

# New evaluations of simple models for small area population forecasts

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## Background

Population projection model for Queensland – State & large regions

In 2011 new statistical geography introduced

Queensland Government requested model extension to handle small areas

Undertook a review of small area projection methods  
→ recommended empirical testing of selected models

Comprehensive study:

- 3 countries
- introduced new model
- large no. of averaged and composite models
- went beyond just assessment of forecast accuracy

## Approach

Case study countries: Australia; New Zealand; England & Wales

Obtained 1991, 2001 and 2011 population estimates

Country	Area type	No. of areas	Median pop, 2001
Australia	SA2	2,072	7,704
New Zealand	Area Unit	1,725	2,110
England & Wales	CAS ward	8,839	4,842

Fitted 10 simple models to 1991-2001 population change

Produced projections from 2001:

- “Projected” out to 2011 and compare against actual populations
- Projected further to 2031 to assess characteristics of projections

## Simple projection models

LIN	Linear
EXP	Exponential
LIN/EXP	Linear/Exponential Linear if positive base period change; exponential if negative
MEX	Modified Exponential Growth rate dampened if pop very high or low
CGD	Constant Growth Rate Difference
CSP	Constant Share of Population
FSP	Forecast Share of Population
CSG	Constant Share of Growth
CSG+	Constant Share of Growth Positive shares only
VSG	Variable Share of Growth Initial growth forecast using LIN/EXP Then adjusted to State growth using plus-minus method



## Models tested

### Individual

10 individual models

### Averaged

Average of 2, 3, 4 and 5 of every individual model. Total of 627 models.

### Composite

Different models applied for

- 5 categories of base period growth rates, and
- 5 categories of launch year population size.

Total of 100,000 x 2 models

Two sets of projections

- Forecast-constrained:** small area projections adjusted to sum to State/national medium series projection for 2001-31
- Estimate-constrained:** small area projections adjusted to sum to State/national population estimate in 2011



# Assessment

## Forecast accuracy

Median Absolute Percentage Error (MedAPE)

## Credibility

- (i) Proportion of small areas with negative populations
- (ii) Ratio of the sum of unconstrained small area projections to the State or national total

## Results: individual models: Australia

**Table 2:** Performance of individual models at 10 and 30 year forecast horizons

Model	10 year horizon						30 year horizon	
	Forecast-constrained			Estimate-constrained			Forecast-constrained	
	MedAPE	% -ve	ratio	MedAPE	% -ve	ratio	% -ve	ratio
<i>Australia</i>								
LIN	8.5	0.00	0.99	7.9	0.00	0.95	0.39	1.02
EXP	21.1	0.00	1.40	18.4	0.00	1.34	0.00	1424.64
MEX	10.5	0.00	1.05	8.5	0.00	1.00	0.00	1.12
LIN/EXP	8.3	0.00	1.00	7.7	0.00	0.95	0.00	1.03
CGD	22.1	0.00	1.41	19.2	0.00	1.41	0.00	1273.51
CSP	7.9	0.00	1.00	10.0	0.00	1.00	0.00	1.00
FSP	10.5	0.05	1.00	9.9	0.05	1.00	3.57	1.00
CSG	8.7	0.00	1.00	12.2	0.34	1.00	0.29	1.00
CSG+	7.1	0.00	1.00	7.6	0.00	1.00	0.00	1.00
VSG	8.3	0.00	1.00	8.5	0.00	1.00	0.00	1.00

## Results: individual models: England & Wales

**Table 2:** Performance of individual models at 10 and 30 year forecast horizons

Model	10 year horizon						30 year horizon	
	Forecast-constrained			Estimate-constrained			Forecast-constrained	
	MedAPE	% -ve	ratio	MedAPE	% -ve	ratio	% -ve	ratio
<i>England &amp; Wales</i>								
LIN	6.7	0.01	1.00	6.7	0.01	0.96	0.19	1.00
EXP	7.5	0.00	1.02	6.7	0.00	0.98	0.00	2.19
MEX	6.3	0.00	1.00	6.0	0.00	0.97	0.00	1.02
LIN/EXP	6.6	0.00	1.00	6.6	0.00	0.96	0.00	1.01
CGD	7.5	0.00	1.02	6.7	0.00	1.02	0.00	2.19
CSP	4.6	0.00	1.00	5.5	0.00	1.00	0.00	1.00
FSP	6.9	0.01	1.00	6.9	0.01	1.00	0.31	1.00
CSG	6.9	0.01	1.00	12.0	0.09	1.00	0.23	1.00
CSG+	5.0	0.00	1.00	6.0	0.00	1.00	0.00	1.00
VSG	6.6	0.00	1.00	6.8	0.00	1.00	0.00	1.00



## Results: averaged models

**Table 5:** Percentage of averaged models more accurate than the best individual model at a 10 year forecast horizon

	<b>Forecast- constrained</b>	<b>Estimate- constrained</b>
		%
Australia	7.0	13.7
England & Wales	0.2	2.1
New Zealand	0.6	1.3

## Best averaged models: Australia

**Table 6a:** Lowest MedAPE averaged and individual models: Australia

		10 year horizon			30 year horizon	
		MedAPE	% -ve	ratio	% -ve	ratio
<i>Forecast-constrained</i>						
Best individual model	CSG+	7.1	0.00	1.00	0.00	1.00
Best averaged models	CSP,VSG	6.4	0.00	1.00	0.00	1.00
	CSP,CSG	6.4	0.00	1.00	0.00	1.00
	LIN/EXP,CSP	6.4	0.00	1.00	0.00	1.01
	CSP,CSG+	6.5	0.00	1.00	0.00	1.00
	LIN,CSG	6.5	0.00	1.00	0.00	1.01
<i>Estimate-constrained</i>						
Best individual model	CSG+	7.6	0.00	1.00	0.00	1.00
Best averaged models	LIN/EXP,CSP,CSG+,VSG	6.8	0.00	0.99	0.00	1.01
	CSP,CSG+,VSG	6.8	0.00	1.00	0.00	1.00
	LIN,MEX,CSP, CSG+	6.8	0.00	0.99	0.00	1.03
	MEX,CSP,CSG+	6.8	0.00	1.00	0.00	1.04
	MEX,LIN/EXP,CSP,CSG+	6.8	0.00	0.99	0.00	1.04

## Best averaged models: England & Wales

**Table 6b:** Lowest MedAPE averaged and individual models: England & Wales

	Average of:	10 year horizon			30 year horizon	
		MedAPE	% -ve	ratio	% -ve	ratio
<i>Forecast-constrained</i>						
Best individual model	CSP	4.6	0.00	1.00	0.00	1.00
Best averaged models	CSP,CSG+	4.6	0.00	1.00	0.00	1.00
	MEX,CSP,CSG+	4.9	0.00	1.00	0.00	1.01
	MEX,CSP	4.9	0.00	1.00	0.00	1.01
	LIN/EXP,CSP,CSG+	5.0	0.00	1.00	0.00	1.00
	CSP,CSG+,VSG	5.0	0.00	1.00	0.00	1.00
<i>Estimate-constrained</i>						
Best individual model	CSP	5.5	0.00	1.00	0.00	1.00
Best averaged models	EXP,CSP	5.4	0.00	0.99	0.00	1.60
	CGD,CSP	5.4	0.00	1.01	0.00	1.59
	CSP,CSG+	5.4	0.00	1.00	0.00	1.00
	MEX,CSP,CSG+	5.4	0.00	0.99	0.00	1.01
	MEX,CSP	5.4	0.00	0.98	0.00	1.01

## Results: composite models

**Table 7:** Percentage of composite models more accurate than the best individual model at a 10 year forecast horizon

<i>Model type</i> Country	Forecast- constrained	Estimate- constrained
<i>Growth rate composite models</i>		%
Australia	1.5	2.1
England & Wales	0.0	3.2
New Zealand	0.0	1.3
<i>Population size composite models</i>		
Australia	0.0	0.1
England & Wales	0.0	0.0
New Zealand	0.0	0.0

## Results: growth rate composite models, Australia

**Table 8a: Lowest MedAPE growth rate composite and individual models: Australia**

	Model (by base period growth rate)					10 year horizon			30 year horizon	
	<-0.5%	-0.5-0.5%	0.5-1.5%	1.5-2.5%	2.5%+	MedAPE	% -ve	ratio	% -ve	ratio
<i>Forecast-constrained</i>										
Best individual model	CSG+					7.1	0.00	1.00	0.00	1.00
Best composite models	CSG+	CSP	CSP	CSG+	CSG+	6.6	0.00	1.03	0.00	1.08
	CSG+	CSP	CSP	MEX	CSG+	6.7	0.00	1.04	0.00	1.09
	CSG+	CSP	CSP	LIN	CSG+	6.7	0.00	1.04	0.00	1.09
	CSG+	CSP	CSP	LIN/EXP	CSG+	6.7	0.00	1.04	0.00	1.09
	CSG+	CSP	CSP	CSP	CSG+	6.7	0.00	1.03	0.00	1.07
<i>Estimate-constrained</i>										
Best individual model	CSG+					7.6	0.00	1.00	0.00	1.00
Best composite models	CSG+	CSG+	MEX	MEX	LIN	6.9	0.00	0.97	0.00	1.06
	CSG+	CSG+	MEX	MEX	LIN/EXP	6.9	0.00	0.97	0.00	1.06
	CSG+	CSG+	MEX	LIN	LIN	6.9	0.00	0.97	0.00	1.06
	CSG+	CSG+	MEX	LIN	LIN/EXP	6.9	0.00	0.97	0.00	1.06
	CSG+	CSG+	MEX	LIN/EXP	LIN	6.9	0.00	0.97	0.00	1.06

## Conclusions

Individual models CSG+, CSP, VSG, LIN/EXP & MEX shown to avoid credibility problems and in many cases give low average errors.

Small proportion of averaged & growth rate composite models out-performed the best individual models

Which models are recommended?

Best averaged models tended to include CSP and CSG+ or VSG

Australia & New Zealand: CSP, CSG+, VSG average

England & Wales: CSP, CSG+ average or CSP

These projections can be treated as a 'base layer' which can be improved in certain places (e.g. using housing-unit model)

Age-sex projections can be created by constraining a cohort-component model to totals generated by the simple methods.

Thank you

Questions?

If you would like a copy of the full paper please email me:  
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