Nowcasting 'True' Monthly US GDP During the Pandemic

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Introduction

- Main goal of the paper
  - To produce nowcasts of "true" *GDP* at the monthly frequency during the pandemic period
  - Available data: Two noisy measures of *GDP*: Income and expenditure side *GDP*
  - GDP_I and GDP_E available at the quarterly frequency
  - This paper builds on our earlier work **'Reconciled Estimates of Monthly GDP in the US'** (see ESCoE discussion paper series 2020-16)
- Econometric Model
  - Bayesian Mixed Frequency State Space VAR model with ADNSS measurement error restrictions

- We do this by combining ADNSS and SS
  - ADNSS = Aruoba, Diebold, Nalewaik, Schorfheide and Song. Improving GDP measurement: A measurement-error perspective. Journal of Econometrics, 2016.
  - SS = Schorfheide and Song. Real-time forecasting with a mixed-frequency VAR. JBES, 2015.
  - Our econometric model is a restricted Mixed Frequency Vector Autoregression (MF-VAR) where restrictions reflect measurement error perspective of ADNSS

Review of Economics 101

- What is GDPE?
  - The expenditure approach - the total value of goods and services produced by a country. $Y = C+I+G+(X-M)$
  - This what most empirical macroeconomist use in the literature
- What is GDPI?
  - The income approach - A measure of economic activity based on incomes.
  - GDPI = compensation of employees + gross operating surplus + gross mixed income + taxes less subsidies on production and imports
  - In theory, GDPI should be equal to GDPE, the different source data yield different results and this is due to measurement error.
  - Nalewaik (2010) shows that GDPI is a better early predictor of a recession than GDPE

Writing the ADNSS Model as a Mixed Frequency VAR

- Following our previous work, we rewrite the original ADNSS model in terms of a mixed frequency VAR (KMMP)

$$Ay_t = By_{t-1} + \epsilon_t, \epsilon_t \sim N(0, \Sigma), \tag{1}$$

- where $t = 1, \ldots, T$ is time at the monthly frequency
- $y_t = (X_t', U_t, GDP_t, GDP_{Et}, GDP_{It})'$
- X_t and U_t are other monthly economic indicators (following SS) and the monthly unemployment rate
- Both GDP_{Et} and GDP_{It} are observed at the quarterly frequency
- True GDP_t is an unobserved latent variable in the model
- We need to impose identification in A and we imposed the noise restriction. This specification ensures that the volatility of true GDP is less than the volatility of GDP_E or GDP_I.

- In our original KMMP model, we assumed homoskedastic errors but we relax this assumption for the pandemic period:

$$\epsilon_{i,t} \sim N(0, \lambda_{i,t} e^{h_{i,t}}), \tag{2}$$

$$h_{i,t} = h_{i,t-1} + v_{i,t}, v_{i,t} \sim N(0, \sigma^2_{h_{i,t}}),$$

- We make 3 assumptions about about $\lambda_{i,t}$:
  1. $\lambda_{i,t} = 1$ - SV errors.
  2. $\lambda_{i,t}|\nu_i \sim IG(\nu_i/2, \nu_i/2)$ - Fat-tails SV errors.
  3. $\lambda_{i,t} \sim U(2, 10)$ with probability of (p) and
     $\lambda_{i,t} = 1$ with probability of $(1-p)$ - SV outlier-adjusted errors of Stock and Watson (2016).

- We also consider (2) and (3) without SV.

Table 5. Properties of true gross domestic product predictive densities for 2020Q2: models without stochastic volatility, parameters estimated in real-time

Data vintage	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
		KMMP				KMMP-fat tails				KMMP-outliers		
Dec-19	2.52	8.30	−0.01	3.00	2.53	8.26	0.01	4.06	2.43	13.08	0.13	16.91
Jan-20	2.48	8.07	0.01	2.99	2.59	7.26	0.01	3.97	2.52	11.40	0.13	16.75
Feb-20	2.33	7.61	−0.01	3.02	2.37	6.82	0.00	3.86	2.41	12.42	0.24	28.09
Mar-20	−0.36	7.62	0.00	3.00	−0.93	16.25	−0.18	5.82	−1.13	13.97	−0.01	16.21
Apr-20	−20.16	14.04	−0.02	2.99	−19.00	28.51	−0.40	4.63	−18.32	25.17	−1.12	11.39
May-20	−39.52	32.70	0.14	3.14	−29.03	25.15	−0.12	3.26	−33.95	64.95	−0.43	3.85
Jun-20	−32.66	15.49	0.26	3.33	−16.70	91.84	1.03	3.43	−21.15	73.72	0.15	4.08
Jul-20	−38.95	1.64	0.15	3.09	−36.91	2.60	0.17	2.91	−37.55	2.47	0.30	3.19
Aug-20	−39.27	0.02	0.12	4.15	−39.03	0.01	0.12	4.89	−39.25	0.04	−1.01	9.88

Table 7. Properties of true gross domestic product predictive densities for 2020Q2: models include stochastic volatility (SV), parameters estimated in real-time

	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
Data vintage	KMMP-SV				KMMP-SV-fat tails				KMMP-SV-outliers			
Dec-19	2.59	6.52	0.01	3.11	2.64	6.98	−0.01	3.76	2.58	10.23	0.00	16.43
Jan-20	2.53	6.13	−0.01	3.09	2.54	6.09	0.09	3.90	2.65	9.88	1.01	30.12
Feb-20	2.11	5.91	0.00	3.11	2.14	5.94	−0.01	3.55	2.24	10.10	0.27	21.06
Mar-20	0.60	8.34	−0.04	3.25	0.39	10.10	−0.06	4.65	0.37	15.56	−0.03	13.74
Apr-20	−15.35	22.24	0.16	3.73	−16.77	23.28	−0.22	3.50	−17.81	41.16	−0.64	10.27
May-20	−14.29	20.28	0.02	3.04	−25.90	26.16	−0.06	3.20	−29.07	60.27	−0.64	5.80
Jun-20	−167.52	3200.84	−0.54	4.88	−12.45	125.95	1.03	3.20	−19.85	102.76	0.73	5.46
Jul-20	−36.06	3.51	0.44	3.42	−36.47	2.99	0.18	2.92	−36.94	3.33	0.25	3.04
Aug-20	−39.15	0.02	−0.42	2.66	−39.20	0.02	−0.11	2.77	−39.20	0.03	−0.02	4.33

Table 9. Properties of true gross domestic product predictive densities for 2020Q3: models without stochastic volatility, parameters estimated in real-time

Data vintage	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
	KMMP				KMMP-fat tails				KMMP-outliers			
Dec-19	2.33	8.67	0.00	3.05	2.29	9.02	0.03	4.51	2.16	14.19	0.36	19.95
Jan-20	2.38	8.59	−0.01	3.06	2.54	7.78	−0.05	4.15	2.34	12.13	−0.11	10.34
Feb-20	2.55	8.49	0.00	3.03	2.58	7.60	−0.05	4.01	2.50	14.44	0.18	21.79
Mar-20	−1.27	9.54	−0.01	3.04	−1.96	33.66	−0.59	8.18	−2.40	21.61	−0.13	9.39
Apr-20	−18.73	32.18	−0.06	3.02	−14.60	107.24	−0.20	4.23	−15.36	61.82	−0.12	4.74
May-20	−44.96	65.80	−0.22	3.14	−22.05	99.46	−0.17	4.12	−22.29	63.50	−0.27	5.43
Jun-20	−17.34	17.08	0.02	3.08	−12.24	28.53	−0.19	3.77	−15.79	33.39	0.37	12.44
Jul-20	2.35	13.60	0.14	3.07	−1.49	43.99	−0.13	4.35	−9.74	105.76	−1.18	7.91
Aug-20	14.24	12.39	−0.07	3.01	−0.85	18.46	−0.08	3.27	5.93	36.14	−0.41	6.20
Sep-20	16.38	11.36	−0.07	2.95	5.20	24.33	−0.32	3.13	−2.93	38.82	0.66	3.46
Oct-20	26.37	1.71	−0.11	3.08	26.72	1.44	−0.14	3.08	27.05	1.79	−0.18	3.34

Table 11. Properties of true gross domestic product predictive densities for 2020Q3: models include stochastic volatility (SV), parameters estimated in real-time

Data vintage	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
	KMMP-SV				KMMP-SV-fat tails				KMMP-SV-outliers			
Dec-19	2.50	6.82	−0.02	3.05	2.49	7.42	0.02	3.78	2.45	11.14	0.53	23.24
Jan-20	2.51	6.58	−0.02	3.13	2.47	6.23	0.07	4.11	2.51	10.06	−0.55	32.17
Feb-20	2.35	6.29	0.01	3.16	2.37	6.10	−0.05	3.75	2.45	10.89	0.14	23.59
Mar-20	0.30	12.39	−0.20	4.11	0.01	14.52	−0.22	4.36	0.13	23.04	0.21	9.89
Apr-20	−6.78	47.59	−0.13	4.13	−9.36	70.57	−0.22	3.77	−8.94	108.74	−0.22	6.72
May-20	−13.18	49.75	−0.13	3.48	−18.99	109.60	−0.11	3.91	−15.85	102.83	−0.17	6.24
Jun-20	−75.15	8239.47	−0.12	5.52	−8.78	30.65	−0.12	3.66	−10.79	86.00	−0.11	10.70
Jul-20	−1.35	65.31	0.11	3.27	4.35	51.31	0.03	3.24	−0.87	116.19	−0.99	9.51
Aug-20	−1.78	41.87	−0.01	3.02	5.93	26.06	−0.10	3.22	−2.07	72.49	−0.78	8.02
Sep-20	4.51	32.13	−0.05	2.91	7.29	26.38	−0.34	3.19	0.78	64.91	−0.88	5.30
Oct-20	26.67	1.54	−0.11	3.12	26.89	1.39	−0.04	3.17	27.21	1.85	−0.11	3.27

Empirical Results - April 2021 vintage

Time	KMMP	Phil Fed. GDPplus	GDPE	GDPI
2020 - May	-27.26			
2020 - June	**-35.91**	**-14.48**	**-37.66**	**-39.43**
2020 - July	-29.94			
2020 - August	5.21			
2020 - September	**22.31**	**9.37**	**28.85**	**21.58**
2020 - October	26.84			
2020 - November	14.87			
2020 - December	**10.30**	**11.38**	**4.23**	**14.62**
2021 - January	7.99			
2021 February	7.62			
2021 - March	**5.94**	**7.42**	**6.19**	-

Conclusion

- We extend our original KMMP model via various different error specifications to accommodate the pandemic period.
- We find that the original KMMP model (with homoskedastic errors) is fairly robust in producing nowcasts of True GDP during the pandemic period.
  - This could be due to the measurement error restriction of the ADNSS that we imposed in our model.
  - This evident when we compare our estimates to the Philadelphia Fed GDPplus estimates.
- We find for our KMMP model with heteroskedastic errors, the nowcast's predictive variances are considerably larger during the pandemic period.

Questions

- Thank you for listening to my presentation and this paper will be published in the upcoming special issue by the National Institute Economic Review.

- Please check my personal website, https://sites.google.com/view/aubreybcpoon/home, for the latest monthly 'True' GDP estimates for the US.