Model for Medium Term Economic Forecasting: Projections of Australian Income and Expenditure

Occasional Paper

This paper describes an econometric model designed for Australian economic forecasting in the medium term (from 5 to 10 years). The paper also gives the results of applying the model to predict annual national expenditure and product, in the aggregate and by main components, over the period 1976 to 1983.

BUREAU OF TRANSPORT ECONOMICS

A MODEL FOR MEDIUM TERM ECONOMIC FORECASTING
- PROJECTIONS OF AUSTRALIAN INCOME AND EXPENDITURE

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FOREWORD

The Bureau of Transport Economics provides economic, technical and financial advice on transport matters to the Commonwealth Government, based on *inter alia*:-

- analyses and assessment of transport investment programs and policy proposals, and
- investigations of the availability and use of resources in the transport sector with a view to improving their allocation.

To assess the resource requirements and impacts of prospective alternative transport investment programs and policy proposals, staff of the Bureau maintain a continuing study of past and prospective national resource allocation.

A major requirement of this resource allocation study is medium term trend forecasts of the Australian economy, both in aggregate and for major components. Mr. B.D. Haig, of the Research School of Social Sciences, Australian National University, was commissioned to assist Bureau staff in developing such forecasts.

This paper describes a model developed by Haig, in conjunction with Mr. R.H. Burke of Finance Branch, which is used to predict national expenditure and product, and their main components, over the period 1976 to 1983.

This paper is made public for several reasons, viz:-

- the topicality of resource allocation, as an issue,
- the belief that the techniques developed will be of interest and use to other researchers and practitioners in the field of study, and
- the hope that the methodology of the model described can usefully contribute to increased understanding of the impact of alternative resource allocation policies.

FEBRUARY, 1978

T.M. HOGG
ASSISTANT DIRECTOR
FINANCE BRANCH

PREFACE

This paper describes an econometric model designed for Australian economic forecasting in the medium term (from 5 to 10 years). The paper also gives the results of applying the model to predict annual national expenditure and product, in the aggregate and by main components, over the period 1976 to 1983.

The model's predictive ability appears to be satisfactory when tested by comparing its predictions with actual values for national expenditure and product, both for the aggregates and main components, over various past periods from 1957 to the early or mid 1970's.

The model is a small closed input-output system, which for given values of exogenous variables, describes the changes in the distribution of employment and output of the major sectors of the economy. The model incorporates a number of interrelated sub-models, some of which are of a dynamic nature and others constituting extrapolation of past behavioural patterns.

The model is intended to predict underlying structural changes in the economy and the trend values of national product and expenditure over a medium term period (from 5 to 10 years). As such, the model is not designed to predict seasonal or cyclical variations in economic activity. The model is therefore more suited for use in broad economic analysis and resource allocation over the medium term, than in short term economic adjustment strategies typically embodied within the annual budgetary process.

- Chapter 1 of this paper discusses the main features of the model, lists and describes the equations and gives the values of the coefficients.
- Chapter 2 compares the actual and predicted values over a past period.

- Chapter 3 describes the results of the forecast for the period 1976 to 1983.
- Two appendices describe the sources and methods of the estimates and the computer program used to solve the model computations.

CONTENTS

CHAPTER 1 - THE MODEL

(a) General

The theory underlying the model is based on the Clark-Chenery hypothesis, which relates the distribution of employment between industry sectors to the level of real income per head (Clark, 1940) and to "individual differences in development patterns due to varying resources, trading opportunities, social organisation or other elements" (Chenery and Taylor, 1968). Following Clark, Kuznets (1957) and Fuchs (1965) the relationships between industry structure and real income per head are assumed to be due to the demand and supply characteristics of industries which induce structural change and determine the level of real income per head. The demand and supply factors are inter-related through input-output equations which link the product of industry sectors to final expenditure on the output of industries. The model is thus a small, closed input-output system which, for given values of exogenous variables, describes the changes in the distribution of employment and output of the industries. The exogenous variables are similar to those chosen by Chenery and Taylor to reflect the individual differences in development patterns.

The aim of the model is to predict per capita product and structural change in the medium term for given values of exogenous variables. The effect of changes in these variables can also be easily calculated. It is a five sector model of structural change based essentially on production relations, in contrast to the demand orientated Keynesian or neo-Keynesian models used in cyclical analysis, and some medium term studies. As such, it may have a particular value in projecting trends in countries with good national accounting data, such as Australia or OECD countries.

The model comprises five industry sectors - primary, manufacturing, building, rent and other services - but the analysis of structural change is confined to the changes in the proportion of employment in the manufacturing and other service industries. Employment, product and exports of the primary industry are treated as exogenous. Employment in this industry remained constant in the 1960's and is unlikely to have been affected by changes in the rate of increase in the population or work force, or exports of manufactures, while output, and productivity are largely due to seasonal conditions. Building is treated as a separate sector, partly because there is some doubt as to whether it is properly a part of the manufacturing or service industries, and partly because the rate of change in productivity is quite different to that of the manufacturing and service industries. Rent is shown separately because there is, by convention, no employment in the rent industry.

(b) The Operation of the Model

The main features of the operation of the model may be sketched briefly as follows. The starting point is the level of intermediate and final demand for output of manufacturing industry in the previous year and the level of total employment in the current period. Total demand for output of manufacturing industry in the previous year is translated into manufacturing employment using the production function and input-output relationships. The balance of employment (after deducting employment in the primary industry) is then absorbed fully by the service industries (including government) and building. Output of the building industry is determined by investment demands, including the demand for private dwellings, and these demands are related, in turn, to output of the industries or, in the case of dwellings, to the level of real per capita income and a time trend.

Employment in the building industry is determined by applying a production function to building output. Since output of building depends in part on the output of service industries, the distribution of the residual employment (i.e. total employment less employment in manufacturing and primary industries) between building and service industries, is obtained by simultaneous solution of equations which relate (in part) employment in services and building to output of these industries, and the output of the building industry to output of services.

The output of building and services in the current year induces a demand for intermediate output of manufacturing in the next year. The demand for final output of manufacturing in the next year is the sum of demands in the current year for output of manufacturing for consumption, investment and exports less imports of finished products of manufacturing. Consumer demands for manufacturing output depends on the level of real income per capita (or, strictly, real disposable income) and the relative price of output of the manufacturing and service industries. Relative prices depend on the relative product per person in the two industries. Exports of manufacturing products are exogenous and imports are derived by import equations.

The main dynamic elements in the system are the values of exogenous variables and the time coefficients in the production and demand functions. However, these do not provide a solution for the distribution of employment between sectors each year. This is due essentially to the fact that the demand functions relate final expenditure to the total output of the sectors or real product, while the distribution of employment between sectors, which is determined by the relative levels of final (and intermediate) expenditure on output of the sectors affects, in turn, the level of real product. In order to solve the model each year it is assumed that the level of employment in manufacturing is determined by the level of final and intermediate demands for output of this industry in the previous year. This lag is intended to reflect the delay in changing the level of output, and employment, in response to changes in demands for the products of the industry.

(c) The Equations

(i) Production Functions

1. $\log PF = a \log NF + bt$

2. $\log PB = a \log NB + bt$

3. $\log PS = a \log NS + bt$

4. $PR = a + bH$

5. $H = H_{-1} + D$

(ii) Employment Identity

6. $N = NF + NB + NP + NS$

(iii) Input-output Relations

7. $PF - aEF_{-1} - bPB_{-1} - cPS_{-1} = d + et$

8. $PB - aEB - bPF + cPS = d + et$

(iv) Consumption Functions and Relations

9.	CEG/P	$= a + b\ PN/P + cPCE$
10.	CES/P	$= a + b\ PN/P + cPCE$
11.	PC	$= CEG + CES + CR$
12.	CR	$= a + bPR$
13.	FOOD/P	$= a + bPN/P + cPCE$

(v) Investment Functions and Relations

14.	MF	$= a + b\Delta PF + c\Delta PF_{-1} + d\Delta PF_{-2} + e\Delta PF_{-3}$
15.	BF	$= a + b\Delta PF + c\Delta PF_{-1}$
16.	MBB	$= a + b\Delta PB + c\Delta PB_{-1} + d\Delta PB_{-2} + e\Delta PB_{-3}$
17.	BB	$= a\ MBB$
18.	MS	$= a + b\Delta PS + c\Delta PS_{-1} + d\Delta PS_{-2} + e\Delta PS_{-3}$
19.	BS	$= a + b\Delta PS + c\Delta PS_{-1} + d\Delta PS_{-2} + e\Delta PS_{-3}$
20.	D	$= a + b(PN/P) + ct$
21.	M	$= a[MF + MS + (MBB - BB)]$
22.	EB	$= a[BF + BB + BS] + D$
23.	NFS	$= a + b(PN - PP)$
24.	INFS	$= NFS - NFS_{-1}$

(vi) Import Function

25.	I	$= a + bPN$
26.	CD	$= a\ I$

(vii) National Product and Expenditure Relations

27.	EF	$= CEG + M - FOOD$
28.	PN	$= PF + PB + PS + PP + PR + CD$
29.	PCUR	$= PN - PC - X - M - EB - INFS + I - SD - FS$
30.	PCAP	$= a(MS + BS)$
31.	PAUTH	$= PCUR + PCAP$

(viii) Price Relation

32.	PCE	$= a(\frac{PF}{NF}/\frac{PS}{NS}) + bt$

Notation

Endogenous

NF	Employment in manufacturing
NB	Employment in building
NS	Employment in services
PF	Product in manufacturing
PB	Product in building
PS	Product in services
PR	Product of rent
H	Stock of houses
CD	Customs duty
PN	National product
MF	Investment in machines in manufacturing
BF	Investment in building in manufacturing
MBB	Investment in building
BB	Investment in buildings in building
MS	Investment in machines in services
BS	Investment in buildings in services
D	Expenditure on dwellings
M	Total investment in machines
EB	Total final expenditure on buildings
EF	Total final expenditure on output of manufacturing
PC	Personal consumption expenditure
CEG	Consumption expenditure on goods
CR	Consumption on rent
FOOD	Consumption expenditure on food
CES	Consumption expenditure on services
NFS	Non-farm stocks
INFS	Increase in non-farm stocks
I	Total imports of goods and services
PCUR	Public authority current expenditure
PCAP	Public authority capital expenditure
PAUTH	Total expenditure of public authorities
PCE	Price of services/Price of goods

Exogenous

t	Time (1953/54 =1)
N	Total employment
NP	Employment in primary industries
PP	Product of primary industries
P	Population
SD	Statistical discrepancy
FS	Farm stocks
X	Exports of goods and services

(d) Form and Estimation of the Equations

(i) Production Functions

Specification of production functions was discussed in detail in Haig (1974). In the functions described in that paper the independent variables were time and employment and included a constant. For the present study the equations have been re-estimated using official data instead of the unofficial estimates of product made by Haig, over the full period and two sub-periods to test for likely structural change. They were also estimated with and without the constant. The results are summarised in Table 1.

Although on theoretical grounds the equations with the constant are to be preferred, the coefficients for the independent variables are unrealistic and quite different to those estimated in Haig (1974). On the other hand, the results excluding the constant term, the elasticities of output with respect to employment and the implied technical change appear reasonable. The serial correlation in the residuals may be due largely to cyclical variations. These equations are therefore used in the model.

(ii) Employment Identity

The employment equation is an identity and the relationship is self-evident.

TABLE 1 PRODUCTION FUNCTIONS

(T Values in brackets)

	Constant	Employment	Time	R^2	D.W.
Manufacturing					
1959/60 to 1972/73	4.89 (2.6)	.46 (1.7)	.0042 (7.2)	.99	1.83
1953/54 to 1972/73		1.17 (689)	.026 (26)	.99	.91
1959/60 to 1972/73		1.17 (363)	.027 (17)	.99	.89
Building					
1959/60 to 1972/73	.024 (.004)	1.15 (1.2)	.028 (1.2)	.97	.90
1953/54 to 1972/73		1.17 (319)	.022 (12)	.98	.83
1959/60 to 1972/73		1.16 (170)	.027 (9)	.97	.90
Services					
1953/54 to 1972/73	-4.51 (.7)	1.78 (1.9)	.004 (.2)	.99	.58
1959/60 to 1972/73	6.85 (1.3)	.24 (.3)	.048 (2.5)	.996	.88
1953/54 to 1972/73		1.17 (770)	.020 (20)	.99	.48
1959/60 to 1972/73		1.16 (617)	.024 (23)	.996	.82

(iii) Input-Output Relations

The two input-output equations relate the product of manufacturing and of building to a time trend and to the final and intermediate expenditure on the output of these industries. The coefficients in these equations are derived from input-output coefficients and estimated from data in the 1962/63 input-output table. The constant term and the time coefficient are estimated by regressing final expenditure and intermediate demand for each sector (estimated by multiplying actual product by the input-output coefficients) on time. Hence the coefficients for time will allow (in some fashion) for changes over time in the coefficients. The constant term partly reflects differences between the concepts and data used in the present study and those used in the 1962/63 input-output table. One difference in the data, for example, is that the present estimates are in 1968/69 prices, while the entries in the input-output table are in 1962/63 prices.

The equations were estimated with the first term of the left hand side as the dependent variable. Values were calculated for each year for the remaining terms on the left hand side, and the values of d and e were estimated by regression methods. In the model these equations relate the product of building and manufacturing industries to the final expenditure on their output. Final expenditure on output of any industry of course generates an equivalent amount of final inputs (value added, or product and imports). These equations show this identity, and the regression coefficients allow for the effect of changes in the coefficients relating final expenditure on products of building and manufacturing industries to the value added generated by the expenditure, and errors and omissions in the equations (or specification error).

(iv) Consumption Functions and Relations

Personal consumption expenditure per capita on goods, services and food (processed and unprocessed) is regressed on national product per capita and the price of goods relative to the price of services. Consumption expenditure on rent is regressed on product of rent. In these equations, national product is used as an approximation to the series for personal disposable income.

Total personal consumption is the sum of expenditure on goods, services and rent.

(v) Investment Functions and Relations

Details of investment expenditure by industry and type of plant and machinery and buildings were estimated from 1953/54 to 1970/71 for Haig (1974). These figures have been used in the regression equations in this study. There is a difference between the sum of the item and the total investment on plant and machinery and building due to revisions made to them since the components were estimated. Rather than re-estimate the components, however, the regressions were made using these data and a correction factor applied for the average difference between these figures and the latest estimates published by the Australian Bureau of Statistics. The adjustment factor also allows for investment expenditure in the primary industry.

A simple accelerator model is used, and this appeared to give satisfactory results as indicated by R^2 and Durbin-Watson (D.W.) values. Lengths of lags up to four years were calculated and the length which gave the best was chosen in accordance with R^2 and D.W. values. Table 2 gives the results of using 2 and 4 lags, and for comparison, the result from using one lag plus the lagged value of the dependent variable.

For all equations except the first two (investment in manufacturing industries), the regressions using 4 lags gave satisfactory results. A slightly better result for non-manufacturing industries, and a much better result for manufacturing industries, is obtained by using the lagged value of the dependent variable as an additional explanatory variable. However, equations of this form tend to lead to unstable results, and the goodness of the fit over past periods provides a completely spurious test of the usefulness of the equation for purposes of predicting more than one year ahead. The equations for manufacturing industry are quite unsatisfactory, and comparison of the predicted with the actual results over the sample period shows large and systematic discrepancies. It is probably that this equation is one of the main sources of error in the model.

Expenditure on dwellings is regressed on real income per head and time.

The increase in non-farm stocks is derived as the difference between estimates of total stocks derived by assuming that the level of stocks is a constant ratio of national product.

In equations 21 and 22, the coefficients are the ratio of the average value of actual total investment to the average value of the sum of the series used in the individual regressions. As mentioned earlier, the difference includes investment expenditure by the primary industry.

TABLE 2 INVESTMENT EQUATIONS

(T values in brackets)

	Dep. Var. (-1)	Number of lags	2	3	4	R^2	D.W.
MF		.48	.44			.44	.44
		(2.5)	(2.1)				
		.31	.43	.48	.34	.66	.51
		(1.6)	(2.1)	(1.7)	(1.2)		
	.93	.11				.93	1.79
	(10.2)	(1.4)					
BF		.10	.10			.43	.44
		(2.3)	(2.2)				
		no improvement with more lags)					
	.77	.03				.83	1.96
	(6.7)	(1.3)					
MBB		.30	.28				
		(3.3)	(3.2)				
		.31	.24	.28	.16	.94	1.91
		(6.1)	(4.5)	(5.2)	(2.5)		
	.88	.15				.96	2.45
	(13.3)	(4.3)					
MS		.69	.48			.82	1.13
		(3.4)	(2.1)				
		.54	.29	.41	.41	.96	1.27
		(3.8)	(1.4)	(2.2)	(2.9)		
	.99	.13				.98	1.89
	(15.9)	(1.9)					
BS	.94	1.10	.44			.82	1.05
	(22.0)	(3.8)	(1.5)				
		.61	.31	.59	.27	.96	1.11
		(3.6)	(1.3)	(2.7)	(1.6)		
	.94	.10				.99	1.97
	(22.0)	(1.4)					

(vi) Import Function

Imports are simply regressed on total national product, and it is not thought possible to estimate the price elasticity of demand for imports, nor explain separately imports used for intermediate or final purposes.

In testing the model against past data, imports were badly predicated in the 1970s. It is assumed, however that this is a relatively short period effect due to pressure of demand, and readjustments to the terms of trade, and that these type of effects would disappear over the longer term.

(vii) National Product and Expenditure Relations

The first two equations derive final expenditure on output of manufacturing industries and national product as the sum of product of the sectors. Final expenditure on output of manufacturing is the sum of consumers expenditure on goods plus total investment expenditure on machinery. The equation for national product includes customs duties, since national product is derived as the sum of final expenditure at market prices and exports less imports at c.i.f. valuation, and customs duty is a part of the market price at which product of industries is valued.

Current expenditure of public authorities is derived as the residue, after deducting from national product (estimated as the total of product of industries) the estimated expenditure on other items of final expenditure and the statistical discrepancy (plus the imputed bank service charge).

Public capital expenditure is derived as a proportion of total expenditure on plant and machinery and buildings and structures. The proportion is based on data for about 1970.

(viii) The Price Relation

The price relation is derived from the assumption that prices are determined by a mark-up on unit labour costs, and that average earnings in manufacturing and services vary together.

Using the notations P, Q, N and W to represent prices, quantities of output, employment and average wages, the subscripts F and S for manufacturing and services, and R for the relative level of wages in manufacturing compared to that in the service industries, the derivation of the price relation is as follows:

$$\frac{P_F Q_F}{N_F W_F} = a \qquad \frac{P_S Q_S}{N_S W_S} = b$$

this reduces to

$$\frac{Q_F}{N_F} \Big/ \frac{Q_S}{N_S} = \frac{a}{b} R(P_S/P_F)$$

The equation as estimated is of the form

$$\frac{P_S}{P_F} = A_1\left(\frac{Q_F}{Q_S} \Big/ \frac{N_S}{N_F}\right) + A_2 t$$

where the term A_1 corresponds to $\frac{b}{Ra}$ in the preceding equation, and A_2 a time trend, which may be rationalised as reflecting a systematic bias in the movement of average wages in the two sectors, due perhaps to relative improvements in the quality of labour inputs in manufacturing or to the effects of stronger bargaining power of organised labour in manufacturing.

(e) Estimates of the Coefficients

TABLE 3 COEFFICIENTS AND TESTS OF SIGNIFICANCE

(T values in brackets)

Equation	a	b	c	d	d	R^2	D.W.
1.	1.17	.026				.99	.91
	(689)	(26)					
2.	1.17	.022				.98	.83
	(319)	(12)					
3.	1.17	.020				.99	.48
	(770)	(20)					
4.	-4.89	.069				.997	.77
	(.3)	(81)					
7.	.70	.49	.12	-691.19	-75.74	.73	.89
				(5.4)	(6.2)		
8.	.49	.018	.027	-113.92	-25.64	.96	1.07
				(8.7)	(20)		
9.	.32	.29	-.09			.99	1.70
	(3.3)	(13.2)	(1.7)				
10.	-20	.16	.15			.99	1.73
	(4.7)	(16.9)	(6.6)				
12.	147.14	1.21				.999	1.79
	(13.3)	(139)					
13.	.14	.055	.016			.98	1.80
	(5.4)	(9.7)	(1.2)				
14.	183.4	.31	.43	.48	.36	.66	.51
	(1.5)	(1.6)	(2.1)	(1.7)	(1.2)		
15.	126.5	.10	.10			.43	.44
	(6.5)	(2.3)	(2.2)				
16.	24.6	.31	.24	.28	.16	.94	1.91
	(3.4)	(6.1)	(4.5)	(5.2)	(2.5)		
17.	.30						
18.	198.5	.54	.29	.41	.41	.96	1.27
	(3.5)	(3.8)	(1.4)	(2.2)	(2.9)		
19.	861.9	.61	.31	.59	.27	.96	1.11
	(12.5)	(3.6)	(1.3)	(2.7)	(1.6)		
20.	-1205.5	1170.6	-9.4			.99	1.58
	(8.1)	(10.4)	(1.4)				
21.	1.47						
22.	1.08						
23.	-501.1	.23				.99	.93
	(4.2)	(38.7)					
25.	-626.0	.18				.96	1.06
	(3.4)	(21.1)					
26.	.084					.98	.34
	(98.4)						
30.	.58						
32.	-626.0	.18				.96	1.1
	(3.4)	(21.1)					

CHAPTER 2 - PREDICTION OVER THE SAMPLE PERIOD

The results of applying the model over the period 1957 to the early 1970s are shown in Charts 1 to 10. These charts show the actual and predicted values for each variable and graphs of the figures and the residual.

In general the results appear acceptable. The model accurately predicts employment in manufacturing and services, and employment in building tolerably well, allowing for the large variations in this series. Product estimates are also close to the actual figures, although the calculated product of services increases faster than actual product in each of the last eight years, which is probably a reflection of the serial correlation in the estimated equation for the production function.

There are larger discrepancies in the annual changes in national product. However, there is no systematic variation, and effects of serial correlation in the residuals in the production functions appear to have been offsetting. The error in the increase in total product over the eighteen years - 1957 to 1975 - was less than 4 per cent.

The last three items, investment expenditure, expenditure by public authorities and personal consumption show the same sort of variation from actual values as national product. Public authority expenditure is the ultimate residual and the estimates are reassuring - there is a close correspondence between predicted and actual values until recently, and the larger variations in recent years appear random.

Prediction in the sense of projecting into the future, as distinct from predicting over a (sample) known period as described in this Chapter, is commented on in the following Chapter 3.

CHAPTER 3 - PROJECTIONS 1976 TO 1983

(a) The Method

The model is simulated by inserting values for exogenous variables for each year. As noted earlier exports are assumed equal to imports. Furthermore, the statistical discrepancy is assumed zero. There are only four variables for which values are needed, and these are shown in the next section.

Once these values are selected, the model produces a series of estimates for the endogenous values. Earlier values are brought in through the lagged values of endogenous variables. Since the object is to predict trend, and not cyclical changes we have preferred to start the simulation from 1976, and lagged values are for 1975 and earlier years. As shown in the results there is considerable variation in some variables over the next five years.

(b) Values of Exogenous Variables

These are set out in Table 4.

TABLE 4 - VALUES OF EXOGENOUS VARIABLES

	Population (000s)	Employment+ (000s)	Product of Primary ($m)
1976	13719	4905	4150
1977	13870	4959	4300
1978	14019	5019	4450
1979	14168	5065	4600
1980	14322	5120	4750
1981	14646	5236	5050
1983	14814	5296	5200

\+ Less employment in primary.

Source - refer Appendix A.

(c) The Results

The results are set out in Charts 1 to 10.

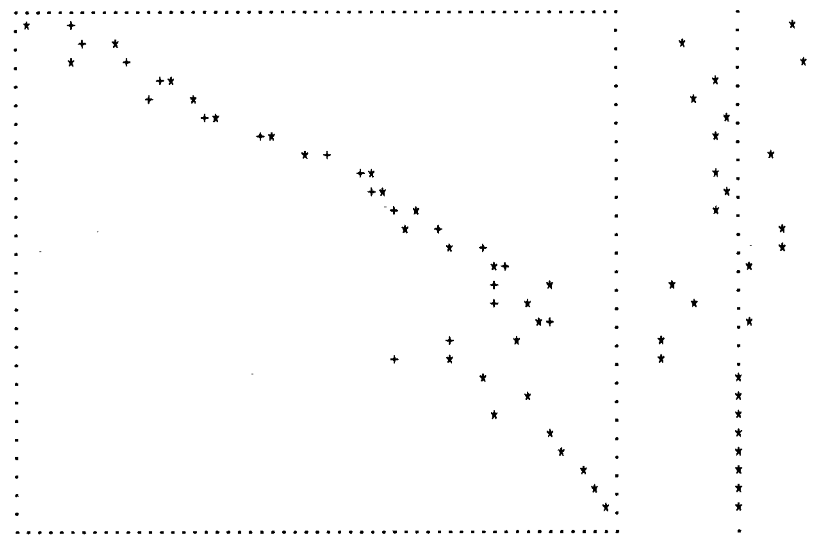
CHART 1. EMPLOYMENT IN MANUFACTURING

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 1045.42 TO 1532.04

RESIDUAL RANGE -53.0 TO 44.1

ACTUAL (1) NF+	SOLUTION NF*	RESIDUAL	
1081.50	1045.42	36.08	1957
1090.80	1124.95	-34.15	1958
1130.80	1086.69	44.11	1959
1155.50	1166.98	-11.48	1960
1151.50	1182.16	-30.66	1961
1194.70	1202.81	-8.11	1962
1241.90	1254.10	-12.20	1963
1301.70	1278.76	22.94	1964
1322.50	1337.27	-14.77	1965
1337.80	1347.52	-9.72	1966
1358.60	1372.69	-14.09	1967
1389.20	1363.57	25.63	1968
1428.10	1401.76	26.34	1969
1446.10	1442.14	3.96	1970
1442.00	1481.91	-39.91	1971
1439.20	1469.97	-30.77	1972
1485.00	1479.22	5.78	1973
1403.00	1455.06	-52.06	1974
1350.00	1403.05	-53.05	1975
1431.86	1431.86	0.00	1976
1469.04	1469.04	0.00	1977
1437.71	1437.71	0.00	1978
1488.51	1488.51	0.00	1979
1493.52	1493.52	0.00	1980
1511.97	1511.97	0.00	1981
1522.97	1522.97	0.00	1982
1532.04	1532.04	0.00	1983



UNITS - THOUSANDS PERSONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

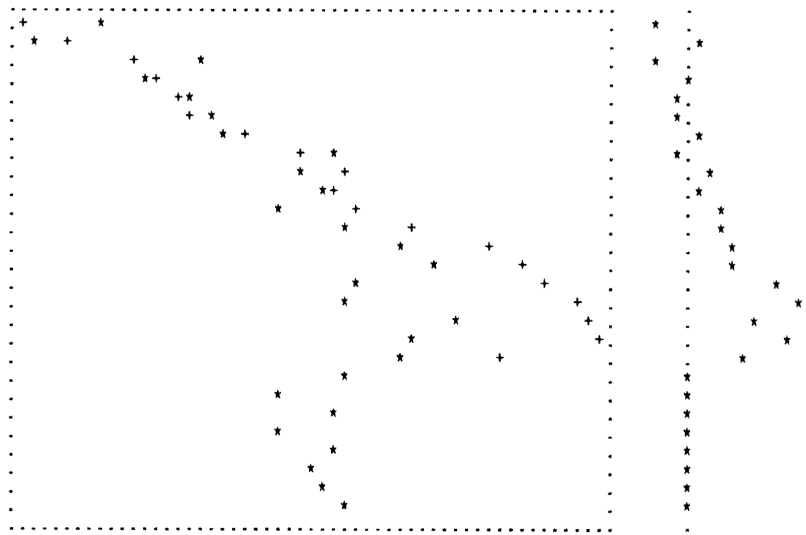
CHART 2. EMPLOYMENT IN BUILDING

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 350.30 TO 518.00

RESIDUAL RANGE -22.6 TO 68.8

ACTUAL (1) NB+	SOLUTION NB*	RESIDUAL	
350.30	372.92	-22.62	1957
361.70	353.81	7.89	1958
382.80	402.48	-19.68	1959
388.00	386.39	1.61	1960
394.20	397.28	-3.08	1961
399.40	405.87	-6.47	1962
415.20	407.15	8.05	1963
431.40	439.47	-8.07	1964
445.30	429.85	15.45	1965
440.20	436.18	4.02	1966
446.20	424.22	21.98	1967
463.30	443.92	19.38	1968
484.70	460.15	24.55	1969
494.40	469.51	24.89	1970
501.80	447.15	54.65	1971
512.90	444.14	68.76	1972
515.00	477.32	37.68	1973
518.00	462.19	55.81	1974
490.00	459.66	30.34	1975
442.55	442.55	0.00	1976
424.10	424.10	0.00	1977
441.42	441.42	0.00	1978
425.28	425.28	0.00	1979
441.34	441.34	0.00	1980
433.41	433.41	0.00	1981
436.01	436.01	0.00	1982
445.07	445.07	0.00	1983



UNITS - THOUSANDS PERSONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

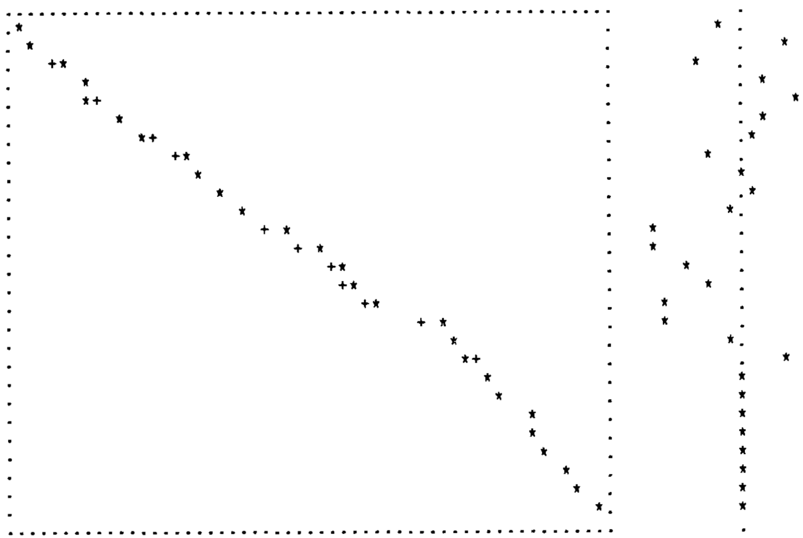
CHART 3. EMPLOYMENT IN SERVICES

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 1870.30 TO 3318.89

RESIDUAL RANGE -50.9 TO 33.7

ACTUAL (1) NS+	SOLUTION NS*	RESIDUAL	
1870.30	1883.76	-13.46	1957
1911.70	1885.44	26.26	1958
1963.60	1988.03	-24.43	1959
2033.60	2023.73	9.87	1960
2079.20	2045.46	33.74	1961
2128.60	2114.02	14.58	1962
2191.60	2187.45	4.15	1963
2263.50	2278.37	-14.87	1964
2318.10	2318.79	-.69	1965
2377.30	2371.61	5.69	1966
2432.80	2440.70	-7.90	1967
2493.80	2538.81	-45.01	1968
2571.80	2622.69	-50.89	1969
2649.80	2678.65	-28.85	1970
2684.00	2698.73	-14.73	1971
2733.70	2772.69	-38.99	1972
2875.00	2917.46	-42.46	1973
2961.00	2964.75	-3.75	1974
3011.00	2988.30	22.70	1975
3030.60	3030.60	0.00	1976
3065.86	3065.86	0.00	1977
3139.87	3139.87	0.00	1978
3151.21	3151.21	0.00	1979
3185.14	3185.14	0.00	1980
3231.62	3231.62	0.00	1981
3277.02	3277.02	0.00	1982
3318.89	3318.89	0.00	1983



UNITS - THOUSANDS PERSONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

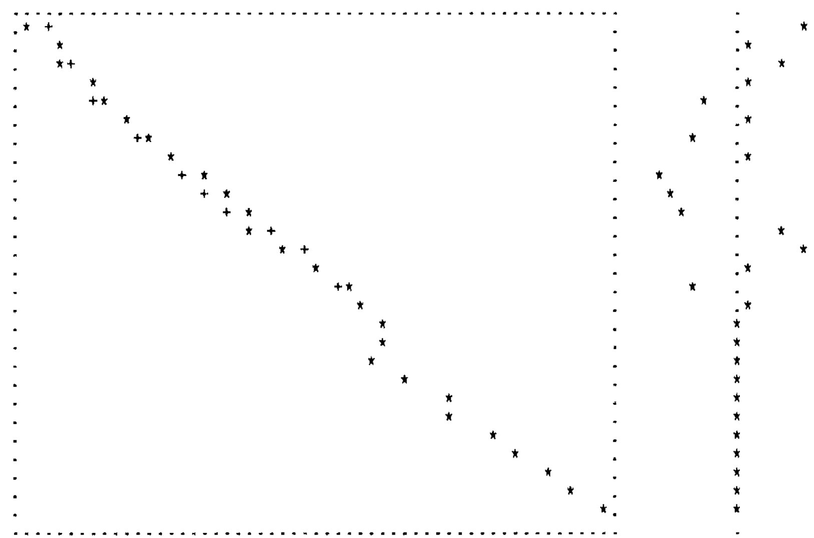
CHART 4. PRODUCT OF MANUFACTURING

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 3956.50 TO 12240.03

RESIDUAL RANGE -373.2 TO 312.7

ACTUAL (1) PF+	SOLUTION PF*	RESIDUAL	
4244.00	3956.50	287.50	1957
4450.00	4426.20	23.80	1958
4577.00	4363.02	213.98	1959
4921.00	4869.30	51.70	1960
4908.00	5074.90	-166.90	1961
5345.00	5316.47	28.53	1962
5523.00	5731.52	-208.52	1963
6057.00	6019.55	37.45	1964
6139.00	6512.15	-373.15	1965
6428.00	6745.14	-317.14	1966
6843.00	7076.11	-233.11	1967
7414.00	7207.42	206.58	1968
7955.00	7642.31	312.69	1969
8139.00	8110.85	28.15	1970
8410.00	8596.04	-186.04	1971
8806.00	8740.90	65.10	1972
9039.17	9039.17	0.00	1973
9101.70	9101.70	0.00	1974
8952.88	8952.88	0.00	1975
9412.22	9412.22	0.00	1976
9956.96	9956.96	0.00	1977
9966.14	9966.14	0.00	1978
10655.89	10655.89	0.00	1979
10981.94	10981.94	0.00	1980
11436.94	11436.94	0.00	1981
11840.75	11840.75	0.00	1982
12240.03	12240.03	0.00	1983



UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

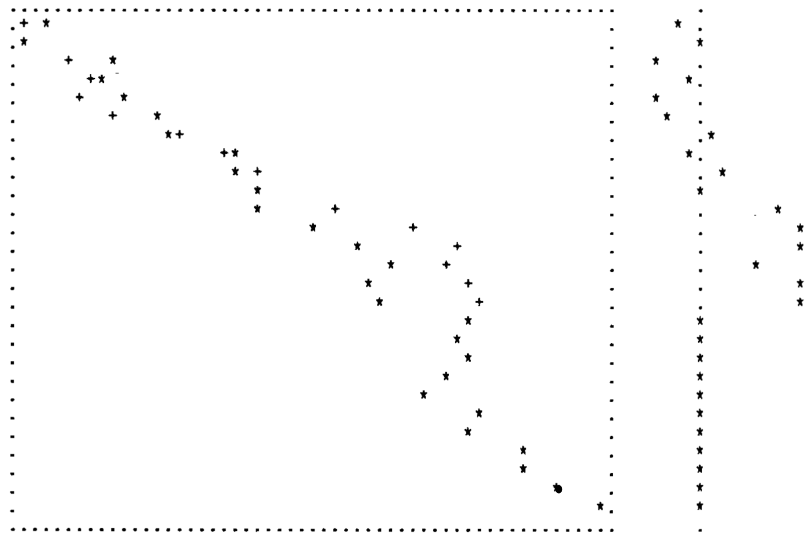
CHART 5. PRODUCT OF BUILDING

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 1076.00 TO 2481.26

RESIDUAL RANGE -125.5 TO 255.2

ACTUAL (1) PB+	SOLUTION PB*	RESIDUAL	
1076.00	1127.29	-51.29	1957
1080.00	1084.12	-4.12	1958
1178.00	1288.78	-110.78	1959
1238.00	1256.66	-18.66	1960
1202.00	1327.52	-125.52	1961
1296.00	1391.94	-95.94	1962
1451.00	1428.69	22.31	1963
1558.00	1597.40	-39.40	1964
1641.00	1591.89	49.11	1965
1647.00	1655.98	-8.98	1966
1820.00	1639.38	180.62	1967
2013.00	1767.82	245.18	1968
2118.00	1885.32	232.68	1969
2110.00	1973.87	136.13	1970
2162.00	1906.80	255.20	1971
2188.00	1934.68	253.32	1972
2152.14	2152.14	0.00	1973
2119.64	2119.64	0.00	1974
2153.79	2153.79	0.00	1975
2107.13	2107.13	0.00	1976
2050.34	2050.34	0.00	1977
2197.15	2197.15	0.00	1978
2151.26	2151.26	0.00	1979
2297.29	2297.29	0.00	1980
2300.12	2300.12	0.00	1981
2368.71	2368.71	0.00	1982
2481.26	2481.26	0.00	1983



UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

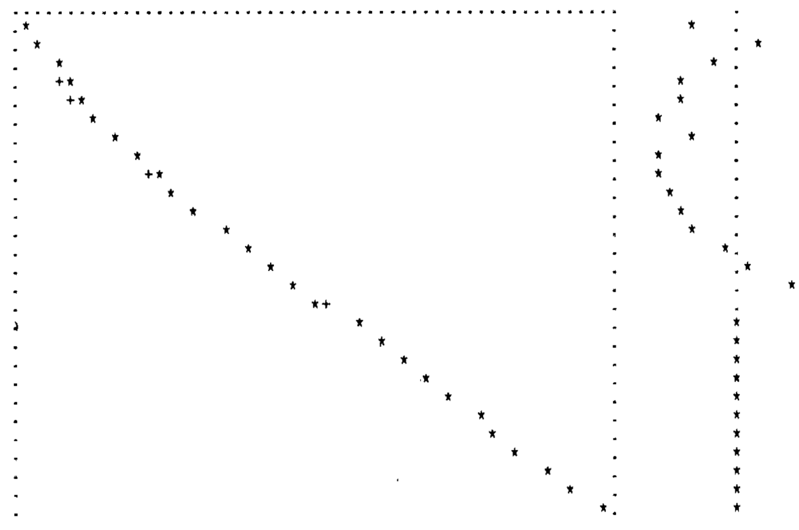
CHART 6. PRODUCT OF SERVICES

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 7437.00 TO 24627.09

RESIDUAL RANGE -263.8 TO 230.0

ACTUAL (1) PS+	SOLUTION PS*	RESIDUAL	
7437.00	7580.33	-143.33	1957
7798.00	7739.97	58.03	1958
8319.00	8400.31	-81.31	1959
8587.00	8748.83	-161.83	1960
8872.00	9036.13	-164.13	1961
9316.00	9579.77	-263.77	1962
10025.00	10170.13	-145.13	1963
10624.00	10880.41	-256.41	1964
11086.00	11328.97	-242.97	1965
11653.00	11864.49	-211.49	1966
12355.00	12515.78	-160.78	1967
13233.00	13369.29	-136.29	1968
14120.00	14165.92	-45.92	1969
14863.00	14811.06	51.94	1970
15428.00	15240.02	187.98	1971
16275.00	16044.96	230.04	1972
17371.35	17371.35	0.00	1973
18055.63	18055.63	0.00	1974
18588.17	18588.17	0.00	1975
19274.66	19274.66	0.00	1976
19928.37	19928.37	0.00	1977
20902.88	20902.88	0.00	1978
21411.13	21411.13	0.00	1979
22115.07	22115.07	0.00	1980
22943.40	22943.40	0.00	1981
23787.84	23787.84	0.00	1982
24627.09	24627.09	0.00	1983



UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

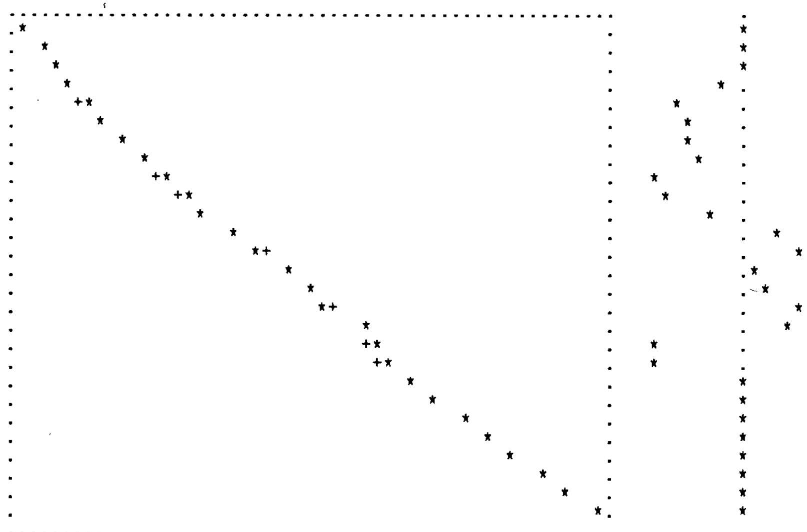
CHART 7. NATIONAL PRODUCT

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 15291.08 TO 48726.25

RESIDUAL RANGE -705.7 TO 526.4

ACTUAL (1) PN+	SOLUTION PN*	RESIDUAL	
15376.00	15291.08	84.92	1957
16414.00	16353.48	60.52	1958
17201.00	17178.83	22.17	1959
18059.00	18182.00	-123.00	1960
18318.00	18829.52	-511.52	1961
19584.00	19979.06	-395.06	1962
20835.00	21200.65	-365.65	1963
22223.00	22541.89	-318.89	1964
22707.00	23348.19	-641.19	1965
24113.00	24716.23	-603.23	1966
25268.00	25504.91	-236.91	1967
27612.00	27321.49	290.51	1968
29379.00	28917.23	461.77	1969
30801.00	30636.65	164.35	1970
32058.00	31864.55	193.45	1971
33368.00	32841.60	526.40	1972
35297.00	34938.00	359.00	1973
35245.00	35875.85	-630.85	1974
35780.00	36485.66	-705.66	1975
37936.59	37936.59	0.00	1976
39380.15	39380.15	0.00	1977
40817.65	40817.65	0.00	1978
42282.36	42282.36	0.00	1979
43776.62	43776.62	0.00	1980
45388.47	45388.47	0.00	1981
47037.13	47037.13	0.00	1982
48726.25	48726.25	0.00	1983



UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

CHART 8. INVESTMENT EXPENDITURE

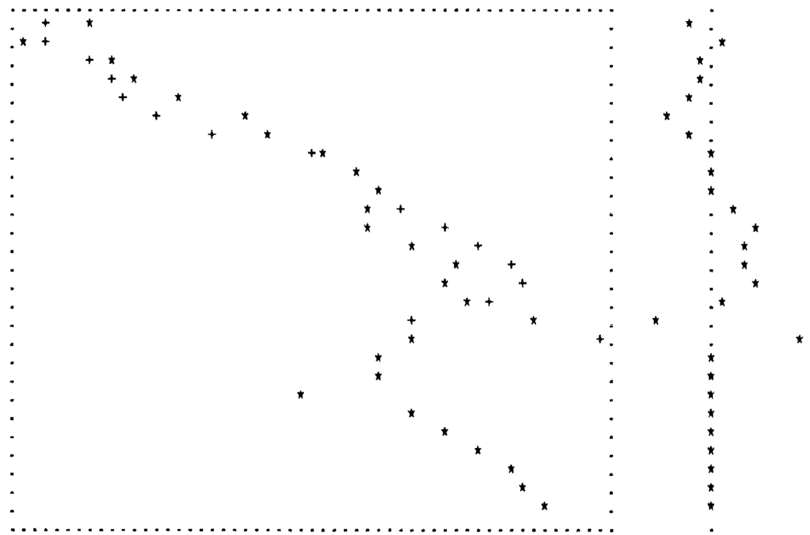
AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

ACTUAL (1) M+	SOLUTION M*	RESIDUAL	
1616.00	1783.30	-167.30	1957
1639.00	1539.53	99.47	1958
1796.00	1865.05	-69.05	1959
1884.00	1972.36	-88.36	1960
1923.00	2136.03	-213.03	1961
2049.00	2389.42	-340.42	1962
2266.00	2461.11	-195.11	1963
2654.00	2674.38	-20.38	1964
2807.00	2821.00	-14.00	1965
2895.00	2900.99	-5.99	1966
3005.00	2868.46	136.54	1967
3169.00	2879.07	289.93	1968
3270.00	3016.08	253.92	1969
3418.00	3197.14	220.86	1970
3478.00	3156.95	321.05	1971
3341.00	3249.50	91.50	1972
3758.00	3519.02	238.98	1973
3046.77	3046.77	0.00	1974
2921.58	2921.58	0.00	1975
2914.03	2914.03	0.00	1976
2586.52	2586.52	0.00	1977
3012.54	3012.54	0.00	1978
3154.91	3154.91	0.00	1979
3290.86	3290.86	0.00	1980
3406.96	3406.96	0.00	1981
3455.84	3455.84	0.00	1982
3550.08	3550.08	0.00	1983

RANGE 1539.53 TO 3758.00

RESIDUAL RANGE

-472.2 TO 711.2



UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

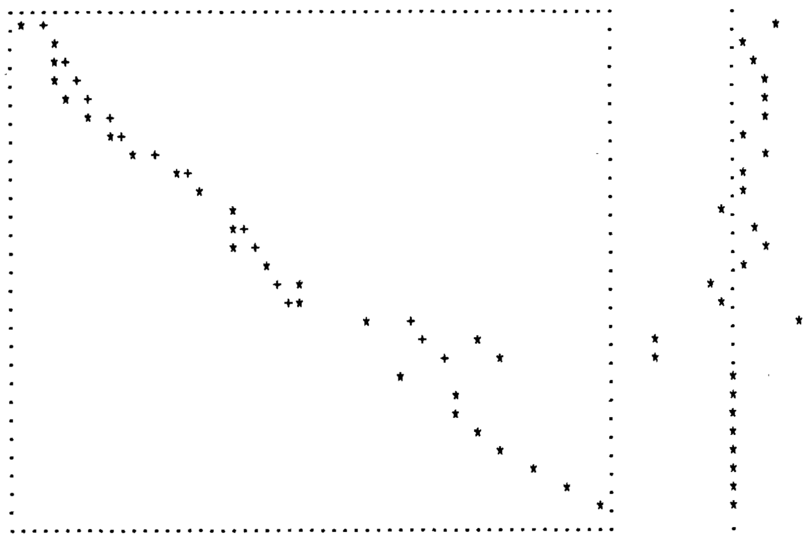
CHART 9. EXPENDITURE BY PUBLIC AUTHORITIES

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

RANGE 2707.78 TO 10386.42

RESIDUAL RANGE -734.0 TO 582.7

ACTUAL (1) PAUTH+	SOLUTION PAUTH*	RESIDUAL	
3029.00	2707.78	321.22	1957
3176.00	3133.16	42.84	1958
3286.00	3140.50	145.50	1959
3476.00	3188.70	287.30	1960
3565.00	3283.07	281.93	1961
3831.00	3539.85	291.15	1962
4024.00	3916.08	107.92	1963
4428.00	4202.50	225.50	1964
4908.00	4826.01	81.99	1965
5136.00	5061.45	74.55	1966
5491.00	5584.51	-93.51	1967
5688.00	5554.38	133.62	1968
5831.00	5563.64	267.36	1969
5990.00	5914.26	75.74	1970
6170.00	6388.60	-218.60	1971
6306.00	6460.31	-154.31	1972
7818.00	7235.30	582.70	1973
8057.00	8791.01	-734.01	1974
8330.00	9001.96	-671.96	1975
7779.81	7779.81	0.00	1976
8432.79	8432.79	0.00	1977
8486.49	8486.49	0.00	1978
8808.91	8808.91	0.00	1979
9059.85	9059.85	0.00	1980
9529.05	9529.05	0.00	1981
9934.13	9934.13	0.00	1982
10386.42	10386.42	0.00	1983



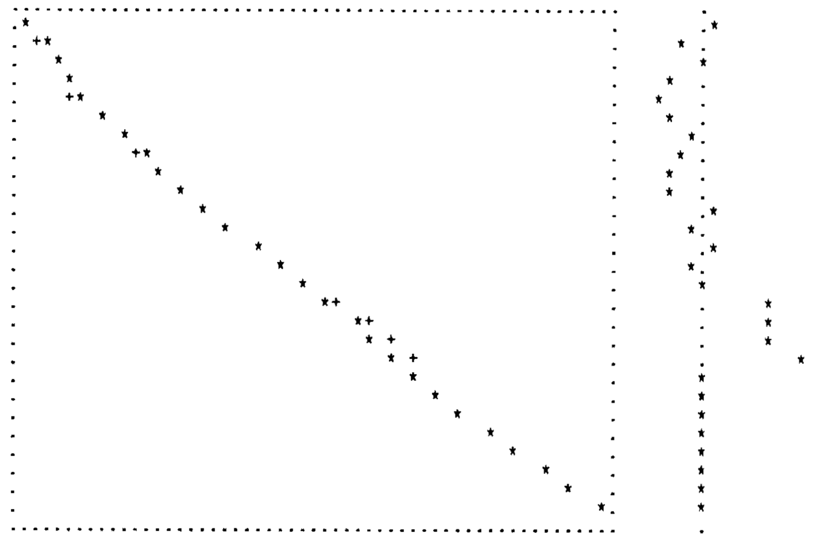
UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

CHART 10. PERSONAL CONSUMPTION EXPENDITURE

AUSTRALIA - MEDIUM TERM MODEL. DYNAMIC SIMULATION 1957 - 1983

ACTUAL (1) PC+	SOLUTION PC*	RESIDUAL	
10075.00	9970.66	104.34	1957
10399.00	10541.74	-142.74	1958
11055.00	10987.14	67.86	1959
11258.00	11540.60	-282.60	1960
11532.00	11931.19	-399.19	1961
12309.00	12541.61	-232.61	1962
13107.00	13196.25	-89.25	1963
13725.00	13908.04	-183.04	1964
14139.00	14388.69	-249.69	1965
14822.00	15118.64	-296.64	1966
15699.00	15590.12	108.88	1967
16508.00	16532.98	-24.98	1968
17519.00	17394.79	124.21	1969
18212.00	18320.86	-108.86	1970
19034.00	19028.60	5.40	1971
20191.00	19605.23	585.77	1972
21265.00	20695.76	569.24	1973
21884.00	21262.07	621.93	1974
22607.00	21677.75	929.25	1975
22490.08	22490.08	0.00	1976
23307.44	23307.44	0.00	1977
24114.16	24114.16	0.00	1978
24956.51	24956.51	0.00	1979
25810.07	25810.07	0.00	1980
26725.12	26725.12	0.00	1981
27662.98	27662.98	0.00	1982
28625.88	28625.88	0.00	1983



UNITS - $ MILLIONS

(1) ACTUAL SOURCE DATA REFER APPENDIX A.

APPENDIX A - SOURCES AND METHODS OF THE ESTIMATES

(a) Used to estimate the equations

Employment

Total employment and employment by industry from 1962-63 to 1973-74 are from Estimates of Gross Project by Industry (A.B.S. 1975). Figures for earlier years are derived from series calculated for Haig (1974), and later figures (1974-75 and 1975-76) are financial year averages of monthly employment given in Employment and Unemployment (A.B.S. 1975).

Product

Product figures are based on the same sources as the employment series. The latest estimates of product by industry which were available when this report was prepared were for 1972-73.

Components of Investment Expenditure

Investment in dwellings, plant and machinery and other buildings are re-based figures from Australian National Accounts. The detailed components (used in the regression equations for investment by type of asset and industry) are series calculated for Haig (1974) and run from 1953 to 1970. Their estimation required a reconstruction of data from several sources using unpublished information, and it has not been possible to calculate the figures for later years.

Other Series

Other estimates are from the A.B.S. national accounting publications. Figures for most recent years are taken from Quarterly Estimates of National Income and Expenditure.

(b) Used in the Projection

Population figures are A.B.S. projections made in 1976 and published in Projections of the Population of Australia 1977 to 2001. They are inclusive of net immigration of 50,000 persons a year.

The <u>employment</u> figures are estimated by applying the average participation rate in 1975-76 to the projections of population in each year.

The <u>statistical discrepancy</u> (including the imputed bank service charge) is assumed to bear the same relationship to national product in each year as in 1975-76.

<u>Product of primary industry</u> is a free-hand extrapolation of trends over the past fifteen years.

The value of <u>exports</u> of goods and services is assumed to equal imports. Imports are calculated by assuming an average propensity to import, and it is assumed that economic policies will constrain the value of exports to that figure. Imports and exports are (of course) valued at constant prices.

APPENDIX B - SOLVING THE EQUATIONS

The program used to solve the set of equations was originally written by Norman at the University of Pennsylvania and later modified by Pagan at the Australian National University. The initial version of the program was used by the Treasury and the Bureau of Statistics to solve the short term Treasury econometric model. It is a program for solving a system of non-linear equations in Fortran IV programing language.

This Appendix discusses the main characteristics of the program and its use in solving the model. Further details of the theory of the program are set out in Norman's original work (Ph.D. thesis submitted in 1968 to the University of Pennsylvania) and in a paper by Pagan (1975).

The Characteristics of the Program

The essential feature of the program is the application of the Gauss-Siedel algorithm for solving a set of non-linear simultaneous equations. However, the model has a large number of advantages which make it particularly useful for forecasting and simulation of any econometric model. Thus while the present model is essentially recursive with only four or five equations being determined simultaneously, the use of this program nevertheless greatly simplifies estimation of the whole system.

The main advantages of the program are as follows:

1. The model prints out actual and computed values for endogenous variables which makes it possible to check the accuracy of the equations and variables as written for the model. The residual between the actual and estimated values for each variable should of course be the same as in the original equation.

2. The model computes the predicted values for all endogenous variables for any given set of exogenous data, and continues automatically from one year to the next to the end of the sample or prediction

period. It is thus ideally adapted for purposes of economic forecasting over a number of periods.

3. The model is well suited to show the effect of altering the values of parameters or exogenous variables and hence can be used to simulate the effects of changes in variables due to changes in economic conditions or policy on the prediction. Much of the difficulty in medium term projection arises from uncertainty in the values of the exogenous variables in particular population level, unemployment and mining exports. By using this model it is easy to allow for the effect of changes and hence the estimation of the model can be made quite simply following any major change in values of exogenous variables.

The equations are solved by an iterative procedure. The program requires an initial set of data for the endogenous variables (which may be the values in a previous period), as well as values for the exogenous variables, and it calculates successive values of endogenous variables until it arrives at a solution set. The solution is determined when the results of further iterations do not alter the previous solution by a prespecified small amount.

The program comprises a number of subroutines. The seven basic routines are listed in Pagan (2), page 5. The solution of the model is handled in two additional routines, FUN x 1 and FUN x 2, and a further sub-routine organises the data into the input form needed for the program. The main problems in using the program occur in setting up the system of equations in the subroutines, FUNx1 and FUNx2. The sub-routine eventually stores the data on disc and retrieves it.

The input cards needed are described in Pagan (1975), page 5. Some important points to be borne in mind in using the program are:

(i) The program provides for a dynamic or one-period simulation. The dynamic simulation continues predicting ahead from calculated values each period, while the one-period simulation predicts forward each period from the actual values for endogenous variables. It is necessary of course, to employ dynamic simulation in using the model for forecasting.

(ii) Computed values of endogenous variables may be graphed, and may be compared with the actual values of endogenous variables. The graph option is only feasible in simulations over the sample period. It is not necessary to enter actual values of endogenous variables until it is desired to print out the comparison of actual and predicted values. Otherwise zero values may be inserted.

(iii) It is essential that the number of iterations before tests for convergence are applied be specified, and the maximum number of iterations in case the equations do not solve.

(iv) The program will also print out the results after each iteration, or the final solution. If the model fails to solve, it may be useful in analysing the reason for this to print out the results of successive iterations.

Application of the program to solve and simulate the medium term model

The program, including the relevant input cards, has been supplied to the Bureau of Transport Economics. The general input cards are straightforward, and the following comments explain the input cards needed for the two subroutines, FUNx1 and FUNx2). These cards enter the system of equations, and the values of parameters.

The equations, described earlier in this paper, need to be modified in two ways before they are entered in the program.

First, the equations must be rewritten so that each endogenous variable appears only once, and only once on the left hand side of an equation. In the equations on page 7, PF and PB appear on the left hand side in two equations (nos. 1 and 6, and 2 and 7), and therefore one PF and one PB must be taken to the right hand side. Also equation 5 has on the left hand side an exogenous variable and this has to be replaced by an endogenous variable.

Secondly, in order to facilitate a solution, the system of equations should be written in "natural" order corresponding to the way they would be solved in the real world. Before entering the equations, a few minor changes were made to the ordering shown on page 7, to assist convergence. For example, the first two equations determine the level of employment in the manufacturing and building industries. The next (logical) step is to derive employment in the service industries as a residual, and equation 5 (after rewriting to read NS = N - NF - NB - NP) is inserted in place of the original equation 3. A few other minor changes were also made to the original list of equations, to facilitate writing the system for the program.

The form and ordering of the equations as entered in the model are as follows (new equation number on left).

1. $NF = aPF^{b}e^{ct}$
2. $NB = aPB^{b}c^{ct}$
3. $NS = N - NF - NB - NP$
4. $PF = a + bEF_{-1} + cPB_{-1} + dPS_{-1} + et$
5. $PB = a + bEB = cPF + dPS + et$
6. $PS = aNS^{b}e^{ct}$

7. and 8. equation 4 (7. $PR = a + bH$

8. $= H_{-1} - DSC + D$)

9. equation 26

10. equation 18

11. to 16. equations 12 to 17

17. equation 18
18. equation 25
19. equation 8
20. to 21. equations 9 and 10
22. Food = (Px (a + b (CEG + CES/P)) + ct)
23. equation 24
24. equation 22
25. equation 29
26. equation 27
27. equation 28
28. equation 20
29. equation 21
30. equation 23.

The equations must then be rewritten in the form needed for the two subroutines FUNx1 and FUNx2. As explained in Pagan (1975), pages 10 and 11, FUNx1 evaluates that part of the equation which remains "fixed" in each iteration, or the predetermined and exogenous variables, while FUNx2 evolves the endogenous variables by the other endogenous variables and the "fixed" variables. In FUNx1, the fixed parts of each equation is written in C(   ) statements, while in FUNx2, the endogenous variables are expressed as Y(   ) statements. (An endogenous varaible on the right of a Y(   ) statement is written as Z variable.

The deck structure needed with the FUNx1 and FUNx2 statements to run a simulation is indicated in Pagan (2) page 12.

Finally, it should be noted that the values of lagged endogenous variables are needed for simulations which limit the first year of the simulation from the start of the sample period plus the maximum number of lags.

REFERENCES

(1) Australian Bureau of Statistics, *Estimates of Gross Product by Industry,* 1975.

(2) Australian Bureau of Statistics, *Employment and Unemployment,* 1975.

(3) Chenery, H.B. and Taylor L., Development patterns: among countries and over time". *The Review of Economics and Statistics,* Vol. L. (November, 1968) 391-416.

(4) Clark, C., *The Conditions of Economic Progress,* 1st Edition (London, Macmillan & Co.) 1940.

(5) Fuchs, V., *The Growing Importance of the Service Industries,* Occasional Paper 96 (New York, The National Bureau of Economic Research), 1965.

(6) Haig, B. *The Australian Economy to the Year 2000,* Commonwealth Bureau of Roads, (Melbourne) 1974.

(7) Kuznets, S., "Quantitative Aspects of the Economic Growth of Nations: II. Industrial Distribution of National Product and Labor Force", *Economic Development and Cultural Change V,* 1957 Supplement.

(8) Pagan, A. "Deterministic Simulation of Econometric Models", (Mimeo), Australian National University, 1975.

Footnote.

1. In order to allow for the effect on local activity and imports of changes in the exchange rate after 1973, adjustments were made to the calculated values of imports and manufacturing product. The adjustments were estimated deviations from trend values.

	Imports ($m)	Manufacturing Product ($m)
1973	+ 1000	
1974	+ 900	-700
1975	+ 500	-700