PREDICTING DOWNTURNS IN THE US HOUSING MARKET: A BAYESIAN APPROACH

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Outline

Background and Motivation

- Boom of the 1990s versus bust in the 2000s in the US housing market (*NAR, 2006*)
- House price significantly influence consumer expenditure $\rightarrow$ financial markets
- Role of asset prices in forecasting inflation (*Stock and Watson, 2003*)

- Questions that we are seeking answers to:
  - Is growth in house prices predictable?
  - Can simple VARs, and their variants, based on only *real house price growth*, give any indications?
  - Could these simple models have predicted the downturns in the US housing market?

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Outline

VARs

- *Atheoretical* but very useful for forecasting
- Unrestricted VAR (Sims, 1980)

$$\vec{y}_t = A_0 + A(L)\vec{y}_t + \vec{\epsilon}_t, \text{ with } \vec{\epsilon}_t \sim N(0, \sigma^2 I_n)$$

▷ VARs use equal lag for all variables → Many parameters to estimate (*overparametrization*)

✓ ***Option 1***: Exclude insignificant lags

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BVARs

$$\vec{y}_t = A_0 + A(L)\vec{y}_t + \vec{\epsilon}_t, \text{ with } \vec{\epsilon}_t \sim N(0, \sigma^2 I_n)$$

✓ ***Option 2***: Instead of eliminating insignificant lags, impose

restrictions on coefficients (Litterman, 1981; Doan *et al*, 1984)

- Coeff. of longer lags more likely to be near zero → Data can override this assumption
- In i^{th} equation, for β_i of the lagged dependent variable, and β_j of any other variable:

$$\beta_i \sim N(1, \sigma^2_{\beta_i}), \quad \beta_j \sim N(0, \sigma^2_{\beta_j})$$

- *Minnesota* prior

BVARs

$$\vec{y}_t = A_0 + A(L)\vec{y}_t + \vec{\epsilon}_t, \text{ with } \vec{\epsilon}_t \sim N(0, \sigma^2 I_n)$$

✓ ***Option 3***: Generate the σs in terms of few hyperparameters,

viz., w, d and a weight matrix $f(i,j)$ (Doan *et al*, 1984)

- Standard deviation of prior distribution of variable j in eq. i at lag m given as $S_1(i,j,m) = [w \times g(m) \times f(i,j)]\frac{\hat{\sigma}_j}{\hat{\sigma}_i}$
  - $f(i,j) = 1$ if $i = j$, and k_{ij} otherwise $(0 \leq k_{ij} \leq 1)$
  - $g(m) = m^{-d}, \ d > 0$
  - d is the decay parameter
  - $\hat{\sigma}_i$ estimated s.e. of univariate autoregression of variable i
  - w tightness parameter, s.d. on first own lag

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SBVARs

Minnesota Prior treats all variables in VAR, except for the first own-lag of the dependent, in identical manner

✓ ***Option 4***: Construct weight matrix based on First-Order Spatial Contiguity (FOSC) (Lesage and Pan, 1995)

- Asymmetric F matrix
- Emphasize variables from neighbors
- 1 for neighbors, 0.1 for non-neighbors

Outline

Data

- 20 largest US states (2000 census) considered:

Arizona (AZ), California (CA), Florida (FL), Georgia (GA), Illinois (IL), Indiana (IN), Massachusetts (MA), Maryland (MD), Michigan (MI), Missouri (MO), North Carolina (NC), New Jersey (NJ), New York (NY), Ohio (OH), Pennsylvania (PA), Tennessee (TN), Texas (TX), Virginia (VA), Washington (WA) and Wisconsin (WI)

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Data

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- Real house price growth obtained from
  - Nominal house price data
  - Conventional Mortgage House Price Index (CMHPI)
  - Personal Consumption Expenditure (PCE)
- Quarterly data from 1976:Q1 to 1994:Q4
- Sources: Freddie Mac, Bureau of Economic Analysis

The FOSC F matrix

$$F = \begin{vmatrix}
1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 \\
0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1
\end{vmatrix}$$

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Forecast details

- Out-of-sample forecast for 1995:Q1 to 2006:Q4
  - Marked difference in house price growth in the US from mid 1990s (Rapach and Strauss, 2007, 2008)
- 'Optimal' model selected based on lowest average RMSE in the period 1995:Q1 to 2006:Q4
- 2 lags for each variable [1]
- RATS Econometrics Software[2]

[1] LR test, AIC, Final Predictor Error, Hannan-Quinn criterion

[2] WinRATS 7.0

Models Compared

- Univariate and Multivariate
  - VAR
  - BVAR $(w = 0.3, d = 0.5)$
  - BVAR $(w = 0.2, d = 1.0)$
  - BVAR $(w = 0.1, d = 1.0)$
  - BVAR $(w = 0.2, d = 2.0)$
  - BVAR $(w = 0.1, d = 2.0)$
- SBVAR

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Outline

Table1. One-to -Four- Quarters-Ahead Average RMSEs (2001:01-2006:04)

	Models												
	VAR		**BVAR1**		**BVAR2**		**BVAR3**		**BVAR4**		**BVAR5**		**SBVAR**
States	*UV*	*MV*	*UV*	*MV*	*UV*	*MV*	*UV*	*MV*	*UV*	*MV*	*UV*	*MV*	
AZ	9.2	8.9	9.0	8.3	8.8	8.5	7.9	8.1	**7.9**	8.6	8.8	8.1	8.4
CA	7.0	7.4	7.0	**6.9**	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.9
FL	8.3	7.9	8.2	**7.3**	8.4	7.6	7.9	7.5	8.4	8.0	9.0	7.9	7.9
GA	3.4	3.4	3.3	3.2	3.3	3.2	2.9	2.9	2.9	3.2	3.3	2.9	**2.9**
IL	3.0	4.1	3.0	3.2	3.0	3.2	**2.9**	3.2	3.0	3.2	3.1	3.3	3.0
IN	2.3	2.7	2.2	**2.2**	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.2
MA	**4.6**	5.3	4.6	4.6	4.6	4.7	4.7	4.6	4.7	4.7	4.7	4.7	4.7
MD	6.0	5.9	6.0	5.8	6.2	5.9	5.9	5.8	6.0	6.0	6.4	5.8	**5.8**
MI	3.3	3.7	3.3	**2.9**	3.3	3.2	3.1	3.0	3.2	3.4	3.5	3.2	3.3
MO	3.4	4.3	3.4	**3.1**	3.4	3.2	3.4	3.7	3.4	3.4	3.4	3.8	3.6
NC	2.6	2.7	2.6	2.6	2.6	2.6	2.4	**2.4**	2.5	2.7	2.7	2.5	2.4
NJ	5.5	5.8	5.5	5.5	5.6	5.4	5.4	5.4	5.4	5.4	5.6	**5.4**	5.4
NY	5.7	6.8	5.6	5.5	5.6	5.4	5.4	5.4	5.4	5.4	5.7	5.4	**5.2**
OH	2.3	2.6	2.3	**2.1**	2.3	2.2	2.2	2.1	2.3	2.2	2.3	2.2	2.1
PA	4.7	4.4	4.7	3.9	4.5	3.8	4.2	4.0	4.1	3.9	4.5	4.0	**3.8**
TN	3.2	4.0	3.1	3.3	3.1	3.2	**2.8**	3.0	2.9	3.3	3.1	3.0	2.9
TX	3.3	3.4	3.3	3.3	3.2	3.4	3.0	3.3	**3.0**	3.5	3.3	3.4	3.1
VA	5.7	5.5	5.7	5.1	5.7	5.1	5.1	**4.9**	5.2	5.2	5.8	4.9	5.0
WA	4.1	4.4	4.0	3.8	4.0	3.8	3.8	3.7	**3.7**	3.9	4.0	3.8	3.8
WI	3.6	4.6	3.6	3.5	3.6	3.5	**3.5**	3.6	3.6	3.6	3.6	3.6	3.5

UV(Univariate); MV(Multivariate);
BVAR1(w=0.3,d=0.5); BVAR2(w=0.2,d=1.0); BVAR3(w=0.1,d=1.0);BVAR4(w=0.2,d=2.0), BVAR5(w=0.1,d=2.0)

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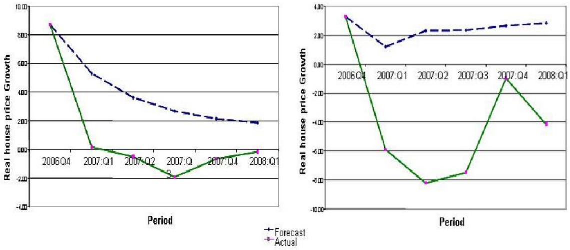
Outline

For the period 2007:Q1 to 2008:Q1

- In 19 of the 20 states, some Bayesian model outperforms
- Use ‘optimal’ model to predict downturn for each state
- For 18 of the 20 states, corresponding ‘optimal’ model could predict the downturn

Figure 5. Predicting turning Points for GA (2007:01-2008:01)

Figure 8. Predicting Turning Points for MA (2007:01-2008:01)



For the period 2007:Q1 to 2008:Q1

- Use ‘optimal’ model to predict downturn for each state
- For 18 of the 20 states, corresponding ‘optimal’ model predicted the downturn
- However, they tend to under predict the downturn
- $\Rightarrow$ Just lagged values of house price not enough
  $\Rightarrow$ information on other fundamentals needed
- None the less, the Bayesian models give useful preliminary indications of downturn
- Immense importance to policy makers (Del Negro, 1999)

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Concluding Remarks

- Bayesian methods influenced by choice of prior
- None-the-less, their importance cannot be disregarded
  - In light of current exercise
  - Existing other literature [3]
- Way forward: Try other large scale Bayesian models that incorporate other potential fundamentals.

[3] Amirizadeh and Todd (1984), Kuprianov and Lupoletti (1984), Hoen *et al.* (1984), Hoen and Balazsy (1985), Kinal and Ratner (1986), LeSage (1990), Gruben and Hayes (1991), Shoesmith (1992, 1995), Dua *et al.* (1999), Gupta (2006, 2007), Liu and Gupta (2007), Zita and Gupta (2007), Banerji *et al* (2008), Das *et al.* (2008), Gupta and Das (2008)