Forecasting UK GDP growth and inflation under structural change. A comparison of models with time-varying parameters

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Motivation

Large literature on time-varying models used to investigate properties of macro-variables

- Time-varying parameters VARs(TVP-VARs)- Cogley and Sargent (2002, 2005), Benati (2007), Cogley, Primiceri and Sargent (2008)

- Regime switching VARs (MS-VARs)- Sims and Zha (2006), Groen and Mumtaz (2008)

- Threshold VARs (TVARs)- Balke (2000)

- Time-varying factor augumented VAR (TVP- FAVAR)- Baumeister, Liu and Mumtaz (2010)

Smaller but increasing literature on time-varying models used for forecasting macro-variable

- TVP-VARs- D' Agostino, Gambetti and Giannone (2011)

- TVP- FAVAR- Eickmeier, Lemke and Marcellino (2011)

- Unobserved component model (UC)- Stock and Watson (2007)

- Threshold and MS VARs- Altavilla and Ciccarelli (2007)

Consider and compare the forecast performance of a large set of time-varying models over a long period of time?

We estimate 24 forecasting models:

- every quarter from 1976Q1 to 2007Q4
- to forecast UK inflation, GDP growth and the interest rate
- at 1, 4, 8 and 12 quarters ahead
- and assess forecast performance using RMSE, Diebold- Mariano and the trace statistics

Data:
- sample: 1955Q1 to 2007Q4
- real time GDP growth
- CPI inflation spliced back with RPIX inflation
- 3 months T-bill rate

Models

- **Regime Switching VARs**
  - ➢ Independent switching in VAR coefficient and error variance
  - ➢ Simultaneous switching in VAR coefficient and error variance
  - ➢ Breaks are allowed only in the VAR coefficients
- **Time-Varying VARs**
  - ➢ General- stochastic vol. and time-varying degree of parameter drift
  - ➢ Standard- stochastic vol. and constant degree of parameter drift
  - ➢ Homoscedastic
- **Time-Varying Factor Augmented VARs**
  - ➢ Stochastic volatility
  - ➢ Homoscedastic
  - ➢ Fixed coefficient
- Unobserved Component with stochastic volatility
- Threshold and Smooth Transition VARs
  - ➢ use each variable as threshold
- Rolling and Recursive VARs
- Bayesian Model averaging

- AR(1) estimated recursively

Results: GDP

RMSE of each model relative to an AR(1) model for GDP

Models	1976-2007				1992-2007			
	1 Q	4 Q	8 Q	12 Q	1 Q	4 Q	8 Q	12 Q
RSVAR two regimes	2.80	1.70	1.42	1.32	3.95	2.03	1.60	1.44
RSVAR three regimes	1.53	1.16	1.07	1.04	1.47	1.06	1.01	1.01
RSVAR four regimes	1.70	1.24	1.13	1.08	1.40	1.08	1.04	1.03
RSVAR* two regimes	1.03	1.04	1.04	1.05	1.38	1.13	1.08	1.06
RSVAR* three regimes	1.00	1.11	1.12	1.13	1.06	1.03	1.05	1.06
RSVAR* four regimes	1.03	1.09	1.11	1.13	1.09	0.98	0.99	1.00
RSVAR** two regimes	1.08	1.04	1.05	1.06	1.35	1.11	1.07	1.06
RSVAR** three regimes	1.02	1.17	1.18	1.18	1.13	1.06	1.08	1.09
RSVAR** four regimes	1.01	1.16	1.19	1.20	1.04	1.00	1.05	1.06
TVP-VAR (General)	1.59	1.31	1.24	1.21	1.21	1.05	1.05	1.07
TVP-VAR (Standard)	0.88	0.94	0.97	0.99	1.01	0.94	0.98	0.99
TVP-VAR (Homoscedastic)	0.92	0.97	0.98	1.00	1.18	1.01	1.02	1.02
TVP-FAVAR	1.00	1.04	1.03	1.03	1.17	1.12	1.09	1.08
TVP-FAVAR (Homoscedastic)	1.07	1.06	1.05	1.05	1.23	1.17	1.13	1.12
FAVAR	1.02	0.99	0.99	0.99	1.11	1.14	0.97	0.98
UC	0.94	1.04	1.06	1.06	1.19	0.95	1.13	1.09
TVAR (GDP)	1.18	1.05	1.06	1.06	1.01	0.98	1.02	1.03
TVAR (Inflation)	0.89	0.96	0.99	1.01	0.99	1.02	1.00	1.02
TVAR (Rate)	1.01	0.99	1.00	1.02	1.19	0.97	1.02	1.03
ST-VAR (GDP)	0.96	0.98	0.99	1.00	1.09	0.97	0.98	0.99
ST-VAR (Inflation)	0.94	0.97	0.98	1.00	1.09	0.97	0.98	0.99
ST-VAR (Rate)	0.94	0.97	0.98	1.00	1.09	1.01	0.99	1.00
VAR (Rolling)	0.96	0.99	1.03	1.04	1.00	1.02	1.06	1.06
VAR (Recursive)	0.97	0.98	1.00	1.01	1.19	1.17	1.02	1.02
BMA	1.10	1.07	1.05	1.05	1.24	0.00	1.13	1.12

Legend

Our model outperforms an AR(1) model

The AR(1) model outperforms our model

Results: GDP

Diebold-Mariano forecast evaluation statistic relative to an AR(1) model for GDP

Models	1976-2007				1992-2007			
	1 Q	**4 Q**	**8 Q**	**12 Q**	**1 Q**	**4 Q**	**8 Q**	**12 Q**
RSVAR two regimes	6.10	2.70	0.76	0.89	6.75	1.80	0.26	0.21
RSVAR three regimes	2.50	-0.60	-0.20	1.65	2.67	-1.13	-0.98	1.26
RSVAR four regimes	3.02	-0.80	-0.43	0.95	2.39	0.21	1.11	0.97
RSVAR* two regimes	0.78	0.85	2.40	0.83	1.73	0.73	1.38	0.93
RSVAR* three regimes	-0.38	1.16	1.74	1.83	0.00	0.69	1.83	1.05
RSVAR* four regimes	0.21	1.09	1.66	1.89	0.07	-0.75	1.57	1.02
RSVAR** two regimes	0.29	0.55	2.24	1.45	1.57	0.73	1.37	0.96
RSVAR** three regimes	-0.02	1.05	1.16	1.27	0.50	0.98	1.78	1.13
RSVAR** four regimes	0.07	1.04	1.21	1.44	-0.28	0.58	1.74	1.14
TVP-VAR (General)	3.73	1.72	2.08	2.41	1.05	0.63	5.25	3.00
TVP-VAR (Standard)	-1.09	-0.25	1.40	1.35	0.70	0.32	1.29	0.96
TVP-VAR (Homoscedastic)	-1.09	-0.25	1.40	1.35	0.70	0.32	1.29	0.96
TVP-FAVAR	0.08	0.76	1.08	0.69	1.47	2.19	1.58	-0.18
TVP-FAVAR (Homoscedastic)	1.12	0.99	1.51	0.80	1.90	1.99	1.05	0.49
FAVAR	0.73	0.03	0.62	-0.43	0.52	-0.80	0.78	0.71
UC	-1.68	3.21	2.38	0.98	1.13	2.73	3.02	0.43
TVAR (GDP)	1.54	0.31	1.48	0.16	-0.37	0.01	1.31	-0.86
TVAR (Inflation)	-0.21	-0.35	0.76	1.39	-0.24	-0.17	0.80	0.74
TVAR (Rate)	0.77	0.17	0.91	1.10	0.66	-0.30	0.89	0.70
ST-VAR (GDP)	0.16	-0.08	0.99	0.69	0.10	-0.11	1.09	0.79
ST-VAR (Inflation)	-0.44	-0.45	1.00	1.30	0.17	-0.03	1.08	0.82
ST-VAR (Rate)	-0.87	-0.27	0.97	0.95	0.14	-0.05	1.13	0.81
VAR (Rolling)	0.24	0.75	2.39	1.33	-0.27	0.71	1.96	0.81
VAR (Recursive)	-0.60	0.00	1.30	1.46	0.78	0.28	1.26	0.88
BMA	1.37	0.83	1.54	0.69	1.90	1.98	0.99	0.50

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Results: inflation

RMSE of each model relative to an AR(1) model for inflation

Models	1976-2007				1992-2007			
	1 Q	4 Q	8 Q	12 Q	1 Q	4 Q	8 Q	12 Q
RSVAR two regimes	4.31	2.22	1.54	1.29	2.28	1.19	0.85	0.73
RSVAR three regimes	1.91	1.61	1.37	1.27	1.29	0.97	0.86	0.85
RSVAR four regimes	1.45	1.38	1.19	1.12	1.21	0.94	0.86	0.85
RSVAR* two regimes	1.07	1.12	1.14	1.15	0.73	0.65	0.67	0.73
RSVAR* three regimes	1.04	0.97	0.88	0.85	0.71	0.51	0.43	0.42
RSVAR* four regimes	0.99	0.94	0.85	0.82	0.69	0.52	0.43	0.40
RSVAR** two regimes	1.08	1.04	1.05	1.05	0.73	0.65	0.67	0.72
RSVAR** three regimes	0.92	0.91	0.84	0.82	0.66	0.50	0.43	0.42
RSVAR** four regimes	0.98	0.96	0.87	0.83	0.72	0.52	0.43	0.40
TVP-VAR (General)	0.91	0.85	0.85	0.82	0.75	0.57	0.50	0.49
TVP-VAR (Standard)	0.85	0.80	0.76	0.74	0.67	0.50	0.42	0.41
TVP-VAR (Homoscedastic)	0.97	0.88	0.84	0.83	0.71	0.57	0.52	0.51
TVP-FAVAR	0.89	0.77	0.70	0.68	0.76	0.55	0.44	0.41
TVP-FAVAR (Homoscedastic)	0.95	0.78	0.68	0.65	0.81	0.49	0.38	0.35
FAVAR	1.10	0.97	0.92	0.90	0.88	0.46	0.70	0.72
UC	0.87	0.80	0.77	0.75	0.62	0.69	0.38	0.36
TVAR (GDP)	0.97	0.99	1.03	1.06	0.71	0.66	0.72	0.75
TVAR (Inflation)	1.01	0.95	0.91	0.89	0.87	0.73	0.54	0.51
TVAR (Rate)	1.04	1.01	1.03	1.01	0.84	0.65	0.68	0.67
ST-VAR (GDP)	0.96	0.95	0.97	0.98	0.74	0.66	0.65	0.69
ST-VAR (Inflation)	0.96	0.95	0.96	0.97	0.75	0.66	0.66	0.69
ST-VAR (Rate)	0.97	0.96	0.98	0.99	0.75	0.49	0.67	0.71
VAR (Rolling)	1.04	0.97	0.93	0.90	0.66	0.61	0.42	0.40
VAR (Recursive)	0.97	0.95	0.98	0.99	0.71	0.49	0.60	0.64
BMA	0.99	0.81	0.73	0.68	0.81	0.00	0.38	0.35

Legend

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Results: inflation

Diebold-Mariano forecast evaluation statistic relative to an AR(1) model for inflation

Models	1976-2007				1992-2007			
	1 Q	4 Q	8 Q	12 Q	1 Q	4 Q	8 Q	12 Q
RSVAR two regimes	4.94	1.69	-0.03	-0.52	5.11	-4.11	-6.52	-5.63
RSVAR three regimes	2.22	3.47	1.90	1.39	2.25	-1.12	-3.71	-3.81
RSVAR four regimes	1.15	2.95	0.87	0.72	2.40	-0.90	-3.17	-3.67
RSVAR* two regimes	0.69	1.32	1.89	1.24	-4.82	-8.39	-8.25	-7.97
RSVAR* three regimes	-0.16	0.15	-0.15	-0.15	-3.02	-6.29	-5.97	-4.73
RSVAR* four regimes	-0.66	-0.08	-0.14	-0.37	-2.21	-6.56	-5.60	-4.72
RSVAR** two regimes	0.15	0.58	1.40	0.57	-4.80	-8.22	-9.46	-9.96
RSVAR** three regimes	-0.86	0.26	-0.05	-0.12	-4.19	-6.58	-6.08	-5.12
RSVAR** four regimes	-0.70	0.39	-0.09	-0.29	-3.18	-6.48	-5.97	-4.96
TVP-VAR (General)	-0.98	-1.07	0.16	-3.05	-4.24	-7.10	-6.63	-6.10
TVP-VAR (Standard)	-0.63	-0.74	-0.37	-1.68	-5.17	-7.98	-7.86	-6.34
TVP-VAR (Homoscedastic)	-0.63	-0.74	-0.37	-1.68	-5.17	-7.98	-7.86	-6.34
TVP-FAVAR	-1.43	-4.67	-3.18	-3.23	-4.29	-6.93	-5.99	-5.07
TVP-FAVAR (Homoscedastic)	-1.00	-4.71	-4.02	-4.13	-3.10	-7.35	-6.32	-5.00
FAVAR	0.37	-0.44	-0.12	-1.32	-1.09	-6.90	-8.46	-7.04
UC	-1.08	-1.33	-0.54	-1.07	-4.75	-6.93	-5.91	-4.99
TVAR (GDP)	-0.84	0.26	1.57	1.24	-4.03	-4.56	-3.44	-2.36
TVAR (Inflation)	-0.38	0.09	0.52	-0.29	-2.56	-8.68	-7.48	-5.81
TVAR (Rate)	0.05	0.59	1.28	0.33	-1.86	-9.39	-9.32	-7.54
ST-VAR (GDP)	-0.94	0.01	0.82	0.11	-4.96	-8.61	-9.77	-9.40
ST-VAR (Inflation)	-0.72	0.01	0.68	-0.32	-4.64	-8.73	-9.79	-8.46
ST-VAR (Rate)	-0.73	0.18	1.11	0.26	-4.76	-8.51	-9.72	-9.94
VAR (Rolling)	0.34	0.56	0.60	0.15	-3.72	-6.13	-5.93	-4.78
VAR (Recursive)	-0.59	0.45	1.24	0.49	-4.69	-8.14	-9.34	-9.11
BMA	-0.58	-1.13	-1.05	-3.74	-3.10	-7.35	-6.32	-5.00

Legend

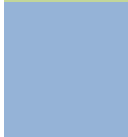Our model outperforms an AR(1) model

The AR(1) model outperforms our model

Model specific results

Trace- multivariate forecast evaluation statistic relative to an AR(1) model

Models	1976-2007				1992-2007			
	1 Q	4 Q	8 Q	12 Q	1 Q	4 Q	8 Q	12 Q
RSVAR two regimes	16.07	2.86	1.73	1.32	12.15	1.08	0.43	0.38
RSVAR three regimes	4.21	2.50	1.78	1.52	2.34	0.72	0.68	0.70
RSVAR four regimes	4.40	2.82	1.73	1.53	1.87	0.84	0.75	0.74
RSVAR* two regimes	1.03	1.25	1.38	1.48	1.12	0.62	0.79	0.90
RSVAR* three regimes	1.05	1.25	0.93	0.92	0.73	0.44	0.43	0.40
RSVAR* four regimes	1.03	1.18	0.88	0.82	0.73	0.35	0.34	0.28
RSVAR** two regimes	1.13	1.07	1.14	1.19	1.08	0.60	0.78	0.89
RSVAR** three regimes	1.02	1.49	0.96	0.94	0.82	0.51	0.53	0.53
RSVAR** four regimes	1.05	1.58	0.96	0.90	0.70	0.39	0.42	0.40

- The TVAR model that uses lag inflation as threshold outperforms the other models at 4, 8 and 12 Q forecast horizon
- The estimates of the ST-VAR model suggest a similar result although differences less stark

- The homoscedastic TVP-FAVAR performs better than the model with stochastic volatility at 4, 8 and 12 Q horizon over the full sample.
- It's interesting that the time-varying FAVAR delivers a better forecast than the constant coefficient model

| VAR (Recursive) | 0.97 | 1.00 | 1.12 | 1.08 | 0.84 | 0.50 | 0.64 | 0.73 |
| BMA | 1.09 | 0.87 | 0.69 | 0.50 | 0.93 | 0.42 | 0.31 | 0.29 |

Legend

Our model outperforms an AR(1) model

The AR(1) model outperforms our model

Forecast performance and the recent financial crisis
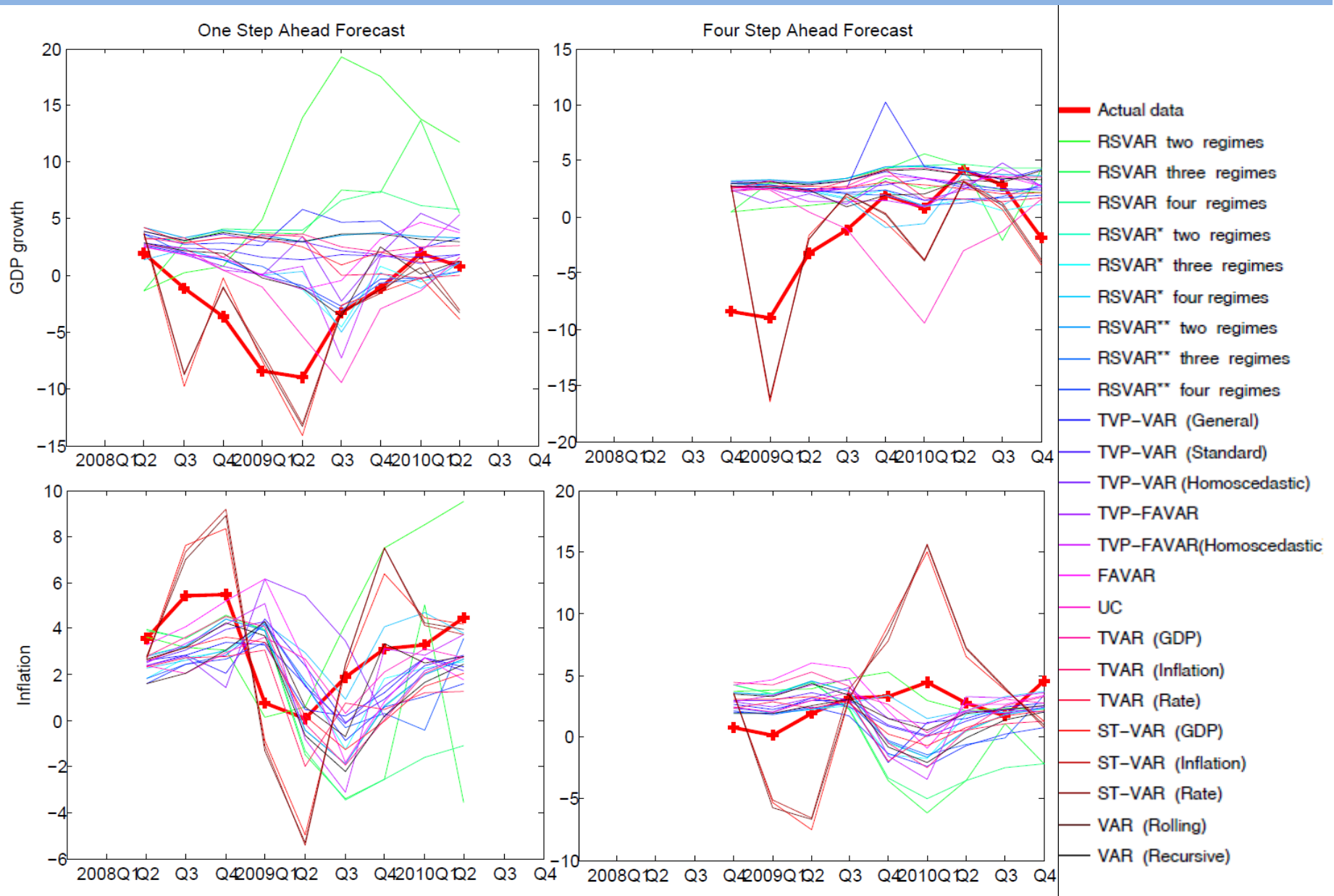
Conclusions

- We investigate the performance of a variety of models with time-varying parameters in forecasting UK GDP growth and inflation

- TVP- VAR and the TVAR models provide better forecasts for GDP growth with a lower average RMSE than an AR(1)

- Models with time-varying parameters produce better forecasts for inflation than an AR(1). TVP-FAVAR, TVP-VAR and UC models do particularly well

- Across the three variables, TVP-FAVAR stands out delivering the most accurate forecast at 4Q horizon over the full sample.