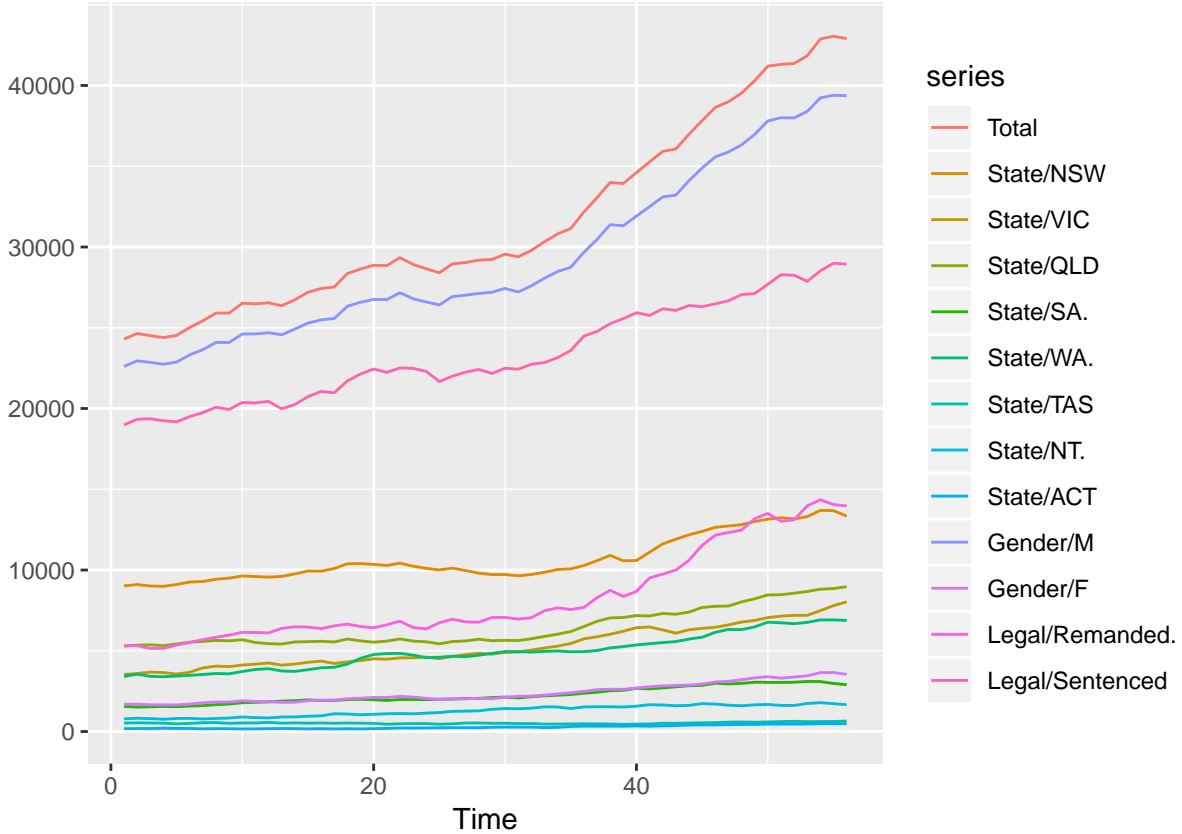# Prison Data Analysis

Prison data disaggregate into 4 grouping variables, namely states(8), gender(2), legal status(2) and indigenous/non-indigenous. We chose only states, gender and legal status as the grouping variables in this analysis. Thus we have $m = 32$ bottom level series and $n = 81$ total number of series in the hierarchy.
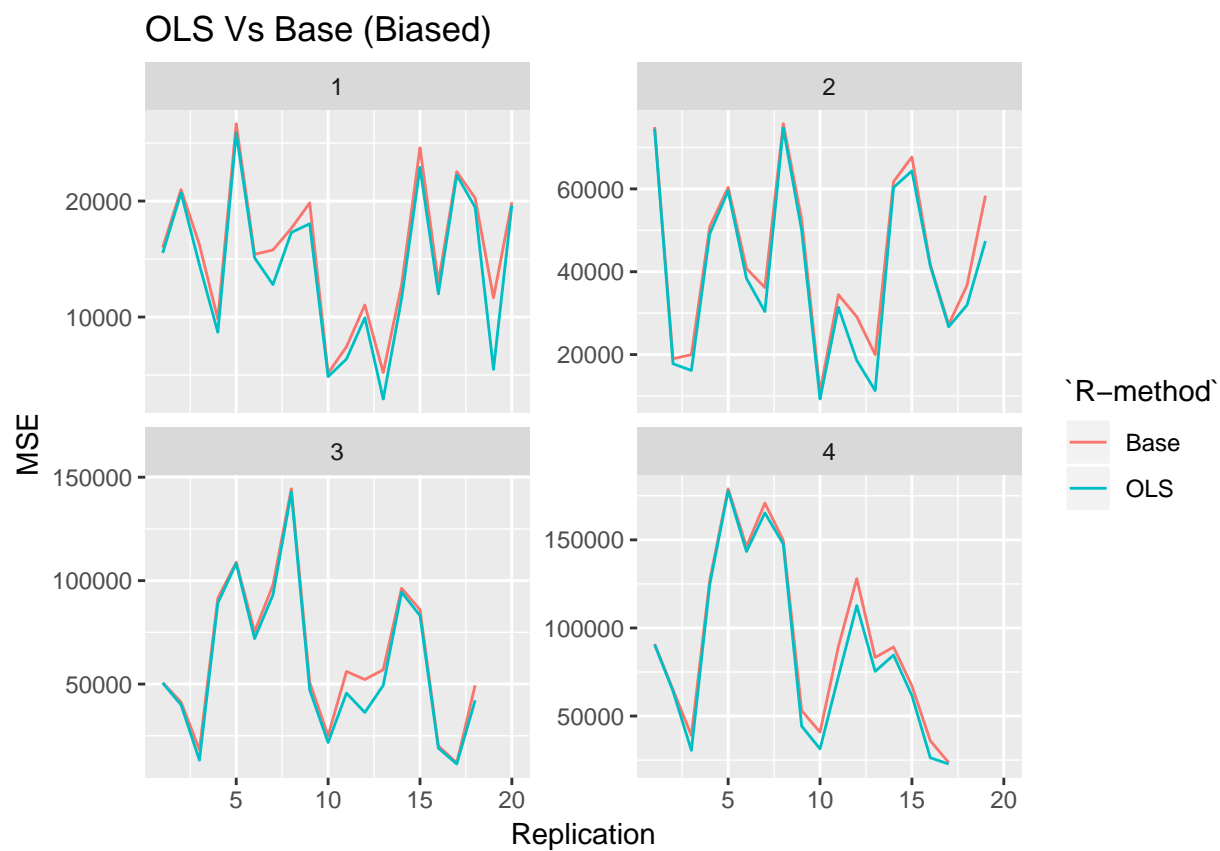

In this experiment we are trying to show that the reconciliation via projection still increase the accuracy for biased incoherent forecasts after adjusting for bias.
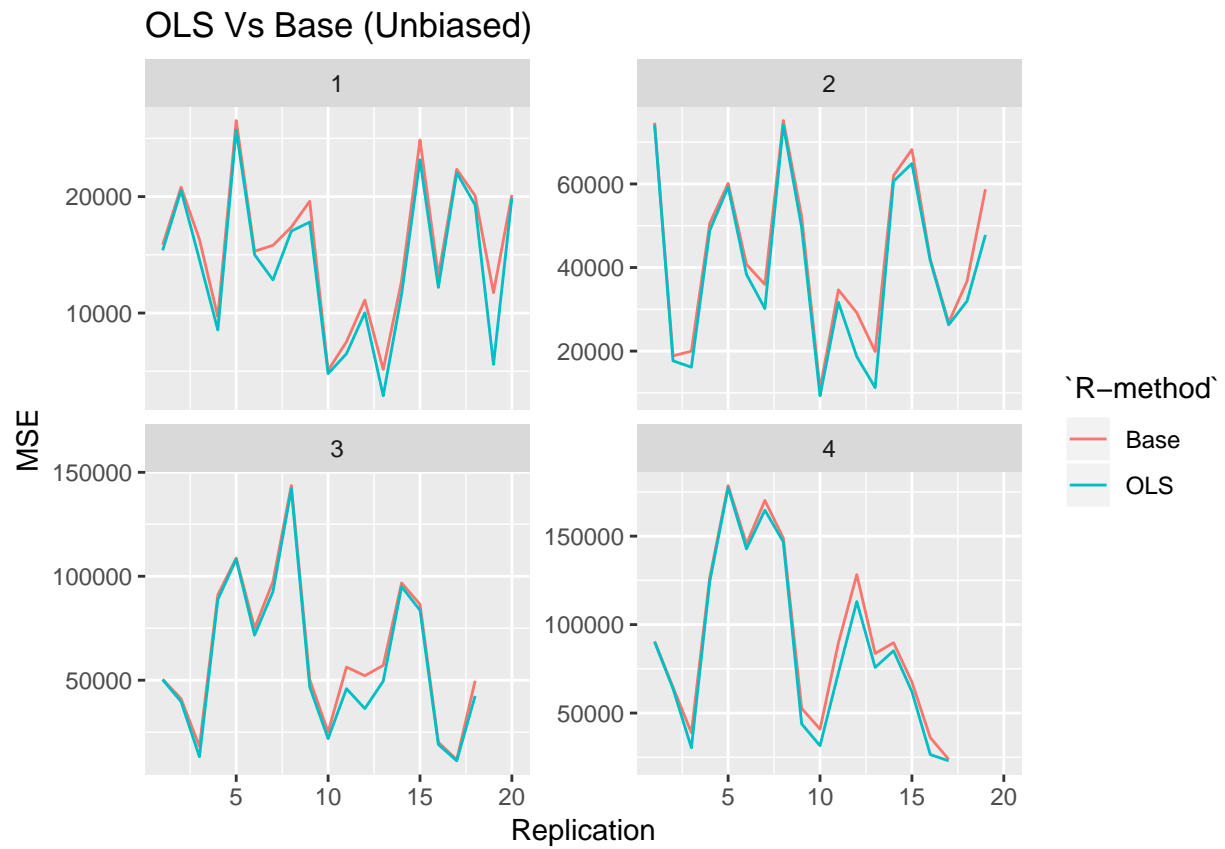
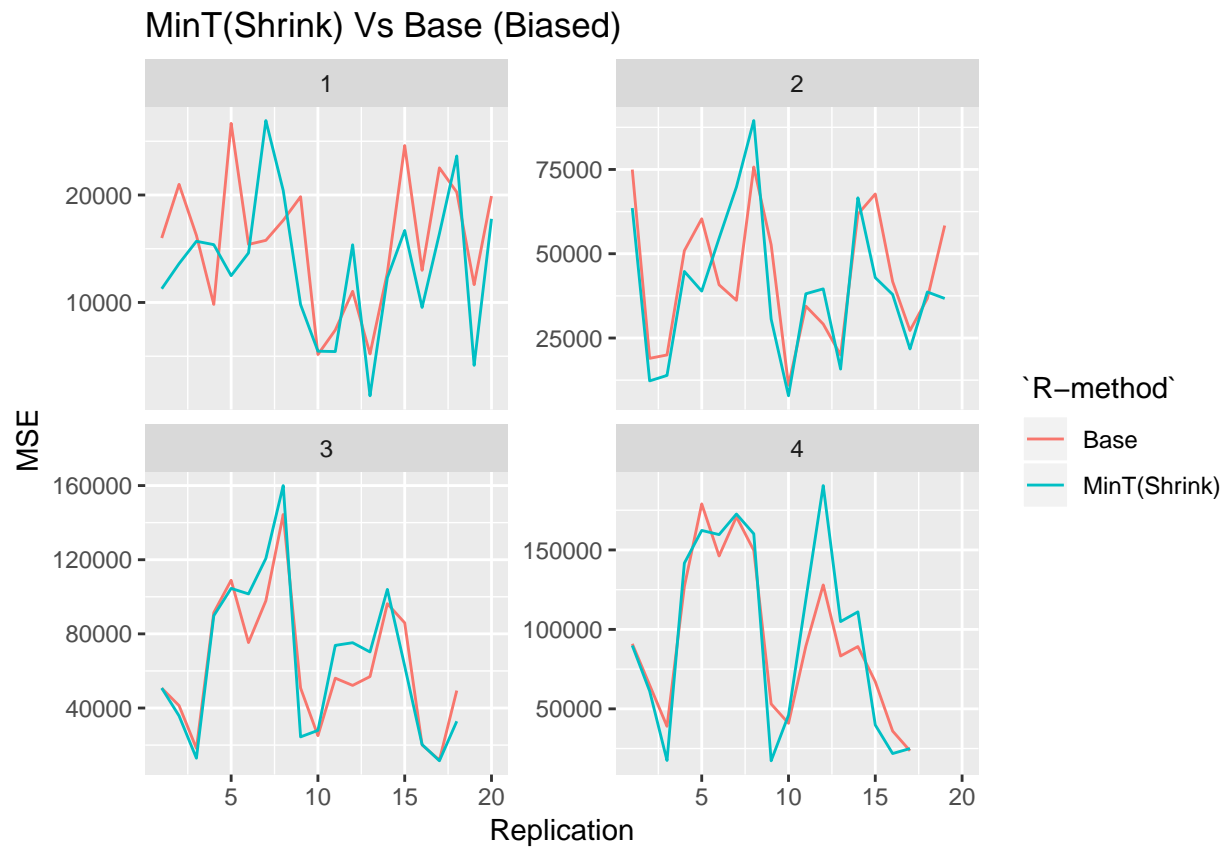**Experiment 1 - Univariate ARIMA models with log transformation**

We consider data from Q1-2005 to Q4-2013 as the training set and Q1-2014 to Q4-2018 as test set. we fit univariate ARIMA models for each series for log transformed data. The back-transformed forecasts will be biased. Unbiased forecasts will be obtained by adjusting the bias forecasts.

R-method	h=1		h=2		h=3		h=4	
	Biased	Unbiased	Biased	Unbiased	Biased	Unbiased	Biased	Unbiased
Base	15596.86	15566.79	43082.93	43025.19	62942.46	62869.26	92837.58	92737.19
Bottom-up	18124.62	17862.70	49554.40	48876.40	70491.85	69457.42	98082.37	96784.22
MinT(Shrink)	13415.61	13345.78	40199.14	40004.29	65495.92	65207.16	96483.41	96096.26
OLS	14298.46	14274.63	39648.06	39607.03	58849.52	58801.06	86802.44	86735.41
WLS	14222.09	14168.63	38911.89	38784.84	57076.13	56896.55	81219.17	80984.06

	h=1		h=2		h=3		h=4	
R-method	Biased	Unbiased	Biased	Unbiased	Biased	Unbiased	Biased	Unbiased
Base	15596.86	15566.79	43082.93	43025.19	62942.46	62869.26	92837.58	92737.19
Bottom-up	-16.21	-14.75	-15.02	-13.60	-11.99	-10.48	-5.65	-4.36
MinT(Shrink)	13.99	14.27	6.69	7.02	-4.06	-3.72	-3.93	-3.62
OLS	8.32	8.30	7.97	7.94	6.50	6.47	6.50	6.47
WLS	8.81	8.98	9.68	9.86	9.32	9.50	12.51	12.67

OLS Vs Base (Biased)

OLS Vs Base (Unbiased)

MinT(Shrink) Vs Base (Biased)

MinT(Shrink) Vs Base (Unbiased)

Experiment 2 - Time series regression with ARIMA errors for log transformed data

In this exercise we fit time series regression models with ARIMA errors for each series for log transformed data. All bottom level series were considered as the regressors for each aggregate level series. Lag of all bottom level series except the bottom level regresand were considered as the regressors. All models were fitted to the back-transformed series. Then the back-transformed forecasts will be biased. Unbiased forecasts will be obtained by adjusting the bias forecasts.

R-method	h=1 Biased	h=1 Unbiased	h=2 Biased	h=2 Unbiased	h=3 Biased	h=3 Unbiased	h=4 Biased	h=4 Unbiased
Base	20484.932	20484.534	42769.163	42768.046	69639.55	69639.03	632091.2	632147.6
Bottom-up	78866.636	78866.042	193452.964	193443.170	363975.27	363977.08	5084302.6	5084787.3
MinT(Shrink)	2714.651	2714.630	5071.284	5071.297	12838.79	12838.90	229209.9	229232.0
OLS	9892.024	9891.992	20004.445	20004.447	33120.79	33120.94	249777.7	249799.2
WLS	3093.040	3093.025	6518.795	6518.791	13598.32	13598.40	119322.6	119333.6

R-method	h=1 Biased	h=1 Unbiased	h=2 Biased	h=2 Unbiased	h=3 Biased	h=3 Unbiased	h=4 Biased	h=4 Unbiased
Base	20484.93	20484.53	42769.16	42768.05	69639.55	69639.03	632091.15	632147.61
Bottom-up	-285.00	-285.00	-352.32	-352.31	-422.66	-422.66	-704.36	-704.37
MinT(Shrink)	86.75	86.75	88.14	88.14	81.56	81.56	63.74	63.74
OLS	51.71	51.71	53.23	53.23	52.44	52.44	60.48	60.48
WLS	84.90	84.90	84.76	84.76	80.47	80.47	81.12	81.12