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Preliminary and incomplete

A Small Estimated Model (SEM) for New Zealand

working paper prepared for the 2002 Australasian Macro Workshop

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Abstract

This paper presents a small estimated model of the New Zealand macroeconomy. The model is empirically based, aggregate in nature and consists of five estimated equations – for the output gap, import prices, unit labour costs, skill shortages and consumer prices. The stylised facts underlying each equation are discussed and estimation results are presented.

The model's primary use is to examine macroeconomic developments over the short- to medium-term. Dynamic responses of SEM to selected shocks and some preliminary in-sample forecasts are illustrated.

[1] The views expressed here are those of the authors and do not necessarily reflect official positions of the Reserve Bank of New Zealand. The authors would like to thank Leni Hunter, Christopher Plantier, and Weshah Razzak for their comments on earlier work. Errors and omissions are the responsibility of the authors.

1. Introduction

The small estimated model (SEM) presented in this paper is a combination of five fully estimated equations – for the output gap, import prices, unit labour costs, skill shortages and consumer prices. Our modelling approach draws heavily on the Reserve Bank of Australia (RBA) modelling approach detailed in Beechey et al (2000). Unlike the RBA macro model, SEM does not have a well defined steady state with appropriate theoretical properties that would also make it useful for policy analysis. However, the main purpose of SEM is to forecast macroeconomic developments over the short to medium term horizon.

While SEM is fully estimated, we also wanted to arrive at coefficients that were consistent with economic theory. This played a role in determining what variables to include in the regressions, and the lag structure of each of the equations. The equations were estimated separately, then combined to form a model. However, we also estimated the model as a system using the Seemingly Unrelated Regression (SUR) and Full Information Maximum Likelihood (FIML) techniques. The results suggested that we did not forego any additional information by estimating the model equations separately, and estimating the equations separately allowed us greater flexibility. The chosen sample period for estimation was 1994Q1 to 2001Q3 due to data availability. We did test the stability of the estimated coefficients over different sample periods, and the coefficients – at worst – maintained the correct signs

Section 2 presents the estimation results and a discussion of the model equations. In Section 3 we illustrate the dynamic properties of the SEM model through a variety of 'deterministic' shock simulations. Section 4 then presents some preliminary in-sample forecasts from SEM. Section 5 concludes.

2. Model description

The SEM is a combination of five estimated equations[2] – for the output gap, import prices, unit labour costs, skill shortages and consumer prices. From the outset, this model was built for the purposes of it being used for short to medium term forecasting, with a forecast horizon of up around 8 quarters. In this section we detail each of these equations and their underlying theory. As already noted, the equations have been estimated separately, and then combined to form the model. The results from systems estimation using SUR and FIML were not too different from individually estimating each equation. Separate estimation afforded us greater flexibility in terms of model specification and estimation techniques, which were important considerations given our limited data sample. A complete description of the variables used and their sources is provided in the Appendix.

2.1 Inflation

The error-correction equation used to forecast quarterly consumer price inflation (*d1pd*) is based on the mark-up framework used in the RBA model and the one presented in Hampton (2001a), and forms the core of the SEM. The long-run level of consumer prices (*pd*) is driven by a cointegrating relationship that incorporates the level of unit labour costs (*ulc*) and import prices (*pm*).[3] Static homogeneity is accepted and imposed – meaning that a 10 percent increase in import prices and unit labour costs will lead to a 10 percent increase in consumer

[2] All econometric estimation and simulation work was carried out in *Eviews 4*.

[3] Import prices feeding into consumer prices are NZD import prices as measured by Statistics NZ plus tariffs and adjusted for the fact that productivity growth in the traded sector is higher than it is in the non-traded sector. See Hampton (2001a) for details of this adjustment.

prices in the long-run. The short-run dynamics are explained by a three quarter lag of the output gap (*GAP*) and a contemporaneous quarterly change in import prices (*d1pm*).

$$d1pd_t = \alpha + \gamma_1 pd_{t-1} + \gamma_2 ulc_{t-1} + (-\gamma_1 - \gamma_2) pm_{t-1} + \delta GAP_{t-3} + \beta d1pm_t + \varepsilon_t \qquad (1)$$

Dependent Variable: D1PD

Parameter	Coefficient	Std. Error	t-Statistic	Prob.
α	-0.02	0.01	-2.46	0.02
γ_1	-0.21	0.08	-2.58	0.02
γ_2	0.18	0.08	2.36	0.03
δ	0.12	0.03	3.65	0.00
β	0.07	0.015	4.46	0.00

R-squared	0.614637	Mean dependent var	0.005100
Adjusted R-squared	0.555350	S.D. dependent var	0.003146
S.E. of regression	0.002098	Akaike info criterion	-9.349304
Sum squared resid	0.000114	Schwarz criterion	-9.118015
Log likelihood	149.9142	Durbin-Watson stat	2.235459

Combining the short and long-run coefficients of the equation suggests that a 10 percent increase in import prices would lead to (approximately) a 0.9 percent increase in consumer prices in the first quarter, and 1.5 percent in the long-run (1 - $\gamma_2/-\gamma_1$). Similarly, a 10 percent increase in unit labour costs will lead to a 1.8 percent increase in consumer prices in one quarter, and to an 8.5 percent increase in the long-run ($\gamma_2/-\gamma_1$). Note that unit labour costs can be thought of as incorporating inflation expectations to some extent.[4] The forecasts of quarterly consumer price inflation are combined with the historical level of consumer prices to produce forecasts of consumer prices and annual consumer price inflation.

An important characteristic of the mark-up specification is that shocks to consumer prices must be reversed in so far as they do not impact on the long-run level of consumer prices as determined by the level of import prices and unit labour costs. As a result, although monetary policy can impact consumer price inflation via the output gap in the short-run, this impact will be reversed over the medium-term unless there is something that causes the long-run level of unit labour costs to change. In this model the required shift in unit labour costs can come via a movement in the output gap and via feedback from consumer prices into unit labour costs – see equation (4).

For equation (1) to be operational as a forecasting device we require projections for import prices, the output gap and unit labour costs. We now present the equations for each of these series.

[4] See Hampton (2001a) for further details.

2.2 Import prices

Quarterly import price inflation (*d1pm*) is estimated as a function of quarterly changes in the nominal Trade-Weighted Index – TWI (*d1ntwi*), and semi-annual growth in GDP14 (*d2wgdp*). GDP14 is a series constructed from New Zealand's 14 largest export-weighted trading partners.

$$d1pm_t = \alpha + \sum_{i=0}^{4} \beta_i d1ntwi_{t-i} + \sum_{0,2} \gamma_i d2wgdp_{t-i} + \varepsilon_t \quad (2)$$

Dependent Variable: D1PM

Parameter	Coefficient	Std. Error	t-Statistic	Prob.
α	-0.038227	0.016012	-2.387394	0.0248
γ_0	1.187715	0.608180	1.952901	0.0621
γ_2	1.166199	0.712575	1.636599	0.1142
β_0	-0.55565	0.12369	-4.49224	
β_1	-0.19931	0.06862	-2.90444	
β_2	-0.02596	0.08592	-0.30220	
β_3	-0.03563	0.08523	-0.41801	
β_4	-0.22829	0.13343	-1.71095	
Sum of β_i Lags	-1.04484	0.25298	-4.13012	

R-squared	0.603998	Mean dependent var	0.005772
Adjusted R-squared	0.524797	S.D. dependent var	0.027447
S.E. of regression	0.018920	Akaike info criterion	-4.925170
Sum squared resid	0.008950	Schwarz criterion	-4.647624
Log likelihood	82.34014	F-statistic	7.626183
Durbin-Watson stat	2.961330	Prob(F-statistic)	0.000181

The coefficients on the nominal TWI changes sum to around one, and are jointly significant – suggesting that stage one pass-through is complete after 5 quarters. The nominal TWI coefficients were estimated using an Almon lag structure with a quadratic profile on the coefficients. This approach helps impose the prior of a smooth response over all of the lags and improves the estimation efficiency.

The coefficients on the two semi-annual GDP14 growth variables sum to just over 2, and impact on import prices with a lag of 0 to 4 quarters. Using semi-annual growth rates rather than quarterly growth rates helped stabilise the coefficients.[5] The quarterly forecasts of the import price series are combined with the historical import price level data to produce a series of future import price values.

For forecasting purposes, GDP14 forecasts are taken from *Consensus* forecasts. The TWI exchange rate is exogenous to the model so any plausible profile can be used. Typical alternatives include assuming a constant TWI over the forecast, or having the TWI converge to some assumed long run equilibrium.

2.3 Output gap

Given the high degree of volatility in quarterly GDP growth in New Zealand, we model the output gap directly rather than estimate GDP growth, and then calculate a gap. Here the output gap is defined as actual real GDP less potential real GDP, where potential is an HP filtered series of the actual data starting from 1985Q1, with λ = 1,600. The equation for estimating the output gap is essentially an IS curve relationship, with the output gap (*GAP*) modelled as a function of real 90 day interest rates (*REALIR*), the real TWI gap (*RTWIGAP*),

[5] Note that we only include the contemporaneous and the second quarter lag growth rates to avoid double counting.

the real house price gap (*HPGAP*, reflecting the wealth effect), and the world output gap (*WGAP*).

Real interest rates are calculated as the nominal 90 day interest rate less actual annual CPI inflation. The real TWI is the nominal TWI adjusted for the difference in the New Zealand consumer prices and equally-weighted consumer prices in the US and Australia. Real house prices are nominal house prices deflated by the CPI. The gap variables for the real house price, the real TWI, and the GDP-14 series are the actual series less an HP filtered series of the actual data starting from 1985Q1, with λ = 1,600.[6] The coefficients on the real interest rate, the real TWI gap, and the real house price gap are all estimated using Almon lags with a quadratic profile imposed.

$$GAP_t = \alpha + \sum_{i=5}^{8} \beta_i REALIR_{t-i} + \sum_{i=4}^{7} \gamma_i RTWIGAP_{t-i} + \sum_{i=1}^{3} \delta_i RHPGAP_{t-i} + \phi WGAP_{t+2} + \varepsilon_t \qquad (3)$$

Dependent Variable: GAP

Parameter	Coefficient	Std. Error	t-Statistic	Prob.
α	0.023156	0.008850	2.616588	0.0165
ϕ	0.519953	0.166754	3.118090	0.0054
β_5	-0.02521	0.11366	-0.22179	
β_6	-0.04083	0.10684	-0.38216	
β_7	-0.09806	0.09038	-1.08500	
β_8	-0.19690	0.15006	-1.31218	
Sum of β_i Lags	-0.36100	0.16900	-2.13611	
γ_4	-0.00926	0.05857	-0.15805	
γ_5	-0.07077	0.03930	-1.80088	
γ_6	-0.09529	0.03616	-2.63570	
γ_7	-0.08284	0.05216	-1.58828	
Sum of γ_i Lags	-0.25816	0.04797	-5.38144	
δ_1	0.10446	0.13024	0.80209	
δ_2	0.07338	0.14750	0.49749	
δ_3	0.15067	0.10437	1.44358	
Sum of δ_i Lags	0.32851	0.08795	3.73509	

R-squared	0.900236	Mean dependent var	0.004648
Adjusted R-squared	0.850353	S.D. dependent var	0.013390
S.E. of regression	0.005180	Akaike info criterion	-7.416655
Sum squared resid	0.000537	Schwarz criterion	-6.907821
Log likelihood	125.9582	F-statistic	18.04723
Durbin-Watson stat	2.528002	Prob(F-statistic)	0.000000

The real interest rate impacts with a lag of 5 to 8 quarters, with a total coefficient of –0.36 (jointly significant). This lag length is long relative to our priors, and even more so given that a majority of the impact is on the 8th lag. However, when the equation is estimated with shorter lags, the coefficients become positive and/or insignificant. A possible explanation for this result is monetary policy endogeneity. As the Reserve Bank has used the output gap as its main indicator of future inflation, a positive output gap is likely to result in rising interest rates over the short term.[7] Another point is that the implied monetary policy transmission lag

[6] Before running the HP filter through the real house price series, the future values for this series for the first 3 years after the end of history were set equal to the average for the previous three years. For the real TWI, the future values were set to equal the average of the real TWI over the entire sample period (1985 to 2001). For GDP-14, the future values are calculated from *Consensus* forecasts. This approach mitigates the end point problem associated with using filters such as the HP filter.

[7] The fact that monetary policy is endogenous makes it difficult to accurately estimate its effect using traditional econometric methods. We attempted to allow for policy endogeneity by estimating the model in a system using

from interest rates to inflation is around 8 to 11 quarters (at least 5 quarters from interest rates to the output gap, then a 3 quarter lag between the output gap and inflation).

The real TWI gap impacts with a lag of 4 to 7 quarters, with a total coefficient of –0.26 (jointly significant) with the weights fairly evenly spread across all of the lags. The real house price gap impacts with a lag of 1 to 3 quarters, with a total coefficient of 0.33 (jointly significant). The short lag on this may reflect a wealth effect in that rising house prices are often good for consumer confidence, and hence boosts consumption quite quickly.

Finally, the world GDP gap enters with a lead of two quarters and a coefficient of 0.55. At first it may seem counter-intuitive that New Zealand GDP leads world GDP.[8] However, what this most likely reflects is that New Zealand firms exposed to the external sector are likely to look to *expected* world demand before deciding whether or not to further investment. Further, global commodity prices often move in anticipation of a change in world demand, and can therefore lead the world output gap cycle. The world output gap term can also be considered as a proxy for confidence – both business and consumer. The sample period used for this estimation includes two significant global shocks – the Asian crisis during 1997 and 1998, and the global slowdown during 2001.

For forecasting, all right hand side variables are essentially exogenous to the model. We can enter plausible assumptions for the real TWI, and real house prices. Forecasts for the world output gap are derived from *Consensus* forecasts. Finally, nominal interest rates can be entered exogenously – for example, held constant – or determined by a simple reaction function like a Taylor rule. Real interest rates are then estimated by subtracting the endogenous consumer price inflation series from the nominal interest rates series. However, given the intended short to medium term forecast horizon for SEM (of up to, say, 8 quarters), the profile for interest rates, however it is determined, will not materially affect the overall model forecasts.

FIML that included a Taylor rule as a policy reaction function. However, the coefficients on interest rates at short lags still remained positive and/or insignificant.

[8] Ideally, we would like to use expectations of the future world output gap in equation specification. This is something we will try at a later date.

2.4 Unit labour costs

Unlike the previous quarterly equations, unit labour costs are estimated using an annual growth model. The cornerstone of this equation is the 7 quarter leading relationship from QSBO skill shortages (*SKILLED*) to annual wage growth (*d4ulc*).[9] We have also included a lag of the dependent variable to account for autocorrelation in the residuals. Finally, lagged annual consumer price inflation (*d4pd*) is included to allow feedback from consumer prices into wages.

$$d4ulc_t = \alpha + \beta SKILLED_{t-7} + \gamma d4pd_{t-3} + \delta d4ulc_{t-1} + \varepsilon_t \qquad (4)$$

Dependent Variable: D4ULC

Parameter	Coefficient	Std. Error	t-Statistic	Prob.
α	0.003838	0.001335	2.874766	0.0078
β	-4.63E-05	1.61E-05	-2.870138	0.0079
γ	0.117765	0.031700	3.715018	0.0009
δ	0.575695	0.087341	6.591331	0.0000
R-squared	0.937009	Mean dependent var		0.016272
Adjusted R-squared	0.930010	S.D. dependent var		0.003065
S.E. of regression	0.000811	Akaike info criterion		-11.27733
Sum squared resid	1.77E-05	Schwarz criterion		-11.09230
Log likelihood	178.7986	F-statistic		133.8770
Durbin-Watson stat	1.370475	Prob(F-statistic)		0.000000

The inclusion of consumer price inflation as an explanatory variable could be seen as a proxy for inflation expectations. If price inflation were not included here then there would be no allowance for price inflation persistence from an exogenous price level spike – see the discussion in section 2.1. However, given that the coefficient is substantially less than 1, there will not be much persistence in the model's dynamics from a shock to CPI inflation. The drawback from this result is that, essentially, monetary policy is redundant. Shocks to the system will not have long lasting effects that require a policy response to re-anchor the model. See section 3 for more on this.

2.5 Skill shortages

Although skill shortages feed into unit labour costs with a lead of 7 quarters, it is not essential to have forecasts of skill shortages in order to forecast unit labour costs. Any forecast for skill shortages will not have a large impact on the overall SEM forecasts at the intended forecast horizon of around 8 quarters. For completeness, we estimate an equation for skill shortages (*SKILLED*) modelled as a function of the output gap (*GAP*). In practice, though, there is no reason why we cant enter an exogenous assumption for forecasted skill shortages, particularly given the poor fit of the estimated equation.

$$SKILLED_t = \alpha + \beta GAP_t + \varepsilon_t \qquad (5)$$

Dependent Variable: SKILLED

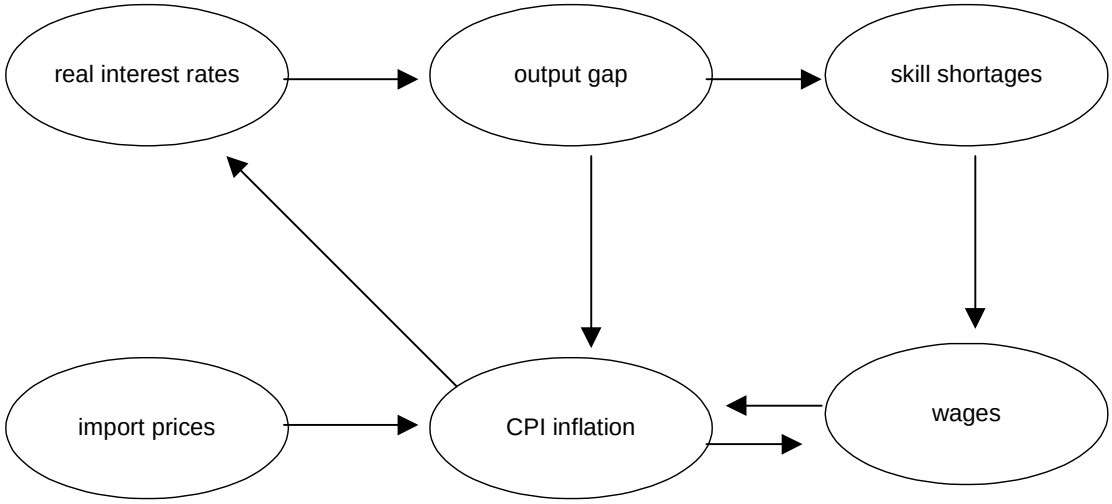
Parameter	Coefficient	Std. Error	t-Statistic	Prob.
α	-24.84517	2.764361	-8.987671	0.0000
β	-748.3578	197.8997	-3.781500	0.0007
R-squared	0.330250	Mean dependent var		-28.32381
Adjusted R-squared	0.307155	S.D. dependent var		17.43702
S.E. of regression	14.51411	Akaike info criterion		8.250460
Sum squared resid	6109.120	Schwarz criterion		8.342975
Log likelihood	-125.8821	F-statistic		14.29974
Durbin-Watson stat	0.241461	Prob(F-statistic)		0.000722

[9] This relationship is formalised in Hampton (2001b), but the Bank's forecasting team and external forecasters had been using it for a number of years prior to that.

It is through this avenue that monetary policy can have permanent impacts on consumer price inflation. However, the transmission lag is very long such that it would not have any permanent effect within the intended forecast horizon. In more detail:

- interest rates affect the output gap (lag of 5 to 8 quarters)
- the output gap impact temporarily on inflation (lag of 3 quarters – temporary impact from monetary policy occurs after 8 to 11 quarters)
- the output gap also impacts on skill shortages (contemporaneously)
- skill shortages affect unit labour costs (lag of 7 quarters)
- unit labour costs affect consumer prices permanently (lag of 1 quarter – permanent impact from monetary policy occurs after 13 to 16 quarters).

A stylised representation of the SEM model relationships is shown below.



3. Dynamic properties of SEM

In this section we look at the dynamic behaviour of three key series - annual wage inflation (*d4ulc*), annual price inflation (*d4pd*), and the domestic output gap (*gap*) - following different shocks to SEM. The purpose of these simulations is to highlight the main transmission channels of SEM so that we can better understand the cost-push mark-up framework that underpins the model's structure.

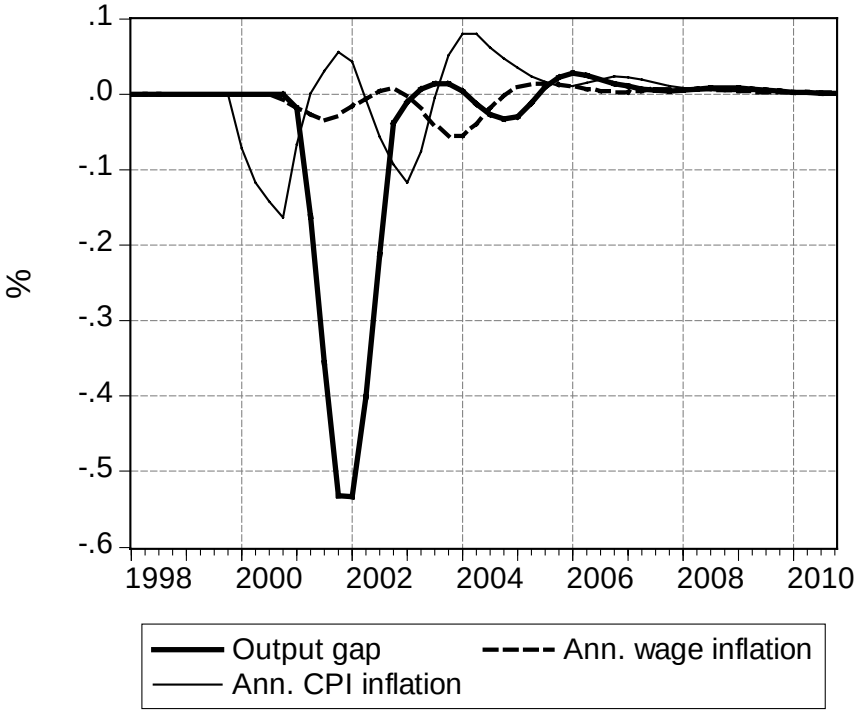
In the following simulations, nominal interest rates have been held constant with real interest rates determined endogenously.[10] Because there are not inherent dynamics that make model paths explosive, monetary policy reaction is not needed to re-anchor the model following a shock. During the model design stage, we could have imposed or calibrated the relevant coefficients to make the model properties more theoretically appealing. However, given that the main purpose of SEM is for forecasting over the short to medium term, we preferred to 'let the data speak.'. All shocks occur at 2000Q1

3.1 Exchange rate shock

Figure 1 (shown in 'shock minus control' format) plots the profile of the domestic output gap, annual wage inflation and annual price inflation produced by SEM following a shock of +2 per cent to the real exchange rate gap (appreciation) lasting for 1 year.

This shock results in 2 cycles in CPI inflation. The first cycle is caused by the direct passthrough from exchange rate movements to import prices and CPI inflation - with annual CPI inflation falling by nearly 0.2 percent. The second cycle is caused by the negative output gap resulting from the 2 percent real exchange rate appreciation. The fluctuations of CPI inflation around its control solution is an illustration of the error correction mechanism in the inflation equation. Because there are no permanent effects on the level of import prices or level of wages, any change in the level of consumer prices are reversed out over a period of time.

Figure 1: SEM dynamics from an exchange rate shock



The CPI inflation dynamics are mirrored (albeit with less amplitude) by annual wage inflation with a lag of 3 quarters. Finally, the 2 percent real exchange rate appreciation has a significant impact on real activity, with the output gap falling as low as –0.5 percent after 6 quarters.

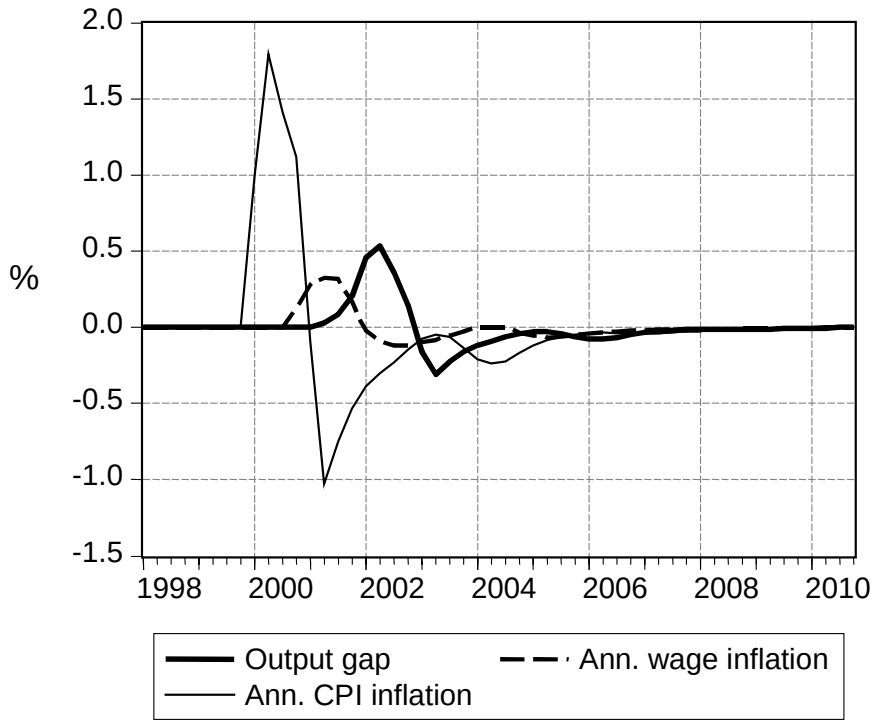
[10] It is possible to include a monetary policy reaction function, such as a Taylor rule. The effect of this would be to speed up the model's convergence back to 'equilibrium' following a shock

3.2 Consumer price shock

Figure 2 plots the profile of the domestic output gap, annual wage inflation and annual price inflation produced by SEM following 2 quarters of +1 percent consumer price inflation per quarter.[11] This shock gives the best demonstration of the impact of the error-correction-mechanism in the inflation equation.

Annual inflation starts declining sharply immediately (and becomes negative) after the initial shock as it tries to achieve equilibrium with unit labour costs and import prices. Consumer prices do not fully unwind increase because there is some pass-through from CPI inflation into wage inflation, and hence a slightly higher level of unit labour costs results. However, the passthrough from CPI to labour costs is small. The impact on the output gap is small and protracted as the change in real interest rates is not very strong. With a constant nominal interest rate, the initial rise in inflation means that real interest rates fall and the output gap becomes positive. Again, the CPI inflation dynamics are mirrored by wage inflation, but with a smaller amplitude.

Figure 2 – SEM dynamics from a CPI inflation shock



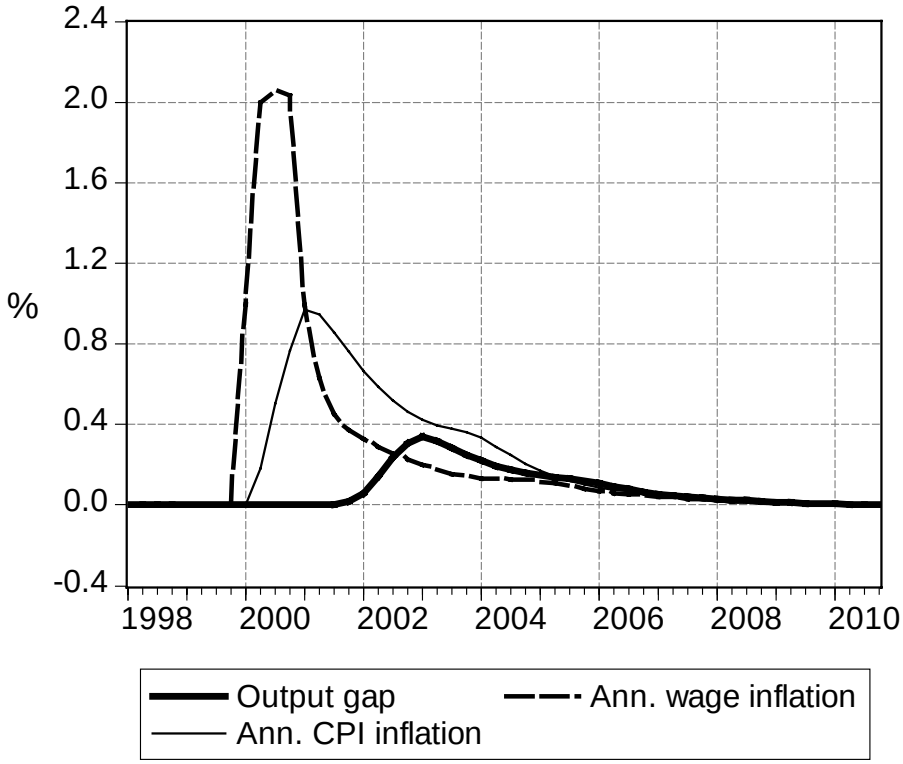
[11] That is, 1 per cent above the equilibrium inflation rate.

3.3 Wage inflation shock

Figure 3 plots the profile of the domestic output gap, annual wage inflation and annual price inflation produced by SEM following 2 quarters of +1 per cent wage inflation per quarter.

After the initial spike, wage inflation returns gradually to its control value. The passthrough from wages into CPI inflation is around half the size of the initial shock. So while there is relatively little passthrough from consumer prices to wages, there is quite strong passthrough from wages to consumer prices.[12] The CPI inflation dynamics are more protracted because the rise in inflation causes real interest rate to fall and the output gap to become positive, which adds to the inflationary pressures. Unlike previous simulations, CPI inflation does not unwind itself the level of unit labour costs are permanently higher. Eventually, consumer prices will end up increasing by 85 percent of the increase in wages.

Figure 3: SEM dynamics from a wage inflation shock



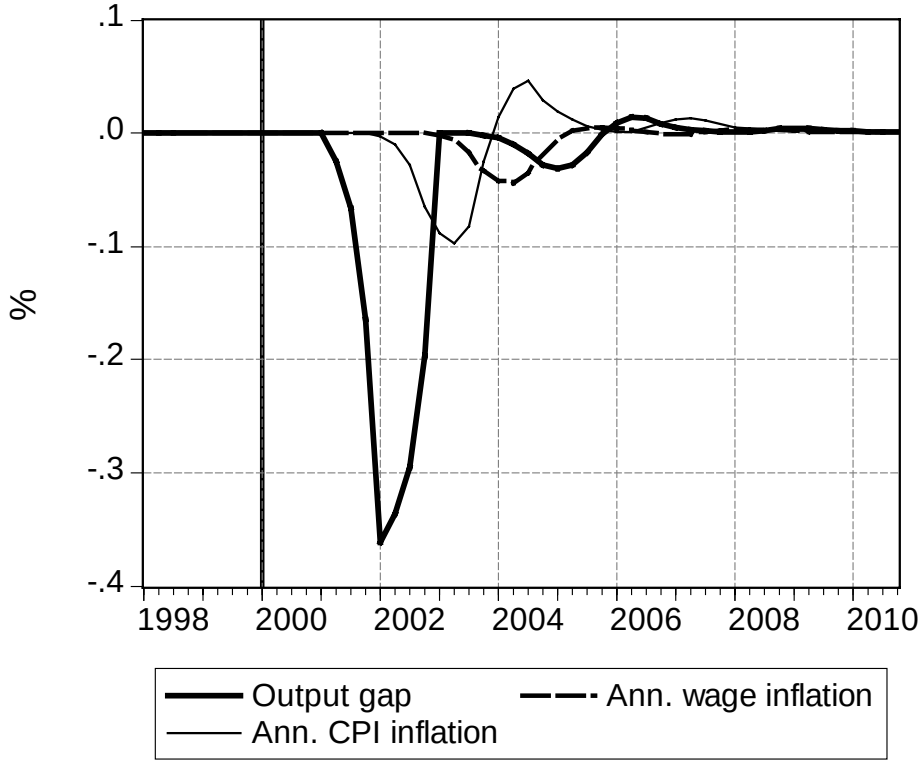
[12] In other words, in this model, CPI inflation is not a determinant of wage inflation, but wage inflation is a determinant of CPI inflation.

3.4 Nominal interest rate shock

Figure 4 plots the profile of the domestic output gap, annual wage inflation and annual price inflation produced by SEM following a 4 quarter period where nominal interest rates were held 100 basis points above equilibrium.

The first impact is via to the output gap, which troughs at around –0.35 percent about 8 quarters after the start of the shock. There is a resulting fall in annual consumer price inflation of around –0.10 percent after around 12 quarters, with a smaller wage deflation cycle following. This shock highlights the long (and relatively muted) monetary policy transmission from interest rates to inflation.

Figure 4: SEM dynamics from a nominal interest rate shock

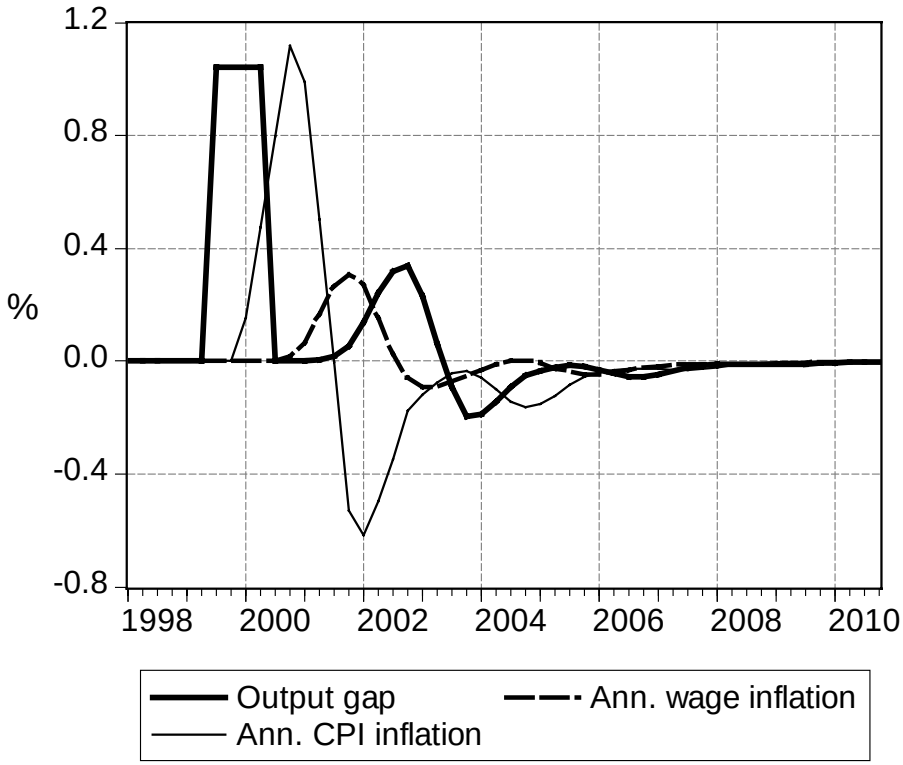


3.5 World output gap shock

Figure 5 plots the profile of the domestic output gap, annual wage inflation and annual price inflation produced by SEM following a 4 quarter period of a +2 per cent world output gap (and world growth).

The shock to the world output gap affects SEM via two avenues. Firstly, the higher world demand leads to higher import prices, which are passed quickly into consumer price inflation. The second is via the output gap into domestic inflation. As noted above, the domestic output gap actually anticipates the world output gap movement. Another interpretation is that *expectations* of the world economic cycle have a quick passthrough to the domestic activity. The passthrough from world activity to domestic activity and inflation is quite large.

Figure 5: SEM dynamics from a world output gap shock



4. Forecasting with SEM

In this section we take a preliminary look at the forecasting ability of SEM. The analysis here is not overly rigorous in that we do not formally evaluate and compare the SEM forecasts with alternative forecasts such as those from simple autoregressive models. Instead, we produce two in-sample forecasts – one for the last 8 quarters, and another for the 4 quarters – to see if macroeconomic picture from SEM is broadly consistent with what actually happened.[13]

For this exercise, we use actual values for the model's exogenous variables (world growth, house prices, nominal TWI, nominal interest rates). The results for annual CPI inflation, annual wage inflation, quarterly import price inflation, and the output gap are shown in figures 6a to 6d. Overall, these forecasts seem broadly consistent with what actually happened – the trends and turning points correspond with the actual data. Not surprisingly there is little difference between the 8 quarter ahead and 4 quarter ahead forecasts for import prices and the output gap, as the right hand side variables in these two equations are exogenous variables. Given that we have used actual data for the exogenous variables, it is comforting to see that these forecasts do correspond with actual outturns. More formal testing will follow at a later stage.

Figure 6a: Annual CPI inflation

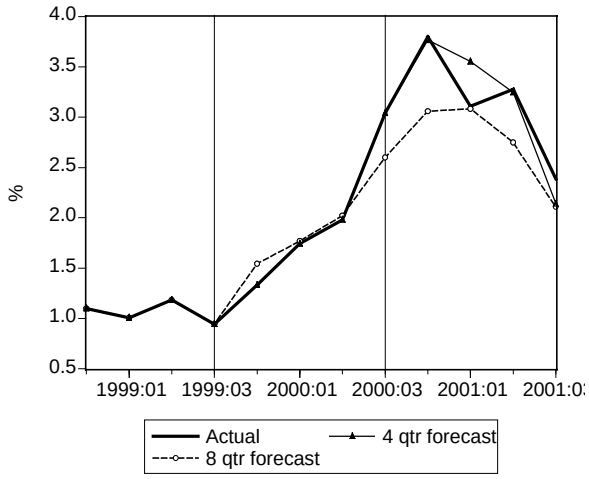


Figure 6b: Annual wage inflation

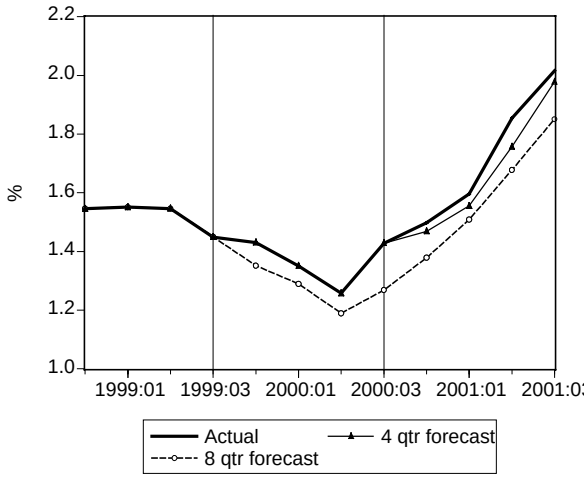


Figure 6c: Quarterly import price inflation

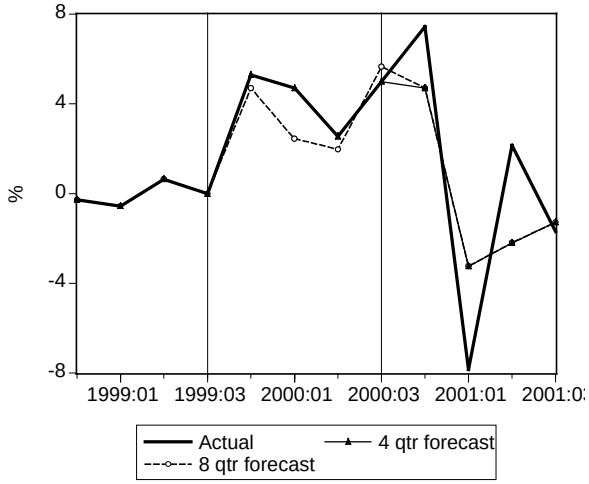
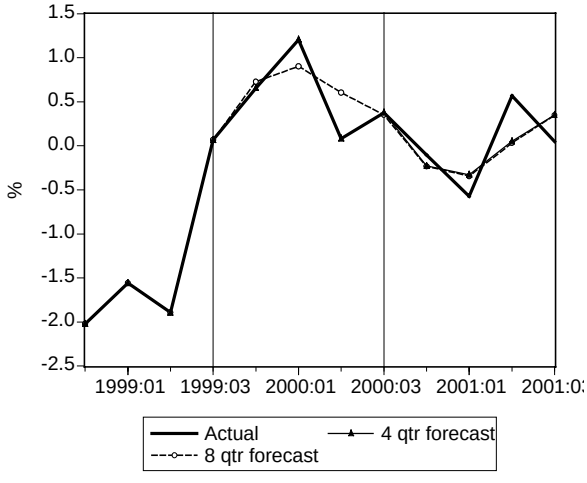


Figure 6d: Output gap



[13] We do intend to formally evaluate the forecasting capability of SEM at a later stage, including out-of-sample forecasting.

5. Concluding comments

The SEM model consists of five estimated equations for the output gap, labour costs, import prices, skill shortages, and CPI inflation. The main purpose of SEM is to examine macroeconomic developments over the short to medium term. For that reason, the equations are entirely estimated over the period from 1994Q1 to 2001Q3. The core of the model is the CPI inflation equation, which is based on a mark-up framework. The resulting inflation dynamics are predominantly 'cost-push' driven with the output gap playing a relatively minor role. There are a couple of unappealing features – such as the long transmission lag between interest rates and the output, and the lack of persistence in inflation dynamics which effectively makes monetary policy redundant in the model. However, recognising these limitations, SEM has the potential to be a useful addition to the Reserve Bank of New Zealand's forecasting framework.

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Appendix

Variable	Series name	Description	Source
pd	Consumer prices	Log of CPI ex-interest (1985Q1 to 1999Q2), log of CPI (1992Q3 to 2001Q4)	Statistics New Zealand
d1pd	Quarterly consumer price inflation	Quarterly change in *pd*	Generated
d4pd	Annual consumer price inflation	Annual change in *pd*	Generated
pm	Import prices	Log of import price index – total merchandise imports	Overseas Trade Indices
d1pm	Quarterly import price inflation	Quarterly change in *pm*	Generated
ulc	Unit labour costs	Log of total salary and wage rates private sector (s.a.)	Labour Cost Index
d4ulc	Annual unit labour cost inflation	Annual change in *ulc*	Generated
d1ntwi	Quarterly change in nominal exchange rate	Quarterly change in log of nominal Trade Weighted Index	RBNZ
realtwigap	Real TWI gap	The real exchange rate is the log of (nominal TWI* domestic CPI/ ((Australian CPI)$^{0.5}$ * (US CPI)$^{0.5}$)). The real TWI gap is the difference between the real exchange rate and its equilibrium value, where the equilibrium real exchange rate is a Hoderick-Prescott filtered series of the real exchange rate series with λ = 1600. Before filtering, we make an endpoint adjustment to 'stiffen' the filtering process. This is achieved by splicing the average of the real TWI (from 1985 – 2001) onto the end of the historical series.	RBNZ
gap	Domestic output gap	The gap is the difference between the log of real GDP (s.a.) and potential real GDP, where potential GDP is a Hoderick-Prescott filtered series of the logged actual real GDP series with λ = 1600.	Statistics New Zealand National Accounts

Variable	Series name	Description	Source
realir	Real interest rate	The nominal 90 day interest rate minus *ex-post* annual domestic inflation – *d4pd*.	Reserve Bank of New Zealand
rhpgap	Real house price gap	Real house prices are calculated as the log of (house prices divided by the consumer price level). The house price gap is then calculated as the difference between real house prices and trend real house prices, where trend house prices is a Hoderick-Prescott filtered series of the real house price series with $\lambda = 1600$. Before filtering, we make an endpoint adjustment to 'stiffen' the filtering process. This is achieved by splicing the average of the real house price series (from the last 3 years only) 2001) onto the end of the historical series.	Quotable Value New Zealand Quarterly House Price Index
wgap	World output gap	World GDP is the log of GDP14 (export-weighted), which is calculated by the RBNZ based on data gathered by *Consensus*. The world output gap is the difference between actual GDP14 and potential, where potential GDP is a Hoderick-Prescott filtered series of the logged actual real GDP series with $\lambda = 1600$.	*Consensus*
d2wgdp	Semi-annual world GDP growth	Semi-annual change in log of GDP14.	Generated
Skilled	Survey skill shortages	Economy wide limiting factor – labour	Quarterly Survey of Business Opinion – NZIER