052	(12)	-.090	(45)	.016	(4)	.117	(41)
-1	.040	(22)	-.050	(71)	.023	(9)	.069	(65)
-2	.033	(30)	-.028	(85)	.026	(15)	.038	(70)
-3	.028	(37)	-.016	(93)	.027	(21)	.022	(87)
-4	.024	(42)	-.009	(97)	.026	(34)	.013	(91)
-5	.021	(48)	-.005	(100)	.025	(39)	.076	(93)
-6	.019	(52)	-.002	(101)	.023	(45)	.046	(96)
-7	.017	(56)	-.001	(102)	.021	(49)	.028	(97)
-8	.016	(60)	-.001	(102)	.020	(54)	.018	(98)
-9	.014	(64)	-.000	(102)	.018	(58)	.012	(98)
-10	.013	(67)	-.002	(102)	.017	(61)	.009	(98)
-11	.012	(70)	-.002	(102)	.015	(64)	.007	(98)
-12	.011	(72)	-.002	(102)	.014	(70)	.006	(99)
-13	.010	(75)	-.002	(101)	.013	(73)	.005	(99)
-14	.009	(77)	-.002	(101)	.012	(75)	.004	(99)
-15	.008	(81)	-.002	(101)	.010	(77)	.003	(99)
Steady state	.42	(100)	-.20	(100)	.42	(100)	.28	(100)

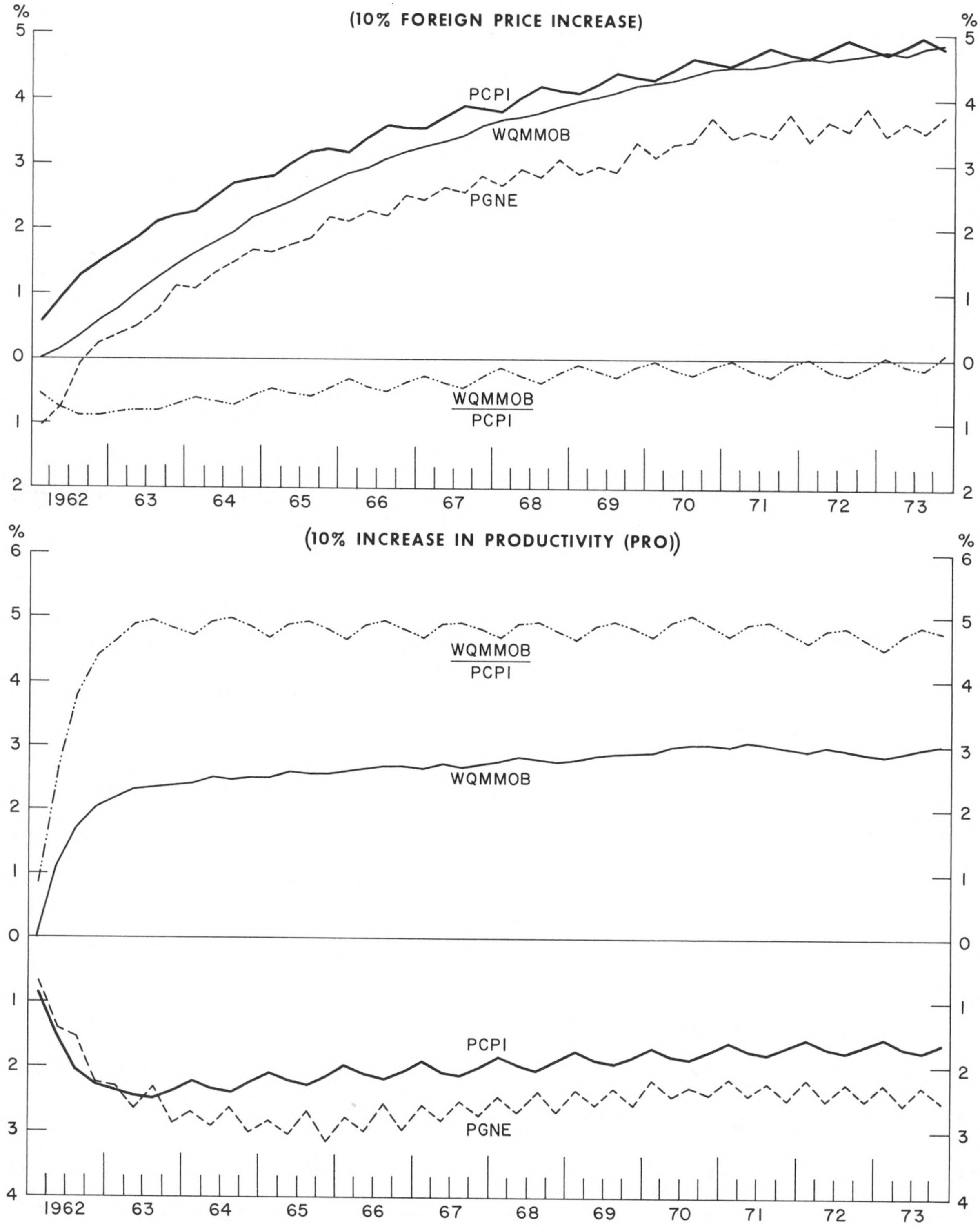
* Percentage cumulant.

A comparison of the results of simulations of the price and wage sectors, presented in Figure 15, with the above table shows the effectiveness of the reduced form in explaining price-wage linkages. Because of the slow speed of adjustment twenty-five quarters are required to obtain a consumer price index elasticity of .42 with respect to foreign prices. On the other hand, the response to an instantaneous 10 percent productivity increase is faster because prices decrease and wages increase simultaneously in order to push up real wages by about 4.8 percent. In fact the response of real wages to the productivity shock is at 93 percent of its long-term solution in only four quarters.

The dynamics of the price-wage sub-model under a productivity shock are very different in the short and medium term, if one takes into account the difference between the productivity term of the wage equation UGPPA/NMMOBD and the productivity term of the price equation UGPPS/NMMOB. If the lag

Figure 15

PRICE AND WAGE EQUATIONS : SIMULATION RESULTS



structure estimated between NMMOB and NMMOBD* (see equation 5.1) is used to link both productivity terms, then

UGPPS/NMMOB = .9(UGPPA/NMMOBD) + .91 J1L(UGPPS/NMMOB)

and the lag structures J2W and J4W in (11) and (12) will respond much more slowly. In the short and medium term the consumer price index will increase because workers capitalize on their actual productivity gains faster than on their expected long-term productivity gains.

The response of PGNE to a 10 percent increase in foreign prices, shown in Figures 13 and 15, reveals a negative short-term impact produced by the small short-term elasticity of domestic prices with respect to foreign prices. This lag structure implies that producer profits absorb the losses or the gains over the short term. When modelling a foreign price shock one must define the shock to be exogenous to export prices: PXMV12, PXMIS12, PXMIS13, PXNW13, and PXS. In the foreign price shocks presented in Figures 13 and 15 all these prices, except PXS, were increased throughout the simulation period by 10 percent.

E. Future Improvements

Interesting questions are raised in section D. First, the price and wage sectors should be approached as a single sector in order to solve the problem of the homogeneity of the price equation with respect to different costs and of the wage equation with respect to prices. We must therefore put a great deal of effort into the production of more homogeneous price equations. This effort will be crucial in determining the response of RDX2 to monetary and fiscal shocks. Second, we must try again to increase the impact of foreign prices, particularly on export prices, on the price deflator for other consumer durables, and on the price index for non-residential construction materials. Third, we must concentrate on the effect of the supply-demand imbalance, which should be reinforced if we are to gauge its short-term impact on monetary policy more accurately than is now possible.

Footnote

[1] We are indebted to Brian L. Scarfe for the advice he gave us as a consultant during the estimation of the price sector.

CHAPTER 8

INCOME COMPONENTS: SECTOR 8

Jean-Pierre Aubry

Leo de Bever

A. Introduction

In Sector 8 variables including expenditures, revenues, transfers, and direct and indirect taxes, which are explained in other sectors of the model, are brought together in a series of technical relationships such as gross national expenditure, gross national product and disposable personal income. There are also four stochastic equations in Sector 8 that explain dividends and the net income of nonfarm unincorporated business. In this chapter these four equations are analyzed. The equations modelling capital gains and corporate profits are also described together with the saving-investment identity. The reader is reminded that some of the income component identities, such as the disposable wage income and the permanent disposable nonwage personal income, are described and analyzed in Chapter 2.

B. The Dividend Equations

As in the preceding version of RDX2 [29] there are two dividend equations: one for dividends paid to Canadian residents (YDIV11, equation 8.1), and another for dividends paid to foreign shareholders (YDIVF, equation 8.2). Except for the exclusion of the lagged dependent variable in the YDIVF equation, the specification is the same as that in the two previous versions; ie, dividends are assumed to be proportional to a cash flow variable, defined as the after-tax profit plus book depreciation.

The ratio of the international indebtedness of Canadian residents to the replacement value of business capital stock determines the proportion of this cash flow attributable to Canadian and foreign shareholders. The indebtedness ratio has an average value of .48 over the sample period 1Q58-4Q72, but has followed a strong downward trend since 1958 (.53 in 1958 and .43 in 1972). For Canadian and foreign shareholders the payout ratio is 17.2 percent and 22.3 percent of the cash flow respectively. In terms of after-tax profits, the payout ratio is 32.3 percent and 41.4 percent respectively, according to 1972 data series.

C. Net Income of Nonfarm Unincorporated Business, Including Rent

In this version of the model the net income of nonfarm unincorporated business, including rent (YNFNC, equation 8.3), and nonfarm non-residential unincorporated business rent (YRENT, equation 8.4) are endogenous. The quarter-over-quarter change in YNFNC-YRENT is a function of the quarter-over-quarter change in corporate profits and in the labour income accruing to this group, approximated by WQMMOB*NEUPB. The change in corporate profits is lagged to allow for differential cyclical behaviour in the two income categories. The rent component of YNFNC, which is YRENT, is explained by the value of the stock of multiple dwellings. We tried without success to include the value of the stock of single-detached dwellings.

D. Gross Private Business Product

In Chapter 4, the gross private business product (YGPP) was shown to be one of the key concepts in RDX2. It is obtained by subtracting from gross national expenditure (YGNE) the following variables: government wage expenditure, indirect taxes less subsidies, government capital consumption allowances, gross rent, and the accrued farm income. In the next version of the model, we plan to include a definition of the gross private domestic business product by removing from YGPP the value added by Canadian producers abroad and by including the value added by foreign producers to Canadian production.

E. Corporate Profit Before Taxes

In the original version of RDX2, corporate profits before tax (YC, equation 8.1 [32]) were explained stochastically by three explanatory variables approximating charges for the use of capital, sales plus inventory accumulation, and the cost of labour. In that version, the discrepancy between total expenditure and the revenues in the National Accounts framework (YRES, equation 8.7, [32]) was defined as an endogenous variable. In this version, corporate profits, being residually determined, automatically adjust the revenues to the National Accounts expenditure. With this specification the YRES equation is no longer needed.

F. Capital Gains

The accrued capital gains (YKGPA, equation 8.13), the stock of accrued unrealized capital gains (AYKGPA, equation 8.14), and the realized capital gains (YKGPR, equation 8.15) are modelled in Sector 8. The main variable, accrued capital gains, has two components: capital gains resulting from the increase in market valuation of the business capital stock, and direct capital gains of Canadian residents resulting from retained earnings. The first component is multiplied by two terms: the 1968 proportion of total business capital not owned by government business enterprises (.775), and the proportion of return on Canadian business assets that goes to Canadian residents. Accrued unrealized gains are cumulated into a stock, with realized gains (YKGPR) being defined as 1.8 percent of the stock. This value is an estimate of the proportion of accrued gains that would be realized and is based on U.S. experience and adjusted to reflect particular aspects of the Canadian law on capital gains. Since 1972, capital gains have been taxable income, therefore in Sector 9, YKGPR is added to assessed nonwage income (equations 9.18-9.21).

It should be noted that capital gains resulting from changes in the market value of government bonds held by Canadian residents are not included in YKGPA as they were in the previous capital gains variable, YKGP. Given the fact that the personal sector held a small proportion (approximately 16 percent in 1972) of the government bonds (with the exception of savings bonds, treasury bills and bonds held by foreigners), realized capital gains or losses are very small and have been excluded. The 1972 taxation data support this procedure.

G. The Saving-Investment Identity

When a shock is analyzed, it is useful to be able to describe its impact on the saving and the investment decisions of the various economic agents. The saving-investment identity is not directly coded in the model specification. This identity can be derived however, by solving the following subset of RDX2 equations: YGNE (8.5), YC (8.8), YCR (8.11), GBALF (14.6), GBALPM (14.7), GBALH (14.8), GBALCPP (14.10), GBALQPP (14.11), TILGS (10.8), YTOTPM (13.9), YDP (8.10), TPYF (9.4) and TCAPM (9.32) with the following result:

IPRF$ + IIB$ + GCAP$ + IIG$ + ENARES$ = SVF + SVP + SVC + SVG
  - ENARES$

where

Total consumption expenditure

CON$ = PCNDSD*CNDSD + CS*PCS + CMV*PCMV + CDO*PCDO

Private fixed investment

IPRF$ = IRC*PIRC + IME*PIME + INRC*PINRC

Change in business non-farm inventories

IIB$ = J1D(PKIB*KIB) + YIVA

Government fixed capital expenditure

GCAP$ = (INRCGF+INRCGPM+INRGSM)PINRCG
  + (IMEGF+IMEGPM)PIMEG + IH*PIH

Government current expenditure on goods and services

GCUR$ = GCNWF + GCNWPM + NGPAF*WQPAF + NGPAPM*WQGPAPM + NIS*WQISM
  + GCGSH + GCGSQPP + GCGSCPP + GWIF + GWSF + GWPASPM
  + GWIPM + GWSSM + GMPF

Gross foreign saving

SVF = XBAL$ - MIH$ + XIH$

Gross personal saving

SVP = YDP - CON$ - (YF-YFA) - MTRP$ - YTCORP + CCA$
  - CCAC$ - CCAGF$ - CCAGPM$ - CCAGH$

Gross government saving

SVG = GBALF + GBALPM + GBALH + GBALCPP + GBALQPP + GCAP$ + IIG$

Gross corporate saving

SVC = YCR + YIVA + GASSTF + GASSTPM + YCRGBE + CCAC$

Transfers to the corporate sector

YTCORP = YMISCP + YCRGBE + YGICPP + YGIQPP - GTPINTH

Undistributed profit of government enterprises

YCRGBE (Cansim, D40117)

Net saving, as reported in the National Accounts, can be retrieved by removing the capital consumption allowance from the gross saving terms.

CHAPTER 9

DIRECT TAXES AND OTHER CURRENT TRANSFERS FROM PERSONS: SECTOR 9

Leo de Bever

Elisa McFarlane

A. Introduction

One of the major changes in this version of RDX2 is the revised personal income tax model (equations 9.1-9.34 and S.9.1-S.9.191), which is extensively described in section B. The distribution of income is now endogenous and the 1972 income tax reform and subsequent indexing provisions are explicitly modelled. The main ideas underlying the modelling of the remainder of Sector 9 are summarized in sections C and D.

Upper case variables refer to RDX2 concepts; for exposition purposes lower case variables are defined, following RDX2 nomenclature conventions wherever possible.

B. The Personal Income Tax

The income tax model in RDX2 provides the rest of the model with the level of aggregate income tax revenues (tp). The total personal income tax revenues are divided into TPS and TPO for the determination of tax incidence, and into TPYF and TPYPM to establish the division of revenues by level of government.

The amount of taxes withheld at source (TPS, equation 9.1) is interpreted in RDX2 as a tax on wage income. Taxes not withheld at source (TPO, equation 9.2) are viewed as a tax on nonwage income. The main impact of TPS is on YDW (disposable wage income, equation 8.7) and TPO mainly affects YPDNWP (permanent disposable nonwage personal income, equation 8.12).

The federal portion of tp, TPYF (equation 9.4), increases the federal government's National Accounts balance (GBALF, equation 14.6). The provincial personal income tax revenue share (TPYPM equation 9.3) augments provincial-municipal revenues (YTOTPM, equation 13.9) and the provincial-municipal National Accounts balance (GBALPM, equation 14.7).

A universal flat-rate personal income tax with no exemptions, deductions, credits, 'gross-ups', allowances, write-offs, surcharges or abatements would be simple to model; unfortunately, from a modeler's viewpoint, Canadian income tax legislation is much more complicated. The tax was not designed merely to generate revenue, but also to modify the distribution of disposable income in favor of low-income earners by means of exemptions invariant with income and progressive tax rates. Recently, the tax has become an important vehicle for tax expenditures, ie, subsidies granted through differential treatment of specific income or expenditure components such as Registered Retirement Savings Plans, Registered Home Ownership Savings Plans, and the interest and dividend income exemption. These multiple objectives often give rise to complicated tax provisions. How many of these rules need to be modelled depends on their revenue impact and on the purpose of the analysis. A fiscal-policy study requires more careful attention to detail than a macro-impact analysis. Since RDX2 is used extensively for both purposes, a compromise has been struck which tends to come down quite heavily on the side of detailed analysis.

The current RDX2 tax model is similar to that of the previous version [29] for the period up to 1972. Minor revisions were made to incorporate changes in the tax base following the tax reform of 1972. Additional changes were required following the introduction of indexing in 1974. When the model is used to simulate the period after 1974 a more complex specification is employed, which captures the effects of indexing of the tax brackets and personal exemptions on income distribution.[1] Henceforth, the terms 'pre-1974' and 'post-1974' are used to distinguish between these two sets of equations. Virtually all discussion of model modification refers to the post-1974 specification.

Before discussing specific equations, it is useful to outline the steps required in setting up a model that captures the details of income tax legislation.

First, such a model must specify the tax base subject to assessment under the law. Total assessed income must be modelled as a function of personal income and modified to reflect those items exempted by law. Given the distinction in RDX2 between taxes on wage income and on nonwage income, a similar distinction needs to be made in modelling the base of assessed income.

Next, the number of persons filing tax returns must be modelled, since the total dollar amount claimed in exemptions varies with the number of taxpayers.

Because of the progressive tax-rate schedule, the proportion of assessed income found at a given level of assessed income per return must be specified. Ideally, this should be done with an explicit model of the income distribution. A major difference between the post-1974 model and previous versions of RDX2 is the endogenous specification of transitions in the income distribution.

Exemptions and deductions per return must be calculated, since these items are subtracted from assessed income to yield taxable income.

The effective rate of taxation on taxable income must then be determined from the statutory tax-rate schedules, given the distribution of taxable income. Summing across income classes yields an estimate of total tax accruals. Since 1974, the income tax rate schedule, and many (mainly personal) exemptions and deductions have been indexed. As stated earlier, the post-1974 equations in RDX2 take this into account in the determination of deductions and effective tax rates.

Finally, tax collections must be modelled as a function of accruals over the tax year. Settlements give rise to a seasonal pattern in collections, aggravated by nonuniformity in withholding requirements for wage income and nonwage income. Tax accruals must be modified for dividend tax credits, foreign tax credits, and for rebates applied to statutory tax liabilities.

The characteristics of the current RDX2 income tax model are analyzed in section B.8. Suggestions for change in the tax model are contained in section B.9. In section B.10 a more condensed income tax model is presented for those RDX2 users primarily interested in a macro-forecast of income tax revenues.

1. Assessed income

This version of RDX2 distinguishes two components of assessed income: assessed wage and related income (YWAS, equation 9.8), and assessed nonwage income (YNWAS, equation 9.9). The distinction was motivated by the difference in the withholding requirements for these two income categories, which has implications for the seasonality of tax collections. Moreover, the two-way split seemed useful in determining income tax incidence.

Both YWAS and YNWAS are linked to the relevant components of personal income (YP), via a time trend, as follows:

YWAS = .79417(YW+GMPF-YWSLP-GWSF-GWPASPM-GWSSM)
+ .00741(YW+GMPF-YWSLP-GWSF-GWPASPM-GWSSM)(QTSTEP)
+ (QTXRFM)(YWSLMED+GTPUIBF) + (QTFA)(GTPFAF)

YNWAS = .37401(YP-GMPF-YW-YRENT-YDIV11-GTPUIBF-GTPFAF)
+ .00331(YP-GMPF-YW-YRENT-YDIV11-GTPUIBF-GTPFAF)
(QTSTEP) + (QTXRFM*.33+1)(EYDIVA11)
+ (QTXRFM*.5*YKGPR)

Over time, assessed income has tended to grow faster than personal income because of increased efficiency in the tax collection system, more stringent income-reporting requirements, and a reduction in the proportion of income exempt from taxation at the low end of the income distribution.[2] This phenomenon was mainly due to the constancy of personal exemption maxima in the face of rising average rates of pay (until indexing was introduced in 1974).

Note that after the 1972 tax reform (QTXRFM=1) YNWAS includes capital gains. In the same year, a dividend-withholding tax came into effect, paid by Canadian companies declaring dividends and partially refundable to the dividend recipients. To this end, declarations of dividends from Canadian corporations must be 'grossed up' by the 33 1/3 percent withholding tax, and dividend tax credits subsequently subtracted from tax liabilities (equation 9.6, TANW). The 1972 tax reform provided for taxation of unemployment compensation (GTPUIBF) and employer-paid medical premiums (YWSLMED). In 1974, family allowances (GTPFAF) were also made taxable.

The time trend linking YWAS and the personal income tax base in RDX2 is dynamically untenable: after 1977, taxable wage income is predicted to exceed total wage income at an ever increasing rate. Long-run simulations with the current version should therefore constrain YWAS.

In Table 8 the components of taxable income and of YP, the National Accounts definition of personal income, are compared. Also shown, for each item, is the assessment ratio, ie, the proportion of the National Accounts figure for YP, or its components, which appears on tax forms. Assuming that 1974 is not atypical, the table provides a rough test of the assumption (underlying the YWAS and YNWAS equations) that assessment ratios are the same for all items within the wage and nonwage income categories.

YWAS is linked to the first three items in the table. Assessment ratios are roughly the same, indicating that it might have been appropriate to include GTPFAF and GTPUIBF in the time trend.

More serious problems arise with nonwage income. In an attempt to exclude imputed rents on owner-occupied dwellings from nonwage income, noncorporate income (YNFNC), the RDX2 equation for YNWAS subtracts YRENT (non-residential unincorporated business rents) from the tax base. The National Accounts

Table 8

COMPOSITION OF ASSESSED INCOME TAX BASE AND OF PERSONAL INCOME IN 1974
(Millions of 1974 dollars)

	Assessed Income	Personal Income	Assessment Ratio
Wage income received (YW+GMPF-GWSF-GWPASPM -GWSSM+YWSLMED) *	73,501	76,438	.96
Unemployment insurance (GTPUIBF) *	1,958	2,121	.92
Family allowances (GTPFAF) *	1,616	1,769	.91
Residual (investment income & private pensions) **	8,942	9,903	.90
Net nonfarm noncorporate income (YNFNC) minus net imputed rents **	4,430	5,045	.88
CPP&QPP (GTPQPP+GTPCPP) **	389	499	.78
Farm income (YF) **	1,893	3,204	.59
Federal old age pensions **	1,469	3,303	.44
"Gross-up" portion of dividends **	305	excluded	?
Capital gains (YKGPR) **	282	excluded	?
Other transfers (GTPOF+GTPPM - old age pensions)	excluded	6,023	0
Wage supplements (GWSF+GWPASPM+GWSSM -YWSLMED)	excluded	835	0
Imputed rent	excluded	2,329	0
	94,785	111,469	.85

* Included in YWAS equation.
** Included in YNWAS equation.

imputation of rents on owner-occupied dwellings of $2,329 million is about $1,000 million higher than YRENT in 1974.[3]

In addition, certain predominantly non-taxable transfers (GTPOF+GTPPM net of federal old age pensions) are left in the tax base. Federal old age pensions, farm income, and (to a lesser extent) CPP and QPP benefits turn out to have low assessment ratios. Investment income and nonfarm, noncorporate earnings are assessed at a rate only slightly lower than that for components of wage income.

Unless income composition is constant, the existing RDX2 equation for YNWAS gives rise to distortions in the estimation of the tax base. A fiscal stimulus affecting YNFNC (but not YRENT) and other investment income by $100 million will lead to an increase of about $46 million in the tax base, using the present YNWAS equation for 1974. The figures in Table 8 suggest that, given an assessment ratio of .9 for both YNFNC and investment income, the tax base should increase by about $90 million. For 1974, an exogenous increase of $100 million in GTPOF has a direct positive effect of $46 million on the RDX2 equation for YNWAS, whereas figures in Table 8 indicate that the effect is likely to be very small.

2. Number of tax returns filed

In RDX2 it is assumed that the number of tax returns filed (NT) is a linear function of the number of people employed (NE) and the number of old age pension recipients (NOAPR), ie,

$$NT = -2.6604 + 1.2457\,(NE+NOAPR)$$

This equation fits the period 1962-1972 very well, and is probably satisfactory for short-term forecasts; however, its long-term dynamics are open to question, since NT would eventually exceed the entire population over fourteen, which is undoubtedly the upper limit of this variable. The constrained coefficient on NOAPR contradicts the fact that the number of claims for the old age exemption is always far lower than NOAPR ([47], table 2).

The increase in NT is the result of the increasing proportion of personal income subject to taxation. This in turn is partially due to a decline in the relative importance of the personal exemption as a factor absolving part-time workers from the requirement to file a tax return. There has been a secular decline in the number of hours required, at average hourly Canadian wages in manufacturing, to reach an income level equal to the personal exemption, as is shown in Table 9 ([15], p 111 and [47], p 182).

Table 9

HOURS OF WORK, AT AVERAGE INDUSTRIAL WAGES, REQUIRED TO REACH A LEVEL OF INCOME EQUAL TO THE PERSONAL EXEMPTION

	Personal Exemption($)	Average Hourly Earnings in Manufacturing($)	Hours of Work Required to Reach Exemption Level
1966	1000	2.25	444
1968	1000	2.58	388
1970	1000	3.01	332
1972	1500	3.54	424
1974	1706	4.37	390
1976	2000	5.76	347

Moreover, even many casual workers now file individual returns to recoup excess CPP, QPP, UIC contributions, or excess taxes withheld at source.

An exploratory analysis taking these factors into account yielded the following equation (OLS, 1952-1975, annual)

$$\ln(NT/NPOP) = \underset{(4.44)}{.88660} + \underset{(4.73)}{1.0789} \ln ryas + \underset{(2.42)}{.83839} \ln(NE/NPOP) + \underset{(6.48)}{.24280} \ln(NOAPR/NPOP)$$

see = .0107 RB2 = .991 dw = 1.96

where

ryas is the assessment ratio of total personal income.

This equation predicts that the number of tax returns grows at about the same rate as the labour force. The trend in NT is absorbed by the increasing level of ryas. A more sophisticated version of this equation might take into account the fact that unemployment benefits are now taxable and that (NT/NPOP) is partially a function of allowable exemptions.

3. Income distribution

In the pre-1974 RDX2 income tax model it was assumed that, at any time t, an exogenous proportion of YWAS accrued to taxpayers reporting income in four broad income classes ($1-$3,000, $3,000-$5,000, $5,000-$10,000, and greater than $10,000). The same assumption was used for 'spreading' YNWAS and NT across the range of assessed income. Over time, fixed income ranges become troublesome, because of inflation. Eventually, all income and all taxpayers end up in the highest income range. In 1964, only about 10 percent of wage income accrued to taxpayers in the highest income class of RDX2. By 1975, this figure approached 70 percent. To circumvent this problem, and to accommodate the tax reform regulations calling for indexing of tax brackets by 1974, the frequencies of YWAS, YNWAS, and NT were made endogenous in RDX2 as independent, displaced lognormal functions[4] [1], [41], defined over the range of assessed income per return. See Grady and Stephenson [22] for a detailed description of this work.

The distributions of YWAS, YNWAS, and NT were estimated using data from Taxation Statistics [47]. All three distributions exhibited positive skewness. The distribution of NT was the least positively skewed and that for YNWAS the most positively skewed, mainly because of the heavy concentration of pension income in the lower income groups.

After a satisfactory function had been found to describe the three distributions for a given tax year, the intertemporal change of the parameters in each of the three distributions had to be linked to various economic determinants. The parameters of the lognormal distribution can be written in terms of the income levels associated with the distribution quantiles. Hence, either the distribution parameters can be modelled, or the quantiles can be modelled and the distribution parameters derived. It was decided at the time to model the quantiles.

The assessed income per taxpayer, seasonally adjusted at annual rates, is used to explain the quantiles. Quarterly observations for the quantiles were obtained by linear interpolation from the annual taxation statistics. Implicit in the estimated equation is the assumption that the logarithm of the quantile is a linear function of the logarithm of the assessed income per taxpayer. This specification maintains constant elasticity of the quantiles with respect to assessed income per taxpayer. From the results (equations S9.1-S9.9) it can be seen that the elasticity is lowest for the lower quantile and highest for the upper quantile. In retrospect, it might have been better to estimate the quantiles annually. No new information is added by changing annual data to quarterly data through arbitrary adjustments. The procedure followed by Grady and Stephenson [22] is essentially equivalent to duplicating the same set four times, which biases the R2 upward.

The distribution functions are used to obtain the proportions of assessed income and taxpayers in fourteen fixedboundary income groups (equations S9.19-S9.60).[5] From then on, all calculations are performed using this fourteen-part discrete division of the income distribution. To conform to the pre-1974 presentation of results, a further consolidation of the fourteen groups into four income classes takes place after the tax liabilities for the fourteen groups have been defined.

Once the spreading ratios by income group are endogenous, it is possible to derive the number of taxpayers, assessed wage income, and assessed nonwage income by income group.

4. Exemptions and deductions

In the pre-1974 specifications, exogenous values for total exemptions and deductions by type of income and income class (ZEXYWiC and ZEXYNWiC) are derived from Taxation Statistics [47]. Annual figures are distributed quarterly using the assumptions that average exemptions and deductions for wage returns are the same as those for nonwage returns, and that deductions follow the historical seasonal pattern of YWAS and YNWAS respectively.

In the post-1974 specification, the average annual unindexed level of total exemptions and deductions per return within an income group (ZEXYGj) is assumed constant. The same assumption is made for unindexed personal exemptions (ZEXPERj). Average annual indexed exemptions and deductions in each income class (ZEXYGTj) are equal to ZEXYGj + (ZEXPERj)(.8558RTI-1) where .8558 is the fraction of personal exemptions (ie, personal exemptions appearing on non-Quebec returns) that is indexed (equations S9.70-S9.111). The indexing factor RTI (equation 9.30) is derived from the consumer price index (PCPI), in accordance with statutory provisions [16]. Wage returns and nonwage returns are again assumed to have the same level of (indexed) exemptions and deductions within each income group. For comparison with the pre-1974 model, deductions and exemptions for the fourteen income groups are aggregated to yield average exemptions and deductions by the four income classes (ZEXYWiC and ZEXYNWiC), using the spreading ratios for NT (USRNTj) and the seasonal factors for wage income (WZEXW) and nonwage income (WZEXNW, equations S9.112-S9.137).

Income tax expenditures are quite significant, and are likely to become even more so in the future. This makes it imperative that the tax model be structured to facilitate analysis of specific tax changes in this area. For example, RDX2 does not currently model the impact of Registered Home Ownership Plans (RHOSPs) and Registered Retirement Savings Plans (RRSPs), because they are relatively new. The same is true for the pension and interest income deduction, and the dividend income deduction.[6]

5. Accrued taxes

In previous versions of RDX2 accrued taxes (tpa) were modelled as a function of the exogenous average effective tax rate (rtp), assessed income (ypa), the number of tax returns (NT), and exogenous exemptions per return (z), ie,

$$tpa = rtp(ypa - NT.z)$$

Since tax laws in fact call for a progressive rate of marginal income taxation, ypa and NT were divided into the four assessed income classes discussed earlier, using exogenous spreading ratios (rypai and rnti respectively). Class-specific average effective tax rates (rtpi) and exemption levels (zi) replace rtp and z:

$$tpai = rtpi(ypa \,.\, rypai - NT.rnti.zi)$$

$$(i = 1, 2, 3, 4)$$

$$(rypa1 + rypa2 + rypa3 + rypa4 = 1)$$

$$(rnt1 + rnt2 + rnt3 + rnt4 = 1)$$

This modification unfortunately had little effect, since the average effective tax rate also serves as the marginal tax rate in each class. Holding NT constant, total exemptions are still equal to NT.z and

$$rtp = (rypa1.rtp1 + rypa2.rtp2 + rypa3.rtp3 + rypa4.rtp4)$$

That is, a fixed-weight average of constant effective tax rates, yields a constant overall effective tax rate. A progressive income tax model must allow taxpayers to 'graduate' to a higher tax bracket when income increases. In the pre-1974 equations, an increase in taxable income merely leads to a proportionate increase in income for all assessed income classes, taxed at the average tax rate, rtpi. This amounts to a form of indexing.[7]

In the post-1974 specification the spreading ratios, rypai and rnti, are calculated endogenously, which largely eliminates the anomaly discussed above. Moreover, the average tax rates are calculated directly from the tax tables, instead of being exogenously fixed, as in the pre-1974 equations.

In RDX2 a distinction is made by income group, after 1974, between basic federal tax rates (equations S9.152-165) and federal tax rates (equations S9.138-151). The second set of rates is equal to the first set of temporary federal tax cuts from statutory rates. The non-Quebec provincial tax rate is a surcharge on the federal basic tax liability. Quebec has its own non-indexed rate schedule (equations S9.166-S9.179). The group tax rates described above are consolidated into class rates using an income-weighted average of the group rates (equations S9.180-191).

6. Collections

Equations 9.1 and 9.2 link collections to accruals under the assumptions that deductions at source (TPS) constitute taxes on assessed wage income (YWAS) and that other collections (TPO) are taxes on assessed nonwage income (YNWAS). The collection ratio (TPO/TPS) is approximately .2 for most years. By contrast, the accruals ratio (TANW/TAW) is only about .14. Annual and quarterly comparisons for 1974 are listed in Table 10.

Table 10

ACTUAL INCOME TAX COLLECTIONS AND RDX2 ESTIMATES OF TAX ACCRUALS

	TPS	TAW	TPO	TANW	TPS+TPO	TAW+TANW
Q1	3098	2507	549	362	3647	2869
Q2	2238	2635	1372	393	3610	3028
Q3	3754	2841	574	441	4328	3282
Q4	4127	2860	443	394	4570	3254
Year	13217	10843	2938	1590	16155	12433

The seasonal difference of TPS and TPO compared to TAW and TANW was expected, because of the method of tax collection; however, RDX2 underpredicts annual accruals by about one-fourth (one-fifth for TPS, one-half for TPO). As long as the difference is systematic, and can be absorbed by a shift factor, the equations for TPS and TPO will perform reasonably well, but this underestimation is disappointing in view of the attention given to accurate representation of the income distribution. It was impossible to pinpoint a single source for this discrepancy, but a few partial explanations can be given. In Helliwell et al. ([26], p 142) average group tax rates are combined into an average tax rate for each income class, using as weights the assessed income of each group, instead of taxable income. This approximation is only applicable if the proportion of assessed income claimed as deductions and exemptions does not vary with the level of income. It is also pointed out in Helliwell et al. ([26], p 143) that evaluation of the tax rate at the mean of an income class understates the tax rate because of progressiveness in the rate schedule.

Collections at source (TPS) are linked solely to accruals on wage income (TAW). Other collections (TPO) are assumed to be related to accruals on nonwage income (TANW). Strictly speaking this is not correct, because of the treatment of withholdings in the series from which TPS and TPO are derived. Taxpayers that derive the majority of their income from wages and salaries will not pay taxes on their nonwage income until they file a return. Hence, the refund they receive constitutes overpayment of taxes on wage income minus taxes on nonwage income; however, only the final refund is subtracted from TPS, making this variable a mixture of wage and nonwage taxes. All taxes not collected through withholding (including taxes on wage income assessed when the return is filed) are included in TPO. In the future, it would be advisable to estimate taxes on wage and nonwage income directly from the distribution of total income and deductions.

The revenue split between federal and provincial governments (TPYF and TPYPM) is a fairly straightforward function of institutional arrangements. The RDX2 equation for TPYPM relates the income distribution to the difference in tax systems between Quebec and the rest of Canada. Unfortunately, this added detail contributes little to the explanatory power of the TPYPM equation.

7. Sensitivity analysis of the income tax model

The results of a sensitivity analysis of the tax model are presented in Table 11. For sensitivity analysis, the post-1974 equations were stripped of all lags and of modifications which allow for special cases, eg, discontinuous tax abatements and surcharges in effect at various times. Nominal income was increased for all taxpayers by 10 percent, under the assumption that real income remained constant. By exogenizing various parts of the post-1974 model, the importance of some of its provisions can be analyzed and compared with the pre-1974 tax model.

Column 1 in Table 11 is roughly equivalent to the pre-1974 RDX2 equations.[8] The distributions of income and taxpayers are assumed to be exogenous. Average tax rates by income group are also fixed at historical levels. The elasticity of aggregate revenue in this version of the model is 1.5. From column 3 it is apparent that the correction for progressiveness in the tax rate

Table 11

ELASTICITY IN RDX2 OF PERSONAL INCOME TAX ACCRUALS AND COLLECTIONS WITH RESPECT TO AN INCREASE IN TOTAL ASSESSED INCOME

	Fixed Income Distribution Fixed Group Tax Rates		Fixed Income Distribution Flexible Group Tax Rates			Flexible Income Distribution Flexible Group Tax Rates		
	Indexing		Indexing			Indexing		
	(1) None	(2) Full*	(3) None	(4) Partial**	(5) Full	(6) None	(7) Partial	(8) Full
Aggregate revenue (TPS + TPO)	1.57	1.17	2.09	1.35	1.25	1.75	.98	.88
Taxes on wage income (TPS)	1.54	1.16	2.04	1.34	1.24	1.77	1.05	.95
Taxes on nonwage income (TPO)	1.68	1.20	2.32	1.42	1.31	1.63	.70	.58
Federal revenues (TPYF)	1.72	1.21	2.29	1.38	1.33	1.89	.89	.83
Provincial revenues (TPYPM)	1.26	1.07	1.66	1.30	1.11	1.52	1.14	.95

* Full indexing - assumption made that all provinces index their rate schedules and exemptions.
** Partial indexing - allowance made for Quebec's separate, non-indexed tax collection system.

schedule increases the elasticity by .5, but when tax rates and the income distribution are made endogenous, (column 6) elasticity increases by only .2. Column 6 may also be interpreted as the post-1974 model's response to a real income shock. The post-1974 response to a nominal shock in a fully indexed system is given in column 8. Discontinuities in the modelling of exemptions and tax rates appear to bias the revenue elasticities downward, particularly for taxes imposed on nonwage income.

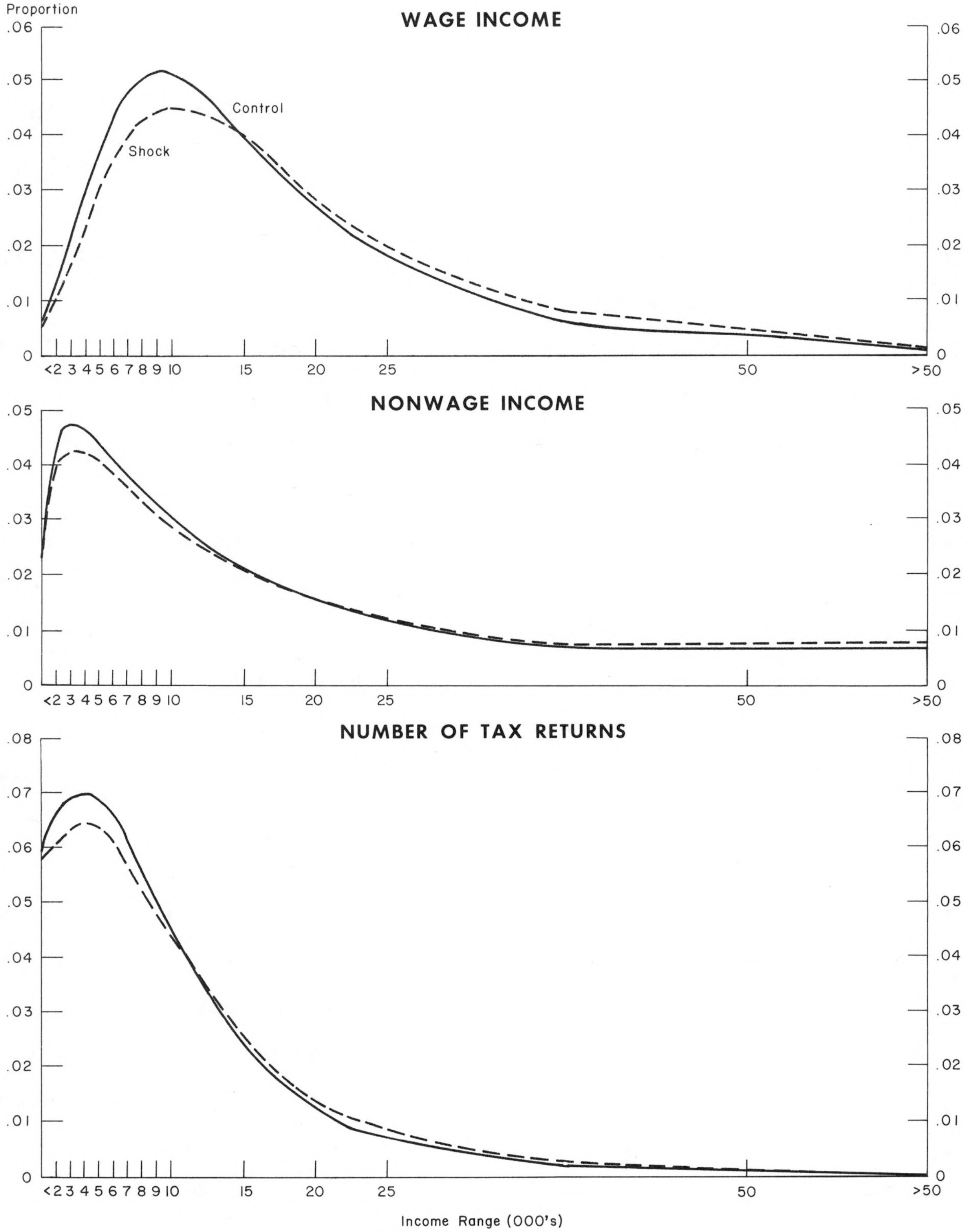
Quebec has chosen not to index tax rates and exemptions. The impact on the overall revenue elasticity of this decision can be gauged by comparing the full indexing, shown in column 8, with the RDX2 approximation for Canada as a whole given in column 7. The endogenous shifts of the distributions of NT, YWAS, and YNWAS in response to a 10 percent shock in average income are illustrated in Figure 16. Since the total area under each curve equals one, the changes in each distribution are offsetting, ie, the sum of the differences between shock and control equal zero by definition.

8. Suggestions for change

The post-1974 income tax model represents a significant improvement in the modelling of income tax legislation. Progress has, however, been accompanied by increased complexity, partly to keep all specifications compatible with the pre-1974 formulation. This section briefly describes how the implementation of the general idea underlying the new tax model could be streamlined and extended.

Figure 16

DISTRIBUTION OF WAGE INCOME, NONWAGE INCOME, AND TAX RETURNS BY ASSESSED INCOME GROUP



Complexity arises from two sources:

(1) The use of separate density functions for YWAS, YNWAS, and NT.

(2) Discontinuous approximation of spreading ratios for income and deductions, using fourteen income groups.

Independent density functions for YWAS and YNWAS are hard to justify, since a tax return usually contains income from both categories. Hence, a change in the distribution of YWAS will typically imply a change in the distribution of YNWAS. Moreover, given the distribution of NT (f) over the range of assessed income (y), the distribution of total assessed income is equal to the integral of f(y)*y/YASP. It would therefore be preferable to estimate only f(y), and to derive from f(y) the distribution of income. Exploratory research has indicated the feasibility of estimating the wage proportion in income as a function of y/YASP or a similar transformation of y designed to capture the position of a tax return in the income distribution.

Discontinuous approximations for the average level of deductions and exemptions within each income group can be replaced by one continuous function (d) measuring exemptions and deductions as a share of assessed income, over range y. By means of multiplicative or additive constants, d can be linked intertemporally to changes in statutory maxima for exemptions, and to changes in demographic conditions. Alternatively, one function (di) can be estimated for every deduction or exemption of interest, and d can then be obtained by aggregation across all di. Using this scheme, the taxable proportion of assessed income is the integral of f(y)*y*(1-d(y))/YASP over range y.

The statutory rate of taxation r can be approximated by a continuous function defined over the range ytax, the level of indexed taxable income. But ytax is equal to y*(1-d(y))/RTI. Hence, r can in principle be written as a function of y. Tax accruals defined as a fraction of assessed income are therefore equal to the integral of f(y)*y*(1-d(y))*r(y), over range y.

The feasibility of the concise alternative outlined above depends critically on the selection of functional forms for f, d, and r which are easy to add, multiply and integrate when combined in the expressions defined earlier. Polynomial functions in the powers of y of the form

$$P = a_0 + a_1 y + a_2 y^2 + a_3 y^3 \; . \; . \; . \; . \; .$$

are most promising in this regard. Continuous functions of y (or a transformation of y such as y/YASP) can be represented to any desired degree of accuracy by a polynomial in y of form P (Weierstrass Theorem). Accuracy increases with the number of terms in P. Multiplication or addition of two polynomials of form P yields a polynomial of form P. The same holds true for integration of P.

A detailed income tax model should be structured to facilitate the analysis of policy alternatives. For this purpose, it is essential that variables in the model can be linked directly to concepts used in the income tax statutes. In the formulations for exemptions and deductions suggested above this can be done using additive or multiplicative constants measuring maximum exemption levels, and demographic variables describing the extent of coverage.

Simulations involving tax cuts defined in very specific ways (eg, $200 + 8 percent of income to a maximum of $500) tend to give rise to much clutter in the current model. Polynomial approximation of the tax schedule also has its advantages in this respect. For simplicity, the model should be presented with a marginal tax-rate schedule with breaks at n distinct points. This implies an average tax-rate schedule for those n points. A polynomial of order n or less can be found that approximates this schedule, through inversion of the Vandermonde matrix ([44], p 127) defined on the n points of the average tax-rate schedule. A tax cut can be implemented by presenting the model with the average rate reduction at the n levels of taxable income, before constructing the continuous approximation to the rate schedule.

9. A simplified tax model

Users of RDX2 that are more interested in a macro-forecast of tax revenues than in the distributional detail provided by the post-1974 equations may find the alternative income tax formulation in Table 12 useful. All equations were estimated annually for 1962-1974. Quarterly equations were constructed by adding seasonal factors and changing YP to J4S(YP) whenever YP appeared as an independent variable.

Table 12

ALTERNATIVE INCOME TAX EQUATIONS

9.1A RYAS Assessment ratio for personal income

(X=58) (1962-1974 annual regression OLS)

$$\ln(RYAS) = -\ .52100 + .01234\ QTSTEP$$

$$(25.1) \quad (11.5)$$

see = .0145 RB2 = .916 dw = 1.24

9.2A NT Tax returns filed

(X=114) (1962-1974 annual regression OLS)

$$\ln(NT/NPOP) = \underset{(4.44)}{.88660} + \underset{(4.73)}{1.0789}\ \ln(RYAS)$$

$$+ \underset{(2.42)}{.83839}\ \ln(NE/NPOP)\ \underset{(6.48)}{.24280}\ \ln(NOAPR/NPOP)$$

see = .0107 RB2 = .991 dw = 1.96

9.3A DED Annual level of deductions and exemptions

(X=84) on personal income

(1962-1974 annual regression OLS)

$$J1D((DED-RRSP)/NT) = -\underset{(2.28)}{18.71416} + \underset{(3.67)}{.0710567}\ J1D((RYAS)(YP)/NT)$$

$$+ \underset{(35.42)}{1.31686}\ J1D((TPERS)(.13+.87\ RTI))$$

where J1D is an annual operator

see = 16.4682 R2 = .99438 dw = 1.95837

Quarterly Version

$$J4D((DED-RRSP)/NT) = -18.71416 + .0710567\ J4D((RYAS)(YP*4/NT))$$

$$+ 1.31686\ J4D((TPERS)(.13+.87\ RTI))$$

9.4A TP Aggregate income tax collections

(X=87) (1962-1974 annual regression OLS)

$$\ln(TP/YP) = \underset{(19.77)}{.874237}\ \ln[(YP*RYAS-DED)/(NT*[.13+.87\ RTI])]$$

$$+ \underset{(2.06)}{1.81717}\ REDUCE - \underset{(26.39)}{9.23314}$$

see = .04364 RB2 = .973512 dw = 1.69

(2Q62-4Q74 OLS)

ln(TP/YP) = .87424 ln[(J4S(YP)*RYAS-DED)/(NT*[.13+.87 RTI])]

+ 1.81717 REDUCE - 9.1099 Q1 - 9.12161 Q2

(516.75) (517.41)

- 9.2852 Q3 - 9.17400 Q4

(526.69) (520.38)

see = .06356 R2 = .94787 dw = 1.92

9.5A TPS Personal income tax collections withheld

(X=179) at source

(1Q62-4Q74 OLS)

TPS/YP = [TP/YP][.70778 Q1 + .44014 Q2 + .70944 Q3

(46.7) (29.7) (46.4)

+ .74609 Q4 + .00666 QTSTEP]

(49.7) (9.61)

see = .0019 RB2 = .996 cov = 2.21% dw = 1.66

9.6A TPO Personal income tax collections not

(X=178) withheld at source

(1Q62-4Q74 OLS)

TPO/YP = [TP/YP][.29222 Q1 + .55986 Q2 + .29056 Q3

(19.3) (37.8) (19.0)

+ .25391 Q4 - .00666 QTSTEP]

(16.9) (9.61)

see = .0019 RB2 = .983 cov = 7.94% dw = 1.66

9.7A TPYPM Provincial personal income tax collections

(X=181) (2Q62-4Q75 OLS)

TPYPM/TP = .02724 Q1 + .00728 Q2 + .02857 Q3 + .03456 Q4

(2.19) (.613) (2.41) (2.91)

$$+ (QTXRFM)(.00975\ Q1 - .03107\ Q2 - .01590\ Q3$$
$$(.885) \quad (2.81) \quad (1.44)$$
$$- .00701\ Q4) + .00752(RTPYPQ+RTPYPXQ)$$
$$(.636) \quad (20.6)$$

see = .017   RB2 = .921   cov = 6.65%   dw = 2.15

The equation for NT is that given in section B.2. Instead of YWAS and YNWAS, the alternative specification employs RYAS*YP as the volume of assessed income. RYAS is assessed income ([47], table 2), divided by annual YP. RYAS can be represented reasonably well as a simple loglinear time trend, even though this may not be true at the margin for policy simulations involving pensions, transfers, or farm income (see section B.3).

The equation for deductions and exemptions (DED, equation 9.3A) implies an income elasticity of DED, different from that implicit in the post-1974 specification in RDX2. Since this turns out to be the major reason for differences in tax revenue elasticities obtained from the two models, this question is discussed in some detail.

A cross-sectional analysis of tax returns by level of assessed income ([47], table 2) shows that three-quarters of DED consists of personal exemptions. The dollar amount of personal exemptions per return rises very slowly with income, but this is mainly a result of the fact that persons with higher than average income tend to have a higher than average number of dependents. The number of dependents is a demographic datum. Hence, exemptions depend largely on statutory maxima, and not on income.

From Table 2 of the Taxation Statistics [47] we also learn that deductions are a reasonably stable share of assessed income (.14 in the lower income deciles, .10 in the middle range, and .13 in the upper deciles). A unit aggregate elasticity of deductions with respect to income therefore seems, a priori, defensible.

Implicit in the post-1974 RDX2 specification is the assumption that the level of total deductions and exemptions is a function of the level of assessed income. Hence, deductions and exemptions are highly income elastic. An increase in income per return results in a shift of taxpayers into higher income groups. Exemptions and deductions of new arrivals in a given income group are assumed to rise to levels claimed by previous occupants of that income group. This means that total dollar claims for personal exemptions will rise. Hence, there must be an increase in the number of exemptions, or in dollars claimed per exemption. Neither assumption is easy to justify; therefore, RDX2 will tend to overstate personal exemptions in response to an income shock.

In equation 9.3A DED excludes exemptions and deductions in excess of assessed income appearing on non-taxable returns. In view of the problems discussed above, DED is assumed to vary with personal exemption maxima, as well as with the level of assessed income per return.

Equation 9.3A is estimated in first difference form, in dollars per tax return, as a function of the maximum allowable personal exemption (TPERS), assessed income (RYAS*YP), and an exogenous variable RRSP. RRSP is the sum of claims for exclusion of the first $1,000 of interest and dividends, and contributions to registered retirement and home ownership savings plans, as recorded in Table 2 of the Taxation Statistics. Because of recent drastic changes in legislation, no endogenous specification for RRSP was attempted. The indexing factor (.13 + .87RTI) is a weighted Canadian average, in which .13 represents Quebec's portion of personal income, which is not affected by indexing. Since exemptions for spouses and dependent children have generally followed the time path of TPERS, this variable can be used as a summary index for all personal exemptions.

The interpretation of the DED equation is straightforward. An increase of $1 in the level of personal exemptions gives rise to an increase of $1.31 in personal exemptions per return. A $1 increase in income per return gives rise to $.071 in deductions per return. There is a residual negative time trend in DED/NT of $18 per year.

The proportion of aggregate tax collections (TP) in YP is modelled as a loglinear function of average indexed taxable income per return, and a dummy variable REDUCE, which takes on a non-zero value whenever a tax cut from statutory rates is in effect. Every 1 percent increase in average taxable income per return has historically led to a .87 percent increase in the tax rate (equation 9.4A). Holding NT constant, and assuming that DED rises pari passu with YP, the revenue elasticity of YP is 1.87; if DED rises more slowly than YP, the growth of average taxable income will exceed the growth of YP, resulting in a revenue elasticity in excess of 1.87.

The proportionate split of TP into TPS and TPO can be modelled as a simple time trend (equation 9.5A and 9.6A). The provincial-municipal share of TP can be represented as a function of two variables (RTPYPQ, RTPYPXQ) describing the provincial tax as a surtax on the basic federal levy.

Annual observations for the variables introduced in equations 9.1A-9.7A are listed in Table 13. To obtain quarterly values, one simply repeats the annual values four times. The total personal income tax, TP, is the sum of existing variables TPS + TPO.

The dynamic properties of the resulting model were analyzed and the results are shown in Table 14. The experiment documented in section B.7 with the standard RDX2 equations was repeated for the alternative model. In the alternative model, the elasticities of TP, TPS, TPO, TPYF, and TPYPM are nearly identical. This is not surprising in view of the method of estimation of the last four variables, using TP.

Table 14

ELASTICITY OF PERSONAL INCOME TAX WITH RESPECT TO INCOME
(Equations 9.1A-9.7A, Table 10)

	Indexing		
	None	Partial	Full
A. RRSP constant			
Revenues (TP)	2.61	1.29	1.09
Deductions (DED)	.17	.78	.89
B. RRSP growing at same rate as income (10%)			
Revenues (TP)	2.54	1.23	1.03
Deductions (DED)	.27	.88	.98

The aggregate elasticity of tax revenues with respect to assessed income is considerably smaller in the standard RDX2

Table 13

DATA REQUIRED FOR INCORPORATION OF A SIMPLIFIED TAX MODEL INTO RDX2

	NT (Mls.)	RYAS	TPERS	RRSP (Mls.$)	REDUCE	DED (Mls.$)
1962	6.137	.6927	1000	40	0	11606
1963	6.350	.6970	1000	45	0	12055
1964	6.715	.7236	1000	57	0	12806
1965	7.163	.7316	1000	75	0	13565
1966	7.733	.7430	1000	100	-.04	14835
1967	8.133	.7481	1000	118	0	15456
1968	8.495	.7504	1000	142	0	16051
1969	8.882	.7518	1000	178	0	16680
1970	9.183	.7628	1000	225	0	17226
1971	9.533	.7560	1000	319	0	18176
1972	10.382	.7909	1500	645	-.03	27115
1973	11.003	.7988	1500	922	-.03	30620
1974	11.602	.8255	1600	3259	-.03	36785

(post-1974) model. This is mainly because of a more elastic response of exemptions and deductions to an income shock, as discussed earlier.

As in section B.7, the income shock is assumed nominal. In the case of no indexing, this distinction is irrelevant. But a real income shock has no indexing effects. Hence, line 1 may be interpreted to equal the response to a real income shock.

The second set of experiments shows the impact of allowing RRSP to increase at the same rate as income, which is the polar extreme of assuming RRSP to be constant.

C. Corporate Income Taxes

Taxable corporate profits (YCT, equation 9.35) are defined as a function of corporate profits net of charitable donations and mining and logging taxes (YPCCB and TCAPLMT); the change in the four-quarter average of business output net of unintended inventories (UGPPA) is included to capture the trend in output. No systematic attempt has yet been made to take account of the stabilization measures designed to encourage investment in particular regions and industries, mostly via accelerated capital consumption allowances. Only the 1963 measures have been modelled using an exogenous variable (ECCA63A). Variable ECCA66R, intended to capture the reduction in depreciation allowances in 1966, became insignificant in this re-estimation of RDX2, and was removed from the equation. A more systematic look at the effects on YCT of these and more recent attempts to stimulate investment is planned.

Federal corporate income tax accruals (TCAF, equation 9.36) are estimated as a function of YCT, of the federal weighted average tax rate (RTCAF) and an exogenous error term EDTCA. The coefficient on RTCCAF rises to 1.111 when the equation is re-estimated through 1975, indicating that tax reforms since 1972 warrant another look at the structure of this equation.

D. Transfers from Persons to Government

Transfers from persons to provinces (equations 9.31 and 9.32) have remained unchanged from the previous version of the model. Hospital and medical insurance premiums (TRHPMPR) are linked to average premium per person (ERTPHPM) and the size of the labour force. Motor vehicle licenses and permits for persons (TRMVPMPR) are a function of average license costs (ERTPMVPM) and the stock of non-commercial vehicles (UKRMVNC).

Footnotes

1 The current version is estimated through 4Q72, but can be simulated beyond this quarter. Statutory reforms contributed in [16], and changes in the formulation of the identities required to arrive at TANW and TAW (equations 9.5 and 9.6) were made under the assumption that (equations 9.1 and 9.2) are unaffected.

2 Underreporting of wage income has become relatively minor in recent years according to statistics. The 1976 revisions of the National Accounts for 1971-1975 used assessed wage income to adjust the lower National Accounts wage figures obtained by other estimation techniques. Because of the secularly increasing rates of taxation, shortening of the average work week, and reductions in the age of retirement, opportunities for and benefits from tax evasion are likely to increase. This should to some extent offset increases in the efficiency of the tax collection system.

3 National Income and Expenditure Accounts. Vol 1, p 283. Statistics Canada 13-531.

4 Income follows a displaced lognormal distribution if the logarithm of income plus some constant is normally distributed. If income were distributed normally, the share of income found at a particular income level per return would be symmetrical around mean income. If income were distributed lognormally the same statistic

would be symmetrical around the logarithm of mean scale. The displaced lognormal distribution allows for variations in the amount of skewness: if the displacement is positive, the distribution is intermediate in skewness between normal and lognormal. A negative displacement results in an even more positively skewed distribution than in the lognormal case. Thus, the displaced lognormal can, in general, be used to describe certain positively skewed distributions.

5 The formula for UDISi (eq. S9.10-S9.12) should read UDISi = UQMi [(UQLi)(UQUi)/(UQMi)**2-1]/[2-(UQLi)/(UQMi)-(UQUi)/UQMi)]. The exponent of e in equations S9.16-S9.46 should be of the form .5((X-UMEAN)/USIGMA)**2.

6 To make matters even more complicated, it is now widely recognized that the interest income exemption, and the deductibility of interest on money borrowed to obtain income earning assets, encourages borrowing by rational taxpayers without substantial assets, in order to show approximately $1,000 in gross interest earned, and somewhat less in gross interest paid both of which are tax deductible. If taxpayers take advantage of this arrangement, the reported amount of gross interest will tend to be inflated.

7 To illustrate this in a grotesque reductio ad absurdum, assume that ypa increases 100 fold as a result of a 100-fold increase in price level. If the historical

mean income in the $1-$3,000 tax brackets is $1,500, taxpayers in this class now find themselves at an income level of $150,000. Without indexing of tax brackets and under any reasonable change in deductions and exemptions, each taxpayer will have more nominal income taxable at a higher average rate. When RDX2 is simulated before 1974, however, the tax share increases only because exemptions and deductions are fixed, since taxpayers now earning $150,000 remain 'stuck' in the original $1-$3,000 income class. Since this example assumes inflation to be the cause of the income increase, this formulation corresponds to near perfect indexing. If ypa increases because of a real income increase, the model implies a form of regression at the margin since the post-shock tax rate on $150,000 is lower than the historical rate on the same amount.

[8] The main difference is that fourteen instead of four income groups are used to estimate effective tax rates and exemptions.

CHAPTER 10

GOVERNMENT TRANSACTIONS OTHER THAN INCOME TAX COLLECTIONS: SECTORS 10-14

Leo de Bever

A. Introduction

The equations describing government revenue from sources other than the personal income tax have been changed very little from those in the previous version of RDX2. The same holds for equations representing Unemployment Insurance Fund transactions, interest payments on the government debt, government purchases of goods and services, and change in government assets and liabilities. A summary of the main ideas underlying these equations is given below.

B. Indirect Taxes and Other Government Revenues

Most indirect taxes in Sector 10 are modelled using exogenous weighted average tax rates and variables intended to approximate the tax base.

The most important indirect tax, the manufacturers sales tax (TISF, equation 10.1), is levied on most products manufactured in Canada and on those imported from abroad. Food, clothing, medical supplies, and most machinery and equipment are exempt, as are goods purchased by hospitals, governments, and certain institutions. In the equation for TISF, the constants .54, .46, and .12 denote the estimated average proportion of expenditures subject to the tax for the consumption or investment components with which they are associated. Terms of the form (assessed proportion of tax base)(tax rate)/[100 + (assessed proportion of tax base)(tax rate)] attempt to convert the base from post-tax to pre-tax levels.

Several conceptual problems complicate the estimation of TISF. First, since the tax has the character of a turnover tax rather than a value-added tax, double taxation may occur in a non-integrated, multi-stage processing industry. Part of this problem is solved in practice by the granting of selective tax reductions whenever severe distortions are apparent. Second, post-manufacturing costs (eg, transport and advertising) should ideally be omitted from final expenditures. Third, provincial and municipal sales taxes should be eliminated from the tax base. Fourth, it might be desirable to break up the expenditure categories to a greater extent than is done in equation 10.1. This would allow direct estimation of the proportions of expenditures taxed, by expenditure categories. The first and second problems are hard to solve. The other two are attacked in the alternative to equation 10.1 presented below. This specification eliminates provincial sales taxes, assuming that the proportion of outlays of a given type (eg, construction expenditures) on which sales taxes are levied is the same for federal and provincial governments.

For example, assume that share A1 of expenditures on non-durables (CNDSD) is subject to federal manufacturers sales tax; by assumption, the same share is taxed by the provinces. Outlays on non-durables net of provincial sales taxes are therefore, as a first approximation, equal to

(PCNDSD)(CNDSD)/(1+.01(RTISPM)(A1))

where RTISPM is the weighted rate of provincial sales taxation, and where retail sales by province are used as weights. Ignoring variations in the proportion of value added that originates in distribution activities, the tax base for the federal sales tax is

(PCNDSD)(CNDSD)/[(1+.01(RTISPM)(A1))(1+.01(RTISFS)(A1))]

and the federal sales tax yield from this item alone is the above expression multiplied by (A1)(RTISFS). The parameter A1 can be directly estimated. Other expenditures can be combined with their respective tax rates to yield the following equation:

(1Q58-4Q74 OLS)

TISF = AO

+ A1(RTISFS)(PCNDSD)(CNDSD)/[(1+.01(RTISFS)
(A1))(1+.01(RTISPM)(A1))]

+ A2(RTISFS)[(PCMV)(CMV) + (PCDO)(CDO)]/
[(1+.01(RTISFS)(A2))(1+.01(RTISPM)(A2))]

+ A3(RTISFR)[(INRC)(PINRC) + (IRC)(PIRC)]/
[(1+.01(RTISFR)(A3))(1+.01(RTISPM)(A3))]

+ A4(RTISFME)(PIME)(IME)/
[(1+.01(RTISFME)(A4))(1+.01(RTISPM)(A4))]

Parameter	Value	t-statistic
A0	95.96	10.14
A1	.2405	5.17
A2	.9135	5.63
A3	.7739	13.21
A4	.2779	5.26

see = 14.70 R2 = .996 dw = 1.71

Excise taxes and duties, excluding manufacturers sales tax (TIEXF, equation 10.2), were estimated as a direct function of non-durables, semi-durables, and other durables, on which these taxes are levied.

Provincial and municipal retail sales taxes (TISPM, equation 10.3) are estimated by the same method used for equation 10.1: exogenous ratios of taxable to total expenditures are combined with the exogenous tax rate and the volume of final expenditures to yield an approximation of the tax base.

The equation for gasoline taxes (TIGASPM, equation 10.4) depends on weighted average tax rates for gasoline and diesel oil, exogenous ratios indicating the number of gallons of gasoline per non-commercial vehicle (EGAS), the number of gallons of diesel oil per commercial vehicle (EDO), and the stock of non-commercial and commercial motor vehicles. The stock of commercial motor vehicles is assumed to be proportional to KME.

Motor vehicle licenses and permits issued to businesses (TIMVPM, equation 10.5) are estimated as a function of the stock of commercial vehicles and a weighted average of licence fees applicable to such vehicles.

Taxes withheld from gross interest and dividends earned in Canada by foreigners (TWF, equation 10.6) are estimated as a proportion of the tax base, with an adjustment term for changes in withholding legislation made in 1960 (QHOS).

Customs duties (TICUSF, equation 10.7) are approximated by multiplying imports in each category by the applicable rate of duty. A residual term (ETICUSF) contains the difference between the approximation and the actual collections.

C. Unemployment Insurance Fund Transactions

With the exception of equation 11.5, various aspects of the Unemployment Insurance Fund (UIF) are modelled in Sector 11. The rules for operation of the fund were changed extensively in 1968, 1971, and 1972; dummy variables QDUIF, QDUIF71 and QDUIF72 are used in this sector to capture the associated structural changes.

The number of persons insured by the UIF (NINS) is modelled in equation 11.3. There is an error in [6]. In equation 11.3 the terms involving QTIME and QSEA should be multiplied by (1-QDUIF72). The number of employed contributors to the Unemployment Insurance Fund (NEMPS, equation 11.6) is assumed to be equal to NINS minus the number of claimants (NCL, equation 11.4). The number of claimants depends on the level of unemployment (NU). The number of persons insured is a function of the labour force covered under UIF legislation. Unemployment insurance benefits (GTPUIBF, equation 11.2) depend on a weighted average of maximum benefits available under the law (ERUIB) and the number of claimants. Contributions to the fund (TUIRF, equation 11.1) depend on the number of insured persons that are employed.

The number of persons claiming unemployment insurance (NCL) turns out to be a poor proxy for beneficiaries of the UIF. The ratio (NCL/NU) is on average 1.24 (1958-1974). The elasticity of NCL with respect to NU as measured by direct loglinear estimation is somewhere between 1 and 2, depending on the method of estimation and the presence of other explanatory variables. This riddle is resolved once one recognizes that there is a crucial difference between claiming benefits and receiving benefits. Claims can be turned down, and it appears that ineligible claims vary cyclically with unemployment.

An alternative equation for GTPUIBF is presented below. The equation contains NU instead of NCL. We also include the first and fourth quarter differences in NU to capture, respectively, dynamic adjustments to both short-run and seasonally adjusted changes in the level of unemployment.

(1Q58-1Q77 OLS)

GTPUIBF Unemployment Insurance Benefits

GTPUIBF = 90.5357 Q1 + 38.9927 Q2 - 3.4585 Q3 + 19.7113 Q4
(12.04) (4.88) (.45) (2.45)

+ [8.8863 Q1 + 7.1243 Q2 + 6.2631 Q3 + 6.3588 Q4]
(34.32) (27.68) (25.61) (26.02)

[(NU)(ERUIB)] - 20.2458 QDUIF + 107.81 J14L(QDUIF)
(3.78) (9.89)

- 15.3775 J1L(QSEA) + [-16.1534 J1D(NU) + 3.58053 J4D(NU)]
(2.32) (6.19) (7.30)

[ERUIB]

see = 15.8 RB2 = .997 cov = 6.01 dw = 2.03

Extension of the TUIRF equation beyond 1972 was difficult without specific allowance being made for the upward drift in the percentage of wages that employers and employees contribute to the UIF (RUIF), and the repeatedly revised maximum level of insurable earnings (QYUIF). Furthermore, it was found that the variable NEMPS can be replaced by its close substitute NE. An alternative equation for TUIRF incorporating this additional information is presented below. Data for RUIF and QYUIF [16] are given in Table 15.

Table 15

UNEMPLOYMENT INSURANCE FUND PREMIUM RATE AND MAXIMUM INSURABLE EARNINGS PER EMPLOYEE

	RUIF	QYUIF
before 1972	.014	7800
1972	.019	7800
1973	.024	8320
1974	.028	8840
1975	.0305	9600

To capture changes beginning in 1974 we also included the dummy variable QTFA. The revised formulation yielded the following results:

(1Q58-4Q74 OLS)

$$\begin{aligned}
\text{TUIRF}/(\text{NE}*\text{RUIF}*\text{QYUIF}) = &- \underset{(2.87)}{.0673638}\ \text{Q1} - \underset{(3.15)}{.0726440}\ \text{Q2} \\
&- \underset{(2.94)}{.0667582}\ \text{Q3} - \underset{(2.828)}{.0656728}\ \text{Q4} + \underset{(5.357)}{.469702}\ \text{WQMMOB}/\text{QYUIF} \\
&+ \underset{(6.43)}{52.1221}/(\text{NE}*\text{RUIF}*\text{QYUIF}) - \underset{(1.54)}{.00469746}\ \text{QDNINS} \\
&+ \underset{(7.69)}{.0264667}\ \text{QDUIF} + \underset{(14.11)}{.0324548}\ \text{J1L(QSEA)} + \underset{(11.04)}{.0402027}\ \text{QTFA}
\end{aligned}$$

see = .00512 R2 = .966 dw = 2.11

Using the alternative equations for UIF benefits and UIF premiums, the equations for NINS, NEMPS and NCL can be dropped.

To analyze the balance of the UIF we consolidated equations 11.1-11.4 and equation 11.6 into two equations by substitution of NCL, NINS, and NEMPS into the equations for GTPUIBF and TUIRF. Ignoring seasonality (ie, terms involving QC1, QC2, QC3) and setting all structural dummy variables to their post-1971 values (ie, QDUIF = QSEA = QDUIF71 = QDUIF72 = 1) one obtains,

$$TUIRF = - 16.3 + 20.9\ NE + .01863\ (NE)(QTIME) - 12.86\ NU + .01524\ (NU)(QTIME)$$

$$GTPUIBF = [-3.7 + .96\ NE + 7.66\ NU - .00348\ (NU)(QTIME) - .00425\ (NE)(QTIME)]ERUIB.$$

The first equation predicts that the reduction in TUIRF due to a shift of a million workers from NE to NU is about $34 million per quarter, or $136 million per year. This is clearly too high since the maximum (1972) contribution per worker is less than $136 per year. In the second equation (assuming ERUIB = 100, its approximate 1972 value) this same shift from NE to NU implies an increase of about $670 million per quarter in GTPUIBF, which amounts to $2,680 per year per newly unemployed worker. The balance of the Unemployment Insurance Fund for 1972 will drop by approximately $2,816 per year per newly unemployed worker.

When the same procedure is applied to the alternative equations for TUIRF and GTPUIBF presented above, one obtains a marginally higher increase in GTPUIBF than is found in equation 11.2. The decrease in TUIRF is half of what it is in equation

11.1, a more plausible solution given historical contribution maxima per worker. These differences are mainly due to the inclusion of NU in the reduced form of equation 11.1 and of NE in the reduced form of equation 11.2.

Users simulating beyond 1972 will find that simulation errors for TUIRF increase rapidly when using equation 11.1 as a result of the changes in premium rates and insurable maxima discussed earlier. Explicit introduction of these two policy variables in the alternative TUIRF equation makes the marginal response of UIF receipts more plausible.

D. Interest on the Federal Debt

Equation 11.5 is an estimate of interest on the federal public debt, excluding interest on pension funds, non-market issues held in government accounts, and on Bank of Canada holdings of federal debt. Excluded payments amounted to 35.5 percent of total federal interest payments in 1968. The remaining payments are explained by the end-of-quarter stocks of Government of Canada direct market issues (LGBF), treasury bills (LGFTB), and Canada Savings Bonds (LGFCSB), each weighted by their weighted average coupon rate.

E. Federal Current and Capital Expenditure on Goods and Services (Sector 12)

It is not realistic to argue that government expenditure policy over the last twenty years has been characterized by rigid adherence to some structural model. The federal expenditure equations in Sector 12 should therefore be viewed primarily as plausible long-run simulation rules, to be preferred over exogeneity. That is, a simulation experiment involving changes in real income, prices, or population, becomes implausible if government adheres rigidly to pre-shock expenditure levels.

Employment in federal public administration and defence (NGPAF, equation 12.1) is modelled as a function of lagged NGPAF, to capture habit persistence. In addition, real per capita income is introduced, on the assumption that consumer tastes for public goods are income elastic. Population is included as a measure of economies of scale in the provision of public goods. The unemployment rate captures countercyclical hirings by the federal government. A decrease in government unit labor costs relative to the unit cost of non-labour purchases is assumed to increase government employment. The constant 1261.10 is the quarterly average of 1961 current wage costs per employee (WQGPAF+GWSF/NGPAF).

Quarterly earnings in federal public administration and defence (WQGPAF, equation 12.2) are a function of average private wage payments. (The equations in [6] contain an error: the coefficients on JW(WQAXF) and JW(ln(WQAXF/RNU)) should be reversed). Long-run homogeneity requires a unit elasticity of WQGPAF with respect to WQAXF. The sum of the coefficients on WQAXF exceeds one. This is due to rapid expansion of the public service since the late sixties, particularly in professional occupations. The use of WQAXF (involving WQGPAF itself) could have been avoided by using WQMMOB instead. The dynamics of the (WQAXF/RNU) term are somewhat suspect. The model records a very strong wage response to a comparatively mild expansionary shock affecting RNU.

Federal current nonwage government expenditure (GCNWF, equation 12.3) is modelled net of depreciation allowances, in per capita terms, and deflated by the price index PGCNWG. The structure of the equation resembles that of equation 12.1 in other respects.

Federal investment in non-residential construction (INRCGF, equation 12.4) net of depreciation (.00875 J1L(KNRCGF)), is estimated as a function of the level of civil service employment, and the level of real income. The lagged capital stock appears with a negative sign, to capture a stock adjustment process of the form: INRCGF = ALPHA (desired stock - actual stock), where ALPHA is between 0 and 1. The actual stock J1L(KNRCGF) has a coefficient of .095, implying a desired stock of (.01389/.095)JW(YP/PCPI)+(274.41/.095) NGPAF (ignoring seasonal effects). In other words, Canadians 'desire' $0.14 of government capital per dollar of personal income, and $3,044 of capital per government employee (1961 prices).

F. Provincial-Municipal Current and Capital Expenditure on Goods and Services (Sector 13)

Employment in provincial-municipal public administration (NGPAPM, equation 13.1), is modelled as a function of real personal income and the unit price ratio of wage and nonwage expenditures. The long-term interest rate (RL) and the term (RABELCD-RABELCDD)/RABELCD is used as a measure of supply conditions in the bond market, which affect opportunities for deficit financing. The equation also postulates a positive link between hiring and the ratio of non-borrowed funds (including pension fund borrowing) to total income (taxes, borrowings, change in financial assets).

Constant dollar provincial-municipal current nonwage expenditure (GCNWPM) net of depreciation and medical payments, is estimated as a function of real personal income, and of a financing constraint variable identical to that in equation 13.1. The relative unit price ratio of (nonwage)/(wage) outlays appears with the theoretically expected negative sign. The variable QDCENT is included in an attempt to capture irregular expenditure patterns connected with the Canadian Centennial.

Quarterly earnings in provincial-municipal public administration (WQGPAPM, equation 13.2) are assumed to grow slightly faster than average private sector earnings.

Employment in elementary and secondary schools under municipal control (NIS, equation 13.3) is estimated on a per student (NPOPS) basis. A positive relationship between NIS/NPOPS and (GTGMP/NPOPS)/WQISM implies that an increase in per student provincial transfers to schools has the same effect as a proportionate decrease in quarterly earnings in primary and secondary schools. Employment is assumed to vary negatively with student population, but positively with the change in student population. There is some question about the plausibility of this specification. For instance, NIS/NPOPS is a negotiating point between school boards and teachers' unions, rather than a variable responding only to demographic trends.

Provincial-municipal investment in construction, excluding schools, (INRCGPM, equation 13.5) is estimated as a function of the change in real consumption expenditure, the level of other investment expenditure, and the long-term interest rate, as a measure of the cost of borrowing.

Municipal investment in school construction (INRCSM, equation 13.6) is assumed to conform to a stock-adjustment model, in which the desired stock depends on real personal income, the student population, the pattern of provincial transfers to municipalities, and the past level of net investment in school construction.

G. Government Asset and Liability Changes (Sector 14)

In equations 14.6-14.10 we define the net National Accounts position of the federal government, the provincial-municipal governments, hospitals, and the Canada Pension Plan and Quebec Pension Plan respectively. Equation 14.11 is the identity equating total sources and uses of funds for the federal government. Any net use of funds not financed by an increase in Government of Canada direct market issues (LGBF) or a decrease in government cash balances (DDGFB) will lead to an automatic increase in the stock of treasury bills (LGFTB). The difference between corporation taxes accrued and collected, which is an important use of funds, is determined endogenously, since TCCF is explained in equation 14.1. The specification of this equation is intended to capture actual payment practices as set out in the relevant legislation and is described in some detail in Helliwell et al. [26] pp 72-80. Net changes in federal asset accounts, excluding advances to the Foreign Exchange Fund, are represented by GAMIS, an exogenous variable defined residually by equation 14.11.

The gross borrowing requirements of provincial-municipal governments (GBRPM), as defined in equation 14.13, are used in equation 14.14 to determine the stock of direct and guaranteed bonds outstanding. We weight the resident-held stock of all government bonds by a market-valuation ratio (PLGI, equation 14.12) and the resulting market value (VLGB11) enters the private sector wealth variable (see equations 18.3 and 18.4). As well as adding directly to the stock of wealth, VLGB11 is used in the creation of the series for permanent nonwage disposable income (YPDNWP) and revaluation gains and losses (YKGP), which directly influence consumption behaviour.

The variable PLGI is a weighted average of federal and provincial-municipal valuation ratios, which are themselves weighted averages of stochastically determined valuation ratios for each of the four maturity classes of Government of Canada direct market issues (equations 14.2-14.5). Variables PLGF1C, PLGF2C, PLGF3C and PLGF4C are weighted by the proportion of total resident-held Government of Canada direct market issues in each maturity class, and the results are summed to get an aggregate federal valuation ratio. This ratio is then scaled by EWLF, which represents the proportion of resident-held Government of Canada direct market issues to all government bonds held by residents. Since no breakdown of the maturity structure is available for provincial and municipal bonds we assume that such bonds are issued at regular intervals with an initial term-to-maturity of fifteen years. This assumption gives rise to the constants used to weight PLGF1C, PLGF2C, PLGF3C and PLGF4C in equation 14.12. We then scale the provincial-municipal valuation ratio by 1-EWLF in order to calculate PLGI.

Finally we should comment on the specification of the four valuation ratios modelled in equations 14.2-14.5. The data source for the valuation ratios is an issue-by-issue analysis of Government of Canada direct market issues outstanding at quarter-end from 1955 forward. However, rather than attempt to relate these price indexes to interest rates in a general way, we used the same data to derive weighted average coupon rates and term-to-maturity variables for the four maturity classes. Given this information and market yields generated elsewhere in RDX2, we used the general formula for the present value of a bond with semiannual coupon payments to generate synthetic price series. These series were then used as regressors in our valuation equations. Evaluated at the sample means, the elasticities of PLGF1C, PLGF2C, PLGF3C, and PLGF4C with respect to the relevant interest rates are -.05, -.16, -.29 and -.60, respectively.

CHAPTER 11

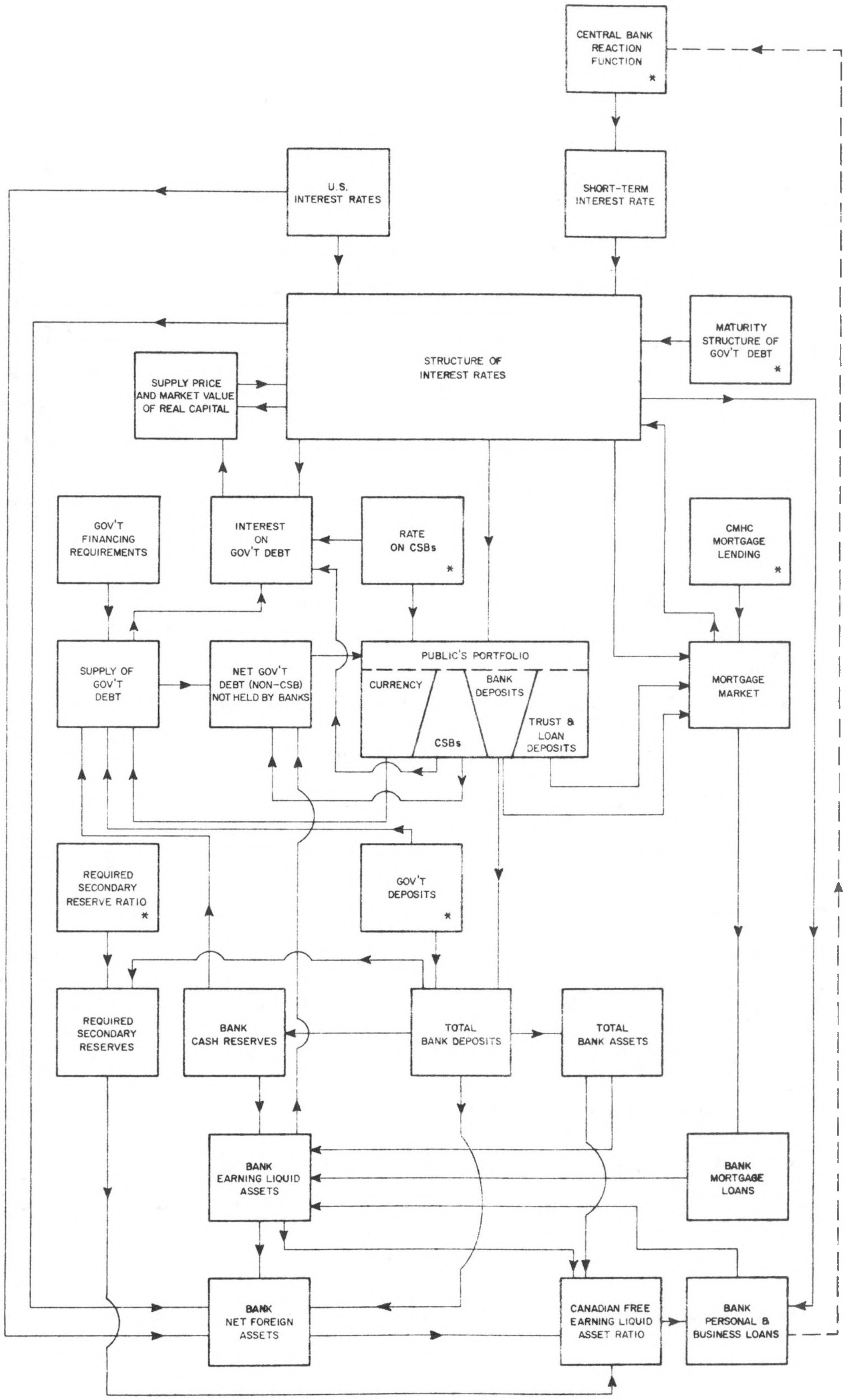
THE FINANCIAL SECTORS: SECTORS 15-18

David Longworth[1]

A. Introduction

The financial sectors of the model consist of equations that determine the liquid wealth of the nonfinancial public, the assets of financial intermediaries, interest rates, mortgage approvals, the supply price of capital, and wealth. The structure of the financial sectors is similar to that of these sectors of the first version of RDX2 [32]. In Figure 17 we outline the basic relationships among the financial variables. The lines of causation in the chart are thought of as starting with the central bank reaction function, which sets the short-term interest rate.[2] The structure of interest rates is determined by the short-term government bond rate (RS), U.S. interest rates, and the maturity structure of Government of Canada debt. In addition, the demand for mortgage funds affects the conventional mortgage rate (RMC), and the market value of real capital affects the term structure of interest rates. Deposit rates endogenous to the model are the rate on nonpersonal term and notice deposits (RNPT), term deposits in trust and mortgage loan companies (RTTL), nonchequable savings deposits in trust and mortgage loan companies (RSTL), and the average rate paid on personal deposits in chartered banks (RPD). The chartered bank prime business loan rate (RPRIME) is also endogenous to the model. Liquid assets of the nonfinancial public are determined by a vector of interest rates, gross

Figure 17
THE FINANCIAL SECTOR



* POLICY INSTRUMENT

national expenditure, and marketable government debt held by the nonfinancial public.

We determine the supply price of capital and the market value of real capital in a reduced form equation that relates the differential between the supply price of capital and the rate on long-term government bonds to the ratio of earnings from real capital to earnings from government debt.

The mortgage interest rate is determined by an equation incorporating the supply and demand elements in the mortgage market. Supply equations then explain the mortgage loans of various financial intermediaries. The supply of mortgage funds is dependent on the assets of banks, trust and mortgage loan companies, life insurance companies (and therefore on the deposits of the first two groups of financial intermediaries), the lending of Central Mortgage and Housing Corporation (CMHC), the interest rate on mortgages, and the rates of return on alternative assets.

Deposits in chartered banks fix chartered bank total assets, required secondary reserves, and required and actual primary reserves. Chartered bank total assets minus cash reserves, mortgage loans, business and personal loans, and certain miscellaneous (exogenous) assets fix chartered bank earning liquid assets.

Chartered bank net foreign assets are determined by the rate of return on Canadian and foreign assets, chartered bank total assets, and by the earning liquid asset position of the banks. Earning liquid assets minus the sum of required secondary reserves and net foreign assets all divided by chartered bank total assets gives the Canadian free earning liquid asset ratio.

This ratio is one of the explanatory variables in the reduced form equations determining bank loans. The percentage change in business and personal loans feeds back into the reaction function of the central bank.

Growth in Canadian earning liquid assets; which implies an increase in chartered bank holdings of government debt or in chartered bank day, call, and short-term loans; reduces the net government debt held by the Canadian nonfinancial public when total government debt is kept constant.

B. The Demand for Liquid Assets (Sector 15)

The demand for liquid assets continues to be cast in a Brainard-Tobin framework [9]. Defined in abbreviated terms the eight categories of liquid assets held in the private domestic nonfinancial sector are: currency (ANFCUR), demand deposits (DDB), personal bank deposits (DPB), nonpersonal term and notice deposits (DNPTB), savings deposits in trust and mortgage loan companies (DSTL), term deposits in trust and mortgage loan companies (DTTL), Canada Savings Bonds (LGFCSB), and net marketable government bonds (ANFGN). Since the supply of bonds must equal the demand for bonds, the estimated equation for marketable government bonds implicitly determines the liquid assets held in the private domestic nonfinancial sector of the economy.[3]

The basic hypothesis is that the desired (*) ratio of asset i (A(i)) to total liquid assets (A) is a function of the rates of return (R(j)), the ratio of nominal income (Y) to total assets, and the inverse of the size of the real portfolio (1.0/(A/P)), where P is the price level. Thus

$$\left[\frac{A(i)}{A} \right]^* = a(i) + b(i) \frac{P}{A} + c(i) \frac{Y}{A} + \sum_j d(i,j)\, R(j)$$

If one uses a stock adjustment model in which actual assets are adjusted to the disequilibrium positions of all assets held, then

$$\frac{A(i)}{A} = \sum_j e(i,j) \left[\left[\frac{A(j)}{A} \right]^* - \frac{J1L(A(j))}{A} \right]$$

This formulation leads to the estimation of many parameters in each equation, because each lagged ratio term must be included in each equation. Also, there is nothing to guarantee that the estimated coefficients will determine a stable system. Early experiments showed that plausible results could only be obtained when there are constraints on the speed of adjustment. Thus a common own speed of adjustment (f) is assumed for all assets and an additional term e(i) [J1D(A)/A] is used to fix the initial allocation of an increase in total liquid assets. Thus

$$\begin{aligned} \frac{A(i)}{A} &= a(i) + b(i) \frac{P}{A} + c(i) \frac{Y}{A} + \sum_j d(i,j)R(j) \\ &\quad + (1-f) \frac{J1L[A(i)]}{A} + e(i) \frac{J1D(A)}{A} \\ &= (a(i)+e(i)) + b(i) \frac{P}{A} + c(i) \frac{Y}{A} + \sum_j d(i,j)R(j) \\ &\quad + (1-f) \frac{J1L[A(i)]}{A} - e(i) \frac{J1L(A)}{A} \end{aligned}$$

The constraints necessary for consistency[4] are

$$0 = \Sigma b(i) = \Sigma c(i) = \sum_i d(i,j) \ \forall j$$

$$1 = \Sigma[a(i)+e(i)]$$

$$(1-f) = \Sigma e(i)$$

Estimation of the equations was carried out by using Zellner's two-stage procedure [56].

Certain institutional features create problems in the estimation of the demand for liquid assets. The 1967 changes in the Bank Act allowed the chartered banks to compete more agressively for funds, through interest rate competition and nonprice competition, than had previously been the case. They encouraged the use of nonchequable savings deposits and personal chequing accounts so that the composition of personal deposits changed radically. At about the same time the growth in savings deposits in trust and mortgage loan companies slowed considerably. Thus there were indications that a dummy variable used from 3Q67 onward might pick up much of the institutional change or changes in taste that occurred over the fitting period. This proved to be the case - the Bank Act dummy entered many equations significantly.[5] As hypothesized, the wealth elasticity of demand for personal deposits in banks increased significantly and the wealth elasticity of demand for savings deposits in trust and mortgage loan companies decreased significantly. The elasticities of demand of wealth for currency, nonpersonal term and notice deposits, and term deposits at trust and mortgage loan companies also increased. At the same time the wealth elasticity of demand for marketable government debt fell substantially while that for Canada Savings Bonds (CSBs) fell slightly.

The inclusion of CSBs in the financial portfolio creates another problem because most purchases of CSBs are made in the fourth quarter of the year and therefore depend on interest rate differentials between assets competing then with CSBs. Each issue of savings bonds has varying interest rates over its life so that it is difficult to define these differentials. The first-year rate may differ from the average rate paid, which in turn may differ from the compound rate when a bond is held to maturity. As well, the sale of new CSBs may be cut off shortly after the issue is offered. Given the limited number of observations used in the regression, little can be done about these problems. However, an attempt was made to determine whether the first-year rate or the rate to maturity on new CSBs performed better than the average rate on the outstanding bonds. The latter rate performed best.

The finance paper and commercial paper markets grew considerably in importance during the period 1958-1972. We experimented extensively to see whether the inclusion of finance paper and commercial paper in the portfolio would improve the fit of the other equations. The fit did not improve when this was done. Swapped deposits in chartered banks, which had earlier been included in the portfolio, were dropped because the constraints placed thereon at the request of the Bank of Canada meant that too many degrees of freedom would have been consumed by the inclusion of dummy variables in modelling the constraints.

In the first experiments with Sector 15 all interest rates were allowed to enter the equations. As expected, multicollinearity between rates appeared to create problems. Thus the interest-bearing portfolio was initially divided into two subsets: the first subset (DPB, DSTL, LGFCSB) comprised assets in which many households invest, and the second (DTTL, DNPTB, ANFGN) comprised assets in which companies and households with large portfolios invest. Nonzero cross-interest-rate elasticities were allowed within each group, as well as between ANFGN and DPB, ANFGN and LGFCSB, and DSTL and DTTL. The rate on nonpersonal term and notice deposits in banks (RNPT) and the average yield on one- to three-year Government of Canada bonds (RS) were taken to be the opportunity cost of holding the non-interest-bearing assets (ANFCUR) and (DDB). Additional zero cross-interest-rate elasticities were imposed to ensure that complementarity did not exist.

By setting the interest rates at their average values and by solving the equations of Sector 15 with lag operators one can obtain the reduced form of Sector 15. The steady state of Sector 15 before the 1967 Bank Act amendments were made is described in the following equations with interest rates set at their 1963-1967 average values:

$$ANFLIQ = -10528\ PGNE + 2.4279\ YGNE + 1.3962\ ANFGN$$

$$DCDPB = -1392\ PGNE + 1.3031\ YGNE - .0272\ ANFGN$$

$$ANFCUR = 665\ PGNE + .1176\ YGNE + .0044\ ANFGN$$

$$DTL = -6069\ PGNE + .6470\ YGNE + .1458\ ANFGN$$

$$LGFCSB = -3737\ PGNE + .3610\ YGNE + .2736\ ANFGN$$

where

$$DCDPB = DDB + DNPTB + DPB, \text{ and}$$

$$DTL = DSTL + DTTL$$

The parallel equations for the period after the 1967 Bank Act changes took place (with interest rates set at average 1968-1972 values) are:

ANFLIQ = -25127 PGNE + 3.0427 YGNE + 1.7498 ANFGN

DCDPB = -10980 PGNE + 1.7568 YGNE + .2337 ANFGN

ANFCUR = -1404 PGNE + .2011 YGNE + .0524 ANFGN

DTL = -6037 PGNE + .6381 YGNE + .1407 ANFGN

LGFCSB = -6706 PGNE + .4470 YGNE + .3231 ANFGN

The dynamic versions of the above equations are presented in Tables 16 to 20. Note that chartered bank total assets (ABT) are given by ABT = DCDPB + DDGFB + LONB, where the latter two variables are exogenous. Similarly assets of trust and mortgage loan companies (ATL) are given by ATL = DTL + LONTL, where LONTL is exogenous. Thus ABT and ATL are effectively determined by the demand equations of Sector 15.

In Table 21 we present the equilibrium properties of each asset equation as they were after the 1967 Bank Act revision. The partial effect, shown in the first four columns, is based on individual equations. The total effect, shown in column 5, is based on the entire Sector 15, with ANFGN exogenous:

$$\frac{dAi}{dYGNE} = \frac{\partial Ai}{\partial YGNE} + \frac{\partial Ai}{\partial ANFLIQ} * \frac{\partial ANFLIQ}{\partial YGNE}$$

$$= \frac{\partial Ai}{\partial YGNE} + \frac{\partial Ai}{\partial ANFLIQ} * 3.0427$$

$$\frac{dAi}{dANFGN} = \frac{\partial Ai}{\partial ANFLIQ} * \frac{\partial ANFLIQ}{\partial ANFGN} = \frac{\partial Ai}{\partial ANFLIQ} * 1.7498$$

Table 16

THE DYNAMICS OF ANFLIQ

ANFLIQ = J1W(ANFGAN) + J2W(YGNE) + J3W(PGNE)

	J1W	%*	J2W	%	J3W	%
t=0	2.015	(115)	.686	(23)	-5668	(23)
-1	-.060	(112)	.531	(40)	-4389	(40)
-2	-.046	(109)	.412	(54)	-3399	(54)
-3	-.036	(107)	.319	(64)	-2632	(64)
-4	-.028		.247		-2038	
-5	-.027		.191		-1578	
-6	-.017		.148		-1222	
-7	-.013	(102)	.115	(87)	- 946	(87)
-8	-.010		.089		- 733	
-9	-.008		.069		- 567	
-10	-.006		.053		- 439	
-11	-.005	(100)	.041	(95)	- 340	(95)
-12	-.004		.032		- 263	
-13	-.003		.025		- 204	
-14	-.002		.019		- 158	
-15	-.002	(100)	.015	(99)	- 122	(98)
-16	-.001		.011		- 95	
-17	-.001		.009		- 73	
-18	-.001		.007		- 57	
-19	-.001	(100)	.005	(100)	- 44	(99)
Steady state	1.749	(100)	3.042	(100)	-25127	(100)

* Percentage cumulant

Table 17

THE DYNAMICS OF DCDPB

DCDPB = J1W(ANFGN) + J2W(YGNE) + J3W(PGNE)

	J1W	%	J2W	%	J3W	%
t=0	.707	(302)	.506	(29)	-3483	(32)
-1	-.107	(256)	.370	(50)	-2500	(55)
-2	-.083	(221)	.269	(65)	-1778	(71)
-3	-.064	(194)	.195	(76)	-1250	(82)
-4	-.050		.140		- 865	
-5	-.038		.099		- 587	
-6	-.030		.070		- 389	
-7	-.023	(133)	.048	(97)	- 249	(101)
-8	-.018		.032		- 149	
-9	-.014		.021		- 82	
-10	-.011		.014		- 35	
-11	-.008	(112)	.008	(101)	- 6	(104)
-12	-.006		.004		14	
-13	-.005		.004		25	
-14	-.004		.000		31	
-15	-.003	(104)	-.001	(101)	33	(103)
-16	-.002		-.002		34	
-17	-.002		-.002		32	
-18	-.001		-.002		30	
-19	-.001	(101)	-.002	(101)	27	(102)
Steady state	.234	(100)	1.756	(100)	-10980	(100)

Table 18

THE DYNAMICS OF ANFCUR

ANFCUR = J1W(ANFGN) + J2W(YGNE) + J3W(PGNE)

	J1W	%*	J2W	%	J3W	%
t=0	.049	(94)	.039	(19)	-265	(19)
-1	.001	(96)	.031	(35)	-216	(34)
-2	.001	(98)	.025	(47)	-175	(47)
-3	.001	(100)	.020	(57)	-142	(57)
-4			.016		-115	
-5			.013		- 94	
-6			.011		- 76	
-7			.009	(82)	- 62	(82)
-8			.007		- 50	
-9			.006		- 40	
-10			.004		- 32	
-11			.004	(92)	- 27	(92)
-12			.003		- 21	
-13			.002		- 17	
-14			.002		- 14	
-15			.002	(97)	- 11	(97)
-16			.002		- 9	
-17			.001		- 7	
-18			.000		- 6	
-19					- 6	(99)
Steady state	.052	(100)	.201	(100)	-1404	(100)

* Percentage cumulant

Table 19

THE DYNAMICS OF DTL

DTL = J1W(ANFGN) + J2W(YGNE) + J3W(PGNE)

	J1W	%	J2W	%	J3W	%
t=0	.137	(98)	.124	(19)	-1174	(19)
-1	.001	(99)	.100	(35)	- 946	(35)
-2	.001	(99)	.081	(48)	- 762	(48)
-3			.065	(58)	- 614	(58)
-4			.052		- 495	
-5			.042		- 399	
-6			.034		- 321	
-7			.028	(82)	- 258	(82)
-8			.021		- 209	
-9			.018		- 168	
-10			.015		- 135	
-11			.012	(93)	- 108	(93)
-12			.010		- 87	
-13			.008		- 70	
-14			.006		- 57	
-15			.005	(97)	- 46	(97)
-16			.004		- 37	
-17			.003		- 29	
-18			.003		- 24	
-19			.002	(99)	- 19	(99)
Steady state	.140	(100)	.638	(100)	-6037	(100)

Table 20

THE DYNAMICS OF LGFCSB

LGFCSB = J1W(ANFGN) + J2W(YGNE) + J3W(PGNE)

	J1W	%*	J2W	%	J3W	%
t=0	.122	(38)	.018	(4)	-747	(11)
-1	.045	(52)	.031	(11)	-729	(22)
-2	.035	(63)	.036	(19)	-685	(32)
-3	.027	(71)	.038	(28)	-628	(42)
-4	.021		.039		-564	
-5	.016		.036		-499	
-6	.012		.034		-437	
-7	.010	(89)	.030	(59)	-379	(70)
-8	.007		.027		-326	
-9	.006		.024		-279	
-10	.004		.020		-237	
-11	.003	(95)	.018	(79)	-201	(85)
-12	.003		.015		-169	
-13	.002		.013		-142	
-14	.002		.011		-118	
-15	.001	(98)	.009	(89)	- 98	(93)
-16	.001		.007		- 82	
-17	.001		.006		- 68	
-18	.001		.006		- 56	
-19	.000	(99)	.005	(95)	- 46	(97)
Steady state	.323	(100)	.447	(100)	-6706	(100)

* Percentage cumulant

Table 21

THE EQUILIBRIUM PROPERTIES OF SECTOR 15

Asset (A_i)	$\frac{\partial A_i}{\partial ANFLIQ}$[1]	$\frac{\partial A_i}{\partial ANFLIQ} * \frac{ANFLIQ}{A_i}$	$\frac{\partial A_i}{\partial YGNE}$	$\frac{\partial A_i}{\partial YGNE} * \frac{YGNE}{A_i}$	$\frac{dA_i}{dYGNE} * \frac{YGNE}{A_i}$	Total[2] Measure	Mean[3] Proportion
ANFCUR	.0311	.64	.1099	2.24	1.29	.055	.049
DPB	.2214	.90	.3371	1.36	1.27	.294	.247
DSTL	-.0122	-.45	.1339	4.96	.46	.041	.027
LGFCSB	.1847	1.90	-.1148	-1.18	1.43	.150	.097
DNPTB	.0008	.01	.5352	9.23	1.17	.116	.058
DTTL	.0928	.99	.2603	2.77	1.79	.149	.094
ANFGN	.5716	1.63	-1.7386	-4.97	0.0	.199	.350
DDB	-.0885	-1.13	.4772	1.93	.83	.014	.078

[1] This is the same as $.5716 dA_i/dANFGN$

[2] $\left(\frac{1.08 dA_i}{dYGNE} + \frac{dA_i}{dANFGN}\right) / \left(\frac{1.08 dANFLIQ}{dYGNE} + \frac{dANFLIQ}{dANFGN}\right)$

[3] $\frac{\text{Mean } A_i}{\text{Mean ANFLIQ}}$ in 1970

Since ANFGN and YGNE tend to grow together (over the sample period YGNE = -4963.2 + 1.08 ANFGN), RDX2 may yield plausible results even though dAi/dYGNE and dAi/dANFGN taken separately may be questionable. Thus in the last columns we compare the asset shares

$$\left(1.08\,\frac{dAi}{dYGNE} + \frac{dAi}{dANFGN}\right) \Big/ \left(1.08\,\frac{dANFLIQ}{dYGNE} + \frac{dANFLIQ}{dANFGN}\right)$$

of an increase in ANFLIQ, resulting from typical increases in YGNE and concomitant increases in ANFGN, to the 1970 mean ratios of assets over ANFLIQ. Note that in simulations where ANFGN and YGNE do not tend to grow together the results in Sector 15 may seem strange.

The elasticities of ANFLIQ and M1 may be of particular interest to users of RDX2. In equilibrium one can write for the post-Bank Act revision period, ignoring seasonal dummies:

$$ANFLIQ = (ANFGN - 14361\ PGNE + 1.739\ YGNE)/(.4343 - .0181\ RPD - .0092\ RNPT + .0429\ RS)$$

$$M1 = (.00087 - .00020\ RNPT - .00949\ RS)(ANFLIQ) + 2.8093\ PGNE + .58715\ YGNE$$

When the elasticities are valued at mean values,[6] the result is the elasticity of ANFLIQ and M1 with respect to:

	ANFLIQ	M1
YGNE	.94	.89
ANFGN	.61	-.35
RS	-.19	-.35

In Table 22 we report the results of three partial simulations with Sector 15: a shock of ANFGN by $100 million, a shock of YGNE by $100 million, and a shock of interest rates (RS raised by 100 basis points and allowed to feed into other interest rates through the forward spread and Sector 17).

C. The Reaction Function of the Central Bank, Equation 17.1

Since over the estimation period (1958-1972) interest rates appear to have been one of the main intermediate targets of monetary policy, we continue to incorporate a short-term interest rate reaction function using RS to represent endogenous monetary policy in the model. However, in the context of the current emphasis on controlling the growth rate in narrow money, the reaction function is not an adequate representation of the monetary policy process. Accordingly, it may be appropriate for forecasting and for simulations in a forecast context, to modify the reaction function so as to use narrow money supply as an exogenous policy variable.[7]

The reaction function is similar to that in earlier versions of RDX2. Distributed lags on the rate of growth of bank loans and on the rate of increase in the consumer price index indicate reactions to one intermediate target, and one final target, respectively. The percentage change in the stock of outstanding Government of Canada bonds and treasury bills is included to represent debt management considerations. The coefficient on this variable measures the extent to which the monetary authority allows the short-term interest rate to rise in response to the pressure of federal government borrowing. Varying concern over the value of the exchange rate is allowed for by permitting the

Table 22

EXPERIMENTS IN SECTOR 15
(Shock minus control)

Shock*	Period	Q**	ANFCUR	DPB	DSTL	LGFCSB	DNPTB	DTTL	DDB	ANFGN	ANFLIQ
(1)	1962-66	1	3.28	9.80	3.06	1.54	18.17	9.40	19.29	0.0	64.53
		4	8.61	29.49	9.79	11.35	40.46	26.00	41.48	0.0	167.17
		20	11.06	53.77	18.57	30.31	36.65	40.38	26.52	0.0	217.26
(1)	1968-72	1	3.34	10.43	2.50	.60	17.01	8.75	17.17	0.0	59.81
		4	9.86	36.33	6.87	9.72	40.06	25.15	36.38	0.0	162.70
		20	16.03	80.76	10.91	29.81	41.30	40.68	17.51	0.0	236.00
(2)	1962-66	1	3.42	9.61	1.36	11.46	23.25	13.01	30.05	100.0	192.16
		4	1.46	11.78	2.79	20.64	2.87	10.20	4.11	100.0	153.83
		20	-.23	10.97	3.03	22.61	-11.32	7.14	-14.74	100.0	117.45
(2)	1968-72	1	4.08	13.08	-.38	9.76	22.36	12.54	26.82	100.0	188.26
		4	3.20	21.51	-1.16	16.79	2.33	9.45	-2.83	100.0	149.27
		20	2.68	25.81	-1.26	22.72	-8.07	7.78	-18.84	100.0	130.80
(3)	1962-66	1	-9.75	-67.75	-25.45	-65.62	-135.76	-43.31	-144.56	0.0	-492.20
		4	-20.90	-187.37	-97.68	-253.60	-310.98	-86.36	-316.99	0.0	-1,273.89
		20	-15.29	-386.44	-264.27	-657.83	-496.62	-65.67	-305.82	0.0	-2,191.94
(3)	1968-72	1	-18.30	-108.43	-23.33	-100.05	-199.82	-58.23	-214.44	0.0	-722.60
		4	-47.69	-188.90	-78.78	-384.82	-452.43	-8.80	-437.24	0.0	-1,598.65
		20	-85.17	-4.61	-197.60	-1,017.40	-841.95	407.92	-620.31	0.0	-2,359.11

*(1) YGNE shocked by $100 million
(2) ANFGN shocked by $100 million
(3) RS shocked by 100 basis points, interest rates and forward spread endogenized
** Quarter

coefficient on the U.S. treasury bill rate to differ during various subperiods. For example, the negative coefficient on (QFLEX1D)(RTB2) was an indication of the announced intention of the Bank of Canada to allow the Canadian dollar to depreciate in late 1961 and early 1962. The QDOWN dummy indicates an attempt by the monetary authority to prevent a further appreciation of the Canadian dollar in the last quarter of 1971. The positive value on QCRISIS1 indicates concern with stabilizing the exchange rate during the exchange crisis in 3Q62.

The dynamic adjustment of RS to changes in its determinants under fixed exchange rates and the present floating exchange rate regime appears on the next page.

One of the problems faced by the original builders of RDX2 was the choice of a short-term interest rate for use in the formulation of a reaction function. Ideally, one would choose a ninety-day rate. But the rate on treasury bills could not be used, since during much of the fitting period the treasury bill market was a captive market for the chartered banks (only small amounts of treasury bills were held by the nonfinancial public). The alternative would be the ninety-day finance paper rate (R90). This rate incorporates changing risk elements (for example, the large increase in the rate after the failure of Atlantic Acceptance in 1965). The monetary authority cannot be considered to have looked at only one rate over the entire period we are concerned with. However, the short-term government bond rate (RS) could be considered to be a representative rate over the entire period because an active market in short-term bonds existed throughout the period and no apparent major changes in the risk premium were associated with government bonds.

RS = C + QFIX J1W(RTB2) + QFLEX2 J2W(RTB2)
+ J3W(J1P(LGBF+LGFTB))
+ J4W(J1P(ABLP+ABLB)) + J5W(J1P(PCPI))

	J1W	%*	J2W	%	J3W	%	J4W	%	J5W	%
t=0	.46232	(67)	.40127	(67)	.05384	(67)	.06038	(27)	.17187	(15)
-1	.15142	(89)	.13142	(89)	.01763	(89)	.06171	(54)	.20668	(33)
-2	.04959	(97)	.04304	(96)	.00578	(96)	.04705	(75)	.19659	(50)
-3	.01624	(99)	.01410	(99)	.00189	(99)	.03050	(88)	.17181	(65)
-4	.00532	(100)	.00462	(100)	.00062	(100)	.01670	(95)	.14221	(77)
-5	.00174	(100)	.00151	(100)	.00020	(100)	.00715	(99)	.11103	(87)
-6	.00057	(100)	.00050	(100)	.00007	(100)	.00234	(100)	.07933	(94)
-7	.00019	(100)	.00016	(100)	.00002	(100)	.00077	(100)	.04746	(98)
-8	.00006	(100)	.00005	(100)	.00001	(100)	.00025	(100)	.01555	(99)
-9	.00002	(100)	.00002	(100)	.00000	(100)	.00008	(100)	.00509	(100)
-10	.00001	(100)	.00001	(100)	.00000	(100)	.00003	(100)	.00167	(100)
Steady state	.68749	(100)	.59670	(100)	.08006	(100)	.22697	(100)	1.15010	(100)

* Percentage cumulant

In early experimentation the ninety-day finance paper rate was included in the business loan equation as the rate for alternate sources of business funds. In the R90 equation this rate depends on the nonpersonal term and notice deposit rate, the covered and uncovered U.S. treasury bill rate, and the tightness of the banking sector, which represents increased reliance upon the finance-paper market when rationing occurs in the loan market. Since RNPT depends upon RPRIME, which depends upon RS, a causal relationship runs from RS to R90 - an inverted term-structure relationship that is not logically consistent. In order to obtain sensible simulation results, R90 was dropped from the business loan equation and replaced by RS, which did not significantly change the fit of the equation.

The representation of interest rate determination in RDX2 can be considered to be an 'as if' procedure. Although the reaction process of the monetary authority may be directed toward ninety-day rates during short periods, it is as if, during a quarter, the central bank reacts by setting a new value for RS.

D. Determination of Bank Assets (Sector 16)

1. Cash reserves

In this version of RDX2 the determination of chartered bank statutory deposits (DSTATB) and of Bank of Canada notes held by chartered banks as required by statute (ABSTATN) is arrived at as in previous versions. The amount of Bank of Canada notes held by chartered banks (ABBCN), now depends on a longer distributed lag on currency by the public than was previously the case. The sum of the coefficients indicates the percentage of notes held by the public that the banks estimate they require as inventory. The buffer-stock role of ABBCN leads one to expect a negative coefficient on current public currency holdings.

2. Bank loans

The equations for personal loans (ABLP) and business and other general loans (ABLB) are formulated as reduced form equations derived from supply and demand functions. Demand for new loans is a function of expenditure (ie, nominal investment (I$) is used in the business loans equation (16.5), and consumer durables expenditure (C$) is used in the personal loans equation (16.4)) and of the differential between the rate charged by banks (RPRIME) and the rate on alternate sources of funds (RS). Supply of loans is a function of the amount of available funds as perceived by the banks (ie, chartered bank total assets (ABT) minus minimum desired liquid assets) and the tightness of the banking sector (RABELCD-RABELCDD) scaled by ABT. The interest rate differential term was included only for ABLB because RPRIME is not a good proxy for the rate on personal loans. Only in the personal loan equation was the tightness variable significant.

The loan equations were specified so that they have desirable long-run properties. In particular the coefficient on the lagged dependent variable may be interpreted as 1.0 minus the average repayments ratio of outstanding loans. The positive constant in the first difference ABLP equation is not significant, but is included because of a strong upward trend in the ratio of ABLP to consumer purchases during the period. We resorted to a reduced form approach because there is evidence of significant nonprice credit rationing in the loan market.

The main proxy variable used to indicate the tightness of the banking sector has been changed from that used in earlier versions of RDX2. We now concentrate on Canadian free earning liquid assets, rather than on total free earning liquid assets. The proxy for the desired ratio of Canadian free earning liquid assets to total bank assets is:

RABELCDD = J1L(J12A(RABELCD)) - 6.0

which is an adjusted moving average of the actual ratios.

3. Other bank assets

Bank mortgage assets are essentially predetermined by mortgage approvals and repayments on existing mortgages. The mortgage market is discussed below.

Chartered bank net foreign assets (ABELNF) are now endogenous to the model. The desired ratio of ABELNF to total bank assets is positively related to rates of return on foreign assets, represented by RTB2. The ratio is also negatively related to rates of return on domestic loans (RPRIME), positively related to the earning liquid asset ratio, and negatively related to the desired Canadian earning liquid asset ratio. A partial adjustment model is then used to determine the actual ratio of ABELNF to total bank assets.

E. The Structure of Interest Rates (Sector 17)

1. The term structure

The equations for interest rates on medium-term and long-term Government of Canada bonds (RMS, RML, RL) are now based on the term-structure approach proposed by Modigliani and Shiller [43]. The novelty in the Modigliani-Shiller approach derives from the division of the expected nominal interest rate into the expected real rate of interest and the expected rate of price change. Since the real rate is not directly observable, one is led to take separate distributed lags on the difference between the nominal rate of interest and the rate of price change, and lags on the rate of price change, or equivalently, separate distributed lags on the nominal rate of interest and on the rate of price change. In this last formulation one would expect the sum of coefficients on the nominal interest rate terms to be about 1 (in the absence of other explanatory variables) and the sum of coefficients on the rate of change in prices to be about zero.

A feature of previous versions of the RL equation was that we relied exclusively on the term-structure approach. Thus RL was largely independent of the real sector, whereas it was used in determining the supply price of capital. Now we view RL as a reduced form equation obtained from a constrained portfolio model over three broad classes of assets considered in RDX2 - liquid assets, medium- and long-term government debt, and real capital.

In the equation for long-term government bonds (LGBFR4C) estimated as a proportion of the total portfolio one would expect to find its own rate (RL) and the rates on alternative assets.

Hence, in an equation re-normalized on RL, one would expect to find the ratio of LGBFR4C to the total portfolio along with the various rates of return on other assets on the right-hand side of the equation. With the financial component as a proxy for the total portfolio, we use the relative supply variable:

LGBFR4C/(ANFLIQ+LGB12+LGB13+LGFTBNR)

Determining the rate of return on the nonfinancial part of the portfolio presents certain problems. In the absence of an index of land and housing prices we were unable to get a fix on the rate of return on consumer durables. We initially attempted to employ the term x/v + g, used in determining the supply price of capital - see section G, "The Market Value of Real Capital and the Supply Price of Capital" as a proxy for the rate of return on real capital, but it consistently took the wrong sign. This we interpreted as a failure to capture g. We then used the term VKB/KB$, the ratio of the market value of capital to its replacement cost, which is the RDX2 measure of Tobin's q [52].

An important alternative rate of return on financial assets is RCB2. One can argue that the appropriate rate is RCB2 minus the expected rate of inflation in the United States plus the expected rate of inflation in Canada. When this rate was employed in the regression, and the price expectation process from the RHOR2 equation was used as a proxy for the expected U.S. rate of inflation and PCPICE as the Canadian counterpart, it entered significantly but drove all the other variables out.[8]

The RML and RMS equations were also estimated so that RCB2 and VKB/KB$ could enter. With the exception of RCB2 in RMS, these variables proved to be significant. The results seem to be satisfactory although the sum of the weights on price changes in the RML and RMS equations are a little high.[9]

2. The prime rate

Since, as mentioned above, we do not assume that the prime rate (RPRIME) clears the loan market, we required an interest-rate-setting equation for RPRIME. Over the fitting period RPRIME stayed constant for long periods. We postulated that banks adjust their prime rate slowly to changes in RS. Prior to the 1967 revision of the Bank Act when there was a ceiling on bank loan rates the prime rate in equilibrium increased less than .4 for every point increase in RS. After the 1967 revision the prime rate in equilibrium increased slightly more than 1 for every point increase in RS.

3. Interest rates on deposits

Financial intermediaries are assumed to set deposit rates and to supply deposits to meet the demand at those rates. Slovin and Sushka [48] have demonstrated that financial institutions maximizing profits, or utility functions the arguments of which are profits and deposits, will increase deposit rates when interest rates on their assets increase and when interest rates on competing deposits increase. As well, interest rates on deposits will probably be increased in the short run if the percentage increase in major assets exceeds the percentage increase in deposits, ie, if there is a loss of liquidity.

The interest rate equation for the rate on nonpersonal term and notice deposits (RNPT) reflects the fact that a covered term and notice deposit held in the United States is a major alternative asset to a Canadian certificate of deposit and also that the rate on chartered bank assets (represented by RPRIME) is important in the setting of RNPT. Increased competition among banks meant that the tightness of the banking sector resulted in a significant increase on RNPT after the 1967 Bank Act revision. In addition, lower reserve requirements on time deposits and the re-entry of the banks into the mortgage market meant that the banks could offer higher rates than those charged before the Bank Act was revised. This effect is captured by interacting the Bank Act dummy with the mortgage interest rate. The imposition of a ceiling of 7.5 percent on RNPT, which was binding during at least some months in each quarter from 3Q69-2Q70, led to those quarters being gapped out of the regression. There is no statistical evidence that the agreement reached in Winnipeg among the chartered banks to limit interest rates on their deposits had an effect on the level of RNPT.[10]

The average rate that banks are willing to pay on personal deposits (RPD) depends on the rate earned on loans (RPRIME). After the Bank Act changes were made in 1967 the banks competed more aggressively for funds. Introduction of personal nonchequable savings deposits with a higher interest rate than that paid previously on personal savings deposits immediately increased the average interest rate.[11]

The interest rate paid by trust and mortgage loan companies on term deposits (RTTL) had to be competitive with the rates on short-term Government of Canada bonds (RS), personal deposits in banks (RPD), and nonpersonal term and notice deposits in banks (RNPT). The higher the interest rate on mortgages the more willing are trust and mortgage loan companies to raise RTTL so as to attract deposits.[12] Our experiments showed that, before the introduction of personal nonchequable savings deposits in banks following the 1967 Bank Act revision, the rate paid on personal deposits had little influence on RTTL. After these deposits were introduced, RTTL was set solely with reference to competitive considerations on the deposit side; RMC no longer entered the equation significantly.

The rate paid on nonchequable savings deposits in trust and mortgage loan companies (RSTL) is a function of the interest rate earned on conventional mortgages (RMC), the rate on competing deposits in banks (RPD), and the rate on alternate deposits in trust and mortgage loan companies (RTTL). Because the RSTL series prior to 1967 is constructed as a proxy, it is difficult to explain the early part of the series. Thus the regression begins in 1967.

4. Increases in interest rates: A partial adjustment to equilibrium

One can expect that an increase of 100 basis points in all exogenous or target interest rates will eventually lead to an increase of about 100 basis points in all endogenous interest rates. Otherwise such a shock would lead to continuing arbitrage from assets with interest rates that have increased by less than the 100 basis points to assets with interest rates that have increased by 100 basis points or more.[13]

In the following equations we express the equilibrium changes in endogenous interest rates in terms of RS and of exogenous interest rates, taking into account the forward spread under flexible exchange rates. When two equations are presented, the first (pre) applies to the period before the Bank Act amendments of 1967 were made, the second (post) is applicable to the following period (3Q67-4Q72).

dRL = .55 dRS + .50 dRCB2

dRML = .46 dRS + .41 dRCB2

dRMS = .88 dRS

dRNPT = .73 dRS + .62 dRCD2 - .58 dRTB2 + .01 dRCB2 (pre)

dRNPT = 1.12 dRS + .62 dRCD2 - .58 dRTB2 + .01 dRCB2 (post)

dRPRIME = .37 dRS (pre)

dRPRIME = 1.26 dRS (post)

dRTTL = .73 dRS + .29 dRCB2 + .20 dRCD2 - .19 dRTB2 (pre)

dRTTL = 1.19 dRS + .20 dRCD2 - .19 dRTB2 (post)

dRPD = .12 dRS (pre)

dRPD = .85 dRS (post)

dRSTL = .88 dRS + .12 dRCB2 + .05 dRCD2 - .05 dRTB2 (post)

dRMC = .50 dRS + .45 dRCB2

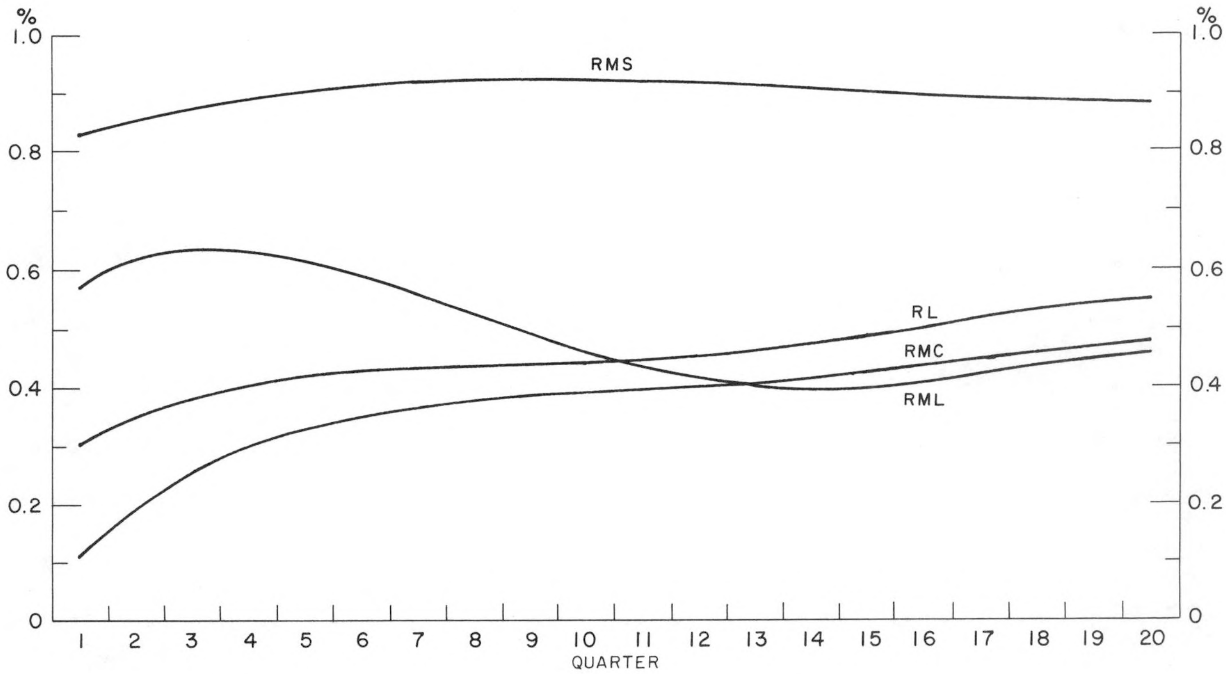
where

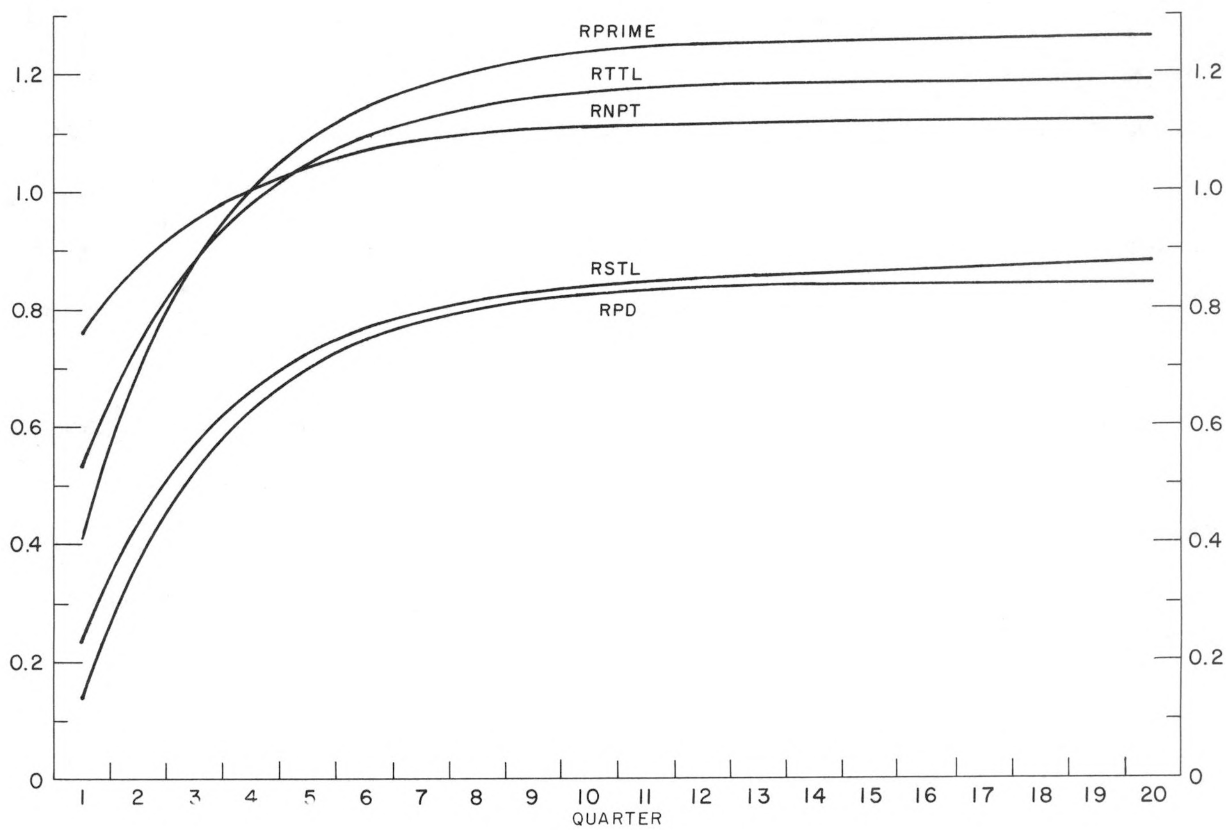
d is the differential operator

In Figure 18 we show the results of a partial simulation of Sector 17 (again taking into account the forward spread under flexible exchange rates) where RS alone is shocked. We present on the page after Figure 18 the dynamic adjustment of RL when RS is determined by the central bank reaction function.

Figure 18

CUMULATIVE EFFECT OF SHOCKING RS BY ONE PERCENTAGE POINT





RL = C + (QFIX)(J1W(RTB2)) + (QFLEX2)(J2W(RTB2))
+ J3W(J1P(LGBF+LGFTB) + J4W(J1P(ABLB+ABLP))
+ .49598 RCB2 + 5.1890 LGBFR4C/(ANFLIQ
+ LGB12 + LGB13 + LGFTBNR) + .52415 VKB/KB$
+ J5W(J4P(PCPI)) + J6W(J1P(PCPI))

	J1W	J2W	J3W	J4W	J5W	J6W
t=0	.13917	.12079	.01612	.01818	.05174	.02727
-1	.06764	.05871	.00788	.02146	.07041	-.00308
-2	.03773	.03275	.00439	.01914	.07483	-.00771
-3	.02286	.01984	.00266	.01488	.07197	-.01059
-4	.01417	.01230	.00165	.01034	.06481	-.01195
-5	.00861	.00747	.00100	.00646	.05493	-.01200
-6	.00505	.00439	.00059	.00380	.04332	-.01094
-7	.00298	.00258	.00035	.00228	.03071	-.00900
-8	.00207	.00180	.00024	.00140	.01762	-.00639
-9	.00209	.00182	.00024	.00098	.01091	-.00331
-10	.00282	.00244	.00033	.00088	.00752	.00001
-11	.00403	.00350	.00047	.00103	.00620	.00337
-12	.00552	.00479	.00064	.00136	.00631	.00655
-13	.00707	.00614	.00082	.00179	.00739	.00934
-14	.00848	.00736	.00099	.00225	.00908	.01152
-15	.00952	.00827	.00111	.00267	.01099	.01289
-16	.00999	.00867	.00116	.00299	.01277	.01322
-17	.00968	.00840	.00113	.00312	.01407	.01231
-18	.00837	.00727	.00097	.00301	.01452	.00995
-19	.00585	.00508	.00068	.00258	.01379	.00592
-20	.00192	.00166	.00022	.00176	.01150	.00000
Steady state	.37657	.32684	.04385	.12432	.62997	.01011

F. The Mortgage Market (Sector 17)

If one believed that equilibrium always held in the mortgage market, then one should have a supply curve for mortgages, a demand curve for mortgages, and the mortgage interest rate determined at the intersection of these curves. However, we assume that there is disequilibrium in the mortgage market involving some form of noninterest rationing that generates observations on the supply curve but not necessarily on the demand curve. We thus have equations for the supply of mortgage funds and for the conventional mortgage rate (RMC).

The conventional mortgage rate equation is a market-adjustment equation in which the change in the mortgage rate is assumed to be a function of the long-term Government of Canada bond rate (RL) and excess demand. Since we assume that the actual position is on the supply curve, the actual supply in the form of approvals is included with demand variables. An increase in the number of families relative to the real supply of mortgage money or relative to the existing housing stock is assumed to put upward pressure on the conventional mortgage rate, as is increased real permanent disposable income. The dummy variable QNHA represents National Housing Act interest rate ceilings from 1Q54 to 3Q67.

The NHA mortgage rate (RNHA) is itself exogenous in the model until 4Q70. From 1Q71 onward it is set, for simulation purposes, equal to the commercial mortgage rate minus .3 - the average difference between RMC and RNHA in the period 1Q71-4Q72.[14]

Direct lending by CMHC (HAPCMHCS, HAPCMHCM) and by miscellaneous financial institutions (HAPNROT) is treated exogenously in RDX2. For life insurance companies, banks, and trust and mortgage loan companies we specify supply functions in the form of lagged adjustment models explaining the flow of mortgage approvals. Desired mortgage assets (M*) depend on the expected difference, scaled by total assets, between the mortgage rate (INT = .5RMC+.5RNHA) and the rate on alternate assets (three- to five-year Government of Canada bonds), and expected assets (A*).

M* = M*(A*,((INT-RMS)(A))*)

A distributed lag on past values can be used as a proxy for expected values.

((INT-RMS)(A))* = JW((INT-RMS)(A))

A* = JW(A)

One can then postulate that approvals (a) reflect a partial adjustment process:

a = e(M*-J1L(M))

a = eJW((INT-RMS)(A)) + eJW(A) - eJ1L(M)

Approvals then feed into the stock of existing mortgages:

M = (1-r)J1L(M) + (1-c)JW(a)

where r is the repayments ratio.

The sum of the weights on approvals (1-c) need not be 1 if there are cancellations.[15] In long-run equilibrium, approvals will be r/(1-c) times the stock of mortgages. Because it is impossible to identify the parameters one cannot differentiate between the above model and

$$a = (r/(1-c))(J1L(M)) + e(M^*-J1L(M))$$
$$= JW((INT-RMS)(A)) + JW(A) - (e-r/(1-c))J1L(M)$$

We estimated the approvals equation for trust and mortgage loan companies subject to the constraint that the coefficient on the lagged mortgage stock is equal to the sum of weights on JW(ATL), where ATL is total assets of trust and mortgage loan companies. If the interest rate variables were not scaled by ATL, there would be a long-run marginal propensity of unity to make approvals out of the excess of assets over mortgage loans.[16] The interest rate on mortgages is taken to be the average of conventional and NHA mortgage rates. An increase in the real mortgage rate tends to reduce approvals.[17]

The long-run equilibrium position of trust and mortgage loan companies is expressed by the following equations representing assets and approvals, respectively:

$$ATLM = -\ 23.675 + .737\ ATL + .100(INT-RMS)(ATL) - .024(INT-PCPICE)(ATL)$$

$$HAPTL = .034\ ATLM + 3.595$$
$$= 2.781 + .024\ ATL + .0034(INT-RMS)(ATL) - .0008(INT-PCPICE)(ATL)$$

The asset variable for life insurance companies is taken to be the difference between life insurance assets and policy loans. An increase in policy loans has a dampening influence on mortgage loan approvals. No significant interest rate effect could be detected. The tendency of life insurance companies to approve fewer mortgage loans when the chartered banks are active in the mortgage market is proxied by the inclusion of chartered bank mortgage approvals in the equation. In equation 17.15 the assets of life insurance companies (ALI) are a function of permanent income. The long-run equilibrium of life insurance companies is expressed by the following equations:

$$\begin{aligned} ALIM &= 847.8 + .644\ (ALI-APLLI) - 4.23\ HAPB \\ &= 847.8 + .644\ (ALI-APLLI) - .068\ ABLM \\ HAPLI &= .028\ ALIM + 63.7 \\ &= -\ 39.8 + .018\ (ALI-APLLI) - .119\ HAPB \end{aligned}$$

It is difficult to explain chartered bank mortgage approvals because the banks were virtually out of the market from 1Q61 to 1Q67 when the ceiling on interest rates imposed by the Bank Act made bank mortgage loans unprofitable. When the ceiling was removed and the banks re-entered the market, they were far from their desired equilibrium position. Thus in equations 16.6 and 17.14 actual mortgage approvals adjust with long distributed lags to desired mortgage approvals, which in turn adjust to the desired stock of mortgages as formulated above. Prior to 1967, when the banks were not allowed to hold conventional mortgages, the bank mortgage rate used in this version of RDX2 is the NHA rate. After 1967 it is a simple average of the NHA rate and the conventional mortgage rate. The asset variable used is earning liquid assets minus required secondary reserves.

Since the asset variable is equivalent to: total bank assets minus primary reserves minus required secondary reserves minus securities (excluding those issued by federal government) minus loans minus mortgage loans, all multiplied by .1, it may be rewritten as .1 (ABT - OC - ABLM), where OC is other commitments. The system may then be solved in equilibrium in terms of ABT - OC:[18]

$$ABLM = (-30.498+(.001967+.005261(RMB-RMS))(ABT-OC))$$
$$/(.00390+.005261(RMB-RMS))$$
$$HAPB = .0162\ ABLM$$
$$= (-.493+(.000032+.000085(RMB-RMS))(ABT-OC))$$
$$/(.00390+.005261(RMB-RMS))$$

In the following table we show the estimated marginal long-run response of mortgage assets, evaluated at average interest rates over the period, to increases in the scale variables (ABT-OC, ATL, and ALI-APLLI) and the actual ratios of holdings of mortgage assets to the scale variables.

	Marginal	Actual 4Q61	Actual 4Q66	Actual 4Q72
ABLM	.859	.228*	.198*	.423
ATLM	.818	.543	.634	.688
ALIM	.644	.396	.461	.409

* Banks did not approve new mortgage loans in this period.

G. The Market Value of Real Capital and the Supply Price of Capital[19] (Sector 18)

1. Estimation of a time series for the market value of real capital

A time series for the market value of domestic business fixed capital assets and inventories was obtained by applying to the aggregate book value of these assets a valuation ratio obtained from balance sheet and stock market data for the seventy-six largest nonfinancial corporations that have traded their shares on Canadian stock exchanges continuously since 1955. An estimate of aggregate book value was obtained by accumulating business investment expenditure at historic cost and deducting depreciation at the rates on declining balances specified for tax purposes, ie, 5 percent per annum for structures and 20 percent per annum for machinery and equipment.

The market value of the capital assets of the firms in our sample was estimated by assuming that the market value of financial assets and liabilities is equal to the book value. Thus, given the market value of a firm's equity, the market value of its capital assets can be calculated as follows:

Market value of capital assets = Market value of equity
- Financial assets at book value

An aggregate valuation ratio was then obtained by dividing the market value of the capital assets of all firms in the sample by the book value. The market value of the capital stock for all firms (VKB) was estimated by applying this ratio to the book value. The valuation ratio was updated for 1971-1972 by using the results of a regression relating the logarithm of the ratio of the current valuation ratio to the valuation ratio in the last quarter to the logarithm of the ratio of the current Toronto Stock Exchange index to the past Toronto Stock Exchange index.

2. A model determining the supply price of capital

The supply price of capital, in the terminology of James Tobin [52], is the rate of return required to induce investors to hold the existing stock of real capital in their portfolios. Since neo-Keynesian monetary theory suggests that the supply price of capital is a key link between the financial sector and expenditure decisions, we have attempted to approximate the supply price of capital empirically in RDX2. To distinguish the theoretical concept from our empirical approximation, we have adopted the convention of referring to the former as r and the latter as RHO. Given r and the expected future earnings stream (x(t)), the market value of real capital (v) is simply the present discounted value given by:

$$v = \int_0^\infty e^{-.01rt}\, x(t)\, dt$$

If the earnings stream is assumed to grow at a constant rate (g) beginning at an initial level (x) this integral reduces to:

$$v = x/(.01(r-g)) \qquad (1)$$

The rate of growth (g) is assumed to be equal to the expected rate of change in the price level as represented by a distributed lag function of the rates of change during the last four quarters of the price of gross private business product (with the weights summing to one) and an error term:

$$g = JW[J4P(PGPP)] + u \qquad (2)$$

The real supply price of capital (RHOR) is thus:

$$r - g = (100)(x/v)$$

It should be noted that the expected rate of growth of earnings refers solely to earnings expected to accrue to holders of the existing stock and excludes earnings generated by future additions to the capital stock financed by new saving. Therefore, we assume that the expected rate of growth of earnings depends on the expected rate of change in the price level but not on expected changes in real output or profits.

The determination of r, according to the portfolio preferences of investors, is represented by a reduced form equation derived from the supply and demand for real capital. Demand is assumed to depend on r and the long-term Government of Canada bond rate (RL). The differential between these rates of return is made a function of relative supply as measured by the ratio of the earnings stream from real capital (rv) to interest paid on all provincial-municipal and federal government debt (h)[20] and an error term (w). Thus:

$$RL - r = a + b\,(.01rv/h) + w \qquad (3)$$

Using (1) to eliminate r from (3), one obtains:

$$RL - (100)(x/v) = g + a + b(x+.01gv)/h + w \qquad (4)$$

Substituting for g and using (2) yields:

$$\begin{aligned} RL - (100)(x/v) = {} & JW[J4P(PGPP)] + a \\ & + b[x+.01JW[J4P(PGPP)]v]/h \\ & + u + w + b(.01v/h)u \end{aligned} \qquad (5)$$

3. Empirical estimation of the supply price of capital and the expected rate of inflation

Estimates of the parameters were obtained from a regression, based on (5), of RL - (100)(x/v) on past rates of change in prices and the relative supply variable (equation 18.1). The current level of earnings (x) from the stock of real capital is taken to be the sum of corporate profits net of tax accruals, corporate interest paid, net income of nonfarm unincorporated business less imputed labour income, and the profits of government business enterprises. A four-quarter moving sum of earnings is used. The average of the beginning- and end-of-quarter value of VKB is v.

Since the weights in the expected-rate-of-inflation variable enter (5) in a nonlinear fashion, the estimation was carried out with an iterative procedure. In the first iteration JW[J4P(PGPP)] was set equal to one in the third term and Almon variables were employed to estimate the distributed lag weights on past changes in prices. The coefficients on the Almon variables were then used to recalculate the third term. The regression was run again and the procedure was repeated until the estimate of b converged.

Because error terms are included in equations (2) and (3), two estimates of r can be obtained. From the definitional equation (1), r can be estimated as (100)(x/v) + JW(J4P(PGPP)). The reduced form portfolio equation (3) gives:

$$r = RL - a + b(x+.01JW(J4P(PGPP))v)/h$$

We simply took an average of these two expressions to obtain a series for RHO. By substitution it can be seen that

$$RHO = (100)(x/v) + JW(J4P(PGPP)) + .5e \qquad (6)$$

where e is the single equation error in the estimating equation.

As we point out above, theory suggests that the sum of the weights of JW should be one. However, when the equation is estimated to the end of 1972 the sum of the coefficients is only .61. We tried using more complicated estimating equations but this situation did not change. The coefficients were multiplied by a constant so that their sum was one. Next they were applied to the percentage increase in prices to create the expected inflation term. This term was then subtracted from RHO to get RHOR.[21] [22]

$$RHOR = (100)(x/v) + JW(J4P(PGPP)) - 1/.61\ JW(J4P(PCPI)) + .5e \qquad (7)$$

4. Interpretation

For purposes of calculating the effect of the variables exogenous to this sector on RHO, RHOR, and VKB, we assumed that PGPP and PCPI move at the same rate.[23] Then

RHOR = 100x/v - .39/.61 JW(J4P(PGPP)) + .5e (7a)

The system of equations can be rewritten (with the actual estimated coefficients and with g = JW(J4P(PGPP))) as:

RL - 100(x/v) = 1.24 - .83((x+.01gv)/h) + g + e (8)

RHO = 100x/v + g + .5e (9)

RHOR = RHO - (1/.61)g (10)

Differentiating one gets

$$\begin{bmatrix} 100\frac{x}{v^2} + .83\frac{.01g}{h} & 0 \\ 100\frac{x}{v^2} & 1 \end{bmatrix} \begin{bmatrix} dv \\ dRHO \end{bmatrix} = \begin{bmatrix} \frac{100}{v} - \frac{.83}{h} & -1 & 1-.83\frac{.01v}{h} & .83\frac{x+.01gv}{h^2} \\ \frac{100}{v} & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} dx \\ dRL \\ dg \\ dh \end{bmatrix}$$

and dRHOR = dRHO - (1/.61)dg

Using the mean values of the relevant variables over the period 1Q61-4Q72 we obtain the partial derivatives and elasticities set out on the next page. The notation E(RHO)/E(RL) represents the elasticity of RHO with respect to RL. Note that in this analysis we ignore time paths to equilibrium arising from the fact that g is a distributed lag, x and h are moving sums, and v is a moving average.

$$\begin{bmatrix} dv \\ dRHO \\ dRHOR \end{bmatrix} = \begin{bmatrix} 5.9 & -9666.3 & 5063.3 & 29.8 \\ .00061 & .92 & .52 & -.0028 \\ .00061 & .92 & -1.12 & -.0028 \end{bmatrix} \begin{bmatrix} dx \\ dRL \\ dg \\ dh \end{bmatrix}$$

$$\begin{bmatrix} Ev \\ ERHO \\ ERHOR \end{bmatrix} = \begin{bmatrix} .48 & -.69 & .09 & .52 \\ .44 & .59 & .08 & -.44 \\ .61 & .82 & -.24 & -.61 \end{bmatrix} \begin{bmatrix} Ex \\ ERL \\ Eg \\ Eh \end{bmatrix}$$

Our next consideration is an economic interpretation of the signs in the elasticities table. After an explanatory variable is changed, RHO and v must adjust to satisfy the identity in equation (9) and the equilibrium condition as expressed in the reduced form equation (8). It is, in general, easiest to interpret the results by examining polar cases such as the effect of the change in an explanatory variable on the supply of and demand for equities, if RHO is unchanged or if RHO is increased by the same amount as the change in an explanatory variable, and so on. The consequent excess demand for or supply of equities enables one to deduce the direction of the change from the hypothesized provisional result.

Suppose, initially, that x and h are increased by the same proportion, RHO would be unchanged and v would increase proportionately. In this case current profits (x), capital gains (gv), and the income from bonds (h) rise by the same proportion. Since the relative supply of equities and debt are unchanged, there is no pressure for change in RHO. If h alone is increased; then the relative supply of debt rises, the demand for equities increases at unchanged RHO, v rises, and RHO falls. Although current profits are unchanged in this conceptual experiment, expected capital gains (gv) rise with the increase in v. Thus there is an equilibrating reduction in the demand for equities as RHO falls and an equilibrating rise in its supply as v rises. If x alone is increased, with RHO initially unchanged and v increased proportionately, there will be an excess supply of equities since current profits and expected capital gains increase. This excess supply of equities will lead to a fall in v and a rise in RHO so that the demand for equities will increase and the supply of earnings from equities will decrease. The outcome is a less-than-proportionate increase in RHO.

An increase in RL clearly reduces the demand for equities at unchanged RHO, which leads to an increase in RHO and a fall in v. The result is an equilibrating increase in demand and a decrease in supply through the fall in gv. The change in RHO is less than the change in RL because of the supply effect. If the change in RHO were equal to the change in RL, then the demand for equities would be unchanged but the supply of equities would fall owing to the change in gv. An excess demand for equities and a consequent fall in RHO would result.

The final experiment involves a change in the expected rate of inflation (g). Suppose initially that RHO increases by the amount of the change in g leaving v unchanged and satisfying the identity, there would then be an increase in the demand for equities, because of the increase in RHO, and an increase in supply, because of the rise in gv. The final result is indeterminate; v can rise or fall. Given the values of the variables and parameters in RDX2, there would be an excess demand for equities, v would rise, and RHO would fall. Thus the final result is that v rises and RHO rises by less than the increase in g.

H. Reaction of the Financial Sector to Real-Side Shocks

The reaction of the financial sector of RDX2 to shocks initiated on the real side of the model is of interest. Consider, for example, a government expenditure shock that causes prices and real income to rise. In Table 23 we show the results of two such experiments. We shocked real government expenditure by $100 million (1962-1966) and let the shock permeate the entire model. In the first experiment we used the RS reaction function; in the second we kept M1 = ANFCUR + DDB at control.

When we used the interest rate reaction function, we allowed the supply of money to vary in order to equal the demand. Increases in bank loans, because of increased investment and the consumption of durables, and in prices will cause the central bank to raise the short-term interest rate. This pushes up all other interest rates.

Increases in real income and in ANFGN, the result of an increased government deficit, lead to an increase in liquid assets held by the general public. Relative interest rate movements and the coefficients on interest rates in the demand functions determine the division of the increase in total liquid assets among individual assets.

If business, personal, and mortgage loans increase by a greater percentage than bank deposits, banks will sell liquid assets. The tightness variable will decrease, signaling banks to cut down on personal loans and, after the Bank Act revision of

Table 23

CHANGES IN FINANCIAL VARIABLES WHEN GOVERNMENT EXPENDITURE IS INCREASED BY 100 MILLION CONSTANT 1961 DOLLARS: 1962-1966

Quarter	RS	RL	RHOR	M1	ABT	ATL	VKB	HAP.[1]	LOANS[2]	RAB.[3]	ANFGN	ANFLIQ	YGNE
The RS reaction function used													
1	.06	.02	.07	25	47	13	756	.4	7	.163	51	118	78
4	.17	.08	.21	71	125	53	-242	2.8	64	.057	255	473	158
8	.19	.09	.20	81	153	100	2,036	3.3	120	-.123	427	761	254
12	.14	.06	.07	89	177	132	3,290	8.4	138	-.081	497	923	285
16	.09	.04	-.02	114	238	157	3,328	12.0	161	-.044	601	1,160	305
20	.03	.06	-.08	129	285	191	1,489	9.8	185	.039	767	1,467	298
M1 at control													
1	.37	.11	.14	0	-17	1	173	-.1	3	-.106	117	95	77
4	.42	.18	.30	0	-48	21	-862	-6.2	33	-.263	401	370	148
8	.44	.19	.25	0	-55	63	1,142	-5.0	66	-.291	607	637	226
12	.38	.16	.12	0	-55	92	2,333	1.4	83	-.238	731	822	251
16	.37	.16	.03	0	-60	112	2,230	1.7	104	-.173	923	1,064	266
20	.30	.19	-.04	0	-50	145	544	.7	119	-.112	1,137	1,374	255

[1] HAPTL + HAPB + HAPLI

[2] ABLB + ABLP

[3] RABELCD - RABELCDD (The tighter the banking system, the smaller this variable)

1967, to raise the rate on nonpersonal term and notice deposits (RNPT).

The increase in interest rates and permanent income will increase the mortgage rate. If the increase in the mortgage rate is less than the increase in the medium-term government bond rate, some financial intermediaries will have an incentive to decrease mortgage approvals. However, this incentive will be outweighed by the increase in the size of their assets as the inflow of their deposits grows. As well, any rise in profits will increase RHOR, RHO, and VKB as described above. The increase in RL will also tend to increase RHOR and RHO, but will tend to decrease VKB.

In the second experiment the $100 million shock is repeated with M1 kept constant. The increase in ANFGN[24] and YGNE require an increase in RS to equilibrate the demand for and supply of M1. This increase in RS feeds through the term structure and the deposit interest rate equations, and thus increases all interest rates. The portfolio grows, although by less than in the previous experiment,[25] and again this growth is spread among individual assets according to relative interest rate movements and the coefficients of interest rates in the demand functions.[26] Changes in the mortgage sector are qualitatively, though not quantitatively, the same as they were in the previous experiment.

I. Transmission of Monetary Policy Within the Financial Sector

In order to determine the direct effect that a change in monetary policy will have outside the financial sector one may wish to know what changes there will be in the values of financial variables, given a change in either the short-term interest rate or the money supply (M1). That is, with the real sector exogenous, what changes take place in the values of the important variables (RS, RL, RHO, RHOR, V, VKB, HAPB, HAPLI, and HAPTL) that feed into the real and international sectors following a change in monetary policy?

We first consider an increase in the short-term interest rate. See the top half of Tables 24 and 25. Through the term structure relationship this increase will increase RL. The increase in RL will increase RHO and RHOR and decrease VKB as described above. An important part of the net wealth of the private sector (V) is VKB.

At the same time there will be a rearrangement of the portfolios of the general public in response to relative changes in interest rates (RS) and deposit rates. In addition there will be a contraction in these portfolios because, with the number of government bonds outstanding given, ANFGN will increase only as chartered bank earning liquid assets fall. To equilibrate the demand for ANFGN with the supply, given an increase in RS and other interest rates, a decrease in ANFLIQ is required. This is necessary because the increase in interest rates will increase the demand for ANFGN, given the estimated coefficients in the implicit ANFGN equation. The effect on mortgage approvals will stem from the changes in chartered bank total assets and trust and mortgage loan company assets brought about by changes in their deposit liabilities, as well as by relative movements in RMC and RMS.

A change in the money supply (M1) will result in a change in RS to equilibrate the demand for and supply of money, given the values of YGNE and ANFGN. See the bottom half of Table 24 and

Table 24

THE TRANSMISSION OF MONETARY POLICY WITHIN THE FINANCIAL SECTORS: SECTORS 15-18*: 1962-1966
(Shock minus control)

Experiment		RS	RL	RHOR	M1	ABT	ATL	VKB	HAP**	ANFGN	ANFLIQ
RS increased	1	1.00	.28	.24	-91	-229	-42	-1,492	-1.6	191	-127
by 100	4	1.00	.39	.40	-279	-688	-130	-4,784	-30.8	422	-581
basis points	8	1.00	.42	.42	-353	-940	-186	-4,406	-41.4	530	-911
	12	1.00	.43	.39	-363	-1,050	-212	-4,392	-37.6	626	-1,029
	16	1.00	.48	.43	-371	-1,132	-227	-5,029	-39.0	733	-1,064
	20	1.00	.53	.52	-384	-1,201	-233	-7,000	-32.7	817	-1,084
M1 reduced by	1	4.44	1.27	1.09	-400	-1,002	-183	-7,594	-6.8	839	-552
$400 million	4	1.03	.46	.47	-400	-1,000	-194	-5,307	-74.0	539	-959
	8	1.10	.47	.47	-400	-1,115	-225	-4,799	-39.0	628	-1,119
	12	1.09	.50	.45	-400	-1,199	-244	-4,750	-38.0	746	-1,163
	16	1.04	.55	.50	-400	-1,252	-247	-5,635	-38.0	830	-1,162
	20	.99	.56	.56	-400	-1,288	-242	-7,322	-29.0	901	-1,134

* The forward spread from Sector 21 is included in these experiments.

** HAPTL + HAPB + HAPLI

Table 25

THE TRANSMISSION OF MONETARY POLICY WITHIN THE FINANCIAL SECTORS: SECTORS 15-18*: 1968-1972
(Shock minus control)

Experiment		RS	RL	RHOR	M1	ABT	ATL	VKB	HAP**	ANFGN	ANFLIQ
RS increased	1	1.00	.29	.27	-144	-334	-46	-2,516	-2.5	252	-207
by 100	4	1.00	.39	.32	-446	-916	-41	-3,485	-88.6	362	-934
basis points	8	1.00	.42	.34	-567	-1,148	50	-3,421	-94.6	219	-1,472
	12	1.00	.44	.39	-617	-1,280	101	-4,667	-81.0	99	-1,865
	16	1.00	.48	.50	-711	-1,487	133	-6,596	-85.0	-60	-2,400
	20	1.00	.52	.50	-797	-1,706	153	-7,659	-81.1	-324	-3,081
M1 reduced by	1	2.60	.80	.74	-400	-923	-127	-6,681	-9.2	699	-571
$400 million	4	.64	.29	.23	-400	-792	10	-2,802	-123.4	200	-938
	8	.66	.29	.23	-400	-810	74	-2,372	-73.5	88	-1,129
	12	.68	.28	.25	-400	-833	97	-3,032	-49.1	-18	-1,324
	16	.56	.27	.28	-400	-853	106	-3,858	-33.9	-201	-1,591
	20	.52	.27	.26	-400	-902	96	-4,087	-21.1	-375	-1,901

* The forward spread for Sector 21 is included in these experiments.

** HAPTL + HAPB + HAPLI

Table 25. The interest rate movement in the first quarter will overshoot its equilibrium values because of the stock adjustment mechanism in Sector 15, and the change in the short-term interest rate will then feed through the economy as described above.

FOOTNOTES

1 The analysis of this sector results from the combined efforts of the author and Charles Freedman. However, responsibility for development and estimation of the financial sector rests with the author.

2 Alternately, one could center this discussion on the money supply and suppress the reaction function.

3 This means that in tracing out the dynamics of Sector 15 one should treat asset demand as a function of the supply of bonds. The sector may be thought of as eight equations of the form $[A(i) = f_i(A, x)]$, where A is liquid wealth and x is a vector of interest rates, income and price, plus the adding up constraint $[\Sigma A(i) = A]$. Since just eight of these equations are independent, there are eight equations and nine unknowns. However, given the value of the stock of bonds (A(8)), one can write $[A = f_8^{-1}(A(8), x)]$. Therefore $[A(i) = g_i(A(8), x)]$ $i = 1, 2, \ldots 7$.

4 That is, the sum of the asset ratios must always be 1. See [55] pp 6-8 for a clear explanation.

5 The constant terms and coefficients of the scale variables were allowed to change after the Bank Act was amended in 1967 in all except the demand deposits equation. The results are not entirely satisfactory. We had to impose a zero as the coefficient of J1L(ANFLIQ)/ANFLIQ in the

equation for savings in trust and mortgage loan companies (DSTL) because otherwise the constant term would be negative in that equation.

6 In evaluating these 'total' elasticities we take into account the equilibrium movements in other interest rates with respect to RS.

$$\frac{dANFLIQ}{dRS} * \frac{RS}{ANFLIQ} = \frac{RS}{ANFLIQ}\left[\frac{\partial ANFLIQ}{\partial RS} + \frac{\partial ANFLIQ}{\partial RPD} * \frac{\partial RPD}{\partial RS} + \frac{\partial ANFLIQ}{\partial RNPT} * \frac{\partial RNPT}{\partial RS}\right]$$

$$\frac{dM1}{dRS} * \frac{RS}{M1} = \frac{RS}{M1}\left[\frac{\partial M1}{\partial RS} + \frac{\partial M1}{RNPT} * \frac{\partial RNPT}{\partial RS} + \frac{\partial M1}{\partial ANFLIQ} * \frac{\partial ANFLIQ}{\partial RS}\right]$$

The interest rates are evaluated at mean 1968-1972 values. Average values for 1970 are used for the asset proportions.

7 Users of the model can replace the reaction function on the short-term interest rate with an assumed reaction function for narrow money (M1) or change the reaction function for RS so that it depends on past deviations of M1 from its desired growth path.

8 We then tried the expression J4A[J1P(PFX)] to represent expected exchange rate movements. It was significant in early experiments, but when the Modigliani-Shiller approach was adopted it became insignificant and so was dropped.

9 Recent work, [45] and [57], has shown that the long distributed lags that maximize R^2 in the study of term structure equations may be spurious. Indeed the length of the lag (five years) is rather disturbing. Experiments are presently being carried out with weekly and monthly data to

get a better understanding of the term structure of interest rates in Canada.

10 This accords with the findings of Clinton and Masson [14]. Of course, the 'Winnipeg Agreement' was in force for only three of the quarters covered in the estimation period (2Q72-4Q72). Recent experimentation with weekly data has given some indication that the interest-rate-setting procedure for RNPT was much different from June 1972 to December 1974 [20]. Since the day loan rate and treasury bill rate are not endogenous and the modelling of the finance-paper rate is not consistent with the reaction function for RS, there is a paucity of Canadian interest rates to explain RNPT.

11 The average rate rather than the marginal rate is used in RDX2 because a consistent series is needed to explain the portfolio allocation behaviour of the public in Sector 15. If a few more years of data were available, Sector 15 could be estimated on the basis of post-2Q67 data. Then one could use, and would want to use, the marginal rate - the posted rate on personal nonchequable savings deposits available from 3Q67.

12 The rate on one-year deposits in trust and mortgage loan companies is RTTL - the only available rate on term deposits in these companies for the 1950s. As Kevin Clinton has pointed out, it would be preferable to use the the more representative five-year term deposit rate, which

depends heavily on the mortgage rate. See Clinton and Masson [14] pp 32, 33, 38.

13 Of course in the case of the average rate payable on personal deposits at chartered banks (RPD), one expects a rise of 100(1-ERBPCA), where ERBPCA is the proportion of deposits on which no interest is paid. The fact that chartered bank reserves at the Bank of Canada bear no interest may also mean that increases in interest rates are not met one for one.

14 Users of the model should note that this causes a large shift in the simulated mortgage supply response after 4Q70, since supply is, among other things, a function of .5(RMC+RNHA).

15 See [49] and [55] for a discussion of similar approaches. The repayments ratios were calculated from disaggregated monthly data for trust and mortgage loan companies and insurance companies. The repayments ratio for banks was calculated in the regression.

16 It probably would have been preferable to impose the average propensity rather than unity.

17 Given that the approvals equations can be considered to be supply equations and that the conventional mortgage rate is determined in a reduced form equation containing demand and supply elements, it is neither theoretically

satisfactory nor indeed is it necessary to have such a demand term in the HAPTL equation. This term will probably be dropped in future versions of the model because of its low t-statistic.

[18] This abstracts from any effect of the tightness of the banking system or the size of the banking system on other commitments and is, therefore, a partial equilibrium result.

[19] The first part of this section is taken directly from [32].

[20] One small error affecting simulation results in the model is: interest on provincial-municipal debt (GTPINTPM) is exogenous, whereas interest on provincial debt held in own accounts (proxied by .0025 (J2A(EACR) (.139 LGBPM)) is endogenous. These terms will probably be replaced in future versions of the model by the exogenous term (1.0-.139)(GTPINTPM).

[21] Since equation 18.1 is estimated on the basis of percentage increases in PGPP, RHOR should be calculated by subtracting a weighted sum of percent increases in PGPP, rather than in PCPI as is now the case.

[22] As mentioned above, the real supply price of capital (RHOR) is theoretically defined as (100)(x/v). Thus the method of calculation followed in the current version of the model gives a biased estimate for RHOR, which is

used to construct the rental prices of capital used in the investment sector. We probably should have defined RHOR directly as (100)(x/v), allowing RHO to remain defined as it is. This said, however, there is no ideal solution when the sum of the weights in the price expectations term do not sum to 1. In this connection, recall that from the theory (RHOR)(v) = 100 x. Thus E(RHOR)E(z) + E(v)/E(z) = E(x)/E(z), where the notation E(a)/E(b) represents the elasticity of a with respect to b, and z is any variable. Therefore the sum of the elasticities of RHOR and v would be 1 with respect to x and zero with respect to all other variables. However, in the model

RHOR = (100)(x/v) + g - 1/.61g

(RHOR)(v) = 100 x - .64gv

and it is not true that

E(RHOR)/E(g) + E(v)/E(g) = 0.

[23] The description that follows is taken from [19].

[24] The increase in ANFGN is greater when M1 is held constant than when it is free to vary because government financing requirements cannot be met by increasing the money supply.

[25] The variable ANFLIQ increases less than it did in the previous experiment, because YGNE increases less and RS increases more.

[26] We note that chartered bank total assets (ABT) decrease but the amount of financial intermediation by trust and mortgage loan companies increases. This unfortunate asymmetry results because the sum of the interest rate coefficients in the DNPTB equation is much less than zero and the sum of the interest rate coefficients in the DTTL equation is much greater than zero.

CHAPTER 12

THE LONG-TERM CAPITAL ACCOUNT: SECTORS 19-20

David Longworth

A. Introduction

Equations for long-term capital flows between Canada and the United States and between Canada and the rest of the world, together with their corresponding stocks, are found in Sectors 19 and 20 of RDX2. The aggregation scheme remains as it is in earlier versions of the model [29] , [32].

Our basic theoretical approach to the capital-flows equations is that set out in Helliwell et al. [32]. The equation for the change in the stock of foreign-held securities cannot be interpreted simply as the securities-demand equation of lenders or the securities-supply equation of borrowers; it should therefore contain both demand and supply elements. We attempt to determine which flows are dominated by lender behaviour and which by borrower behaviour. Thus the flows are split into new issues and trade in outstanding issues. Most of the portfolio capital-flows equations are specified in terms of a stock adjustment model implying geometrically decaying distributed lag weights. A change in interest rate differentials will therefore eventually lead to stock equilibrium.

The typical long-term capital flows equation pertaining to new issues can be written in the form:

F/S = a + b(RC-RF)-c(EPFXE-PFX)-d J1L(L/W)

where

F is the capital flows,

L is the corresponding stock,

S is a scale variable applying to the borrower,

W is a scale variable applying to the lender,

RC - RF is the interest rate differential, and

EPFXE - PFX is the expected exchange rate movement.

B. Changes Compared with Earlier Versions of RDX2

We performed a number of experiments during the re-specification of the long-term capital flows equations. Most of our experiments consisted of minor modifications of these equations in an attempt to capture larger responses to interest rate differentials than were obtained earlier. We also attempted to convert the few remaining pure flows equations into stock adjustment equations, but with little success.

Agricultural investment was removed from the cash requirements variable, which is the denominator of the direct investment equations FIDI12 and FIDI13. In the final specification for sales of gross new issues of provincial and municipal bonds, direct and guaranteed, in the United States (FINIPM12) an interest-rate differential and lagged stock-to-wealth ratio were found to enter in a significant fashion. The proxy for tightness of the banking system no longer entered this equation.

An important change has been made in the equation for net sales of Government of Canada, provincial and municipal bonds in other countries (FIGB13). There was an obvious structural change in these sales at the beginning of 1968 when extensive Canadian borrowing began in the European market. Dummy variables were used to divide the estimation period into two parts. During the period 1Q68-4Q72, FIGB13 was found to be positively related to gross new issues of provincial and municipal bonds (GBRPM) and to the interest rate differential RL - RSWITZGB, which is the average yield on Government of Canada bonds ten years and over minus the rate on long-term Government of Switzerland bonds, when these explanatory variables are used in multiplicative form. The variable RSWITZGB proxies for a Euro-bond interest rate, because the Government of Germany bond rate, although the desirable rate to use since most of the borrowings took place in Germany, performed poorly. The large increase in provincial and municipal borrowing in Europe during the period 2Q72-4Q72 was captured by the dummy variable QBORROW. A look at the data for 1973 shows that this shift was not permanent.

C. The Adjustment Process

It is of some interest to discover what the estimated coefficients in the flow equations imply about the adjustment of the stocks of securities in long-run static equilibrium (ie, when the flows are zero). In the analysis below we neglect the exogenous repayment terms since we wish to derive expressions that will be useful in analyzing changes in the stocks under shock.

Employing the FINIPM12 and FITOGB12 equations one can derive an expression for the stock of Government of Canada, provincial and municipal bonds held by U.S. residents (LGB12) in long-run equilibrium, with all dummy variables set to zero, as follows:

$$LGB12 = [1/(.03213+.0000864\ GBRPM)][VCN\$2]$$
$$[50.770+172.40(PFX-EPFXE)+.34037$$
$$GBRPM+(13.296+.08201\ GBRPM)(RL-RCB2)].$$

In the middle of the sample period gross new issues of provincial and municipal bonds (GBRPM) are approximately \$800 million and the net worth of U.S. households (VCN\$2) is approximately \$3 trillion.[1] Therefore one can approximate the long-run partial derivative of the stock of securities with respect to the interest rate differential between RL and the rate on U.S. corporate bonds (RCB2) as

$$\frac{\partial LGB12}{\partial (RL-RCB2)} = 29.63 \frac{\partial (FINIPM12 + FITOGB12)}{\partial (RL-RCB2)} = (29.63)(78.90) = 2337.9$$

where

$\frac{\partial (FINIPM12 + FITOGB12)}{\partial (RL-RCB2)}$ is the first-quarter partial derivative.

Using the FINIB12 and FITOBB12 equations one can similarly derive an equation for Canadian corporate bonds and debentures held by U.S. residents (LCB12). In long-run equilibrium

LCB12 = [1/(.0064819+.00042639 FRQ)][VCN\$2]

[1.0451 FRQ-.72356 J2A[(RABELCD-RABELCDD)/

RABELCD]FRQ+7.4625+129.28(PFX-EPFXE)]

where

FRQ = J12A[(IME-IMEAG)(PIME)+(INRC-INRCAG)(PINRC)

+J1D[(PKIB)(KIB)]],

PFX is the spot exchange rate, and

EPFXE is the expected spot exchange rate.

Note that there is no direct interest rate effect on LCB12. Financial considerations enter only in the short term through the difference between the actual and desired chartered bank ratios of free Canadian dollar earning liquid assets to total assets

(RABELCD-RABELCDD). Given the estimated coefficients and the average levels of the variables one finds that full adjustment to changes in PFX takes place within the first quarter.

Three categories are next considered in which a shock will not lead to a new stock equilibrium. We detected no evidence of a stock adjustment process at work in the FIGB13 equation, probably because Europe had just recently become a market for Canadian provincial and municipal bonds. Thus the corresponding stock of Government of Canada, provincial and municipal bonds held by residents of other countries (LGB13) will increase infinitely under a shock to RL. The direct investment equations FIDI12 and FIDI13 are also pure flows equations. The effect of increased real capital formation in Canada on direct investment is of some interest. Because there is no longer any direct effect of direct investment on real capital formation, ie, the FIDI timing indices in Sector 3 of [29] have been dropped, one may compute the effect of real capital formation directly from the two FIDI equations. If one is interested in the effect in the medium term when the proportion of foreign ownership remains relatively unchanged but the estimated distributed lags and moving averages have worked themselves out, then a $100 increase in real capital formation will on average lead to a $22.50 increase in FIDI12 and an $8.20 increase in FIDI13.

Net sales of Canadian corporate bonds and shares in other countries (FIBL13), which enter LDIPRV13 along with FIDI13, are dependent on a slow stock adjustment process. Indeed the equilibrium stock corresponding to FIBL13 will rise to 150 times the initial change in FIBL13 when the Canadian supply price of capital (RHO) is subjected to a continuous shock.

If there were a book-value stock corresponding to purchases of Canadian corporate shares on a portfolio basis by U.S. residents (FIPVB12), say, LFIPVB12, one could write:

LFIPVB12 = 28.3(RHOR-RHOR2) + 309.80(VCN$2) - .00773(V) + C

where

C is the initial value,

RHOR is the real supply price of capital, and

RHOR2 is the real U.S. supply price of capital.

Full adjustment to interest rate changes takes place in four quarters; full adjustment to wealth (V) changes takes place in six quarters.

Using the FODI12 and FOPL12 equations one can derive an equation for the book value of U.S. indebtedness to Canada (A12) in long-run equilibrium:

A12 = [V/18434.2][1.0330 J4A((PFX)(USD))/PFX+299.64

+12.582(RHO2-RHO)+10.405(PFX)JW(ODG2)

+23.295(RCB2-RL)+4.8347(J1P(V))]

where

USD = EPD$2 + EPS$2 - YPCC$2 + YDV$2 is U.S. financial requirements,

RHO2 is the nominal U.S. supply price of capital, and

ODG2 is prime U.S. military contracts for defence goods.

Now, since on average over the period V/18434.2 is approximately $10 million, the total stock effect of a change in an explanatory variable is approximately ten times the initial flow effect.

From the FOL13 equation one can derive the following expression for the book value of the indebtedness of other countries to Canada (A13):

$$A13(t) = c + 7.5072(t) + .0075(V)$$

where

t is time and

c is the initial value.

Thus the FOL13 equation has desirable stock equilibrium properties.

D. The Shocked Response

Use of the expressions derived above will be helpful in the analysis of an interest rate shock applied to only the international sectors of the model: Sector 4, the trade prices in Sector 7, and Sectors 19-21.[2] Sectors 19 and 20 are affected by interest rate changes directly, and by changes in the exchange rate as a consequence of the interest rate shock. The latter effect is relatively minor, because a 5 percent appreciation in the exchange rate leads to a first-quarter decrease in capital inflows of $15 million - nearly all from the expectations variables in the equations for FITOGB12 and FITOBB12. This decrease tapers off to less than $10 million by the twelfth quarter and is on average less than $2 million by the eleventh year. Since the maximum exchange rate change in the experiment reported was 1.8 percent, changes in capital flows resulting from exchange rate changes are small. Shocking Canadian interest rates by fifty basis points leads to the changes reported in Table 26.

Table 26

LONG-TERM CAPITAL FLOWS: THE EFFECT OF A FIFTY-BASIS-POINT INCREASE IN CANADIAN INTEREST RATES (Shock - Control Values)

QUARTER	CAPBAL (Total)	LGB12 Components	LCB12 Components	LGB13 Component (FIGB13)	FIDI12 +FIDI13	FIBL13	FIPVB12	-A12 Components
1	59.5	24.5	-.4	0*	-4.1	12.6	7.5	19.3
5	41.9	19.4	-1.6	0*	-2.4	12.4	0	9.3
9	49.0	15.3	-1.6	0*	17.4	12.1	0	5.8
13	64.3	20.5	-.9	0*	28.6	11.7	0	4.4
17	82.3	27.5	.1	0*	38.7	11.3	0	4.6
21	67.0	19.3	.0	9.6	24.1	10.9	0	3.1
25	69.5	20.6	-.1	10.7	24.9	10.5	0	3.0
29	76.8	19.2	.0	10.8	34.5	10.0	0	2.3
33	75.8	16.7	.2	10.4	36.4	9.5	0	2.6
37	81.7	18.1	.3	11.4	39.7	9.0	0	3.1
41	77.7	16.5	.1	10.4	37.8	8.5	0	4.3

* No interest-rate effect is estimated in the equation for years prior to 1968.

According to the data in this table one can only be sure that changes in FIBL13 and FIPVB12 will go to zero. Changes in the components of LCB12, which in this experiment are being influenced solely by changes in the interest rate, are close to zero at the end of the period. Stock adjustment effects dominate the components of A12 for the first thirty quarters, but then the historical growth in the market value of private sector wealth (V) increases the influence of interest rate changes. Changes in the components of LGB12 wander randomly at about $20 million as historical increases in GBRPM and in V tend to offset the relatively weak stock adjustment effects. Of course the effects in the flow equations (FIGB13, FIDI12, and FIDI13) increase over time according to the size of their scale variables.

Footnotes

1 In interpreting the equations the reader should note that interest rates are measured in percentage points, stock variables are measured in millions of dollars, and VCN$2 is measured in trillions of U.S. dollars. Interested readers may consult the List of Variables in Technical Report 5 where the units are set out in which other variables are measured.

2 The variable RL is kept at control in the relative wealth term of the PFX equation.

CHAPTER 13

THE FOREIGN EXCHANGE MARKET AND SHORT-TERM CAPITAL FLOWS: SECTOR 21

Ulrich Kohli

A. Introduction

In this version of RDX2, as in the Helliwell-Maxwell version [29], there are two models of the foreign exchange market - one applicable under a pegged exchange rate, the other under a flexible exchange rate. Recent modelling efforts by Haas and Alexander [23] have focused on the flexible exchange rate system and have included data up to 2Q75. In the last version of RDX2 [29], the spot exchange rate equation was specified and interpreted as a re-normalization of net private demand for foreign exchange. Here the exchange rate equation is interpreted as a re-normalization of net private demand for international short-term assets. This modification and others are described in section C. The fixed exchange rate model is virtually unchanged. It has been described extensively in Helliwell [25], Helliwell et al. [32], and Helliwell and Maxwell [31] so that only a short description of it is necessary here. This is given in the next section.

B. The Fixed Exchange Rate Model

The main feature of the model is the use of separate equations for private and official excess demand for foreign exchange. These two equations, together with a market clearing condition, determine the foreign exchange rate and the change in foreign exchange reserves simultaneously. Short-term capital flows are determined simultaneously through the balance of payments identity. This model, which applies to both fixed and flexible exchange rate systems, contrasts with other foreign exchange models where only private excess demand is taken into consideration, with the exchange rate exogenous in the case of a fixed exchange rate or with official excess demand exogenous in the case of a flexible exchange rate. The present model thus recognizes that, even under a fixed exchange rate system, the exchange rate is endogenous, and is allowed to fluctuate within the borders set by the support points. Only in the neighbourhood of these support points are the foreign exchange authorities obliged to meet whatever private excess demand there may be. This constraint is translated in the official excess demand equation by a reaction function ensuring that the foreign exchange rate elasticity of official excess demand becomes minus and plus infinity at the lower and upper boundaries, respectively. The other variables entering the official demand equation are the deviation of actual reserves from their target value, an official trading strategy variable, and a variable reflecting more resistance by the authorities to above parity exchange rate values than to below parity values. On the private side the excess demand function includes elements of a stock adjustment model in that it contains the lagged stock (smoothed by a two-quarter moving average) of short-term international liabilities as an explanatory variable. The other variables determining private excess demand are the Canadian balance of payments, (a two-quarter moving average expressed in U.S. dollars); a covered interest rate differential and its first difference; three dummy variables reflecting (i) the interest equalization tax (EIET), (ii) expectations prior to the foreign exchange crisis in 1968 (EF68E), and (iii) the effect of regulation Q on the foreign exchange market in 1969 (EREGQ69).

The same theoretical model is applicable to the forward exchange market. A number of difficulties, however, preclude the estimation of the structural equations of the forward exchange rate model. In particular, the rarity of official intervention in the forward market and the difficulty of finding suitable strategy variables make the estimation of an official excess demand equation impracticable (see Helliwell [25]). Instead, a reduced form of the forward exchange rate market is estimated, where official interventions are treated as exogenous.

The model is completed by five technical relationships that determine the Canadian balance of the current account and long-term capital flows with the United States (UBAL12) and all countries (UBAL), Canadian foreign exchange reserves (URES), the net international stock of short-term liabilities (ULS), and an index of weighted exchange rates between Canada and all countries except the United States (PFX13), PFX23 being exogenous.

C. The Floating Exchange Rate Model

Helliwell's basic model [25], which was reviewed in the previous section, applies equally to a system of fixed or floating exchange rates. Difficulties arise, however, from the fact that if little or no systematic official trading takes place, which is likely to be the case under a floating exchange rate system, one can hardly specify and estimate an official excess demand for foreign exchange. For this reason changes in official foreign exchange reserves were treated as exogenous in Helliwell and Maxwell [29] and [30]. Their model contained an explicit exchange rate equation estimated over the periods when the exchange rate was floating. The equation for PFX itself had been derived by solving the private excess demand function for the exchange rate. Official excess demand, however, dropped out from the equation as its estimated coefficient was insignificant or even perverse. Official demand was exogenous and determined actual private excess demand through the market clearing condition.

In the present version of the model, Haas and Alexander [23] replaced the exchange rate equation by an inverse excess demand function for international short-term capital. The basic model has thus been modified in the three following ways:

(1) On the private side, an excess demand function for short-term capital is explicitly specified as a stock adjustment model. Total private excess demand for foreign exchange is then determined by adding the balance of the current account and of long-term capital flows.

(2) Canadian and U.S. wealth enter the model since the determination of the desired stock of net short-term international liabilities is a portfolio problem.

(3) The expectations formation process has been modified. The expected exchange rate is now calculated by an equation obtained by regressing the exchange rate with a one-period lead on past values of the exchange rate and on (1 plus) the rate of change in foreign exchange reserves. This last term is used to give some indication of the expectations of speculators concerning the future value of the exchange rate. The current exchange rate is not used to determine the expected exchange rate since the expected rate itself is used as an explanatory variable in the

current exchange rate reduced form equation. The coefficient of the rate of change in foreign reserves is constrained to be equal to minus the constant term; this ensures that if no changes in reserves take place - ie, no official intervention and private market in equilibrium - the expected future rate will be determined by the historical path of the exchange rate.

Ignoring the forward market for the time being, one can describe the foreign exchange model by the following equations:

$$(FIS/PFX) = f(PFX,\ldots) \quad (1)$$

$$(UBAL/PFX) = (\overline{UBAL/PFX}) \quad (2)$$

$$FXO = \overline{FXO} \quad (3)$$

$$(FIS/PFX) + (UBAL/PFX) + FXO = 0. \quad (4)$$

The first two equations taken together represent private excess demand for foreign exchange. This contrasts with the Helliwell and Maxwell models in [29] and [30] where private excess demand is summed up:

$$(FIS/PFX) + (UBAL/PFX) = FXP = g(PFX,\ldots) \quad (5)$$

Equation 1 is next specified as a stock adjustment model and thus becomes:

$$(FIS/PFX) = f(PFX,\ldots) = \lambda(ULS*(PFX,\ldots) - J1L(ULS)) \quad (6)$$

where

ULS* is the desired stock of short-run liabilities.

The variable ULS* in turn is determined by interest arbitrage, trade credit, long-term borrowing, and spot and forward speculation (see Haas and Alexander [23]) so that ULS* can be written as:

$$ULS^* = ULS^*(\overset{+}{PFX}, \overset{+}{R_d}, \overset{-}{R_f}, \overset{-}{PFXE}, \overset{\pm}{W_d}, \overset{\pm}{W_f}) \qquad (7)$$

where

the expected sign of the partial derivatives is indicated above each argument,

R_d is the domestic interest rate,

R_f is the foreign interest rate,

W_d is domestic wealth, and

W_f is foreign wealth.

Expressing (7) in linear form and substituting it into (6) yields:

$$\frac{FIS}{PFX} = \lambda a_0 + \lambda a_1 PFX + \lambda a_2 (R_d - R_f) + \lambda a_3 PFXE + \lambda a_4 (W_f/W_d) - \lambda J1L(ULS) \qquad (8)$$

To avoid problems of collinearity, interest rates are entered as a difference and wealth as a ratio.

Finally, substituting (2), (3), and (4) into (8) and normalizing for PFX, gives the following inverse excess demand equation:

$$PFX = \frac{a_0}{\lambda} + \frac{1}{a_1 \lambda}\left[\overline{(UBAL/PFX)} - \overline{FXO}\right] + \frac{a_2}{a_1}(R_d - R_f) + \frac{a_3}{a_1} PFXE + \frac{a_4}{a_1}(W_f/W_d) + \frac{1}{a_1} J1L(ULS) \qquad (9)$$

Equation 9 is estimated for the periods 3Q53-4Q61 and 1Q71-2Q75. The coefficient on the expected future exchange rate is allowed to change from the first float to the second float by using the dummy variable QPFX. The interest rate difference is represented by RS - RTB2. The wealth variables are measured by discounted future income expressed in U.S. dollars, using the current long-term interest rates RL and RCB2 as discount rates. As well, alternative measures of wealth such as the market values of wealth (V) and (VCN$2) were experimented with. All coefficients have the expected sign, given that the sign of the coefficient of the wealth ratio is theoretically indeterminate. It is possible to calculate the value of the coefficients of the excess demand function for short-term capital. These are:

λ = 1.0967

a_0 = -17.853

a_1 = 83.862

a_2 = 397

a_3' = 58,978 (first float)

a_3'' = 64,104 (second float)

a_4 = 110

As we have already mentioned, Helliwell's model [25] can be applied to both the spot market and the forward market. Actually the two markets operate simultaneously so that ideally one would like to estimate all four excess demand equations simultaneously.

As in the case of the fixed exchange rate model and in the previous versions of the forward market model under a floating exchange rate system, data limitations preclude the estimation of an official excess demand function. Thus the forward market is characterized by an exchange rate equation balancing private excess demand. The forward exchange rate equation is estimated independently of the equation for the spot rate, although the simultaneous character of the two equations is recognized. The variable PFXF initially enters the equation determining ULS*, but, being itself a function of PFX as well as of PFXE, R_f , and R_d , it is subsequently eliminated for estimation purposes. Thus PFXF is estimated as a function of both the forward interest parity rate and the expected future exchange rate. The coefficient of PFXE is again allowed to differ from one float to the other by the use of QPFX. The estimated equation 21.3B suggests that forward exchange rates are essentially determined by the interest parity mechanism and that the effect of speculation in the forward market was much the same during the two floats.

D. Simulation Experiments

We now report on the results of three partial simulations with the foreign sector of RDX2. This sector can be viewed as being composed of Sector 4, Sectors 19 to 21, (flexible exchange rate model) as well as the import and export price equations contained in Sector 7. The sub-model can be symbolized as follows:

M = M(PM, PD, UGNE)	Imports
PM = PFX*PF	Price of imports
X = X(PX)	Exports
PX = PX(PD, PFX, PF)	Price of exports
XBAL$ = X*PX - M*PM	Current account
CAPBAL = F(RD-RF, J1L(L), PFX-PFXE)	Net long-term capital inflows
L = J1L(L) + CAPBAL	Net stock of long-term liabilities
UBAL = XBAL$ + CAPBAL	Balance of the current and long-term capital accounts
(FIS/PFX) + FXO + (UBAL/PFX) = 0	Balance of payments identity
ULS = J1L(ULS) + (FIS/PFX)	Net stock of short-term liabilities
PFX = PFX(RD-RF, PFXE, (FIS/PFX), (WF/WD), J1L(ULS))	Exchange rate
PFXF = PFXF(PFX, RD-RF, PFXE)	Forward exchange rate
PFXE = PFXE(J1L(PFX), J2L(PFX), URES/(J1L(URES)))	Expected exchange rate

where

PD is the domestic price level,

PF is the foreign price level,

RD is the domestic interest rate,

RF is the foreign interest rate,

WD is domestic wealth, and

WF is foreign wealth.

The first experiment (shock a) is an exogenous quarterly increase of 100 million 1961 dollars in the current account. This simulation was done by shocking XW13, Canadian exports of wheat to countries other than the United States. The second experiment (shock b) is an exogenous increase in the components of domestic expenditure (CDO, CMV, CNDSD, CS, IME, INRC, IRC, INRCGF, INRCGPM, INRCSM, IMEGF, IMEGPM) totalling 100 million 1961 dollars quarterly. The last experiment (shock c) is a shock of Canadian interest rates simulated by increasing RS, RL, RHO, and RHOR by fifty basis points.

Table 27

AN EXOGENOUS INCREASE IN THE CURRENT ACCOUNT

(Shock minus control as a percentage of control)

	4Q62	4Q63	4Q65	4Q68	4Q73
M	1.38	2.06	6.68	1.72	2.25
M$	.53	-.13	2.36	.60	.61
PM	-.84	-2.30	-4.05	-1.11	-1.60
X	5.05	3.87	1.52	1.15	1.15
X$	5.30	3.54	.34	.66	1.32
PX	.24	-.32	-1.17	-.48	.17
XBAL$*	105.86	94.20	-72.05	1.64	61.08
PFX	-1.19	-3.48	-5.75	-1.52	-1.99
UBAL*	102.50	84.74	-81.89	3.56	62.13
CAPBAL$*	-3.37	-9.46	-9.78	1.97	1.04
FIX*	-108.16	-85.74	81.59	-8.64	-63.07
ULS*	-398.39	-740.61	-643.98	-196.02	-330.38

* Shock minus control.

As can be seen from Table 27 a quarterly increase of $100 million in exports (shock a) leads to a rapid fall in the exchange rate: PFX is 6.6 cents below control in the fourteenth quarter but eventually stabilizes at about 2.0 cents below control. (The exchange rate PFX is defined in RDX2 as the Canadian price of U.S. currency; an increase in PFX thus means a depreciation of the Canadian dollar, a fall in PFX means an appreciation.) The volume of imports increases rapidly as the price of imports decreases. The variable M is 8.75 percent above control in the fourteenth quarter (253 million 1961 dollars) when the fall in PFX is largest and is still approximately 2.3 percent above control by the end of the simulation period. The current cost of imports is little affected during the early period of the simulation (1962-1964) as the exchange rate elasticity of imports is close to unity. From 1965 on, however, as the exchange rate elasticity becomes higher than 1, the current value of imports is above control by as much as 4.1 percent in the fourteenth quarter and by approximately 0.6 percent by the end of the simulation period. Exports are adversely affected by an appreciation of the exchange rate (fall of PFX), but, taking account of the exogenous $100 million increase in XW13, aggregate exports are above control for the entire simulation period. In the nineteenth quarter, however, X is only 0.34 percent higher than control (10.9 million 1961 dollars). During the last quarters of the simulation, the quantity of exports stabilizes at about 1.2 percent above control (approximately 63 million 1961 dollars). Export proceeds are 6.8 percent above control in the first quarter of the simulation, but approach control as the foreign demand for Canadian goods is falling. However, the current value of exports remains above control in almost every quarter illustrating the less-than-unit-price elasticity of foreign demand for Canadian goods. The net effect on the current account is positive for the first three years of the simulation owing to the large increase in exports proceeds. It is negative for most of the following four years and remains ambiguous from then on. Long-term capital flows fall below control during the first twenty quarters of the simulation, reflecting the higher exchange rate on FITOBB12 and FITOGB12. In the following two years, inflows are larger than in the control solution as the now smaller long-term Canadian portfolio held by foreign residents has an increasingly positive effect on FINIB12 and FINIPM12. Most of the surplus or deficit in the current account is, however, matched by a corresponding increase or decrease in short-term capital outflows. As a result ULS decreases rapidly relative to the control solution - it is $1,021 million below control in the twentieth quarter. The difference is reduced as the current account falls below control but it is still about $330 million less than control at the end of the simulation.

Table 28

AN EXOGENOUS INCREASE IN DOMESTIC EXPENDITURE COMPONENTS

(Shock minus control as a percentage of control)

	4Q62	4Q63	4Q65	4Q68	4Q73
M	.53	.42	.14	.09	.14
M$	.58	.59	.40	.40	.40
PM	.05	.16	.26	.31	.26
X	.02	.06	.17	.21	.19
X$	.02	.09	.24	.29	.26
PX	.01	.03	.07	.08	.06
XBAL$*	-13.05	-13.46	-6.38	-5.96	-12.48
PFX	.10	.27	.40	.47	.35
UBAL*	-3.51	-7.08	1.25	-1.60	-1.91
CAPBAL$*	9.54	6.38	7.63	4.36	10.54
FIS*	4.00	7.15	-1.24	3.17	2.11
ULS*	31.14	56.86	50.27	77.86	43.59

* Shock minus control.

From Table 28 it can be seen that a quarterly increase of 100 million 1961 dollars in the domestic components of national expenditure (shock b) results in a slight depreciation of the exchange rate. The variable PFX reaches a first high (0.5 cents, 0.43 percent above control) in the thirteenth quarter, and a second high (0.5 cents, 0.51 percent above control) in the thirty-fifth quarter. Higher import prices partially offset the effect of increased UGNE on imports. In the first quarter of the simulation, the quantity of imports increases by 12 million 1961 dollars (0.61 percent). Imports are, however, only 4.25 million 1961 dollars above control when PFX reaches its first peak in the thirteenth quarter and remain slightly above control during the rest of the simulation period. The higher quantity of imports associated with a higher import price raises the current value of imports by a quarterly average of $18 million (0.44 percent). The higher exchange, although accompanied by an increase in the supply price of exports, results in an increase in foreign demand. Because of lags in the export equations, this increase in exports occurs slowly - after twenty quarters exports are 0.20 percent higher than control. They remain at approximately this level until the end of the simulations. Export proceeds increase by an average of 0.31 percent ($11 million per quarter). The current account is below control for the entire simulation period, particularly during the early quarters before PFX increases significantly. The exogenous increase in domestic investment also leads to a higher inflow of foreign long-term capital. Foreign direct investment (FIDI12 and FIDI13) is above control for the entire simulation period; FINIB12 is above control for the first eighteen quarters. But from then on the increased portfolio of Canadian corporate bonds held by U.S. residents tends to offset the effect of increased Canadian investment. Long-term capital inflows thus finance to a large extent the deficit observed in the current account: UBAL remains negative during the first eleven quarters, but becomes positive as the deficit in the current account falls. For the entire simulation period UBAL is actually slightly above control ($0.24 million). The early current account deficit is then essentially financed by short-term capital inflows. The need for this type of financing disappears when the surplus in the long-term capital account tends to offset the deficit in the current account. Thus over the whole period ULS only increases by an average of $58 million.

Table 29

AN EXOGENOUS INCREASE IN DOMESTIC INTEREST RATES

(Shock minus control as a percentage of control)

	4Q62	4Q63	4Q65	4Q68	4Q73
M	.28	-.06	.80	2.94	.86
M$	.00	.20	.32	1.00	.49
PM	-.28	.26	-.35	-1.88	-.37
X	-.10	-.04	-.03	-.95	-.42
X$	-.16	-.04	-.04	-1.40	-.54
PX	-.05	.00	.00	-.46	-.12
XBAL$*	-3.46	-6.41	-16.97	-112.23	-89.86
PFX	-.41	.41	-.51	-2.63	-.54
UBAL*	48.95	44.90	43.00	-52.33	6.73
CAPBAL*	52.48	51.31	59.95	59.93	96.59
FIX*	-50.99	-44.79	-43.00	43.59	-6.99
ULS*	-173.12	-326.45	-681.00	-614.76	-213.08

* Shock minus control.

The results shown in Table 29 indicate that an exogenous increase in interest rates (shock c) has a substantial effect on the inflow of long-term capital, particularly on that of FIDI12, FIBL13, and FINIPM12. In total CAPBAL increases by a quarterly average of $66 million over the simulation period. This increase exerts downward pressure on PFX and, in turn, has an adverse effect on the current account so that eventually the surplus in UBAL will be offset. In the twenty-second quarter of the simulation PFX is 2.26 percent below control. By then imports are 3.09 percent above control in constant dollars and 1.38 percent above control in current dollars. The quantity of exports is 0.42 percent below control. Export proceeds are down by 0.7 percentage points. As a result the current account is below control by $86 million, which is actually more than the surplus in CAPBAL for the same quarter ($71 million). One would therefore expect the appreciation of the Canadian dollar to come to a halt at this point. Moreover, because of the lag structure of the export equations, PFX would have to increase if the deficit in the current account is not to worsen. Indeed, at the end of the simulation period, PFX is only 0.5 percent below control. The current account is $90 million below control, which approximately offsets the surplus in the long-term capital flows account. It is interesting to note, however, that PFX does not start to increase as soon as the deficit in the current account becomes larger than the surplus in CAPBAL (ie, by the twenty-second quarter). The exchange rate actually falls during another five quarters to 2.71 percent below control. By then the deficit in the current account is substantially larger than the surplus in CAPBAL: UBAL is $55 million below control. In fact PFX continues to fall even when UBAL is below control because of short-term capital movements. The initial surplus in UBAL is accompanied by a outflow of short-term capital as the increased interest rate differential between Canada and the United States is offset by a high forward rate relative to the current exchange rate. As ULS decreases, however, ULS is $778 million below control in the twenty-second quarter. This creates downward pressure on the exchange rates that initially offsets the effect of a less-than-control value in UBAL and later tends to slow down the increase in PFX. As a result, FIS is above control for most of the second half of the simulation and ULS is only $213 million below control in the last quarter. A last point to be noted is that the exchange rate is actually above control between the seventh and fourteenth quarters. This result can be attributed to the wealth ratio term in the PFX equation, as this ratio is very sensitive to current changes in interest rates. An increase in Canadian interest rates tends to decrease measured Canadian wealth and exerts upward pressure on the exchange rates. A similar effect is described in Aubry and Kierzkowski [4] where an increase in U.S. prices initially had a perverse effect on the exchange rate because of the increase in the nominal value in U.S. wealth with interest rates lagging behind prices.

E. Concluding Comments

Most of the effort directed to Sector 21 was centered on the re-specification of the floating exchange rate model; this part of the sector becomes increasingly important because Canada is in the eighth year of its second float. The importance of the floating exchange rate model is increased by the fact that, for simulation purposes, the exchange rate was often allowed to float prior to 1971. The framework of Helliwell's original model [25] has been maintained, but private excess demand for short-term international exchange now enters the model explicitly through a stock adjustment process. Further work on the measurement of the wealth variables and on exchange rate expectations is desirable. At present, expectations are generated by an autoregressive process. This builds a considerable amount of momentum into the model: expectations are only altered very slowly and have little effect on the current spot and forward rates. A somewhat disturbing implication is that in general exchange rate speculation is not a profitable operation in RDX2. It might also be useful to pay more attention to the theoretical foundations of portfolio decisions, in particular to recognize the interdependant character of excess demand functions for competing assets when derived jointly from the same portfolio decision.

CHAPTER 14

CONCLUDING REMARKS

Jean-Pierre Aubry

Because of its complexity, RDX2 must initially be approached sector by sector. In the preceding chapters, the authors described the theoretical framework used during estimation and revision of each sector of RDX2 [6], placing special emphasis on differences between this version and the original [32]. Because the theoretical framework did not change substantially, Staff Research Study No. 7 [32] is still a key reference to the theoretical framework of this version of RDX2. In this report the authors also gave information on the dynamics of individual sectors and suggestions on various ways of improving RDX2. In this concluding chapter we review the report and assess how close we came to reaching our initial objectives and also outline future plans for development of the RDX2 model.

A. Where We Are

The specification of the consumption sector of RDX2 explains different components of per capita consumption expenditure using the following variables: permanent wage income, permanent nonwage income, wealth, relative prices, a real interest rate, expectations on price inflation, and credit availability. Permanent income continues to have a fairly stable explanatory power but the explanatory power of the remaining variables differs considerably from one sample period to another. During this latest respecification exercise we tried, with little success, to estimate an aggregated consumption function employing an approach suggested by Modigliani [42]. The major problem was the estimation of components of consumption as a function of aggregate and relative price variables. In the current version, the financial variables (wealth, real interest rate and credit availability) have little impact. Our objective of increasing the impact of financial variables on consumption was not reached. The main channel between real consumption expenditure and the financial sector remains the concept of permanent nonwage income. Further experiments are planned for the near future, and we will also test the impact of institutional savings and age distribution variables.

As in the preceding version of RDX2 [29], investment in residential construction is primarily explained by a lag structure on mortgage approvals. This framework was created to reflect the fact that most investment in residential construction is financed by mortgage loans. This specification also has the advantage of constraining the behaviour of residential-construction investment to follow the mortgage market behaviour defined in the financial sector of the model. Work is currently underway to increase the proportion of mortgage loan activity covered by the mortgage approval series.

Private investment in machinery and equipment and in non-residential construction is explained by the same theoretical framework used in the two previous versions of RDX2 [32, 29]. A forward-looking model of demand pressures and the relative cost of production factors are used to calculate the gap between the desired level of capital and the level of capital obtained with no additional investment. This gap, multiplied by a variable that measures the degree of liquidity of firms, is the main explanatory variable for business fixed investment. In this version, statistical tests rejected real interest rates and foreign direct investment as additional variables. With this specification, monetary linkages are ensured via the imputed rental prices of capital that enter the definition of the desired capital/output ratio. During the re-estimation process we tried, without success, to increase and to accelerate these linkages. Another difference between this version of the model and the preceding version is the use of data series on contract awards, which allows the relaxation of constraints on the estimation of the lag structure between the production gap and the investment in non-residential construction. In the near future we hope to investigate the impact of removing large and irregular investments in projects such as pipeline construction and the St. Lawrence Seaway development from total business investment. We also intend to test other theoretical frameworks.

Disaggregation of the import equations to the first digit Standard International Trade Classification is one of the major modifications in the current specification of the trade sector. This disaggregation together with the use of loglinear specifications, generated substantial increases in the elasticities of imports with respect to relative prices and market-tightness variables. Similar work is being done to disaggregate exports. Studies are also underway to explain Canadian imports via estimation of an aggregate import equation, followed by estimation of the ratio of each import component to the total.

Since capital is relatively fixed in the short- and medium-term, labour is still defined as the most flexible factor of production to adjust supply to demand. Employment is defined as a lag structure on desired employment which is in turn determined by the level of employment needed to produce the demanded output, given the production function, the stock of capital and the long-run productivity of labour working an average number of hours per week. Special attention was given in this version to increasing the influence of supply constraints in the labour market. In order to increase the impact of supply-demand imbalance in the labour market, the variable NMMOBS was constructed as a measure of the maximum supply of labour in mining, manufacturing and other business. This concept is used in the determination of the constrained desired level of employment and in the quarterly earning equations.

Wages are basically explained in RDX2 by a real wage hypothesis. Nominal wages have a constrained elasticity of one with respect to the consumer price index (66 percent and 94 percent of the full catch-up is obtained after four and eight quarters respectively). Productivity growth ensures real-wage growth. The desired real wage is defined as a function of productivity of a labour-market tightness variable. There are studies, both underway and proposed, to test different models that use price expectations as explanatory variables. These studies are also being done using different wage series as dependent variables.

Medium- and long-run price variations are explained by normalized factor (mainly labour) costs in a mark-up theory. Variables that capture the supply-demand imbalance are also introduced in the specification to explain short-run variations. The impact of foreign-price and market-tightness variables was increased; however, the expected linear homogeneity of the price equations with respect to cost factors was not obtained. As pointed out at the end of Chapter 7, the price and wage equations should be specified in the context of a more consistent theoretical framework.

Through the endogenization of the spreading ratios, of some exemptions, and of average tax rates, we have managed to capture to a greater extent the progressive structure of the Canadian personal income tax system. By the indexing of income tax brackets and some exemptions, and by the modelling of tax paid on capital gains and the dividend tax credit, the personal income tax sector takes into account most of the major tax reforms of 1972 and 1974. On the other hand, there are a number of other important provisions in the tax system that we have not yet modelled; among these are the tax effects of the expanded use of Registered Retirement Savings Plans and Registered Home Ownership Savings Plans. Through the years, this model has become increasingly complex. Using additional observations on taxation series we will try in coming years to reduce this complexity without sacrificing the accuracy and flexibility we have managed to achieve.

This version of RDX2 contains no major changes in the specification of government (federal, provincial and municipal) expenditures and indirect tax revenues. Work must be done, however, to achieve a comparable level of endogeneity between the federal and the provincial and municipal variables, and to seek better long-run properties.

The financial sector of RDX2 is still based on a portfolio allocation of financial assets. A constrained estimation of a

Brainard-Tobin model explains the portfolio allocation of the assets of the nonfinancial public. Special efforts were made to capture the impact of the 1967 Bank Act revision. Assets of the financial sector are estimated directly; chartered bank loans are explained by demand and supply variables, however, mortgage loan approvals made by the chartered banks, trust and loan companies and the life insurance companies are determined mainly by the willingness of the lenders to supply funds, given the size of their total portfolio and given the difference between the average yield on government bonds and the mortgage interest rate. To improve the modelling of the interest-rate structure, the chartered bank prime lending rate, the average rate on personal deposits in chartered banks, and the rate on nonchequable savings deposits in trust and loan companies were endogenized. With additional observations (1Q71-4Q72) it was possible to obtain a better estimate of the impact of the 1967 Bank Act revision and of the flexible exchange rate system on the interest-rate structure. Currently, our main concern is the remodelling of the central bank policy reaction function to incorporate more fully the growing emphasis on the control of monetary aggregates.

One of the distinguishing features of RDX2 is the estimation of the real supply price of capital. It is a major input into the determination of the public wealth, of the permanent nonwage income and of the desired capital/output ratio. Recent work, however, revealed a failure of the present equation to predict the length and depth of the post-1972 bear market for equities, and consequently the need for further research.

The exchange rate equation is very important in the dynamics of RDX2. The most recent version is a re-normalization of a short-term capital flow equation based on a portfolio adjustment model. We hope to continue this work in the near future with more emphasis on the modelling of exchange-rate expectations.

B. Where We Are Going

As mentioned in the preceding chapters, we have research projects, both underway and in the planning stage, designed to develop various sectors of the model. We plan to re-estimate the model to 4Q75. The data set will include the 1975 rebased National Accounts price indexes and the new Labour Force Survey data. We have become more involved in the forecasting ability of the model, because we believe that use of the model in a short-, medium- and long-run forecasting context will provide valuable information affecting the model's future development.

Research is also underway to improve the impact of demographic variables in RDX2, particularly in the labour and housing sectors. Other studies will be done to test different theoretical frameworks in the consumption and private investment sectors. The monetary policy channels, the price and wage linkages, as well as the natural rate of unemployment hypothesis will be among our major concerns. Finally, a thorough rethinking of the role of expectations in RDX2 has begun.

We hope that this report will give readers a broad understanding of the different sectors of RDX2. Forthcoming Technical Reports, on the decomposition of the impact of various standard shocks, on the monetary linkages [19], and on forecasting ability [37], will complement the information presented in this report.

All comments on our efforts to date would be welcome.

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