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ECONOMIC PROJECTIONS AND ECONOMETRIC MODELLING: RECENT DEVELOPMENTS AT THE BANK OF CANADA

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CONTENTS

ACKNOWLEDGEMENTS

The projection methodology currently used at the Bank of Canada evolved through time from the efforts of many people. Major impetus to the specific approach now used was given by Tom Maxwell and Bill Alexander. Leo de Bever and Lloyd Kenward supervised various members of the Research Department in the initial developmental work, and the TSP software system was redesigned and expanded by Leo de Bever and Marcel Lemieux. A description of the September 1979 version of the RDXF model and the projection methodology in existence at that time was presented in "Forecasting Methods and Forecasting Models: Recent Experience at the Bank of Canada" by de Bever et al, November 1979. Jean-Pierre Aubry and Bill White added a number of comments and insights to this text. Thanks to Lea-Anne Solomonian for her extremely helpful editorial comments.

ABSTRACT

This Technical Report describes some new techniques for making economic projections that have been suggested for use by the staff of the Bank of Canada. The procedures enable the staff to combine information from a newly developed econometric model of the Canadian economy with judgmental input from various sectoral specialists, an approach which recognizes the fact that an econometric model cannot fully reflect the variety of changing influences affecting the Canadian economy at any given time.

The Bank of Canada's new model, RDXF, and its associated computer software have been jointly designed to facilitate the timely provision of a range of alternative projections conditional on explicit assumptions about policy and other exogenous variables. The main aspects of the model and the software are summarized in the earlier parts of this report. The structure and dynamics of RDXF will be analyzed in more detail in Bank of Canada Technical Reports 25 and 26 soon to be forthcoming. This report concludes with a description of the administrative procedures followed in the course of making economic projections and highlights the contributions made by the various sectoral specialists and the Bank's projection-coordination group.

RÉSUMÉ

Le présent Rapport technique décrit quelques nouvelles techniques de projection dont l'utilisation a été proposée aux économistes de la Banque du Canada. Ces techniques permettent d'utiliser conjointement les renseignements obtenus à l'aide d'un modèle économétrique de l'économie canadienne mis au point récemment et les points de vue de spécialistes de différents secteurs. L'approche adoptée reconnaît qu'un modèle économétrique ne peut refléter pleinement la diversité des facteurs qui influent sur l'économie canadienne à un moment donné.

Le modèle en cause, en l'occurence RDXF, et le logiciel qui l'accompagne ont été conçus simultanément en vue de produire dans de courts délais un éventail de projections utilisant diverses hypothèses explicites sur les politiques et sur d'autres variables exogènes. Les premières pages du Rapport contiennent un résumé des principales caractéristiques du modèle et du logiciel en question. La structure et les propriétés dynamiques du modèle seront exposées de façon détaillée dans les Rapports techniques n^{os} 25 et 26. Les dernières pages, où l'on trouve une description des diverses étapes administratives du travail de projection, mettent l'accent sur la contribution apportée dans cette tâche par les spécialistes de la Banque et par le Groupe de coordination des projections.

INTRODUCTION

The Bank of Canada has recently adopted certain new techniques and procedures for producing economic projections. The projection exercises involve the use of an econometric model of the Canadian economy in conjunction with input provided by sectoral specialists at the Bank. The sectoral specialists monitor individual sectors of the economy on a continuous basis and then derive exogenous variables and constant-term adjustments to the individual equations over the projection horizon. The projections of the economic variables endogenous to the model therefore reflect the structure of the model itself as well as the specific assumptions made by the sectoral specialists.

The use of an econometric model in making economic projections was thought appropriate for a number of reasons. First, projections based on the solution of an econometric model should be internally consistent. Since all those participating in a projection exercise use the same formal model as a basis for their analyses, they will also use the same definitions for variables, the same data set and a common set of assumptions about exogenous variables (for example, U.S. developments and world oil prices). Moreover, the solution of the model provides a single set of projected values for the endogenous variables; in principle this ensures that all sectoral specialists base their projections on a common set of assumptions about variables that are exogenous to their particular sectors. Second, because the structure of the

model is formalized, direct tests of the various economic theories incorporated in the structure of the model can be performed more easily. Third, the fact that econometric models are computer-based facilitates the rapid production and distribution of a range of alternative economic projections. These projections differ with respect to assumptions about the setting of macroeconomic policy or exogenous variables whose future movements may be particularly uncertain. Moreover, since the same basic model of the economy is used to produce these alternative projections, differences between the projections (shock minus control) provide a measure of the potential economic effects of particular assumptions. Fourth, because all data manipulations are carried out by computer, revised projections can be provided promptly whenever new developments warrant.

It should be borne in mind that the econometric model is only a tool, and the mechanical output of even the most carefully specified model must be augmented by the judgement of economists who are continually monitoring the various sectors of the economy. Although the structure of an econometric model will be based initially on some explicit theory about economic behaviour, over time the equations based on these theories may provide predictions that prove to be increasingly incompatible with the emerging historical evidence. When this occurs, the model must be respecified on the basis of some alternative theory in order to improve its projection accuracy. However, it may be difficult to verify any theory empirically because of data limitations or

imperfect estimation techniques. Furthermore, developments also occur regularly that affect individual sectors of the economy but whose influence is not reflected in the structure of the specified econometric equations. Again, specialists must make some judgement as to whether such influences are likely to be permanent and then make the appropriate constant-term adjustments to their equations in order to quantify the effect of these influences on the projection.

Over the past two years the Bank of Canada has developed a number of technical tools designed to facilitate the production of economic projections. For example, RDXF, the recently developed econometric model of the Canadian economy, is easier to use for projection purposes than was our previous model, RDX2. In addition, an associated computer software package has been designed to improve the sectoral specialists' access to RDXF and its data base. Finally, we have adopted a set of administrative procedures designed to streamline the projection exercise. Since our approach involves input from a large number of sectoral specialists from various departments within the Bank as well as the contribution of a centralized projection-coordination group, such administrative procedures are absolutely essential to the proper functioning of the projection exercise.

In Section 2 we present a brief description of RDXF and its historical antecedents. In Sections 3 and 4 the new software package and the administrative procedures used during a projection exercise are considered in turn. The reader desiring more

detailed information about the structure and dynamics of the RDXF model can turn shortly to Bank of Canada Technical Reports 25 and 26 which are now in preparation.

2 RDXF

2.1 Historical Antecedents

Econometric modelling at the Bank of Canada began in 1967 with RDX1. This model was later supplanted by RDX2 which has subsequently been revised and updated on a number of occasions. These models were developed chiefly for the purpose of carrying out policy simulations over a historical period. While they were sometimes used to evaluate the impact of economic shocks of various kinds over the projection range, these models were not used to produce economic projections as such.

The principal reason for not using RDX2 as a projection model was that neither the model itself nor its associated computer software had been designed to meet the very specific requirements of a projection exercise. For example, projections must be carried out on a timely basis and must incorporate the contributions of sectoral specialists. In the case of RDX2, the task of regularly updating the data base for economic projections was both costly and time-consuming. Many of the data series used in the model were not published regularly or had long publication lags and very few were seasonally adjusted, the form with which sectoral specialists were familiar. Moreover, only part of the data management system was computerized. As for the model itself,

not only were the mechanics of incorporating new equations into the model cumbersome, but there was no computerized facility that would allow regular access to updated descriptions of the model's structure and data base. These technical impediments limited the use of RDX2 by sectoral specialists at the Bank. Instead, specialists continued to use a wide range of methods to arrive at judgmental projections for their individual economic sectors. The individual sectoral projections were subsequently modified by the projection-coordination group in the Bank's Research Department in an attempt to provide some general consistency.

2.2 An Overview of the RDXF Model and its Data Base

The Bank of Canada's new model, RDXF, and its associated computer software, have been specifically designed to produce a range of timely economic projections for the short run (one to two years) as well as to address longer run policy questions (up to five years into the future).

The current version of the model incorporates nineteen sectors comprising just over 400 equations. Slightly more than half of these equations are behavioural and the rest are identities. A conscious attempt has been made both to minimize the number of exogenous variables that have to be projected independently by sectoral specialists, and to ensure that these variables can be easily measured using publicly available data. Most equations in the model have been estimated using single-equation estimation procedures, often with an adjustment

for autocorrelation. Cost considerations and the need for sufficient flexibility to allow sectoral specialists to alter individual equations were felt to outweigh the benefits of the more statistically efficient and unbiased estimates that are provided by full-information estimation techniques. Generally, equations have been estimated with data beginning in 1961 and, because of the ease with which equations can be modified using the associated software, many equations are estimated to within a few quarters of the present.

The supporting data base for the RDXF model is generally available from 1952 Q1 onwards. Most of the data series, which are of a standard scale, are seasonally adjusted in order to provide sectoral specialists with data series that correspond to those used in current analysis work. The data base contains series of both quarterly and monthly frequency and the associated computer software allows both the estimation and simulation of mixed-frequency models. It should be noted that whereas quarterly data are sufficient for most variables in the projection exercise, monthly series are more relevant for certain financial projections.

As noted previously, the structure of the RDXF model and its dynamic properties will be described in detail in two subsequent Bank of Canada Technical Reports, one of which will provide the analysis, while the other will present documentation of individual equations. A brief overview of the model's structure can, however, be given here.

In the Keynesian tradition, considerable attention has been paid to modelling the components of aggregate demand. In the RDXF model, the volume of demand for various categories of consumer goods and services is modelled according to the permanent income hypothesis and includes relative price and financial variables. Business investment responds to movements in levels of aggregate demand (a flexible accelerator mechanism) and the implicit rental cost of capital, while investment in residential construction is determined by the interaction of builders and purchasers. As to the external sector in the model, the volume of a disaggregated group of exports and imports is determined primarily by the level of economic activity in Canada and the United States and relative prices.

The supply side of the RDXF model is more highly aggregated than the demand side and is based on a Cobb-Douglas production function in which two factor inputs (labour and capital) are assumed to produce one composite good. Interrelated factor demand equations follow from this production technology and the assumption of profit maximization on the part of employers. These equations determine the desired level of employment and the desired stock of capital. Domestic producer prices are modelled on a flexible markup basis where costs include wages, capital costs, and the prices of energy, raw materials and traded goods. A capacity utilization term is also included in the domestic price equations. The inclusion of the capacity utilization term creates temporary price pressure in periods of excess demand. As for the

factors determining the costs of production, the growth rate of wages in both the private and public sectors is determined by expected inflation (proxied by lagged values of the annual rate of increase in the Consumer Price Index) and by a variable measuring the degree of slack in labour markets. While energy prices are set judgmentally by sectoral specialists in the light of unfolding events, the cost of capital and the prices of traded goods both respond systematically to such influences as interest rates, the exchange rate and foreign prices.

The level of interest rates, the monetary aggregates and the assets and liabilities of various financial intermediaries are determined in a monthly submodel of the financial sector. In the RDXF model most of the influence of the financial sector on nominal expenditures is exerted through interest rates. While interest rates do condition the demand for capital goods, housing and consumer durables, a more important factor is the influence of interest rates on the exchange rate. The latter effect has implications for both domestic prices and foreign demand for Canadian-produced goods. While the exchange rate does respond in the short run to both the current account balance and the interest rate differentials between Canada and the United States, in the longer run the exchange rate adjusts to differences in price levels between Canada and its principal trading partners to maintain purchasing-power parity.

2.3 The Process of Model Development

The procedures established at the Bank of Canada for model development have been designed not only to use the theoretical and practical expertise of sectoral specialists, but also to ensure theoretical consistency and acceptable dynamics for the model as a whole. Although sectoral specialists throughout the Bank bear the primary responsibility for developing the individual sectors of the model, there is, in addition, a projection-coordination group that maintains a comprehensive knowledge of RDXF in order to coordinate the development of the model and to analyze the implications for the full model of structural changes proposed by individual specialists.

Immediately after the completion of each projection exercise, members of the projection-coordination group meet with the various sectoral specialists to discuss work schedules for the development of the model. Priority is given to solving problems that were discovered during the previous quarter's projection. These problems, as a rule, arise from inconsistencies among sectors or involve equations that do not conform to theoretical priors. In addition, recent literature on theoretical developments and their relevance to the RDXF model are discussed.

Between projections, specialists have about two months to develop proposed new equations. In this process they are encouraged to utilize the existing data base or to add only data that are easily accessible and can be updated frequently; attention to such matters minimizes the time required to update

the data base at the beginning of each projection exercise. Sectoral specialists perform all the single equation testing as well as a large part of the analysis of the dynamics of the particular block of equations for which they are individually responsible. In order to facilitate ongoing research and minimize duplication over time, the new equations, the test results and any problems associated with the experimentation are carefully documented.

A deadline for submission of new or revised equations from the sectoral specialists is set by the coordination group three weeks prior to the release of the National Accounts. Before any proposed changes are incorporated into the model, the coordination group runs a series of partial and full-model simulations. The full-model experiments take into account feedback from the various sectors and establish the over-all response of the model to the changes proposed for individual equations. If a proposed equation improves the dynamics of a particular sector without adversely affecting other sectors, and if the equation improves the forecasting ability of the model, it is generally retained. If, however, a proposed change has detrimental effects on other parts of the model, the coordination group isolates the cause and notifies the respective specialist. Often the changes necessary to satisfy both sectoral and full-model requirements can be made quite readily and the equations are then resubmitted. In cases where disputes arise between sectoral specialists and the coordination group regarding the acceptability of proposed

changes, the status quo prevails until the differences can be resolved. Generally, an agreement is reached as a result of discussions that take place during the next period of model development.

When the process of model development is completed each quarter, the projection-coordination group prepares a summary of the changes made and their effects on the dynamics of the model. As well, a complete description of the new equations and the data base are given to the sectoral specialists prior to the initiation of a new projection exercise.

3 SUPPORTING COMPUTER SOFTWARE AND TECHNOLOGY

Given the involvement of a large number of sectoral specialists in both the construction and use of RDXF, a high degree of administrative organization is necessary, and this in turn imposes certain technical requirements. The development of the software for data management and econometric work was designed to meet the following criteria: the system should be easily accessible, user-oriented, cost-efficient, contain a system of checks and balances to minimize data errors, and be able to process quickly and present clearly a large volume of information to sectoral specialists and the Bank's management.

A TSP (Time Series Processor) package, used at the University of Wisconsin, was substantially modified at the Bank of Canada[1]

1. The work was principally carried out under the supervision of Leo de Bever and Marcel Lemieux.

to meet the above requirements. The current version of TSP is activated on a Univac 1100/81A computer and can be accessed using either batch mode or interactive terminals. All tasks related to making projections or to model development can be carried out using the Bank's TSP system. These tasks include data base generation, equation estimation, model simulation, generation of projection tables, and model documentation. In all these respects, the TSP command procedures have been redesigned so that a minimum amount of time is required to learn even the most sophisticated operations, thus encouraging the maximum participation of sectoral specialists in both the development and use of the model.

In adapting the University of Wisconsin's version of TSP, new functions were added to improve the speed and cost-efficiency of data manipulation. In order to reduce the time required for data revisions, an option was included to permit direct access to and manipulation of such external data sources as the Statistics Canada CANSIM base. The regression package was expanded to include a number of more sophisticated estimation techniques including Three Stage Least Squares, Iterative Zellner and Generalized Least Squares, as well as a facility for the estimation of complicated functional forms. During a projection exercise it is also necessary that all participants have detailed knowledge of how the exercise is proceeding in order to assess the implications for their individual sectors. For this reason, the Bank's version of TSP has been adapted to allow for the generation

of tables that present such data quickly and in a clear and straightforward format. As well, sectoral specialists can create their own tables showing any sectoral detail they wish. A further documentation option provides a complete description of each variable in the model, including a definition of the data series, the time period for which the series is available, the associated explanatory equation (if any) and summary statistics, as well as a list of other equations in the model directly influenced by that particular variable. Each quarter, an updated version of this documentation is distributed to all those participating in the projection exercise; this information can also be obtained at any time through a TSP command accessing the RDXF computer file.

All information pertinent to RDXF is stored on a central file. This file contains the data base, equations, parameters, and the most recent version of the model. Specialists have access to the file between projections and a simple set of editing commands allows them to experiment with new equation specifications. In order to promote easier testing of the effects of respecification on the dynamic properties of individual blocks of equations, the equations of the model have been grouped according to sectoral interests. The revised TSP software also contains a library of programmes that can be used by sectoral specialists or others to carry out standard dynamic tests. This facility reduces the time required for sectoral specialists to master the more technical aspects of empirical work and provides a standardized basis for comparing alternative specifications.

Although sectoral specialists have continuous access to the central RDXF file, they cannot make any permanent changes to it. Changes to the model and its data base are made only once each quarter by the projection-coordination group immediately prior to the beginning of the projection exercise. This centralization of responsibility for maintaining and updating the files and programmes reduces the likelihood of errors and inconsistencies that could later impede the economic projection exercise.

4 ADMINISTRATIVE PROCEDURES USED DURING THE PROJECTION EXERCISE

Three weeks prior to the quarterly release of the National Income and Expenditure Accounts data by Statistics Canada, planning begins for updating the range of economic projections to adjust for any new developments. Given the number of individuals contributing to this exercise and the fact that many different departments of the Bank are involved, careful attention must be paid both to the administrative procedures designed to coordinate these contributions and to the deadlines imposed by the procedures.

Preparations during this three-week period prior to the release of the National Accounts include a general issues meeting to discuss the upcoming projection, the preparation of projections of economic developments in the United States and abroad, and some preliminary adjustments to the previous domestic projections (i.e., a review of previous constant-term adjustments and

exogenous forecasts). At this stage much of the work is carried out by the projection-coordination group.

The general issues meeting formally opens the projection exercise. Participants are informed of any unanticipated changes in current economic conditions since the last exercise, as well as recent revisions to the model and their effects on the model's dynamics. Sectoral specialists then present their views about current economic trends and how these views have changed since the previous quarter. Particular emphasis is placed on prospective economic developments in the United States. A projection for the United States is prepared separately before the issues meeting by a group of analysts specializing in U.S. developments. The U.S. projection, plus a set of starting assumptions about trends in domestic exogenous variables, establish a 'point de départ' for the domestic projection exercise (referred to below as Projection Case A). Particular risks associated with assumptions about both the U.S. and Canadian economies are identified at the meeting to provide a basis for the production of alternative projections.

After the issues meeting and before the release of the National Accounts, the projection-coordination group prepares a set of preliminary projections. The purpose of this exercise is to analyze the implications of the most current information for the previous quarter's outlook. In a three-step procedure, information pertaining to altered equation specification, updated exogenous variables, and revised constant-term adjustments is incorporated into the previous quarter's projection. The final

result is a projection prepared just prior to the release of the National Accounts that reflects all the new domestic information that is available plus the final output of the U.S. projection exercise as well as a particular set of starting assumptions about exogenous variables.

The release of the National Accounts signals the combined involvement of the specialists and the coordination group. The National Accounts provide new data for the quarter ending three months previously in addition to revised data for earlier quarters. These data are then incorporated into the data base and sectoral specialists re-examine their equation residuals and alter their constant-term adjustments accordingly. By this time, the specialists may have information concerning the movements of certain variables two to three months into the current quarter. In light of such information, they may choose to override the solution of the model by imposing values for these variables in the first (current) quarter of the projection. Results from the first round of the projection exercise are then compared to the preliminary projections made prior to the receipt of the National Accounts data in order to evaluate the effects of this new information. A number of iterations follow, during which the sectoral specialists modify their exogenous variable forecasts and constant-term adjustments. The coordination group checks all new information and isolates changes that have been made at each iteration. A parallel projection run without the constant-term adjustments determines the over-all effects of the judgmental input in the projection.

Although in principle an econometric model need only be solved once, in practice, the projection exercise requires a number of iterations. There are two reasons for this. First, given the large size of the model, it is very difficult to be familiar with all the relationships among the variables (i.e., the reduced-form elasticities) and to make the appropriate constant-term adjustments in the first iteration. Thus the iteration process performs the mechanical calculations that would be required for sectoral specialists to calculate their constant-term adjustments taking into account dynamic feedback from the rest of the model. Second, a number of variables currently exogenous to the RDXF model because of size limitations, in fact depend on other endogenous variables whose values change in each successive iteration during the projection exercise; the revision of exogenous projections after each iteration allows these effects to be taken into account. However, the flexibility afforded by the iterative procedure has certain drawbacks as well. Care must be taken to ensure that specialists do not change their constant-term adjustments at each iteration solely to reach a particular target which overrides the information from their equations. To minimize this risk, the magnitude and justification of the constant-term adjustments made at each iteration must be defended by the specialists. Large constant-term adjustments, whether they are the result of equation misspecification or special factors, ultimately imply the need for a re-evaluation of the specification of the model.

Once the specialists have completed their iterations, a meeting of department chiefs is held to discuss the general trends in the projection and whether they are consistent with the initial underlying assumptions. Any additional information is incorporated into a final iteration, the results of which are subsequently described as Case A. A series of alternative scenarios (Case B, Case C...), each based on a different set of assumptions about exogenous variables, provides a range of possible projections. The choice of alternative assumptions is based upon the areas of risk that were identified at the issues meeting in the early stage of the exercise as well as any other factors that may have become apparent during the course of the Case A projection. Since most of the contributions likely to be made by the sectoral specialists have already been incorporated into the Case A projection, the coordination group produces these conditional projections. However, in the event that the change in assumptions affects the exogenous variables and judgmental adjustments in a particular sector, participation by selected specialists is sometimes necessary. In this case, specialists would apply special factors to their constant-term adjustments in the alternative projections. A summary document completes the projection exercise and a final meeting to discuss alternative projections takes place approximately three weeks after the release of the National Accounts.

In the period between these quarterly forecast exercises, any one of the projections may be used as a starting point for

analyzing policy questions (e.g., OPEC pricing scenarios, federal budgets, etc.). These simulation experiments are useful in that they familiarize the specialists with the dynamics of the full model and provide background information for the upcoming projection.

5 CONCLUSION

We have made substantial progress in our ability to produce alternative economic projections that combine the technical advantages of an econometric model with the expertise of the sectoral specialists at the Bank of Canada. The introduction of RDXF, the Bank's version of TSP and our new projection procedures have enabled us to provide alternative projections on a timely basis.

Nevertheless there still remains considerable progress to be made. For example, we have much to learn about the optimal method of generating adjustment terms that are to be used in conjunction with econometric equations. The main difficulties in incorporating constant-term adjustments into an econometric model lie in differentiating between permanent and temporary shocks and avoiding the temptation to use these adjustment terms to override the information being provided by the model. We would also like to evaluate, on a more systematic basis, the differences between comparable projections done in different quarters. This will help us understand more clearly why the range of projections has

changed over time and may also help us to reduce the number of iterations required to produce any given set of projections.

With respect to the RDXF model itself, work is progressing on modelling the supply side of the economy in more detail and on analyzing the effects of supply-demand imbalances on price and wage determination. We will also continue our efforts to improve our understanding of the channels through which financial variables affect the Canadian economy. Independent work currently underway in the Special Studies section of the Research Department on the construction of a Small Annual Model (SAM), may be very helpful in this respect. We also plan to reduce the size of RDXF by using a satellite approach to handle certain disaggregated sectors of the model. Accordingly, different submodels will be attached to a smaller core model depending on the scope of the analysis; this procedure will give us more flexibility and a lower cost of operation.

As was the case with the RDX2 project, computer tapes allowing those outside the Bank to make use of the TSP software, the RDXF model and the supporting data base are available upon request from the Research Department of the Bank of Canada. Details concerning the equation specification and the dynamics of the RDXF model will be provided in Technical Reports 25 and 26 shortly to be published.

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