A BEGINNER'S GUIDE TO THE RBNZ MODEL OF THE NEW ZEALAND ECONOMY

For 15 years the Reserve Bank has used an econometric model of the New Zealand economy to generate forecasts and to perform policy analysis. This article provides a non-technical introduction to the Bank's model.

Introduction

When confronted for the first time with an econometric model, many people are confounded by what appears to be page upon page of indecipherable mathematics. To compound matters, the text accompanying the exposition of most models is usually couched heavily in economic and statistical jargon. In order to go some way towards redressing this situation, this article attempts to describe the Reserve Bank model in a straightforward, easily digestible manner. Economic terminology will not be avoided where it is necessary to the exposition. However, where it is used, an attempt is made to explain each word or phrase in clear terms and a glossary of the key words (highlighted in the text) is provided.

For those readers who wish to examine the RBNZ model in greater detail, a Research Paper will be forthcoming in the near future describing in a more technical manner the latest version of the model.

What is a Model ?

Economies are undoubtedly complex and the reason for using a model arises out of this complexity. A *model* is an abstraction from reality, drawn in such a way as to reveal the major features of the system. Any real world problem will, in general, involve a large number of complex relationships. If any headway is to be made in the analysis of such situations, it is necessary to try and isolate the most important elements and relationships. Clearly, there can be 'good' and 'bad' models. If the abstraction is taken too far, the model may have little to say about the corresponding real world situation. If, on the other hand, the abstraction is not taken far enough, the model may be too complex to be of value in gaining insights into the workings of the real system.

A useful analogy to summarise the use of a model is that of a flight simulator. The simulator embodies the essential characteristics of an aircraft in flight and the would-be pilot acquires experience without leaving the ground and so without putting an actual plane at risk in the learning process. Similarly an economic model can be used to study the impact of alternative shocks to the economy which could not otherwise be conducted in a real world situation. This comparison can only be taken so far. The flight simulator is a mechanical construct which utilises well established physical principles with near certainty. In economics, the theories developed are much less firmly established. Moreover, economies are liable to change over time and are characterised by considerable uncertainty.

Models can exist in many forms. The models with which the economist is typically concerned are expressed in mathematical form. This characteristic may be distracting for some, but the mathematics is no more than a useful tool for representing the relationships in the economy.

Suppose, for example, we wanted to know by how much consumption in New Zealand is likely to change for a given change in the income of New Zealanders. To make progress, the relationship between consumption and income must be given some explicit form. One way in which this can be done is to observe past income and consumption patterns. A *theory* may then be developed which is consistent with the observed historical behaviour and this may be represented by a mathematical relationship.

If our theory stated that consumption depended only on the level of income, then the relationship, between total consumption (C) and national income (Y), could take the form:

$$C = 10 + 0.8\,Y \qquad (1)$$

This statement of the relationship between C and Y is an *equation*. As noted, C and Y are our measures of consumption and income which will have different values at different points of time (i.e. C and Y are *variables*). The numbers 10 and 0.8, on the other hand, are fixed, and so while C and Y both vary over time, it is assumed (in this example) that the relationship between them does not.

For example, suppose that consumption and income are observed over two periods of time as set out below:

Table 1

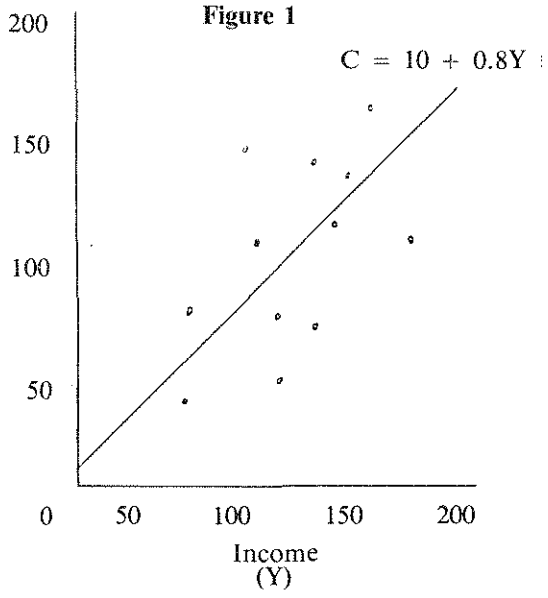
	C	Y
	units	
Time 1	90	100
Time 2	170	200

Over these two periods consumption and income assume different values but the relationship between C and Y remains the same (as represented in equation (1)).

Thus, equation (1) could be used to tell us what the level of consumption would be if income was 150 units; i.e. 130 units, even though this combination of C and Y may not have actually been observed in the past. Similarly, if income rises by 1 unit, the model predicts that consumption would rise by 0.8 units. Because the value of C depends on Y, C is called the *dependent variable* whereas Y is known as the *explanatory variable*. the fixed numbers 10 and 0.8 are known as the *parameters* of the equation relating C to Y.

If, in the real world, consumption behaved exactly as described by equation (1), then by forecasting the value of income in some future period we could calculate the exact value of C for that period. In reality, however, no such exact relationship between C and Y exists. Instead, if we were to collect data for consumption and disposable income over various time periods we would find that they would form a pattern such as that in Figure 1.

Figure 1



The actual consumption/income combinations would be scattered around a line such as that given by equation (1). The objective of the model builder is to find a relationship (or equation) which is consistent with his underlying theory of consumer behaviour and which also best 'fits' the observed points. Thus, assuming that the form of equation (1) is consistent with accepted theory, the estimates of the unknown parameters are calculated so as to minimise in some way the differences between the observed points and the line denoted by the resulting equation (these differences are called *sampling errors*). That is, the parameters chosen are those which provide the best overall explanation of past behaviour.

The branch of economics which specialises in estimating such equations is called *econometrics*. Econometrics is thus a discipline combining aspects of economics, mathematics and statistics. The econometrician is an economist who, in trying to understand the workings of economic systems, combines economic theory, statistics and past observations of economic data to estimate mathematical relationships which are representative of economic behaviour.

Systems of Equations

A model can be made up of a single equation or, as is usually the case, a number of equations representing a complete economic system. The Reserve Bank model of the New Zealand economy comprises several equations explaining different aspects of the economy such as consumption, investment, prices etc.

It is often the case that an explanatory variable in one equation might be the dependent variable in another equation. For example, while the level of consumption in an economy might depend on the income available in that economy, that income may in turn be partly influenced by the level of consumption. In other words both C and Y in this example are determined *simultaneously* within the system.

The Reserve Bank model is a simultaneous system of equations which seeks to explain the major elements of the New Zealand economy. In particular, the model is primarily concerned with explaining the country's gross domestic product (or national income (Y)) which is defined as the sum of a range of expenditures, including consumption (C), investment (I), government spending (G) and the net outcome of the balance of payments, i.e. exports (X) less imports (M). This requirement, that national income be equal to the sum of these expenditures, is expressed by an *identity* as:

$$Y = C + I + G + (X - M) \qquad (2)$$

In the context of this simplified representation, G and X are examples of economic variables that are determined outside of the model framework (in this case by the Government and foreigners demand respectively). In technical terms this sort of variable is known as an *exogenous variable*, a variable which, although perhaps playing an important role in the model, is determined by forces outside the model. The counterpart to an exogenous variable is an *endogenous variable* which is explained within the model and, as such, is represented by an equation.

The equations which explain the endogenous variables in equation (2) can be conveniently written using the notation where f reads as 'is a function of'. Thus, using this notation, equation (1) would become:

$$C = f(Y) \qquad (3)$$

i.e. consumption is a function of income.

If it is assumed that investment depends on the level of national income, and the current interest rate (i) then we may also write:

$$I = f(Y,i) \qquad (4)$$

i.e. investment is a function of Y and i.

As national income changes so too does the amount of imports purchased so that:

$$M = f(Y) \qquad (5)$$

Finally, while equation (2) states the accounting

requirement for national income, income itself is also influenced by the interaction between the supply of productive capital (K) and the level of employment (L):

$$Y = f(K, L) \quad (5)$$

In summary, the simplified model structure is:

$$\begin{aligned} Y &= C + I + G + (X - M) \\ C &= f(Y) \\ I &= f(Y, i) \\ M &= f(Y) \\ Y &= f(K, L) \end{aligned}$$

This system of equations represents the essential relationships which underly the basic structure of the Reserve Bank model. If this model were to be used for forecasting, it is clear that to forecast C, I and M we would need to know the value of Y (and i). However, before we can forecast Y we need to know the values of C, I and M (as well as G and X). This illustrates the essence of a simultaneous equation model. The forecasts of the variables must be determined simultaneously (i.e. jointly). For a large system of equations this is a very complex exercise although it is handled easily by today's computers.

Construction of a Model

The process of constructing a model involves considering both economic theory and the structure of the economy; the availability and quality of data; the estimation of the parameters of the relationships; and the analysis of the fully constructed model.

Sound economic theory should provide the basis for any economic model that is expected to represent the main structural relationships in the real economy and thus be a useful tool for policy analysis and forecasting. This approach forces the model-builder to state explicitly the characteristics and assumptions underlying the model.

The set of relationships that make up the model must take account of not only established economic theory but also factors peculiar to the economy under consideration. For example, in the New Zealand context, in addition to incorporating the usual sorts of policy variables — such as tax rates and government expenditure — there has been a need in the past to allow for other aspects such as controlled interest and exchange rates. As these sorts of controls have changed or have been abolished the structure of the model has required updating. Also, the emergence of new types of financial institutions and financial assets further complicates model construction.

Once an adequate theoretical framework for the model has been derived it is necessary to obtain historical statistical data for all the variables in the model. In many cases, adequate series of data over time may be already regularly published by various statistical agencies. But in other cases deficiencies in the availability of appropriate data mean that series may have to be constructed from scratch.

Each variable to be explained by the model must be represented by an equation or mathematical relationship of some form using the techniques discussed above. A range of statistical tests are used to help determine the properties of individual equations and to assist in assessing the historical importance (based on *empirical evidence*) of the different explanatory variables entering each equation. These tests help to provide some indication of the relative qualities of the various model equations. If a relationship performs badly in these tests it may then be necessary to go back and reconsider the structure of the equation and the quality of the underlying historical data. Economic theory unfortunately does not prescribe a unique set of explanatory variables for each structural relationship and consequently, a degree of experimentation is required to determine which structures give the best historical explanation. The final specification of the model is thus the net result of an interaction between theory and empirical testing. The intention is that this should lead to a model which is both theoretically plausible and statistically acceptable in the sense of being able to explain past behaviour.

The ability of the model to track out the path of past economic history is tested by using the model for various *simulation* tests. Simulation involves using a computer to solve the system of equations to generate values for all the variables it is designed to explain. The results produced by the model can then be compared with what actually happened to see how closely the model explains past history.

History of the Reserve Bank's Model

Fifteen years have passed since the first version of the Reserve Bank's econometric model of the New Zealand economy was published in 1971. Since that first model a number of different versions have been produced and published. However, throughout this time, the major objectives of the Bank's modelling programme have remained essentially unaltered: to improve our understanding of the way in which the economy functions; to provide forecasts of the likely future path of the important economic variables; and to provide a framework for further debate and analysis of economic policy options available to New Zealand.

The construction of the early models was hampered by severe data limitations which meant that a large part of the model development involved the collection and organisation of data. The lack of adequate official quarterly series describing output and expenditures, and incomplete data on government accounts, constituted major gaps in the statistical framework from which the model could be built. Equations were based on unofficial quarterly aggregate expenditure series produced by the Bank that approximated, but did not bear a precise relationship to, the official annual national accounts. With the introduction in 1978 of New Zealand's new system of national accounts (SNA) the Bank undertook a major exercise to provide a quarterly set of national accounts beginning in 1961 that were fully consistent with the official annual SNA data series. The results of this work were published in 1981 and the first model based on these data was published in 1983.

The nature and detail of the model has evolved in response to more appropriate data becoming available, to developments in economic theory, and to changes in the structure and nature of the New Zealand economy. The model has drawn on various strands of theory with the intention of producing an integrated model which

approximates real world economic behaviour in a realistic manner. As the emphasis in the mainstream economic literature has moved from one strand of the theory to another, the model has tended to reflect these trends. The need to take account of the particular institutional characteristics of the New Zealand economy has continually posed problems for the model builder. Not only is it difficult to quantify in an objective manner many institutional influences on the New Zealand economy (such as those due to regulations and restrictions) but the institutional characteristics have also often been subject to numerous, and in some cases substantial, changes. In addition to changes initiated by government, the economy has also developed as a result of the impact of technological changes, such as the increasing use of computers, and as a result of the changing tastes and preferences of the community.

Technology has had its own significant impact on the methods of construction and use of the Bank's model. The phenomenal advances made in the capacity and power of computing facilities over the period of the model project have removed many of the technical constraints that originally existed. More sophisticated techniques of analysis are now available and the reduction in computer processing time has meant that a greater proportion of resources can be devoted to exploring and understanding the properties of the model.

Throughout the history of the Reserve Bank model the variables on which most attention has focused have remained largely unchanged. Table 2 sets out some of these more important variables with brief non-technical notes on the economic factors which are currently incorporated in the equations for these variables.

Table 2

Selected Variable*	Major Explanatory Factors
Private Consumption	Personal disposable income (i.e. after tax income), the difference between desired and actual holdings of money.
Private Investment	Private sector output, output price relative to the cost of capital goods, availability of finance.
Exports of Goods and Services	Overseas aggregate demand, price competitiveness.
Imports of Goods and Services	Domestic activity, relative cost of imports.
Gross Domestic Product	Determined jointly by aggregate demand and aggregate supply.
Consumer Price Index	Weighted average of prices of domestically produced goods and assets, and imported goods.
Employment	Private sector output, real wage costs.
Personal Disposable Income	The main components are determined by wage and employment levels, farm incomes and personal taxes.

* All variables and their determinants are expressed in real terms (i.e. price deflated).

Use of the Reserve Bank's Model

As the objectives for the overall modelling programme suggest, the main purposes for which the model is used within the Bank are to assist in the analysis of policy options and to provide short-term forecasts. In fulfilling these functions the model also provides a basis for improving our general understanding of economic structures and the role of alternative assumptions and theories in shaping economic outcomes.

The model can be used to examine a variety of alternative policy options. For instance the model may be used to assess how the economy would have reacted if average personal income tax rates had been 10 per cent lower than they actually were from 1979. By altering the path of an exogenous variable in the model it is then possible to examine the impact of this change on the endogenous variables. In this way policy options and alternative policy combinations can be analysed.

If the model is being used for forecasting then the values of all exogenous variables required by the model must themselves be forecast, usually for a period of about two years ahead. Such variables include policy variables such as tax rates and government expenditure as well as external variables such as trade prices and volumes. Assumptions may also be required as to average wage settlements over the forecast period. A major source of the differences over time between actual outcomes and the paths forecast by the model can be attributed to changes in government policy or international economic developments which render one or more of the assumptions inappropriate. The forecasts are generally compiled on the basis of no change in government economic policies.

The case for including an econometric model in the forecaster's tool-kit rests on three main points. First, a model provides a systematic framework for the storing and processing of the various pieces of information employed by forecasters. Secondly, a model imposes strict requirements on the internal consistency of forecasts. Thirdly, the explicit theoretical and quantitative assumptions required as input into the model help to identify potential sources of error as well as aiding in the analysis and discussion of the forecast results obtained.

Conclusion

An econometric model is neither magic nor mysterious. It may appear mathematically complicated but this is only because it endeavours to represent an

economic system which is itself complex. Of course, this is one of the major advantages of using a model — that it can cope with a multitude of relationships and a large number of economic variables in a systematic and efficient manner. However, a model is not a substitute for sound subjective judgement and should be viewed as just one of a number of tools which can be used to improve our understanding of the economy.

Glossary

Dependent Variable:	A variable whose value depends on the values taken by other variable(s). Sometimes also referred to as an *endogenous variable*.
Econometrics:	The combination of economic theory, and mathematical and statistical techniques to establish economic relationships and obtain estimates of a model's *parameters*.
Empirical Evidence:	Evidence obtained by analysing historical data or facts.
Endogenous Variable:	A variable explained within the model (i.e. represented by an equation).
Equation:	Statement, in mathematical form, which describes a relationship between variables.
Exogenous Variable:	A variable determined outside the model (i.e. does not require an equation).
Identity:	A particular form of equation which defines a variable by an accounting relationship with other variables.
Explanatory Variable:	A variable which helps explain the behaviour of another.
Model:	A relationship or set of relationships which attempt to reflect the essential elements of a situation in the real world.
Parameter:	A constant value which determines the strength of the relationship between variables.
Sampling Errors:	The difference between the outcome predicted by the model and the actual historical outcome.
Simulation:	The use of a model to attempt to reproduce the essential workings of some system or process.
Simultaneously:	Occurring or operating at the same time.
Theory:	The expression of ideas or general principles explaining some concept or relationship.
Variable:	A measure of a quantity (such as consumption, prices etc.) which is capable of taking different values over time.

billion in the first three weeks of February. This high level of primary liquidity is necessary to accommodate the strong withdrawals which will occur in March as a result of tax payments to government.

Treasury bills amounting to $340 million of Treasury bills were sold by tender during January. Of these, $73 million were January maturities, $167 million February maturities, and $100 million were March maturities. The first three tenders held in February sold $390 million of Treasury bills. Of these, $175 million were February maturities and $215 million were March maturities. The choice of maturities reflected the Bank's desire to match Treasury bill maturities with forecast liquidity withdrawals from the system.

The Reserve Bank conducted open market operations on six occasions during January and on two occasions during the first three weeks of February. Three of these operations were sales of Treasury bills which were carried out in response to strong forecast cash injections on these days. On four occasions the Bank conducted sell-back transactions in order to moderate the tightening of liquidity conditions which was expected to occur on these days. On 27 January, the Bank offered to purchase $75 million of government securities, but since most of the bids were below market rates, it purchased only $6 million of securities.

Stock settlements in January totalled $317 million, $198 million was received for stock sold in Tender 25 and $119 million for stock sold in Tender 26. Stock tender settlements during the first three weeks of February totalled $503 million, $240 million for stock sold in Tender 26, $93 million for stock sold in Tender 27 and $170 million for stock sold in Tender 28. In line with past months, a large proportion of Tender 25, 26 and 27 settlements were received on the final day of the settlement period for each of these tenders.

Liquidity Projections

The Governor of the Reserve Bank, Mr S.T. Russell, released on 19 February 1986, revised liquidity projections, following the announcement of a revised 1985/86 fiscal deficit by the Minister of Finance, the Hon. R.O. Douglas. Mr Russell said that a $1.7 billion fiscal deficit implied a net public sector injection of $2.9 billion, the amount that has been raised through tender sales of government stock this financial year.

Reserve Bank Prepares Modifications to Tender Procedures

The Reserve Bank has prepared modifications to the procedure for tendering for government securities but they will not be put into effect until they have been discussed with the market, the Governor of the Reserve Bank, Mr Spencer Russell, said on 21 February 1986.

"We want to be sure that they are reasonable and workable and, above all, that they do not adversely affect the widespread participation in the system which has produced funds for the Government at the lowest market-related cost", he said.

The changes, which will be circulated to dealers in government securities in a discussion paper, include:

— A review of the existing exemptions from the deposit requirement with the intention of making the exemptions limited to an amount which would be negotiated between the Bank and the registered bidder.

— As a general rule, the limit to be related to the financial substance of the bidder.

— Special limits to be granted to a particular bidder in an individual tender where these can be justified to the Bank.

— For registered bidders without an exemption, the deposit requirement to be 10 per cent instead of the present 5 per cent.

In addition, consideration will be given to changing the settlement period for tenders and to a number of other minor changes.

Mr Russell said that the modifications resulted from the internal examination which had begun when the Bank learned that Rakiura Holdings Limited had defaulted after making a successful tender for Government stock.

"There can never be a positive guarantee that such an incident will not recur but our aim is to reduce the possibility as much as possible without unduly limiting the competition which is the major advantage of the present system.

We will now invite the comments of the market which shares with the Bank the desire that the system be fair and efficient and we expect that changes will be made shortly."

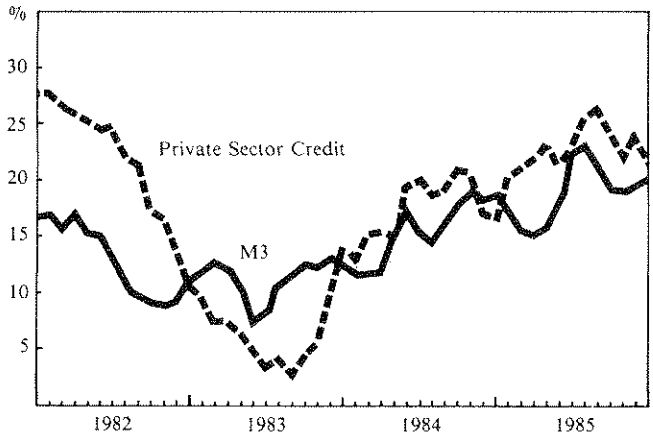
ECONOMIC UPDATE

Monetary Indicators

The *Money Supply* (M3) is estimated to have grown 1.5 per cent in December after rising 1.4 per cent in November. For the year ended December M3 rose 20.1 per cent compared with a 19.6 per cent increase for the November year (D1, D2, D3).

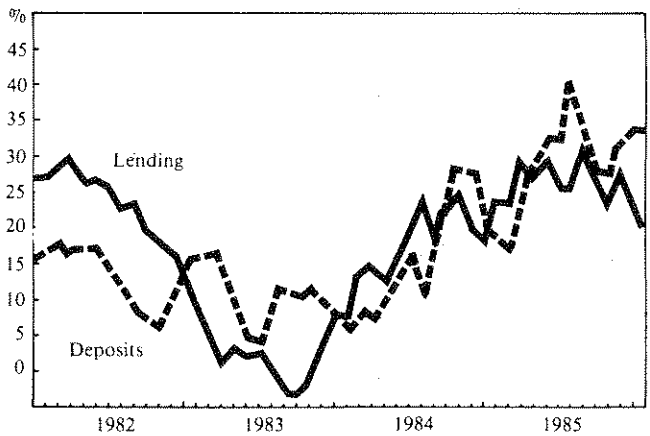
Private Sector Credit (PSC) rose by 0.3 per cent over December following 1.4 growth in November. Over the twelve months to December PSC is estimated to have risen 21.1 per cent which compares with a 24 per cent increase for the year ended November (D2, D3, D4).

Monetary Aggregates
(twelve month percentage changes at monthly rests)



Trading bank lending rose 20.2 per cent in the year to January having risen 23.9 per cent in the year to December. *Trading bank deposits* over the same period were up 34.5 per cent, unchanged from the December year increase (B2, B3, B4, B7, B8, B11). As a result, the *trading banks' lending to deposits ratio* rose to 72 per cent in January compared with 71.4 per cent in the previous month and 80.9 per cent in January 1985.

Trading Bank Deposits and Lending
(twelve month percentage changes at monthly rests)



Total credit limits at trading banks in December were 19.2 per cent higher in annual terms (B12).

The level of *primary liquidity*, expressed as a daily average (non-seasonally adjusted), fell over January to $2,298 million compared with $2,397 million in December.

In the year to December:

— *Savings bank lending* rose 19.6 per cent and *deposits* 7.2 per cent.

— *Trustee savings bank lending* and *deposits* increased by 7.4 per cent and 10.3 per cent respectively (C2).

— *Post Office Savings Bank lending* rose 96.1 per cent and *deposits* 9 per cent (C1).

— *Private savings bank lending* and *deposits* fell 16.8 per cent and 15.9 per cent respectively (C4).

— *Large finance companies' lending* rose 25.6 per cent and *deposits* 25.5 per cent (F4).

— *Building societies' lending* and *deposits* were up 8.2 per cent and 10.1 per cent respectively (F5).

Trading bank deposit interest rates on terms of less than twelve months fell sharply over December while longer term rates were virtually unchanged (I2).

External Sector

(Figures not seasonally adjusted.)

A $22 million net inflow of *private capital* was recorded over November after eight successive months of net outflows (G4).

The *OET current account deficit* for the year ended November was $2,548 million compared with $2,390 million for the year ended October and $2,012 million for the November 1984 year (G4).

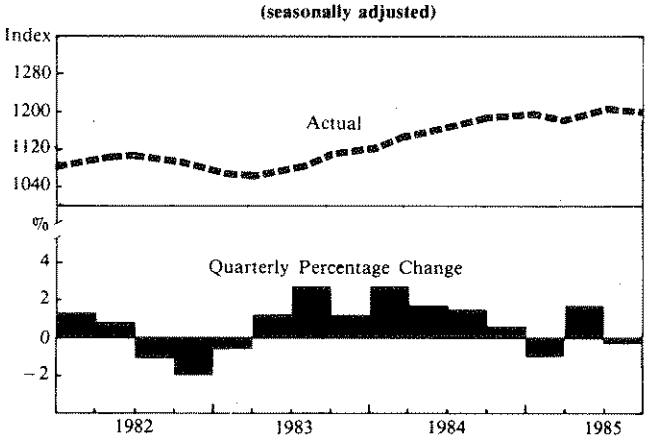
Merchandise trade figures for December show an excess of exports over imports of $176.2 million. A year earlier imports for the month exceeded exports by $29.8 million (G4).

New Zealand's *official overseas reserves* rose by $360.3 million during December to an end-of-month level of $3,254.9 million. At the end of December 1984 reserves stood at $3,698.4 million (G1).

National Income

After rising 1.7 per cent in the June quarter, *real GDP* fell by 0.3 per cent in the September quarter. The increase for the year ended September was 3.2 per cent, down from the 4.7 per cent growth rate recorded for the year ended June. The largest falls in the quarter were recorded in the trade, restaurants and hotels industry and the agricultural sector while the strongest increases were in the electricity, gas and water group, and the construction sector.

Real Gross Domestic Product
(seasonally adjusted)



Investment

The *number of new dwelling permits* issued in December was a sharp 17.6 per cent down on the number issued in November. The number issued over the twelve months to December was 9.8 per cent higher than for the corresponding period in 1984 (J2).

The *value of surveyed import orders* for machinery and electrical equipment over the three months to November was 13.1 per cent lower than for the three months to November 1984 (J2).

Consumption

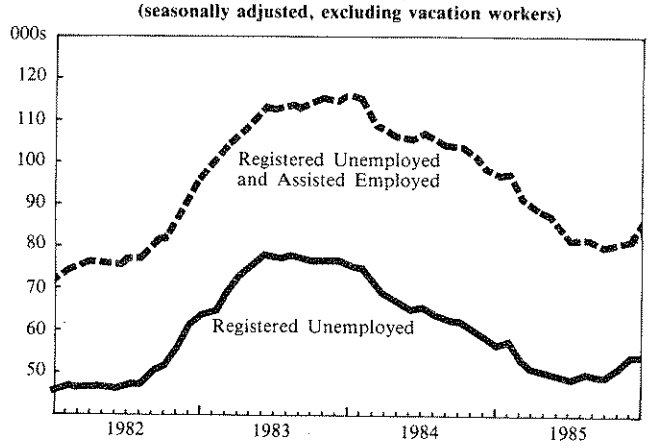
Retail turnover (in real terms) fell 1.3 per cent over the December quarter, having fallen 2 per cent the previous quarter. Automotive stores' sales again accounted for most of the movement and sales excluding this group rose by 0.1 per cent over the quarter (J1).

Labour Market

The number of *registered unemployed* rose by 0.2 per cent in December to 53,883, having risen 5.7 per cent the previous month. This latest figure is 5.1 per cent down on December 1984. The total of *registered unemployed and assisted employed* rose 6.1 per cent in December to 86,319, 11.5 per cent less than a year earlier (J4).

A net outflow of 1,540 *permanent and long-term migrants* was recorded over December, bringing the net outflow over the last year to 19,284.

Labour Market
(seasonally adjusted, excluding vacation workers)



Prices

The *Food Price Index* rose 1.9 per cent in January, the highest monthly increase since March 1985. This brought the annual rate of increase to 11.6 per cent (J3).

Government Sector

(Figures not seasonally adjusted.)

Government net expenditure for the nine months ended December was 20.7 per cent higher than for the corresponding period in 1984 while *government revenue* was up 19.5 per cent. The *government deficit before borrowing* for the nine months was $3,646.1 million, 24.1 per cent higher than for the nine months to December 1984 (E2).

Note

All quarterly and monthly data are seasonally adjusted unless otherwise stated. The figures in brackets refer to the *Bulletin* tables in which the relevant statistics appear. However, the statistics in the *Bulletin* tables have not been seasonally adjusted and therefore may differ from the statistics given here.