A Quarterly Forecasting Model of the New Zealand Economy*

P.C.B. PHILLIPS AND J. YEABSLEY†

"small is beautiful"

- Anon.

1. INTRODUCTION

A series of research papers issued by the Reserve Bank of New Zealand[1] over the last few years has described the construction of a large quarterly econometric model of the New Zealand economy. This model (RBNZ for short) represents a considerable body of work and our paper attempts to evaluate at least one aspect of it. The approach taken is to contrast the forecasting performance of RBNZ with that of a small model developed in this paper. It is our belief that forecasts obtained from small models provide useful criteria in the evaluation of large macroeconometric systems such as RBNZ. Although the model we developed is almost completely linear, estimates will be obtained by means of full information maximum likelihood (FIML) so that we can expect our model to have an inherent advantage over RBNZ in forecasting. The fact that econometric models, when estimated by FIML, may well yield better forecasts than when they are estimated by other methods such as

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† University of Essex, and Department of Trade and Industry, Wellington.

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1. See Deane (1971) and later papers in this series, Nos. 2-12.

two stage least squares (2SLS) has only recently been recognised.[2] FIML has two main advantages. In the first place all à priori information is used, which we can expect to be beneficial provided the model is correctly specified (see Summers (1965) and Cragg (1968)). This will be more likely for smaller models where we include only those equations in which we have most confidence. Secondly, we now know, from the recent seminal work of Sargan (1973), that estimation by FIML reduces the size of the tails of the distribution of the estimated reduced form coefficients (and hence those of the forecast error). In contrast, estimation by 2SLS leads to reduced form coefficients which possess no finite moments[3] and whose distribution, therefore, can be expected to have long tails, increasing the probability of outliers.

Another objective in the development of this small model is to analyse its dynamic properties more formally than can be done for the RBNZ. This is because the RBNZ is not only large, but incorporates features (such as Almon lags) which mean that the only practical means of examining its dynamic properties is simulation.

To ensure close comparability with RBNZ, our model has been estimated using not only the same time period (1960/1970 by quarters), but whenever possible, the same data.[4] In some cases this has meant that the definition of the series does not correspond exactly to the variable we intended to include, but this was not felt to be as important as comparability with RBNZ.[5] Our model is founded substantially on earlier work by Bergstrom and Brownlie (1965 and 1967) and can therefore be described as a modification of their demand oriented system based on quarterly data.

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2. For some earlier practical results see the ex post forecasts of the Klein-Goldberger model in Klein (1969).

3. See McCarthy (1972).

4. Our sample period data have been drawn largely from Deane et al. (1972), although the post sample data have been obtained directly from the Economic Department of the Reserve Bank, for which we are most grateful. We understand that the aggregate expenditure series we are using has recently undergone a major revision and we hope to make use of the new series in further work on our model. For the purposes of the present paper, however, we have kept to the published series in order to achieve as close a comparison as possible with the simulation results published in Deane (1972).

5. Exact relationships between our data and that of RBNZ are detailed in the Appendix.

2. STRUCTURAL EQUATIONS OF THE MODEL

The model assembles the variables into four behavioural equations and two definitions. These are:

$$(1) \qquad E_t = \alpha_0 + \alpha_1 \tfrac{1}{2}(Q_t+Q_{t-4}) + u_{1t}$$

$$(2) \qquad Q_t = \beta_0 + \beta_1 \tfrac{1}{2}(D_t+D_{t-4}) + \beta_2(aD_{t-2}-S_{t-2}) + u_{2t}$$

$$(3) \qquad X_t = \gamma_0 + \gamma_1 W_{1t-4} + \gamma_2 W_{2t-4} + \gamma_3 W_{3t-4} + u_{3t}$$

$$(4) \qquad M_t = \delta_0 + \delta_1(E_t+X_t) + \delta_2 A_{t-4} + u_{4t}$$

$$(5) \qquad \Delta S_t = S_t - S_{t-1} = Q_t + M_t - E_t - X_t$$

$$(6) \qquad D_t = Q_t - \Delta S_t$$

where:

E	=	real domestic aggregate expenditure
Q	=	real aggregate expenditure
D	=	real aggregate demand for domestic production
S	=	end of quarter stock level
X	=	real exports
M	=	real imports
W_1	=	real GNP of Australia × exchange rate
W_2	=	real GNP of Great Britain × exchange rate
W_3	=	real GNP of U.S.A. × exchange rate
A	=	official overseas reserves of N.Z. in constant (import) prices.

Equation (1) is an expenditure equation. It explains the present level of expenditure in terms of the average of income in the current quarter and the same quarter a year ago. This can be interpreted as a crude form of "permanent income". A corresponding form is used in the output equation, (2), where our output variable Q is given by an aggregate expenditure variable used in RBNZ.[6] However, in this equation averaging is of demand in quarters twelve

6. Where it is called YR1.

months apart. As well as this straight-forward demand effect, another demand element is included. The second systematic component in equation (2) is a stock adjustment component whereby output is assumed to be greater the greater the excess of desired stocks (aD) over actual stocks. The mean time lag in this adjustment is taken to be six months and for simplicity we assume the adjustment is not spread over a number of periods (this may be relaxed later).

Equation (3) reflects the desire to make exports endogenous and generalizes an equation found useful in Brownlie and Hool (1971) where they used U.S. GNP alone. Our equation includes Australian and British GNP as well. These variables are incorporated separately to measure the relative importance (in the sixties) of these trading partners. In the final relation, equation (4), imports depend on two basic forces. These are: expenditure augmented by receipts from exports and lagged overseas assets levels which are intended to capture the attitude of the government to import controls, something otherwise difficult to include.

3. ESTIMATION AND RESULTS

The parameter estimates obtained by FIML from quarterly data (1960(i) - 1970(iv)) are given in Table 1.

Seasonal dummies were used in each stochastic equation of the model but we do not include the estimated coefficients in the above table to simplify presentation. Our main purpose in using raw quarterly data rather than deseasonalising before estimation is to allow the possibility of interaction between seasonal dummies and economic variables in further work on the model. Such a step, we believe, would be useful for forecasting but leads to a structural model which is non-linear in variables and therefore, rather difficult to estimate and use for forecasting.[7] We hope to conduct work on this aspect later.

7. Some form of linearisation so that conventional programmes could be used would be possible but it is difficult to conjecture on the effects of such a linearisation, particularly for forecasting.

TABLE 1

Parameter	Estimate	Standard Error
α_0	157.7730	52.5884
α_1	0.8958	0.0458
β_0	-218.1864	124.2705
β_1	1.0238	0.1331
β_2	0.2329	0.1275
a	1.1780	0.5252
γ_0	-51.4247	54.7075
γ_1	19.5688	11.8532
γ_2	0.3428	0.4738
γ_3	8.1921	5.6758
δ_0	-68.2932	30.1309
δ_1	0.2329	0.0196
δ_2	0.1391	0.0379
χ^2 value of likelihood ratio (27 degrees of freedom)		1909.75

All the estimates in Table 1 seem plausible and, ignoring constants, we note that the signs accord with prior expectations. Some of the parameter estimates are highly significant (particularly, α_1, β_1, δ_1, δ_2); others less so. This is important because we must be careful in our interpretation of the usual 't ratios'. For, the FIML structural parameter estimates possess no integral finite sample moments (see Sargan (1970)) and thus the tabulated 't values' are presumably too small.

We can draw some parallel between our estimates of certain parameters and estimates of corresponding parameters in Bergstrom and Brownlie (1965) (B-B, for short). Our estimates imply that the marginal propensity to spend is 0.89 and the marginal impact on output of demand is 1.02, where B-B obtained 0.54 and 0.62, respectively. These estimates seem somewhat large and we would expect them to affect the stability of the model. We will return to this point later.

Of the remaining parameters, our estimates suggest that the desired level of stocks is 18 per cent greater than the level of aggregate quarterly demand (parameter a), the marginal propensity to import is 0.23 and the marginal impact on imports of a change in reserve assets is 0.14. All these figures seem realistic and the later two are comparable in order of magnitude to estimates of similar parameters in B-B.

In Table I we also record the calculated value of the χ^2 statistic derived from the likelihood ratio. The statistic is significant and leads to a rejection of the overidentifying restrictions. This outcome is by no means unusual particularly since the likelihood ratio based test is known to perform badly in small samples.[8] Nevertheless, the large value of the statistic does suggest that some future re-specification of the model may be fruitful.

From the structural equations (1)-(6) and the estimated parameters in Table I the reduced form was obtained and written as a 4^{th} order difference equation system with the exogenous variables W_1, W_2, W_3, A_t and seasonal dummies. The dynamic behaviour of this system then depends on the eigenvalues of the coefficient matrix in the corresponding enlarged first order system. The dominant eigenvalues were found to be -1.08, -0.97 and $0.90 \pm 0.14i$. Thus, if the impressed forces were constant, the model is seen to generate an explosive sawtooth about the path of a damped 11 year cycle around the equilibrium values. We would expect the large estimated values of α_1 and β_1 to be influential here as they imply very small leakages in the income determination process. Moreover, as B-B remark on the instability of their earlier system, many stabilising influences (such as interest rate feedbacks and the real balance effect) are not incorporated in the simple expenditure functions we have used. On the other hand, as we will see in the next section, the model's tracking performance within the sample period and short-term ex post forecasts beyond the sample period are very satisfactory. Thus, the model may provide a kernel for a more highly developed medium sized model.

8. See Byron (1974).

4. FORECASTING PERFORMANCE

To establish comparability with RBNZ we report forecasts over the period 1965(iii) - 1971(iv), the same period used in the RBNZ simulation. Moreover, we confine our attention to the main output variable Q, which is used in RBNZ to summarise the tracking performance of their own model. Two types of forecasts will be considered:

(a) Single period forecasts (i.e. forecasts for only one period ahead for each of the 26 quarters), and

(b) Multi-period forecasts (i.e. a dynamic simulation for the whole 26 quarters using model generated values for lagged endogenous variables).

Only non-stochastic simulations are used, as in RBNZ.

Our results are presented in Table II below together with those of the RBNZ simulation. Our worst performance seems to be in the early years, particularly 1967 where we fail to pick up the sharp downturn. We also underestimate the expansion in economic activity up to mid-1966 and do not capture the slowdown towards the end of the sample period. To a lesser extent RBNZ[9] have the same difficulties in these periods, although it should be noted that the tracking ability of RBNZ is no doubt improved by the use of selected dummies, especially for 1967. Despite these shortcomings, we are sufficiently encouraged by the results to feel that we have picked up the underlying structure of economic activity fairly well and have traced out the observed cyclical movements in periods of normal development with some success. The latter is particularly evident in the rolling forecast between 1968(2) and 1970(2).

To assist in the comparison of our forecasts with those of RBNZ we have computed root mean square errors (RMSE's) according to the formula:

9. Cf. Graph 1 on page 30 of Deane (1972).

TABLE II

SIMULATIONS

Quarter		Actual Q	PY Single Period	PY Multi Period	RBNZ
1965	3	879.3	861.9	861.9	862.2
	4	939.2	871.2	871.2	907.3
1966	1	918.1	877.0	867.5	910.0
	2	962.7	931.3	914.3	949.6
	3	937.6	893.3	868.2	946.7
	4	963.2	952.6	897.9	972.2
1967	1	865.3	939.0	893.7	876.6
	2	901.2	985.9	952.6	932.9
	3	905.4	934.8	903.1	908.2
	4	926.2	963.2	940.6	927.7
1968	1	950.8	900.6	925.5	944.4
	2	960.5	947.0	985.7	1000.5
	3	933.4	940.0	929.8	941.2
	4	968.6	976.3	988.2	961.4
1969	1	944.3	988.8	965.6	937.9
	2	1035.3	1014.1	1044.9	1036.3
	3	1002.9	971.6	986.4	1000.7
	4	1073.8	1023.8	1066.7	1047.2
1970	1	1013.8	996.1	1027.7	1000.7
	2	1102.7	1085.3	1114.4	1101.3
	3	1089.1	1041.7	1048.8	1080.0
	4	1067.8	1125.4	1130.3	1082.1
1971	1	1042.0	1068.4	1070.5	1090.0
	2	1105.0	1153.1	1162.6	1119.8
	3	1098.0	1091.1	1080.8	1125.1
	4	1084.0	1080.4	1169.4	1121.1

$$RMSE = \{ \sum_{t=1}^{T} (Q_t - \hat{Q}_t)^2 / \sum_{t=1}^{T} Q_t^2 \}^{\frac{1}{2}}$$

where $\hat{Q}_t$ is the forecast of Q_t, and these are presented in Table III for the within sample period (1965(3)-1970(4)), the ex post forecasting period (1971(1)-1971(4)) and the total period (1965(3) -1971(4)).

TABLE III

RMSE's

	PY Single Period	PY Multi Period	RBNZ	Naive Models (a)	(b)	(c)
1965(3)-1970(4)	0.043	0.038	0.016			
1965(3)-1971(4)	0.048	0.041	0.020			
1971(1)-1971(4)	0.025	0.050	0.031	0.044	0.016	0.052

The naive models referred to above are:

(a) $Q_t = a + bQ_{t-4}$, fitted for each quarter with sample data;

(b) $Q_t = Q_{t-4}$;

(c) $Q_t - Q_{t-4} = Q_{t-4} - Q_{t-8}$.

We see from Table III that our main success is with single period ex post forecasts beyond the sample period. The RMSE of our model (PY for short) is smaller than that of two out of three naive models and smaller also than the RMSE of RBNZ's post sample simulation. The latter is, of course, not strictly comparable with the PY single period results but rather PY multi period. However, we have chosen to include PY single period forecasts in our results because these are better than the multi-period outside the sample period, as would be expected, and RBNZ in reporting their own simulations rejected a simulation from base 1970(4) rather than 1965(3) since it gave inferior results. Even on a straight comparison of RBNZ with our multi-period forecasts we find some room for satisfaction in that the within sample RMSE of PY is well over twice that of RBNZ whereas the post sample RMSE of PY is well under twice that of RBNZ. In view of our failure to pick up the early years in the simulation well and the absence of dummy variables in our model, this indicates that PY's performance is perhaps closer to that of RBNZ than the RMSE's for 1965(3)-1970(4) and 1965(3)-1971(4) suggest.

5. FINAL COMMENTS

If this paper serves any purpose it is to suggest that further work on small quarterly models of aggregate economic relations in New Zealand is justified. Our model, which is tiny by any standards, seems to perform relatively well against RBNZ, but without an explicit government sector and no policy equations it is not very useful as it stands. We have already indicated some areas where it is natural to extend the model such as the introduction of a monetary sector and interaction between seasonal dummies and economic variables (leading, for instance, to variable spending propensities) but further work is also needed on the lag structure which in the present model is based solely on prior specification. With such developments the model could be enlarged to a 10-15 stochastic equation system, so that we would still have the advantage of estimation by FIML. Such a model, we believe, would provide the Reserve Bank of New Zealand with a regular and objective means of testing and evaluating the results of their larger more disaggregated system.

APPENDIX A

The correspondence between PY Model variables and RBNZ variables is as follows (the notation for RBNZ is as in Deane et al. (1972)):

PY	RBNZ
E	$YDR3$
Q	$YR1$
D	$YR1 - KTR$
S_t	$\sum_{i=1960(1)}^{t} \Delta KTR$
X	$CRER + CROR$
M	$ICR + CPOR$
A	$\frac{\text{Overseas Reserves}}{PI}$

APPENDIX B

DATA IN $N.Z. MILLION (1965 PRICES)*

	E	Q	D	S	X	M	A	W_3	W_2	W_1
1960 1	656.2	734.8	696.4	38.4	200.1	159.9	334.7	89.0	12.08	2.82
2	707.1	750.4	766.0	22.8	226.0	167.1	380.9	92.5	12.72	2.78
3	723.5	712.1	697.3	37.6	159.4	185.6	334.3	90.1	12.47	3.01
4	777.8	724.7	735.4	26.9	153.4	195.8	243.8	96.5	13.15	3.41
1961 1	727.9	777.8	732.1	72.6	204.9	200.7	216.4	88.0	12.85	2.90
2	774.0	808.0	789.9	90.7	234.6	218.7	237.0	94.1	13.28	2.70
3	735.1	715.1	695.1	110.7	167.2	207.2	200.8	92.7	13.18	2.94
4	813.2	769.6	798.9	81.4	159.1	173.4	186.1	101.9	13.32	3.38
1962 1	692.6	752.4	746.6	87.2	215.7	161.7	220.2	94.7	12.76	2.97
2	745.9	776.5	775.7	88.0	219.1	189.3	264.8	100.7	13.25	2.98
3	722.0	740.4	726.5	101.9	182.9	178.4	252.5	99.6	13.14	3.12
4	834.5	798.8	813.8	86.9	161.2	181.9	237.4	109.3	13.39	3.70
1963 1	739.1	800.2	781.3	105.8	237.6	195.4	282.7	99.4	12.56	3.17
2	797.9	837.7	825.5	118.0	229.0	201.4	300.3	105.4	13.69	3.02
3	736.9	764.5	729.3	153.2	179.6	230.8	268.2	104.6	13.75	3.43
4	899.1	821.1	842.8	131.5	169.8	226.1	222.4	113.3	14.43	4.03
1964 1	770.1	824.1	780.8	164.8	235.1	214.4	271.4	105.0	13.74	3.36
2	836.3	878.8	872.4	172.2	250.4	214.3	318.7	111.1	14.40	3.34
3	856.2	830.9	805.3	197.8	185.6	236.5	278.4	110.2	14.24	3.66
4	929.9	831.1	864.0	164.9	170.3	236.2	234.8	119.5	14.82	4.10
1965 1	824.6	858.1	829.1	193.9	221.8	217.3	270.5	110.8	14.05	3.60
2	894.6	914.8	891.7	217.0	236.8	239.7	271.7	117.3	14.41	3.51
3	862.7	878.3	839.5	256.8	198.6	270.2	205.3	117.1	14.54	3.73
4	1009.0	939.2	941.9	254.1	192.1	259.2	167.5	129.6	15.15	4.14
1966 1	897.5	918.1	883.6	288.6	234.4	248.3	187.1	119.9	14.35	3.57
2	950.8	964.5	955.4	297.7	264.1	259.5	193.6	126.3	14.76	3.56
3	967.0	937.6	909.5	325.8	217.8	275.8	188.2	124.4	14.84	3.88
4	1033.1	963.2	973.1	315.9	201.3	261.3	158.2	132.1	15.08	4.39
1967 1	892.2	865.3	856.3	324.9	222.6	258.5	171.7	123.4	14.71	3.97
2	928.0	901.2	915.6	310.5	246.3	258.7	163.6	130.4	15.10	3.81
3	885.5	905.4	877.3	338.6	223.1	231.3	161.6	130.9	15.21	4.02
4	947.4	926.2	953.6	311.2	209.9	203.7	214.4	170.4	16.61	5.75
1968 1	859.9	950.8	933.4	328.6	285.4	211.9	259.6	159.1	15.99	4.91
2	884.3	960.5	967.5	321.6	296.3	213.1	263.2	171.6	16.06	5.06
3	890.7	933.4	905.1	349.9	267.2	252.8	228.5	168.6	16.35	3.44
4	991.6	968.6	988.1	330.4	245.8	249.3	173.9	179.9	16.87	6.33
1969 1	868.2	944.3	922.1	352.6	277.1	223.2	235.0	165.5	16.00	5.45
2	930.7	1035.3	1014.3	373.6	328.7	245.1	271.4	174.6	16.54	5.47
3	954.3	1002.9	973.8	402.7	307.2	287.7	231.5	172.5	16.78	5.91
4	1060.9	1073.8	1090.1	386.4	284.1	254.9	213.1	178.5	17.48	6.61
1970 1	927.6	1013.8	986.9	413.3	300.4	241.1	264.0	163.5	16.21	5.80
2	1042.1	1102.7	1091.8	424.2	355.0	305.3	271.7	173.5	17.02	5.94
3	1027.9	1089.1	1060.1	453.2	317.4	285.2	269.6	170.3	17.14	6.23
4	1111.1	1067.8	1105.6	415.4	276.8	282.3	222.0	179.1	18.05	6.76

* W_1, W_2 and W_3 are in $N.Z. billion.

APPENDIX C

DATA SOURCES:

Deane et al. (1972): *E*, *Q*, *D*, *S*, *X*, *M*, *PI*.

Reserve Bank of New Zealand Bulletin: N.Z. official overseas reserves.

Survey of Current Business: GNP of U.S.A. in current prices.

Economic Trends: GNP of U.K. in current prices.

International Financial Statistics:

GNP of Australia in current prices.

U.S.A. consumer price index.

U.K. consumer price index.

Australia consumer price index.

REFERENCES

Bergstrom, A.R. and A.D. Brownlie (1965), "An Econometric Model of the New Zealand Economy", *Economic Record*, 125-126.

Bergstrom, A.R. and A.D. Brownlie (1967), "Forecasting the New Zealand Economy", *Economic Record*, 303-305.

Brownlie, A.D. and R.B. Hool (1971), "Money, Prices and Production in New Zealand 1956-1970", *New Zealand Economic Papers*, 5, 129-130.

Byron, R.P. (1974), "Testing Structural Specification using the Unrestricted Reduced Form", *Econometrica*, 42, 869-883.

Cragg, J.G. (1968), "Some Effects of Incorrect Specification on the Small Sample Properties of Several Simultaneous Equation Estimates", *International Economic Review*, 9, 63-68.

Deane, R.S. (1971), "Towards a Model of the New Zealand Economy", Research Paper No. 1, Reserve Bank of New Zealand.

Deane, R.S. (ed.) (1972), "A New Zealand Model: Structure, Policy Uses and Some Simulation Results", Research Paper No. 8, Reserve Bank of New Zealand.

Deane, R.S. et al. (1972), "New Data for Economic Research", Research Paper No. 3, Reserve Bank of New Zealand.

Klein, L.R. (1969), "Estimation of Interdependent Systems in Macro-econometrics", *Econometrica*, 37, 171-192.

McCarthy, M.D. (1972), "A Note on the Forecasting Properties of Two Stage Least Squares Restricted Reduced Forms - the Finite Sample Case", *International Economic Review*, 13, 757-761.

Sargan, J.D. (1970), "The Finite Sample Distribution of FIML Estimators", *World Congress of the Econometric Society*, Cambridge, 1970.

Sargan, J.D. (1973), "The Tails of the FIML Estimates of the Reduced Form Coefficients" (to be published).

Summers, R. (1965), "A Capital Intensive Approach to the Small Sample Properties of Various Simultaneous Equation Estimators", *Econometrica*, 33, 1-41.