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UK Regional Nowcasting using a Mixed Frequency Vector Autoregressive Model

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Background: Frequency and Timeliness

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- Regional UK nominal GVA data is currently available at annual frequency
- Having regional data at higher frequency (e.g. quarterly) desirable
- Regional UK GVA data is currently released with long delay (right now only have 2016)
- Desirable to have quicker estimates
- Other data is available more frequently and in a more timely fashion
- GVA for UK as a whole is available quarterly and shorter release delay (right now have 2017Q4)
- Can we use this higher frequency and more timely data to produce estimates (nowcasts and forecasts) of regional GVA growth?

What does this paper do?

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- Constructs a consistent historical dataset for annual regional GVA in the UK going back to 1966
- Uses a mixed frequency Vector Autoregression (MF-VAR) to produce nowcasts of annual GVA growth for the UK regions.
- Regional nowcasts updated each quarter as newly released UK GVA data becomes available
- Nowcasts might be used as regional flash estimates which are released quarterly on same schedule as UK wide releases
- Thus, more timely and more frequent estimates of annual GVA growth for UK regions

Mixed Frequency Econometrics

- Growing literature on building econometric models which combine data of different frequencies
- Schorfheide and Song (2015). Real-time forecasting with a mixed-frequency VAR. Journal of Business Economic Statistics
- Brave, Butters and Justiniano (2016). Forecasting economic activity with mixed frequency Bayesian VARs. Federal Reserve Bank of Chicago Working Paper.
- McCracken, Owyang and Sekhposyan (2016). Real-time forecasting with a large, mixed frequency Bayesian VAR, Federal Reserve Bank of St. Louis Working Paper
- Ghysels (2016). Macroeconomics and the reality of mixed frequency data. Journal of Econometrics.
- We will use (and extend) the stacked VAR approach of the last two

Definitions

- $r = 1, .., R$ is an index for the UK regions.
- $t = 1, .., T$ is an index for time at the *annual* frequency.
- $Y_t^{r,A}$ is annual GVA for region r.
- $y_t^{r,A} = \left(\frac{Y_t^{r,A} - Y_{t-1}^{r,A}}{Y_{t-1}^{r,A}} \right)$ is annual GVA growth in region r.
- $Y_{t,q}^{UK}$ is UK GVA in the q^{th} quarter of year t where $q = 1, .., 4$.
- $y_{t,q}^{UK} = \left(\frac{Y_{t,q}^{UK} - Y_{t-1,q}^{UK}}{Y_{t-1,q}^{UK}} \right)$ is annual GVA growth in the UK relative to the same quarter in the previous year.

The Stacked VAR

- Vector Autoregessive Models are most popular multivariate time series model for macroeconomics
- If y_t is a vector of several dependent variables

$$y_t = B_0 + \sum_{j=1}^{P} B_j y_{t-j} + \varepsilon_t \tag{1}$$

- The stacked VAR is simply a VAR (at the annual frequency)
- The variables are $y_t = \left(y_{t,1}^{UK}, y_{t,2}^{UK}, y_{t,3}^{UK}, y_{t,4}^{UK}, y_t^A \right)'$
- $y_t^A = \left(y_t^{1,A}, .., y_t^{R,A} \right)$ stacks all the annual variables into vectors.

Why Do We not Use this Version of the MF-VAR?

1. MF-VAR literature typically use more high frequency variables than low frequency ones
2. E.g. 3 monthly macroeconomic variables and quarterly GDP growth
3. Our frequency mis-match is opposite: 9 annual (regional) variables and 1 quarterly variable
4. Each quarterly variable will appear as 4 variables in the MF-VAR
5. 13 dimensional VAR (and we have aspirations to go bigger)
6. We have relatively short annual sample
7. Lots of VAR parameters to estimate
8. And we want to add stochastic volatility (SV)
9. Note: in many macro applications time varying variances are found to be important
10. Trying to estimate too much with too little data
11. In theory, MF-VAR-SV is estimable, but in practice?

Bayesian VAR Methods and Entropic Tilting

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- Bayesian methods popular with large VARs
- Prior shrinkage helps with over-parameterization concerns
- We use popular Minnesota prior (see paper for details)
- More importantly, we use two sorts of information to improve our regional nowcasts:
- Cross-sectional restriction: A weighted average of regional GVA growth rates adds up to UK growth
- The new information provided by newly released UK GVA growth
- We do this using entropic tilting methods

Entropic Tilting

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- Stacked VAR will provide an (unconditional) predictive density
- Entropic tilting combines this predictive density with some other restriction to produce new predictive density
- New predictive distribution has mean that satisfies restriction, but otherwise is as close as possible to unconditional predictive density
- Density is "tilted" so that predictive mean satisfies restriction
- Technical details: see paper

Entropic Tilting: An Example

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- Stacked VAR estimated using data through 2016 will produce unconditional nowcasts of annual regional GVA growth in 2017 as well as the four UK quarterly GVA growth (including 2017Q1)
- After 2017Q1 UK GVA data is released, entropically tilt UK GVA growth to the known 2017Q1 value
- UK GVA predictive density now reflects new release
- But regional nowcasts will also be updated
- Joint predictive density involving all 13 variables
- Changes in one part will spill over onto all other variables

The Data

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- Construction of a new regional data set going back to 1966 is one contribution of the paper
- Statistical regions changing over time (NUTS-1 begins 1995)
- See appendix to the paper
- Data set has 10 regions
- One of these is the continental shelf (UKCS)
- I will only present results using 9 regions ... omit UKCS
- Results with UKCS are in paper

Results - Descriptive statistics nominal growth rates (1967 - 2015)

	Mean	St. Dev.	Correlation with UK GVA
North	0.0774	0.0531	0.9409
York. & Humber	0.0790	0.0569	0.9157
East Midlands	0.0844	0.0620	0.9236
London & South East	0.0875	0.0485	0.9464
South West	0.0889	0.0621	0.9086
West Midlands	0.0777	0.0499	0.9374
Wales	0.0791	0.0590	0.9230
Scotland	0.0819	0.0549	0.9522
N. Ireland	0.0892	0.0643	0.7915
UKCS	-0.2589	2.8419	-0.1863

Empirical Results

- Present results for real time (first release) recursive nowcasting exercise using MF-VAR with and without stochastic volatility
- Nowcast evaluation period 2005-2016
- Paper has several forecast metrics (including density nowcast metrics).
- Here will focus on RMSFE (other metrics give similar results)
- Results presented relative to a benchmark univariate AR(1) model
- Where metric is <1 we are producing better estimates than the AR(1) model.

Results - without SV

Tilting Using New Information:	None	Q1	Q2	Q3	Q4
RMSFE					
North	0.96	0.61	0.58	0.56	0.59
York. & Humber	0.92	0.48	0.51	0.49	0.48
East Mids	0.90	0.56	0.44	0.42	0.45
West Mids	0.88	0.47	0.37	0.35	0.37
Lon & SE	1.09	0.37	0.35	0.39	0.38
South West	0.97	0.48	0.45	0.42	0.35
Wales	1.06	0.62	0.55	0.53	0.58
Scotland	0.92	0.45	0.41	0.41	0.44
N. Ireland	1.05	0.71	0.77	0.77	0.76
Average RMSE	0.97	0.53	0.49	0.48	0.49

Results - with SV

Tilting Using New Information:	None	Q1	Q2	Q3	Q4
RMSFE					
North	0.78	0.63	0.61	0.59	0.63
York. & Humber	0.71	0.45	0.40	0.38	0.37
East Mids	0.75	0.55	0.44	0.43	0.43
West Mids	0.82	0.51	0.40	0.39	0.39
Lon & SE	0.92	0.36	0.34	0.39	0.36
South West	0.79	0.47	0.44	0.41	0.37
Wales	0.86	0.58	0.52	0.50	0.56
Scotland	0.76	0.46	0.41	0.41	0.43
N. Ireland	0.88	0.69	0.75	0.74	0.75
Average RMSE	0.81	0.52	0.48	0.47	0.48

Summary of Nowcasting Exercise

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- The VAR-MF itself only moderately successful at beating simple benchmark
- Unconditional nowcasts a bit better than AR(1) ... and SV is important in producing good unconditional nowcasts
- Entropic tilting to newly released data is very successful.
- Huge improvements in every region's RMSFEs as quarterly UK data is released and tilted towards

What do the Nowcasts Look Like?

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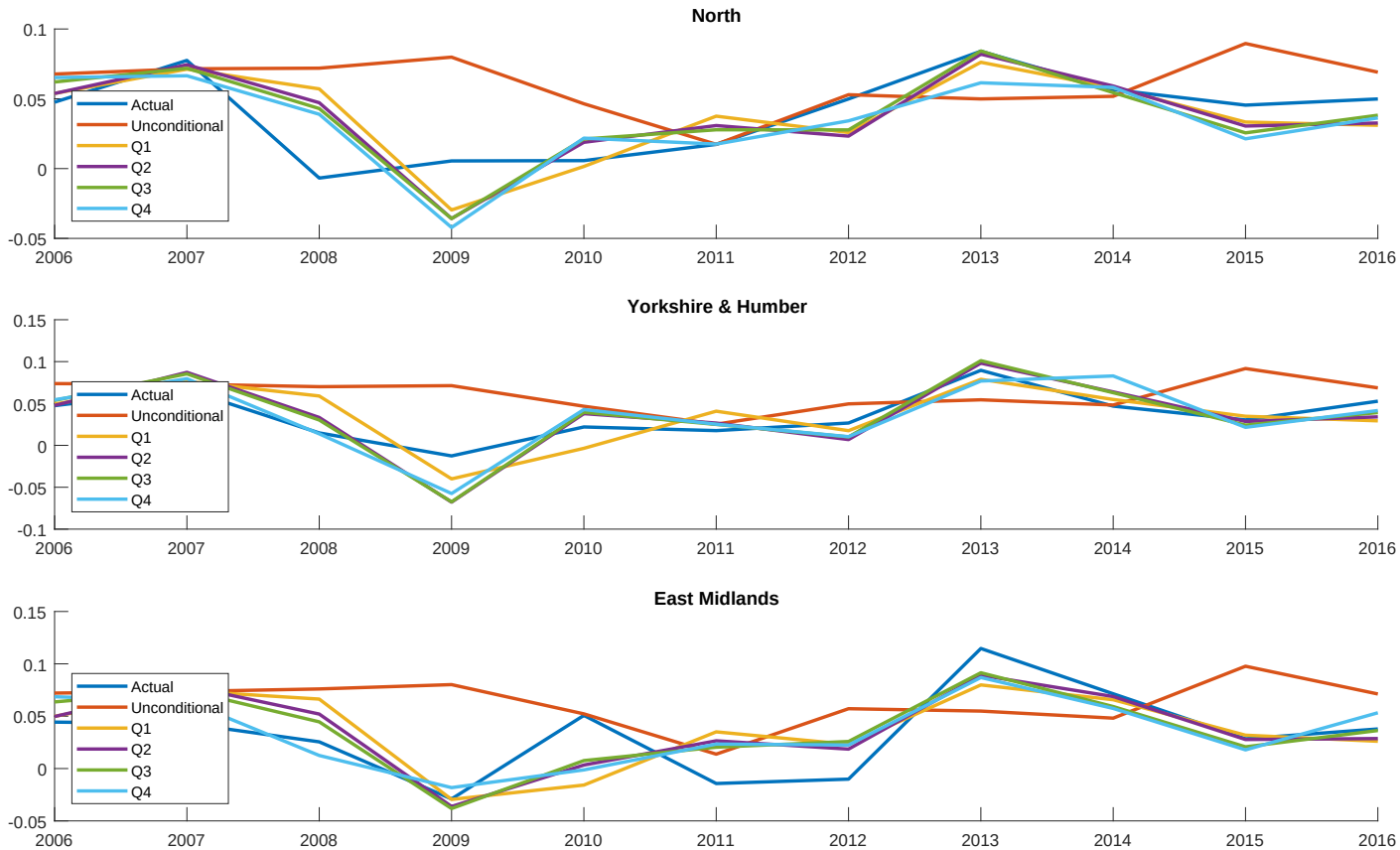
- For any annual regional growth rate we have six concepts:
- The actual data
- The unconditional nowcast
- The four entropically tilted nowcasts using the 4 quarterly UK GVA releases
- Next figures plot these for each region
- Unconditional nowcasts are often inaccurate, subsequently tilted ones much better
- Take a look at the 2009 results in particular

GVA Growth and Nowcasts for the UK Regions



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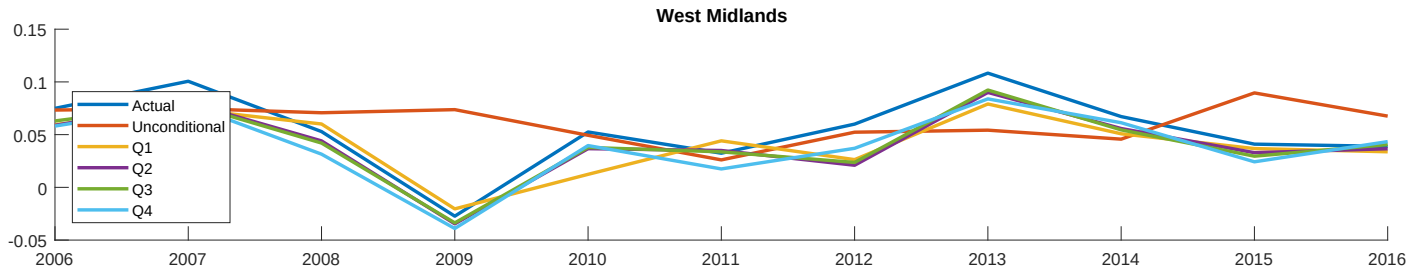

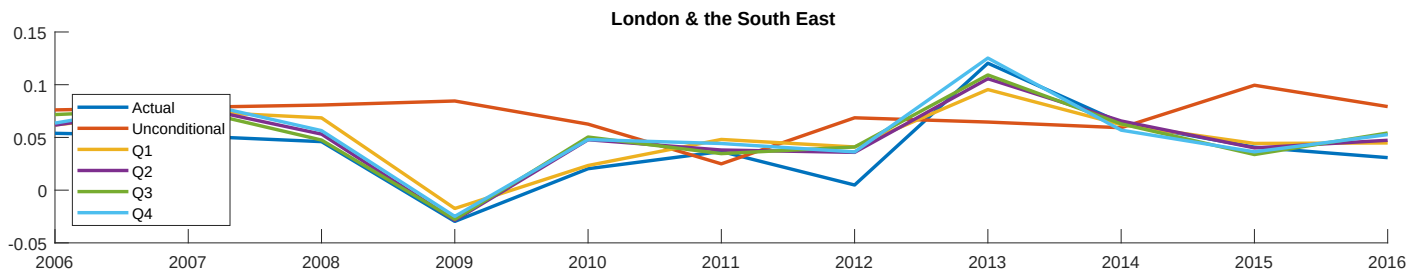

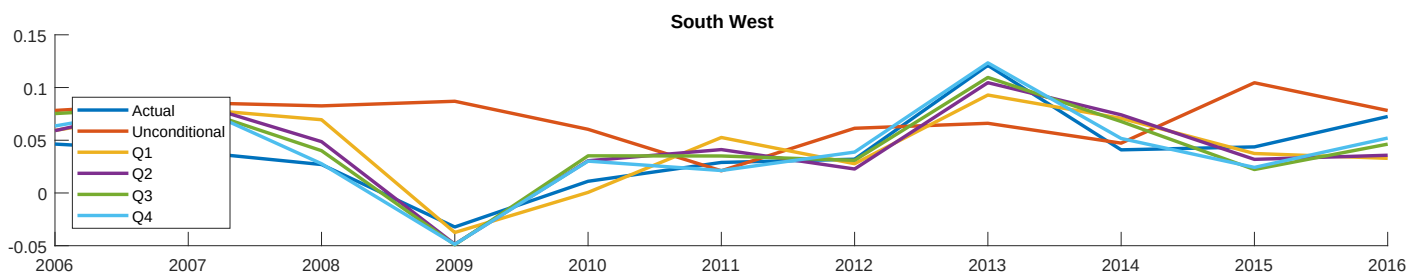

GVA Growth and Nowcasts for the UK Regions

Conclusions and Next Steps

- The mixed frequency VAR, augmented with entropic tilting to new quarterly GVA releases and a cross-sectional restriction works well
- We produce timely, high frequency estimates of annual regional GVA growth rates
- Possible next steps:
- Incorporate other UK quarterly data (or even other regional variables such as PMI?) to further improve nowcasts
- Challenge: VAR will get very big (machine learning methods?)
- Repeat the analysis for real GVA growth
- Challenge: Short sample span (state space methods?)
- Work with NUTS-2 level data
- Challenge: Getting high quality data for long enough time span plus VAR will get very big