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Does the open economy help forecast domestic variables in DSGE models?

Michał Rubaszek
SGH Warsaw School of Economics, Narodowy Bank Polski

Marcin Kolasa
SGH Warsaw School of Economics, Narodowy Bank Polski

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Motivation

Direct motivation

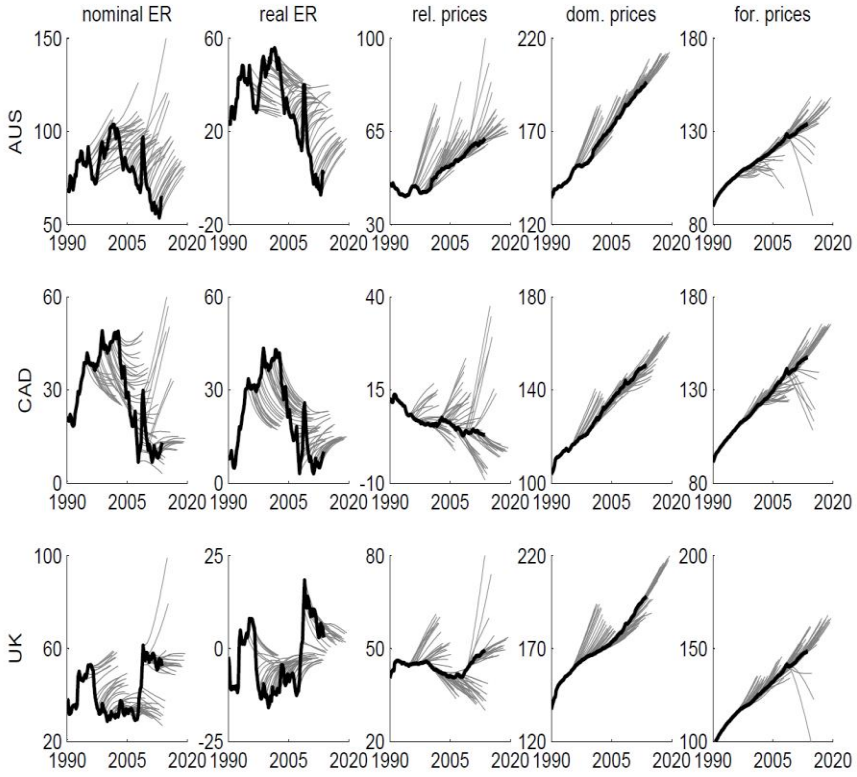
Trigger:

One of the findings in the project **„Exchange rate forecasting with DSGE models”** is that the inability of open economy DSGE model to forecast NER is due to its **failure to forecast domestic and foreign prices**

Question:

Does adding the foreign sector to NK model help in forecasting the domestic economy at all?

Recursive forecasts from DSGE model



Source: Ca’ Zorzi, Kolasa, Rubaszek (2017 JIE)

Motivation

- DSGE models: workhorse framework in policy analyses and forecasting
- DSGE model-based forecasts are competitive with:
  - time series models (e.g. Smets and Wouters 2007)
  - professional forecasters (e.g. Kolasa, Rubaszek and Skrzypczynski 2012).
  - survey in Handbook on Econ. For. chapter (Del Negro and Schorfheide 2013)
- Vast majority of studies: US economy, closed economy set-up
- This is at odds with models used in central banks / financial institutions, where open economy models dominate

A brief look at the literature

[All?] studies that evaluate out-of sample performance of NOEM DSGE models:

- ✓ Adolfson et al. (2007): EA; DSGE vs BVAR; evaluation sample 1994-2002
- ✓ Lees et al. (2007): NZL; DSGE vs BVAR vs RBNZ; evaluation sample 1998-2003
- ✓ Adolfson et al. (2008): Sweden; DSGE vs BVAR; evaluation sample 1999-2004
- ✓ Christoffel et al. (2010): EA; DSGE vs BVAR; evaluation sample 1999-2006
- ✓ Gupta and Kabundi (2010): South Africa; DSGE vs BVAR; evaluation sample 2003-2006
- ✓ Alpanda et al. (2011): South Africa; DSGE vs BVAR; evaluation sample 2003-2009
- ✓ Marcellino and Rychalovska (2014): LUX vs EA; DSGE vs BVAR, 2006-2011

The above studies:

- ✓ compare DSGE to time-seriers models (usually BVAR)
- ✓ evaluate forecasts for an individual country and short sample span
- ✓ **are silent about how much we gain by accounting for external block in DSGE models**

Motivation

Our question:

Is it good to have external sector in DSGE models from forecasting perspective?

Why important:

1. If the only target is to produce accurate forecasts, the use of NOEM model might not be cost efficient unless it produces more accurate forecasts

2. There are reasons to be skeptical about empirical success of NOEM framework: Justiniano and Preston (2010) demonstrate that it fails to account for substantial influence of foreign shocks that is identified in VAR studies

What we do

- Start from a standard three-equation **New Keynesian (NK)** closed-economy DSGE setup (habits, sticky prices, Taylor rule)

- Consider two extensions:
  1. A small-scale open economy model that includes exchange rate and the current account in the set of observables (**Lubik and Schorfheide 2007, LS**)
  2. A medium-scale open economy model that also includes foreign sector variables in the set of observables (**Justiniano and Preston 2010, JP**)

- Analyze their out-of-sample performance using:
  1. Data for AUS, CAD and UK over years 1995-2013
  2. Monte Carlo experiment

Forecasting competition design

JP+ model

Model:	Justiniano and Preston (2010, JAE) extended for CA balance shock
Structure:	Households optimizing utility; Firms maximizing profits; Local currency pricing; UIP with risk premium; CB follows Taylor rule
Rigidities:	Habits in consumption, price stickiness with indexation, Incomplete int. financial markets
Shocks:	Productivity, import markups, household preferences, int. risk premium, CA balance, monetary + foreign block shocks (output, inflation and IR)
Estimation:	Bayesian setup, priors as in Justiniano and Preston (2010)
Observables:	output, inflation, 3M interest rate – all three at home and abroad real exchange rate, terms of trade, CA balance

Other models

JP model: JP+ model without CA shock so that the model is identical to the original model of Justiniano and Preston (2010)

LS model: JP model without shocks to preferences, import markups and ER risk premium. Important! foreign variables are treated as unobservable. Setup closely resembles model by Lubik and Schorfheide (2007)

NK model: Openness parameter at 0 so that we have 3-equation closed economy setup:

$$y_t = \frac{1}{1+h}\mathbb{E}_t y_{t+1} + \frac{h}{1+h}y_{t-1} - \frac{1-h}{\sigma(1+h)}(i_t - \mathbb{E}_t\pi_{t+1} - g_t + \mathbb{E}_t g_{t+1})$$

$$\pi_t = \frac{\beta}{1+\beta\delta_H}\mathbb{E}_t\pi_{t+1} + \frac{\delta_H}{1+\beta\delta_H}\pi_{t-1} + \frac{(1-\theta_H)(1-\beta\theta_H)}{\theta_H(1+\beta\delta_H)}mc_t$$

$$i_t = \rho_i i_{t-1} + \psi_\pi\pi_t + \psi_y y_t + \psi_{\Delta y}(y_t - y_{t-1}) + m_t$$

Prior for steady-state inflation

A critique of DSGE models in the context of inflation forecasting in Faust and Wright (2013) is that its good ex-post performance can be attributed to a tight prior imposed on steady-state inflation:

part of the advantage of the DSGE model [in inflation forecasting] stems from use of a prior specified in light of the full estimation sample -- a prior that probably was at odds with what most agents actually expected at the time

We use uninformative (uniform) prior for steady-state inflation

Data and forecast evaluation sample

Three countries: UK, CAN, AUS

Observables: Δgdp and Δgdp^*; Δcpi and Δcpi^*; i_{3M} and i^*_{3M}; $\frac{CA}{GDP}$; Δrer, Δtot

Sample: 1975:1 -2013:4

Forecast evaluation: 1995:1-2013:4 (76 obs. for 1q ahead fcsts, 65 for 12q ahead fcsts)

Forecasting scheme: recursive

Weights for foreign variables based on BIS EER indices:

	Australia	Canada	UK	US	euro area	Japan	Coverage
Australia	.	2.4	8.8	32.5	30.2	26.1	74.3
Canada	0.3	.	2.5	81.5	9.6	6.1	90.8
UK	1.0	2.0	.	18.5	70.9	7.5	91.9

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Results

Point forecasts: RMSFE

General picture:

1. None of analyzed NOEM models can consistently beat NK benchmark

2. Whenever the RMSFE ratios are statistically signicant, they usually point at NK model as the preferred forecasting tool

Table 1: Root Mean Squared Forecast Error (RMSFE) for DSGE models

Horizon	**United Kingdom**			**Canada**			**Australia**		
	LS	JP	JP+	LS	JP	JP+	LS	JP	JP+
	Output								
1	1.27*	1.11***	1.13***	1.43**	1.21*	1.08**	1.03	1.07***	1.17***
2	1.23*	1.12***	1.15***	1.24**	1.13	1.02	1.03	1.07**	1.24***
4	1.16**	1.08***	1.14***	1.12	1.13**	0.97	0.97	1.08***	1.25***
6	1.14**	1.07***	1.13***	1.03	1.13***	0.95	0.89	1.09***	1.19***
8	1.13**	1.07***	1.12***	0.99	1.12***	0.94	0.82**	1.08***	1.10***
12	1.11	1.07***	1.09***	0.91	1.10***	0.92**	0.72***	1.08***	0.98
	Prices								
1	1.19**	1.06	1.12***	1.21*	0.91	1.06*	1.04	1.03	1.07*
2	1.28**	1.00	1.20***	1.32*	0.89	1.13**	1.06	1.05	1.09*
4	1.33**	0.93	1.30***	1.56**	0.89	1.26**	1.05	1.06	1.11
6	1.34**	0.90	1.36***	1.82**	0.94	1.41***	1.03	1.08	1.09
8	1.30**	0.89	1.37***	1.94**	0.98	1.54***	1.01	1.09	1.04
12	1.22**	0.90	1.40***	2.22**	1.06	1.82***	1.05	1.11*	0.98
	Interest rates								
1	1.33*	0.86**	0.91	1.13	0.99	0.98	1.01	1.04	1.15
2	1.30*	0.85***	0.95	1.16	0.95	1.05	0.94	1.09*	1.17
4	1.28**	0.89***	1.06	1.21	0.96	1.16***	1.00	1.14**	1.21**
6	1.28**	0.95	1.20*	1.21	0.95	1.22***	1.09	1.18***	1.23***
8	1.26**	0.97	1.29**	1.18	0.92	1.27***	1.20	1.22***	1.21***
12	1.25***	0.99	1.45***	1.15	0.86*	1.35***	1.37**	1.26***	1.18***

Notes: The figures in the table represent the ratios of the RMSFE from a given model in comparison to the NK benchmark so that the values below unity indicate that forecasts from a given NOEM variant are more accurate than from the benchmark. Asterisks ***, ** and * denote, respectively, the 1%, 5% and 10% significance levels of the two-tailed Diebold-Mariano test, where the long-run variance is calculated with the Newey-West method.

Density forecasts: log predictive scores (LPS)

LPS calculated with the method proposed by Adolfson et al. (2007)

General picture:

1. Similar to RMSFE results

2. For multivariate density forecasts (3 domestic vars.) :

   NOEM indistinguishable from, or significantly worse than closed economy benchmark

Table 2: Log Predictive Scores (LPS) for DSGE models

Horizon	United Kingdom			Canada			Australia		
	LS	JP	JP+	LS	JP	JP+	LS	JP	JP+
	Output								
1	-0.15***	-0.07***	-0.08***	-0.35***	-0.18*	-0.06	0.00	-0.06***	-0.09***
2	-0.14*	-0.06	-0.08***	-0.25**	-0.10	0.00	0.01	-0.06***	-0.12***
4	-0.16	-0.10	-0.12***	-0.20	-0.11*	0.02	0.05	-0.06***	-0.19***
6	-0.21*	-0.17	-0.16***	-0.17	-0.16*	0.02	0.09	-0.07***	-0.24***
8	-0.26**	-0.24	-0.20***	-0.21	-0.21**	0.01	0.13**	-0.08***	-0.28**
12	-0.37***	-0.37***	-0.29***	-0.13	-0.30**	-0.01	0.19***	-0.12***	-0.31**
	Prices								
1	-0.13***	-0.24***	-0.03***	-0.13	-0.04	-0.07**	-0.18***	-0.07***	-0.07***
2	-0.07***	-0.05***	-0.01*	-0.17	0.00	-0.10***	-0.16***	-0.05***	-0.09***
4	0.00	0.14***	-0.01	-0.21**	0.08*	-0.13***	-0.15***	-0.04**	-0.11***
6	0.03	0.22***	-0.02	-0.24**	0.13***	-0.14***	-0.17***	-0.04**	-0.11***
8	0.04	0.26***	-0.04	-0.23**	0.16***	-0.15***	-0.19***	-0.05**	-0.09***
12	0.07*	0.27***	-0.09	-0.21**	0.19***	-0.19***	-0.27***	-0.06**	-0.08**
	Interest rates								
1	-0.13***	-0.06***	-0.03***	-0.06*	-0.04**	-0.02	0.04**	-0.04***	-0.03*
2	-0.13***	-0.04**	-0.02	-0.05	-0.02	-0.03	0.03**	-0.05***	-0.03
4	-0.11*	0.01	-0.02	-0.04	0.02	-0.05	-0.02	-0.06***	-0.06***
6	-0.09	0.03	-0.06	-0.05	0.05***	-0.09**	-0.09***	-0.07***	-0.07***
8	-0.06	0.04*	-0.09*	-0.04	0.08***	-0.11***	-0.15***	-0.08***	-0.07***
12	-0.03	0.05**	-0.15***	-0.02	0.13***	-0.14***	-0.26***	-0.10***	-0.06**
	Three variables								
1	-0.44***	-0.31***	-0.11***	-0.59***	-0.31**	-0.17***	-0.13***	-0.15***	-0.17***
2	-0.41**	-0.09***	-0.06**	-0.66***	-0.23**	-0.11	-0.13**	-0.12***	-0.24***
4	-0.43	0.02	-0.04	-0.85***	-0.18**	0.01	-0.16**	-0.13***	-0.35***
6	-0.46	-0.01	-0.06	-0.90***	-0.18**	0.10	-0.20**	-0.15***	-0.43***
8	-0.47	-0.05	-0.08	-0.86***	-0.17**	0.16	-0.24***	-0.16***	-0.47***
12	-0.49	-0.16	-0.15*	-0.50	-0.16*	0.23*	-0.36***	-0.21***	-0.50***

Notes: The figures in the table represent the differences of the LPS from a given model in comparison to the NK benchmark so that positive values indicate that forecasts from a given NOEM variant are more accurate than from the benchmark. Asterisks ***, ** and * denote, respectively, the 1%, 5% and 10% significance levels of the two-tailed Amisano and Giacomini (2007) test, where the long-run variance is calculated with the Newey-West method.

Discussion

Discussion

Why NOEM models might generate more accurate forecasts?

1. Economic reason:
   a richer specification might better describe DGP
2. Econometric reason:
   the information set used estimation is extended for
   six (JP+), five (JP) or two (LS) variables

Why NOEM models might potentially generate less accurate forecasts?

1. NOEM models (especially foreign block) are misspeciffied
2. Extended models contain larger number of estimated parameters, which inflates estimation forecast error
3. Prior for NOEM is centered on wrong values

BVAR check

Does using additional data compensate for the estimation forecast error?

- Similar comparison for BVAR models that differ in number of observables (NK, LS, JP and JP+)
- Models estimated on the same set of data as DSGE models (in levels)
- Standard Normal-Wishart prior, overall tightness at 0.2 and decay at 1

General finding:

Once again, NK BVAR performs best

similar to the study by Gurkaynak, Kisacikoglu and Rossi (2013):
low-dimensional VAR competitive in forecasting the US economy

Table 3: Root Mean Squared Forecast Error for BVAR models

Horizon	United Kingdom			Canada			Australia		
	LS	JP	JP+	LS	JP	JP+	LS	JP	JP+
	Output								
1	1.04	1.00	1.00	1.08	1.07	1.08	1.14***	1.13***	1.18***
2	1.03	0.97	0.97	1.09	1.11	1.17*	1.27***	1.23***	1.27***
4	1.05	0.95	0.96	1.05	1.14	1.23	1.39***	1.31***	1.40***
6	1.08	0.96	0.96	0.96	1.11	1.13	1.48***	1.33***	1.50***
8	1.11	1.00	0.98	0.92	1.08	1.07	1.51***	1.29**	1.54***
12	1.19**	1.15	1.10	0.91	1.02	1.00	1.46***	1.14	1.41**
	Prices								
1	0.92	0.83**	0.78**	1.05*	1.03	1.06	1.02	0.99	1.11
2	0.91	0.82**	0.75**	1.09*	1.07	1.12*	1.02	0.97	1.15
4	0.91	0.81**	0.70**	1.15	1.14	1.20**	0.99	0.94	1.08
6	0.93	0.84**	0.68**	1.22	1.22	1.30**	0.95	0.90	1.07
8	0.96	0.91	0.72**	1.30	1.32*	1.43**	0.94	0.90	1.12
12	1.03	1.03	0.82*	1.46	1.50*	1.64*	1.00	0.99	1.29
	Interest rates								
1	1.14*	1.06	1.07	1.13	1.01	1.05	1.00	0.99	1.12
2	1.15	1.12	1.11	1.18	1.01	1.10	1.05	1.05	1.21
4	1.14	1.20	1.08	1.25	1.06	1.20	1.15	1.15	1.24
6	1.22	1.33*	1.15	1.28	1.15	1.29	1.22	1.25	1.29
8	1.27	1.42*	1.19	1.28	1.20	1.34	1.27*	1.34*	1.48***
12	1.30*	1.47**	1.20*	1.17	1.17	1.30	1.41**	1.59***	1.92***

Notes: The figures in the table represent the ratios of the RMSFE from a given model in comparison to the NK (3-variable) benchmark so that the values below unity indicate that forecasts from a given open economy BVAR variant are more accurate than from the benchmark. Asterisks ***, ** and * denote, respectively, the 1%, 5% and 10% significance levels of the two-tailed Diebold-Mariano test, where the long-run variance is calculated with the Newey-West method.

Monte Carlo

How much we gain if JP+ is true DGP and we center priors at correct values?

- MC experiment, N=100, T=156 (1975:1-2013:4)
- DGP: JP+ model, parameters set to reflect CAD moments
- Forecast evaluation: as in the empirical study (1995:1-2013:4)
- Comparison of JP+ (priors centered at DGP) and NK, using RMSFE

General findings:

- Forecast esimation error is large enough to roughly offset potential gains from better specication and correct priors in JP+

Table 7: Relative RMSFE of JP+ versus NK - Monte Carlo experiment

	H=1	H=2	H=4	H=6	H=8	H=12
	Output					
Median value	0.95	0.95	0.95	0.95	0.94	0.95
Fraction of <1	0.98	0.89	0.81	0.83	0.8	0.74
Fraction of signif. <1	0.29	0.3	0.26	0.25	0.27	0.26
	Price level					
Median value	0.99	0.98	0.97	0.97	0.97	0.97
Fraction of <1	0.78	0.79	0.78	0.75	0.7	0.69
Fraction of signif. <1	0.11	0.13	0.12	0.16	0.16	0.18
	Interest rate					
Median value	0.99	0.97	0.97	0.97	0.98	0.98
Fraction of <1	0.78	0.77	0.75	0.68	0.65	0.63
Fraction of signif. <1	0.1	0.13	0.15	0.15	0.13	0.11

Notes: This table presents the RMSFE statistics of the JP+ model relative to the NK model obtained in a Monte Carlo experiment in which the data are generated from the JP+ model with fixed parameters. The significance of differences in the RMSFEs is evaluated with the Diebold-Mariano test at 5% significance level.

Conclusions

Conclusions

1. Adding foreign sector to NK DSGE model does not improve or even deteriorates forecasts of domestic variables for AUS, CAD, UK

2. Similar result holds for BVARs

3. Monte Carlo experiment shows that this can be due to increased estimation error (but misspecification may also play a role)

4. DSGE models are not used just to generate forecasts, but also for simulations. The presence of the foreign block may be highly desired. Still, awareness of possible consequences of including open economy variables for forecast quality is important

THANK YOU VERY MUCH FOR YOUR ATTENTION