RESERVE BANK OF NEW ZEALAND
TE PŪTEA MATUA

ANALYTICAL NOTES

Technical appendix to
Monetary policy and regional unemployment

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Data

Our sample covers the period from 1993Q3 to 2019Q4. We use quarterly regional unemployment rates from the *Household Labour Force* survey. We use regional house price indices from *REINZ* to control for time-variant differences between regions.[1] House prices are also a major driver of economic activity in New Zealand. The New Zealand unemployment rate is also included, which controls for the national level factors that may impact regional unemployment rates.

We use the real trade weighted index (TWI) and World GDP (weighted by trading partner) as proxies for global factors. The real TWI proxies New Zealand's international competitiveness (this also captures sensitivity to exchange rates) and World GDP proxies for global demand.[2] As New Zealand is a small open economy with a large trade sector, world economic activity is a significant driver of the New Zealand economy and is important to control for. All variables, except for the unemployment rate and monetary policy, are in logarithms. Lastly, following Hall and McDermott (2016), a dummy variable covering the period from 2008Q1 to 2009Q1 controls for the GFC.

Methodology

We use a regression approach by estimating an auto-regressive distributed lag (ARDL) for each region. The lag structure includes lags of the dependent and independent variables in order to control for dynamics and autocorrelation of the residuals. The lag structure can differ for each region, allowing for varying dynamics across regions. We use AIC to select lags for all variables.[3]

Using the lag structure found in the ARDL, we then follow Ball et al. (2020) and estimate a seemingly unrelated regression (SUR). In using a SUR each region has its own equation (i.e., the equation in the main text), allowing for heterogeneity.

The SUR allows for correlation between the error terms (i.e., spillover effects between regions).[4] The SUR is computed using feasible generalised least squares (FGLS). This is done in two-steps.

In the first step, each regional regression is estimated separately by OLS. The residuals from each regional OLS regression are used to estimate the matrix

$$\Sigma = \begin{bmatrix} \hat{\sigma}_i^2 & \hat{\sigma}_{ij} \\ \hat{\sigma}_{ji} & \hat{\sigma}_j^2 \end{bmatrix},$$

where $\hat{\sigma}_{ij} = \frac{1}{R}\hat{\epsilon}_i^T\hat{\epsilon}_j$ in a simple two-equation case. The variance-covariance matrix is then: $\Omega = \Sigma\, I_R$, where I_R is an identity matrix (R-dimensional). This is then used to estimate the coefficients in the second step:

$$\hat{\beta} = (X^T\Omega X)^{-1}X^T\Omega y$$

Therefore, the SUR allows for contemporaneous correlation between regions.

The reported coefficients represent the equilibrium relationship between unemployment rates and monetary policy. We calculate these at a regional level, as in page 9 of Ditzen (2018). For example, if we take a simple ARDL(1, 1) model:

$$y_t = c + \alpha y_{t-1} + \beta_1 x_t + \beta_2 x_{t-1} + \epsilon_t,$$

1 These are calculated using the SPAR method. See Armstrong, Dunstan and Irrcher (2017) for more detail.

2 These data are taken from estimates from the Reserve Bank of New Zealand Forecasting team.

3 As a robustness check, I use BIC to select lags. The results are qualitatively similar and available on request.

4 The SUR uses conventional standard errors.

where x_t affects future values of y_t, and the size of the impact is $\alpha(\beta_1 + \beta_2)$. This cumulates over time, such that the total effect is equal to $\frac{(\beta_1+\beta_2)}{1-\alpha}$, also called the long-run effect cumulative effect.

Residual diagnostics

We test the residuals for non-stationarity using the Dickey-Fuller test; if the residuals are non-stationary then the parameter estimates are consistent. We do not include a trend in these tests as it has already been included in the regressions.

The null hypothesis of non-stationarity is rejected for all regions (except for Taranaki at eight lags). We also conduct the Portmanteau test for white noise; this is analogous to testing for autocorrelation. There is evidence the residuals are not autocorrelated if the null is not rejected, which is the case for most regions (except for Auckland, Gisborne/Hawkes Bay and Northland at eight lags).Table 1 shows the p-values for each test. These tests show the residuals are well behaved for most regions.

Table 1: Testing regional residuals

	Auckland	Bay of Plenty	Canterbury	Gisborne/ Hawkes Bay	Manawatu /Wanganui	Northland
Dickey-Fuller (4 lags)	0.0008***	0.0000***	0.0118**	0.0000***	0.0001***	0.0002***
Dickey-Fuller (8 lags)	0.0174**	0.0027***	0.0490**	0.0000***	0.0007***	0.0008***
Portmanteau (4 lags)	0.2314	0.5828	0.7416	0.7311	0.3842	0.5660
Portmanteau (8 lags)	0.0419**	0.9007	0.3080	0.0027***	0.2308	0.0202**
	Otago	**Southland**	**Taranaki**	**Upper South Island**	**Waikato**	**Wellington**
Dickey-Fuller (4 lags)	0.0001***	0.0002***	0.0000***	0.0000***	0.0000***	0.0000***
Dickey-Fuller (8 lags)	0.0003***	0.0177**	0.0373**	0.0000***	0.0000***	0.0066***
Portmanteau (4 lags)	0.9083	0.2933	0.4352	0.0980*	0.7933	0.2337
Portmanteau (8 lags)	0.4378	0.4680	0.1185	0.1568	0.3472	0.1583

Note: p-values of tests are reported.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 1 percent level.

We also plot the residuals as an additional check. The autocorrelation function plots the correlation between the residuals and lags of itself, where the shaded grey area is the significance band. The autocorrelation functions largely confirm the Portmanteau test results, with some regions reporting significant autocorrelation at higher order lags, but these are quite rare (Figure A.1). Another concern is the potential endogeneity of monetary policy; however monetary policy and the residuals (for each region) do not appear to be correlated.

The regional residuals also appear to be stationary, supporting the Dickey-Fuller result (Figure A.2).

To confirm monetary policy is not endogenous, we plot the correlation between the monetary policy variable against leads and lags of the residuals. The correlation between monetary policy and the leads and lags of the regional residuals is no higher than approximately 0.2 in absolute value. As the correlations are low, this suggests the control variables and lags are ‘soaking up’ potential endogeneity (Figure A.3).

Figure A.1: Autocorrelation functions

Figure A.2: Time series plot between monetary policy and regional residuals

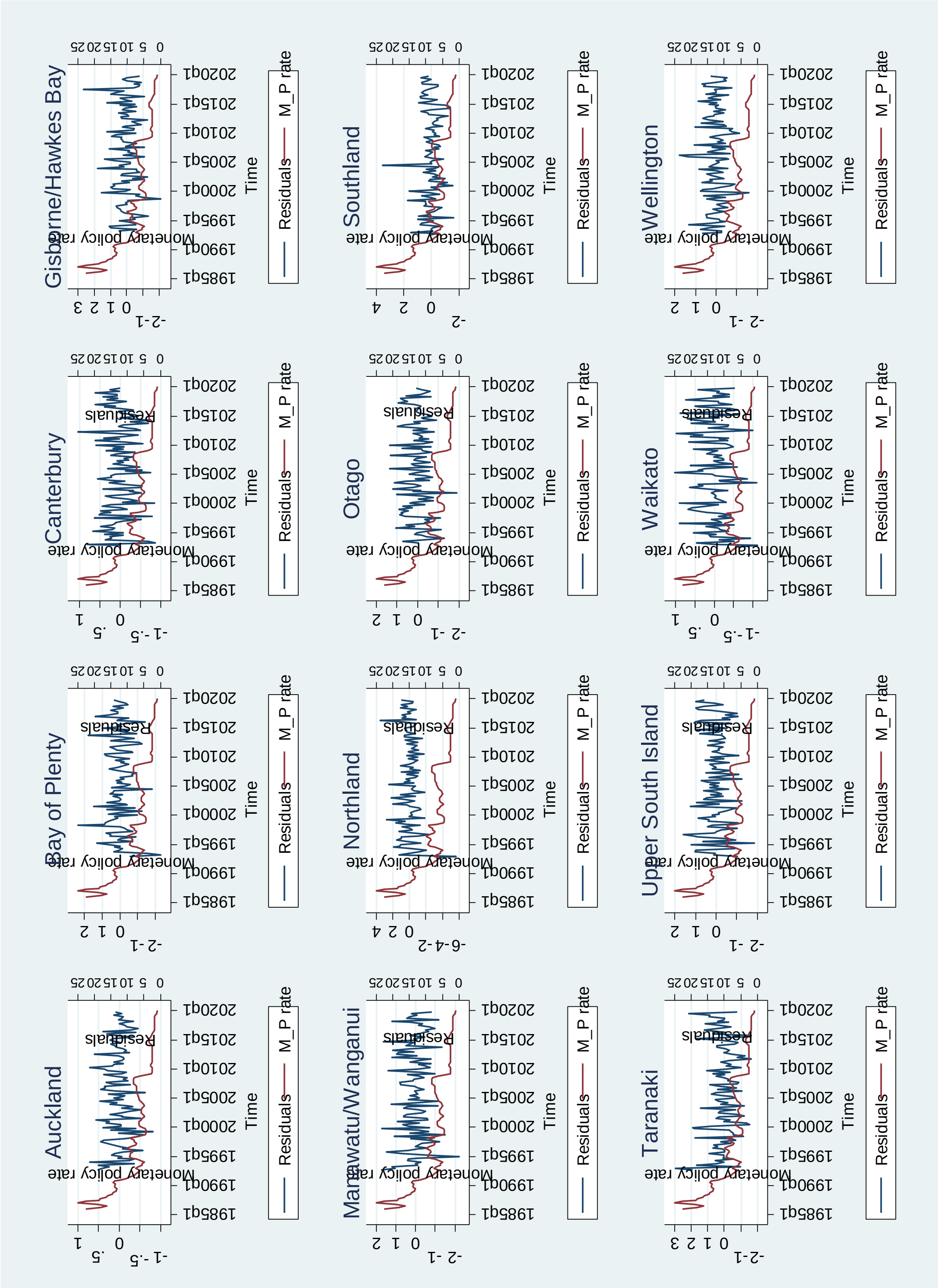
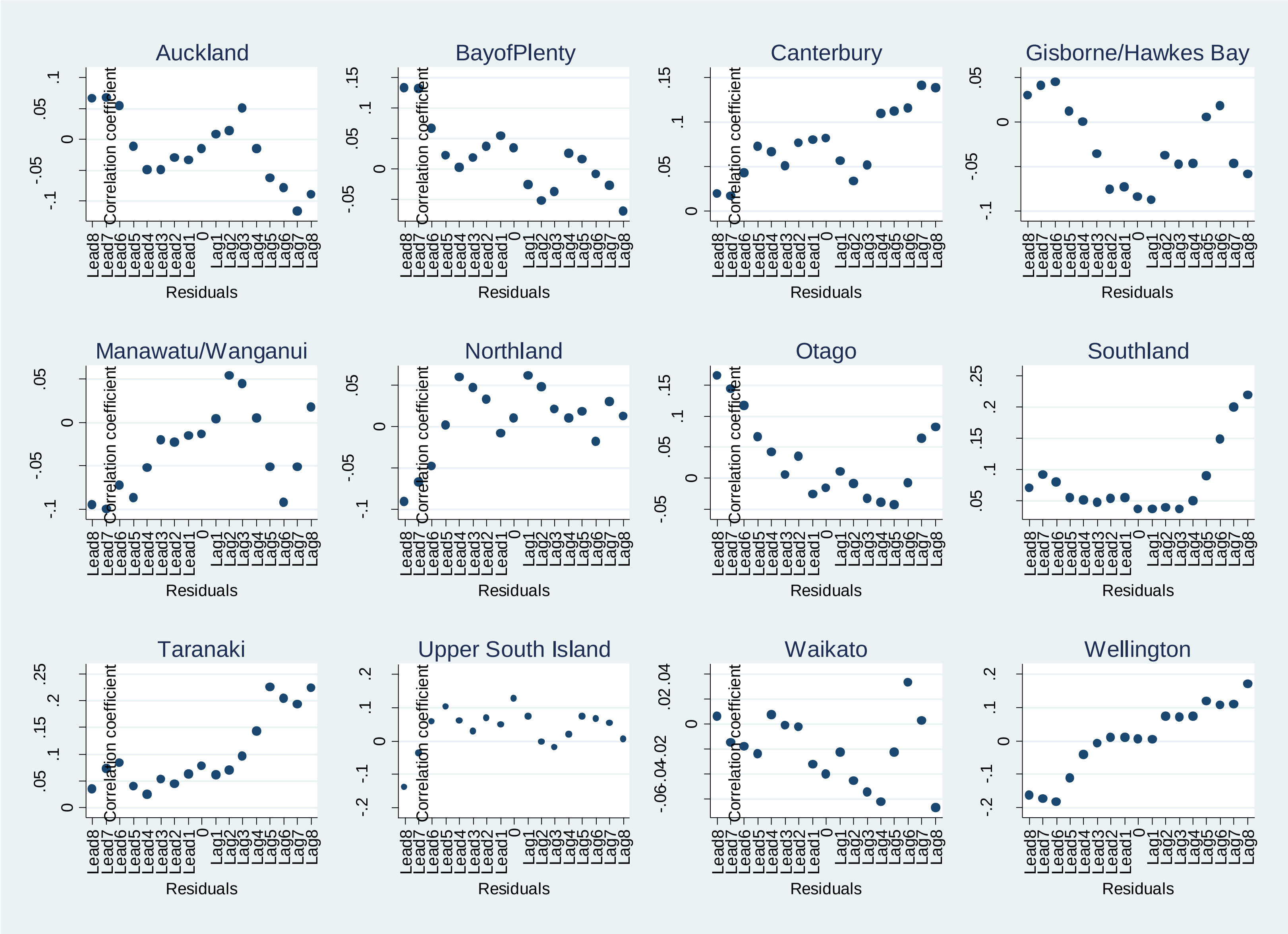


Figure A.3: Correlation between monetary policy and leads/lags of regional residuals



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