Real-time Forecasts of State and Local Government Budgets with an Application to the COVID-19 Pandemic

Online Appendix*

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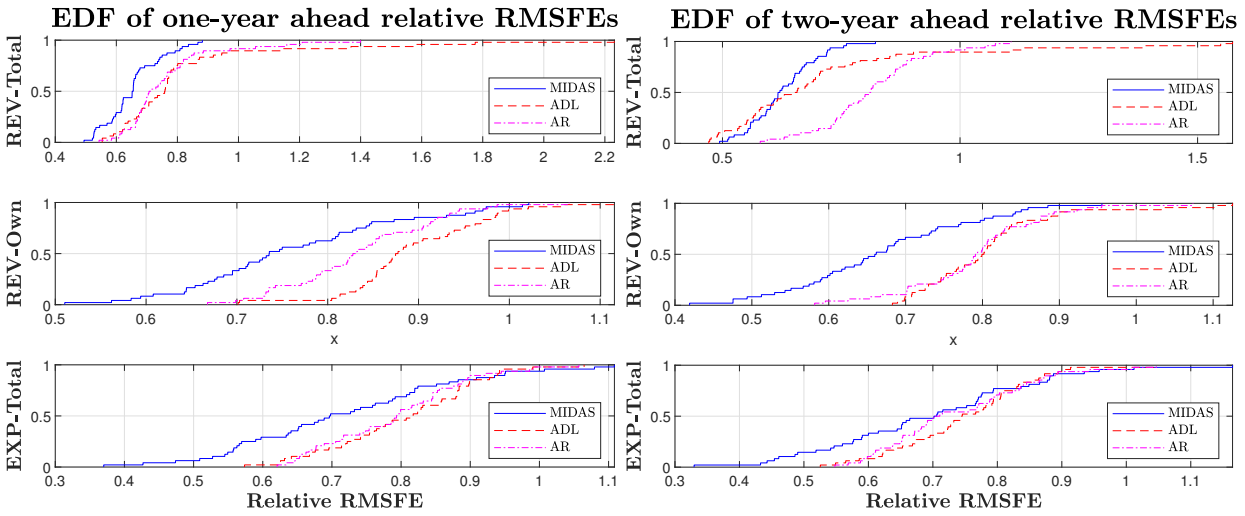
OA Online Appendix

OA.1 Additional relative out-of-sample forecast results



(a) One-year ahead relative RMSFEs **(b)** Two-year ahead relative RMSFEs

Figure OA.1.1: Empirical distribution function of the relative RMSFEs from the forecasts

The figure displays the empirical distribution function (EDF) of the root mean squared forecast error (RMSFE) of the MIDAS model from equation (1), as well as the autoregressive model (denoted by "AR" and represented by equation (3)) and the autoregressive distributed lag model (denoted by "ADL" and represented by equation (4)), relative to the RMSFE of a random walk (RW) model, represented by equation (2), for the one- and two-year ahead forecasts of state government revenues and expenditures. Here, each model is estimated following the procedure described in Section III. The figures on the lefthand side report the results for one-year ahead forecasts, while the figures on the righthand side report the results for two-year ahead forecasts. The top row displays the results for total revenue growth (denoted by "REV-Total"), the middle row displays the results for own source revenue growth (denoted by "REV-Own"), and the bottom row displays the results for total expenditure growth (denoted by "EXP-Total"). Points in each figure represent the state-specific relative RMSFEs associated with each model (ordered from the smallest relative RMSFE to the largest relative RMSFE), and the horizontal axis in each figure presents the percentiles of each empirical distribution function.

Table OA.1.1: Forecast results by state

The table reports the forecast performance of the ADL-MIDAS models for predicting the growth rates of each state government's total revenues (denoted by "REV-Total"), own source revenues (denoted by "REV-Own"), and total expenditures (denoted by "EXP-Total") on a state-by-state basis. Panel A reports the median value of the root mean squared forecast error (RMSFE) from the ADL-MIDAS model, represented by equation (1) and denoted by "MIDAS," relative to the RMSFE of a random walk (RW), represented by equation (2), for the one- and two-year ahead forecasts of each fiscal variable. Panel A also reports the RMSFEs of the autoregressive distributed lag (denoted by "ADL") and autoregressive (denoted by "AR") models relative to the RMSFEs of a RW. In Panel B, $p5$, $p10$, $p25$, $p75$, $p90$, and $p95$ refer to the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles of the distribution of relative RMSFEs across states, respectively. Here, each model is estimated following the procedure for single-equation models described in Section III.

	REV-Total						REV-Own						EXP-Total					
	MIDAS		ADL		AR		MIDAS		ADL		AR		MIDAS		ADL		AR	
$h =$	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Panel A: RMSFEs Relative to Random Walk																		
Alabama	0.59	0.65	0.63	0.69	0.66	0.79	0.81	0.69	0.87	0.70	0.79	0.74	0.57	0.64	0.68	0.73	0.63	0.84
Arizona	0.66	0.59	0.73	0.62	0.70	0.82	0.87	0.85	0.84	0.89	0.79	0.78	0.95	0.88	0.86	0.83	0.85	0.82
Arkansas	0.57	0.58	0.71	0.56	0.68	0.81	0.85	0.60	0.96	0.75	0.83	0.80	0.81	0.70	0.82	0.67	0.89	0.65
California	0.87	0.70	1.37	1.13	1.06	1.05	0.79	0.53	0.92	0.83	0.82	0.75	0.91	1.16	0.72	0.83	0.78	0.76
Colorado	0.74	0.72	0.97	0.85	0.88	0.86	1.02	0.64	1.06	0.85	0.80	0.96	0.64	0.43	0.75	0.59	0.68	0.59
Connecticut	0.66	0.63	0.76	0.61	0.69	0.75	0.97	0.70	0.99	0.79	0.95	0.81	0.82	0.85	0.76	0.75	0.80	1.01
Delaware	0.62	0.64	0.72	0.53	0.70	0.64	0.81	0.81	0.87	0.82	0.94	0.83	0.70	0.71	0.70	0.56	0.71	0.69
Florida	0.66	0.62	0.77	0.69	0.79	0.82	0.70	0.68	0.94	0.81	0.79	0.70	0.88	0.79	0.88	0.91	0.81	0.87
Georgia	0.52	0.49	0.58	0.50	0.54	0.80	0.71	0.66	0.95	0.72	0.82	0.76	0.56	0.65	0.81	0.79	0.66	0.65
Idaho	0.53	0.52	0.62	0.49	0.62	0.81	0.61	0.48	0.98	0.75	0.85	0.80	0.59	0.62	0.71	0.69	0.69	0.57
Illinois	0.79	0.72	0.92	0.86	0.85	1.01	0.83	0.42	0.97	0.80	0.87	0.87	0.56	0.77	0.64	0.71	0.65	0.69
Indiana	0.65	0.62	0.75	0.59	0.68	0.59	0.73	0.72	0.83	0.69	0.77	0.77	0.85	0.88	0.79	0.63	0.66	0.71
Iowa	0.69	0.61	0.80	0.66	0.82	0.87	0.64	0.55	0.87	0.78	0.79	0.71	0.94	0.89	0.79	0.81	0.82	0.84
Kansas	0.53	0.63	0.55	0.70	0.61	0.74	0.51	0.66	0.70	0.82	0.71	0.78	0.79	0.52	0.93	0.77	0.89	0.61
Kentucky	0.59	0.62	0.59	0.47	0.69	0.74	0.58	0.57	0.84	0.76	0.73	0.81	0.65	0.66	0.86	0.62	0.83	0.61
Louisiana	0.65	0.56	0.68	0.55	0.62	0.79	0.93	0.89	0.99	0.88	0.92	0.88	1.08	0.96	0.94	0.78	0.99	0.87
Maine	0.55	0.59	0.65	0.48	0.68	0.69	0.73	0.69	0.85	0.71	0.85	0.70	0.76	0.84	0.88	1.04	0.94	1.05
Maryland	0.60	0.59	0.64	0.55	0.70	0.73	0.71	0.77	0.82	0.74	0.70	0.76	0.66	0.55	0.90	0.79	0.80	0.67
Massachusetts	0.62	0.58	0.68	0.55	0.66	0.89	0.84	0.49	1.00	0.73	0.93	0.81	0.60	0.79	0.63	0.72	0.65	0.83
Michigan	0.62	0.60	0.63	0.63	0.67	0.58	0.64	0.59	0.81	0.71	0.73	0.60	0.78	0.77	0.99	0.65	0.90	0.65
Minnesota	0.74	0.66	0.86	0.79	0.84	0.92	0.74	0.61	0.88	0.73	0.86	0.86	0.64	0.44	0.73	0.67	0.72	0.64
Mississippi	0.53	0.51	0.55	0.49	0.58	0.76	0.56	0.60	0.81	0.75	0.74	0.79	1.11	0.77	0.88	0.81	0.84	0.79
Missouri	0.81	0.67	0.95	0.82	0.85	0.94	0.78	0.69	0.90	0.81	0.89	0.82	0.63	0.59	0.81	0.79	0.79	0.69
Montana	0.62	0.60	0.70	0.68	0.66	0.89	0.67	0.74	0.85	0.84	0.81	0.83	1.01	0.56	0.94	0.77	0.86	0.64
Nebraska	0.59	0.60	0.68	0.54	0.65	0.76	0.85	0.65	0.93	0.79	0.99	0.79	0.53	0.58	0.86	0.74	0.87	0.70
Nevada	0.77	0.70	0.87	0.76	0.81	0.94	0.96	0.84	0.93	0.81	0.91	0.82	0.73	0.66	0.77	0.62	0.85	0.60

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Table OA.1.1 – Continued from the previous page

	REV-Total						REV-Own						EXP-Total					
	MIDAS		ADL		AR		MIDAS		ADL		AR		MIDAS		ADL		AR	
$h=$	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
New Hampshire	0.53	0.55	0.61	0.57	0.61	0.66	0.59	0.51	0.70	0.78	0.67	0.70	0.37	0.49	0.67	0.80	0.71	0.71
New Jersey	0.53	0.56	0.67	0.57	0.68	0.74	0.77	0.59	0.88	0.75	0.82	0.78	0.47	0.93	0.67	0.81	0.72	0.89
New Mexico	0.65	0.61	0.77	0.66	0.77	0.84	0.65	0.64	0.86	0.81	0.73	0.79	0.95	0.74	0.88	0.73	0.85	0.77
New York	0.84	0.68	1.14	1.11	0.97	0.85	0.90	0.80	0.88	0.77	0.92	0.88	0.76	0.77	0.83	0.78	0.79	0.70
North Carolina	0.66	0.67	0.71	0.67	0.75	0.85	0.70	0.68	0.84	0.83	0.84	0.70	0.81	0.77	0.93	0.86	0.82	0.80
North Dakota	0.67	0.55	0.76	0.77	0.73	0.81	0.70	0.62	0.90	1.03	0.84	0.89	0.82	0.88	0.94	0.90	0.90	0.94
Ohio	0.88	0.76	1.58	1.39	1.16	1.07	1.01	0.63	1.12	0.91	1.07	0.92	0.68	0.45	0.90	0.74	0.92	0.68
Oklahoma	0.60	0.55	0.67	0.47	0.71	0.77	0.68	0.62	0.85	0.82	0.73	0.88	0.55	0.33	0.88	0.67	0.75	0.59
Oregon	0.82	0.73	1.78	1.55	1.21	1.11	0.68	0.48	0.80	0.70	0.73	0.79	0.55	1.01	0.62	0.84	0.62	0.87
Pennsylvania	0.68	0.67	0.78	0.73	0.77	0.86	0.75	0.80	0.87	0.84	0.78	0.67	0.82	0.65	0.74	0.70	0.75	0.65
Rhode Island	0.66	0.65	0.80	0.70	0.80	0.90	0.71	0.58	0.86	0.68	0.91	0.79	0.65	0.75	0.76	0.72	0.67	0.68
South Carolina	0.62	0.65	0.63	0.58	0.67	0.73	0.83	0.77	0.84	0.90	0.83	0.83	0.67	0.54	1.06	0.86	0.99	0.80
South Dakota	0.66	0.75	0.77	0.61	0.70	0.76	0.64	0.73	0.85	0.90	0.86	0.63	0.73	0.60	0.83	0.64	0.79	0.55
Tennessee	0.66	0.62	0.76	0.57	0.74	0.82	0.73	0.68	0.89	0.80	0.82	0.80	0.74	0.78	0.90	0.89	0.85	0.79
Texas	0.49	0.51	0.79	0.58	0.71	0.80	0.66	0.57	1.02	0.80	0.91	0.86	0.70	0.59	0.83	0.73	0.88	0.79
Utah	0.62	0.65	0.73	0.71	0.74	0.78	0.75	0.65	0.85	0.77	0.85	0.65	0.57	0.58	0.57	0.55	0.65	0.67
Vermont	0.62	0.56	0.77	0.62	0.76	0.63	0.80	0.54	0.87	0.84	0.82	0.58	0.79	0.72	0.82	0.87	0.74	0.77
Virginia	0.67	0.65	0.78	0.71	0.76	0.86	0.95	0.74	0.95	0.82	0.90	0.75	0.51	0.71	0.74	0.82	0.68	0.85
Washington	0.66	0.56	0.77	0.65	0.70	0.88	0.74	0.73	0.89	0.73	0.78	0.81	0.43	0.46	0.63	0.53	0.75	0.60
West Virginia	0.75	0.69	0.76	0.70	0.81	0.70	0.97	0.86	0.99	1.10	0.93	1.07	0.56	0.49	0.72	0.61	0.79	0.62
Wisconsin	0.73	0.82	2.23	1.57	1.40	0.98	0.69	0.84	0.86	0.79	0.83	0.93	0.69	0.87	0.88	0.87	1.06	0.89
Wyoming	0.73	0.72	0.87	0.90	0.82	0.75	0.81	0.96	0.97	1.13	0.98	0.77	0.87	0.65	0.78	0.72	0.79	0.77
Panel B: Summary Statistics for Relative RMSFE																		
Minimum	0.49	0.49	0.55	0.47	0.54	0.58	0.51	0.42	0.70	0.68	0.67	0.58	0.37	0.33	0.57	0.53	0.62	0.55
$p5$	0.53	0.51	0.57	0.48	0.61	0.63	0.58	0.48	0.79	0.70	0.71	0.62	0.47	0.44	0.63	0.56	0.65	0.59
$p10$	0.53	0.55	0.61	0.50	0.62	0.67	0.62	0.52	0.82	0.71	0.73	0.68	0.53	0.47	0.65	0.62	0.65	0.60
$p25$	0.59	0.58	0.67	0.56	0.67	0.74	0.68	0.59	0.85	0.75	0.79	0.75	0.58	0.58	0.73	0.67	0.71	0.65
Median	0.65	0.62	0.76	0.65	0.71	0.81	0.74	0.66	0.88	0.80	0.83	0.79	0.70	0.70	0.82	0.74	0.79	0.71
$p75$	0.71	0.67	0.80	0.74	0.81	0.88	0.84	0.74	0.95	0.83	0.90	0.83	0.82	0.79	0.88	0.82	0.85	0.83
$p90$	0.80	0.72	1.09	1.05	0.95	0.97	0.96	0.84	0.99	0.90	0.94	0.89	0.95	0.89	0.94	0.87	0.92	0.88
$p95$	0.84	0.76	1.60	1.40	1.16	1.05	0.98	0.86	1.02	1.04	0.98	0.94	1.01	0.96	0.95	0.90	0.99	0.95
Maximum	0.88	0.82	2.23	1.57	1.40	1.11	1.02	0.96	1.12	1.13	1.07	1.07	1.11	1.16	1.06	1.04	1.06	1.05

Table OA.1.2: Comparing nowcasts to the AR and ADL models via relative RMSFE

The table reports the nowcasting performance of the ADL-MIDAS models for predicting the growth rates of each state government's total revenues (denoted by "REV-Total"), own source revenues (denoted by "REV-Own"), and total expenditures (denoted by "EXP-Total)"). Each entry to the table reports the median RMSFEs from one-, two-, and three-quarter ahead nowcasts of the fiscal variables from the ADL-MIDAS model from equation (6) relative to the RMSFEs of the autoregressive (denoted by "AR," and represented by (3)) model in Panel A, and the autoregressive distributed lag (denoted by "ADL," and represented by (4)) model in Panel B. Both of these low-frequency benchmark models are estimated without using any additional quarters worth of high-frequency data. Depending on the value of j, an additional 0, 1, 2, or 3 quarters worth of intra-year high-frequency data are used to produce each forecast from the ADL-MIDAS model. The 5^{th} and 95^{th} percentiles of the distribution of relative RMSFEs across states are reported in parentheses. Finally, each model is estimated using the procedure described in Section III.

	REV-Total		REV-Own		EXP-Total	
	$h=1$	$h=2$	$h=1$	$h=2$	$h=1$	$h=2$
Panel A: RMSFEs Relative to AR						
MIDAS ($j=1$)	0.86	0.75	0.86	0.84	0.90	0.93
	(0.74,0.96)	(0.61,1.00)	(0.69,1.00)	(0.60,1.10)	(0.66,1.20)	(0.66,1.15)
MIDAS ($j=2$)	0.77	0.72	0.79	0.88	0.92	0.91
	(0.62,0.95)	(0.60,0.99)	(0.62,0.96)	(0.58,1.09)	(0.64,1.21)	(0.66,1.16)
MIDAS ($j=3$)	0.75	0.75	0.79	0.86	0.94	0.93
	(0.60,0.92)	(0.62,0.98)	(0.65,0.97)	(0.60,1.11)	(0.68,1.19)	(0.67,1.12)
Panel B: RMSFEs Relative to ADL						
MIDAS ($j=1$)	0.85	0.93	0.81	0.85	0.90	0.92
	(0.61,0.97)	(0.59,1.22)	(0.63,0.95)	(0.66,1.01)	(0.65,1.19)	(0.64,1.22)
MIDAS ($j=2$)	0.76	0.89	0.73	0.87	0.91	0.87
	(0.48,0.98)	(0.59,1.20)	(0.58,0.87)	(0.51,1.03)	(0.68,1.20)	(0.60,1.31)
MIDAS ($j=3$)	0.71	0.91	0.76	0.84	0.91	0.89
	(0.51,0.91)	(0.59,1.19)	(0.62,0.90)	(0.57,1.02)	(0.67,1.16)	(0.64,1.24)

Table OA.1.3: Comparing nowcasts to the AR and ADL models via panel DM tests

The table reports the nowcasting performance of the ADL-MIDAS models for predicting the growth rates of each state government's total revenues (denoted by "REV-Total"), own source revenues (denoted by "REV-Own"), and total expenditures (denoted by "EXP-Total)"). Each entry to the table reports the test statistic from the panel Diebold-Mariano test proposed by Pesaran, Schuermann and Smith (2009). The table also reports the p-value associated with each test statistic in parentheses. In each row of the table, the forecast performance of an ADL-MIDAS model endowed with an additional one-, two-, or three-quarters worth of of intra-year data, represented by equation (6), is benchmarked against the the autoregressive model (denoted by "AR," and represented by (3)) in Panel A, and the autoregressive distributed lag model (denoted by "ADL," and represented by (4)) in Panel B, and an ADL-MIDAS model with no intra-year data (denoted by "MIDAS ($j = 0$)," and represented by equation (1)) in Panel C. Finally, each model is estimated using the procedure described in Section III.

	REV-Total		REV-Own		EXP-Total	
	$h = 1$	$h = 2$	$h = 1$	$h = 2$	$h = 1$	$h = 2$
Panel A: DM tests relative to AR						
MIDAS ($j = 1$)	-1.80	-1.23	-2.57	-1.44	-1.64	-1.34
	(0.04)	(0.11)	(0.01)	(0.08)	(0.05)	(0.09)
MIDAS ($j = 2$)	-1.98	-1.18	-2.83	-1.92	-1.83	-1.23
	(0.02)	(0.12)	(0.00)	(0.03)	(0.03)	(0.11)
MIDAS ($j = 3$)	-2.26	-0.98	-3.25	-2.31	-1.11	-1.03
	(0.01)	(0.16)	(0.00)	(0.01)	(0.13)	(0.15)
Panel A: DM tests relative to ADL						
MIDAS ($j = 1$)	-1.98	-1.51	-4.51	-2.66	-2.23	-1.42
	(0.02)	(0.07)	(0.00)	(0.00)	(0.01)	(0.08)
MIDAS ($j = 2$)	-2.16	-1.56	-4.68	-2.36	-2.35	-1.34
	(0.02)	(0.06)	(0.00)	(0.01)	(0.01)	(0.09)
MIDAS ($j = 3$)	-2.08	-1.49	-5.31	-2.44	-1.58	-1.16
	(0.02)	(0.07)	(0.00)	(0.01)	(0.06)	(0.12)
Panel A: DM tests relative to MIDAS ($j = 0$)						
MIDAS ($j = 1$)	1.19	0.38	-2.17	-0.21	0.48	-1.11
	(0.88)	(0.65)	(0.02)	(0.42)	(0.69)	(0.13)
MIDAS ($j = 2$)	-1.08	0.06	-1.86	-0.33	0.05	-0.72
	(0.14)	(0.52)	(0.03)	(0.37)	(0.52)	(0.24)
MIDAS ($j = 3$)	0.31	0.64	-3.43	-0.62	1.22	-0.19
	(0.62)	(0.74)	(0.00)	(0.27)	(0.89)	(0.43)

OA.2 Results using the Bayesian information criterion (BIC)

Table OA.2.4: Forecast results using the Bayesian information criterion (BIC)

The table reports the forecast performance of the ADL-MIDAS models for predicting the growth rates of each state government's total revenues (denoted by "REV-Total"), own source revenues (denoted by "REV-Own"), and total expenditures (denoted by "EXP-Total)"). Panel A reports the median value of the root mean squared forecast error (RMSFE) from the ADL-MIDAS model, represented by equation (1) and denoted by "MIDAS ($j = 0$)," relative to the RMSFE of a random walk (RW), represented by equation (2), for the one- and two-year ahead forecasts of each fiscal variable. Panel A also reports the RMSFEs of the autoregressive distributed lag (denoted by "ADL") and autoregressive (denoted by "AR") models relative to the RMSFEs of a RW. Panel B compares the forecast performance of the MIDAS ($j = 0$) model to the forecast performance of each of the ADL and AR models, represented by equations (3) and 4, respectively, using the panel Diebold-Mariano test proposed by Pesaran *et al.* (2009). The panel reports both the test statistic and the p-value associated with this test statistic in parentheses. Panel C reports the median value of the RMSFEs from one-, two-, and three-quarter ahead nowcasts of the fiscal variables from three ADL-MIDAS models from equation (6) relative to the RMSFEs of the MIDAS ($j = 0$) model, which is estimated without using any additional quarters worth of high-frequency data. Depending on the value of j, an additional 0, 1, 2, or 3 quarters worth of intra-year high-frequency data are used to produce each forecast. Each model is estimated following the procedure described in Section III, and in Panels A and C the 5^{th} and 95^{th} percentiles of the distribution of relative RMSFEs across states are reported in parentheses. Finally, each model is estimated using the procedure described in Section III, and lag lengths for all models (except the RW) are selected using the Bayesian information criterion (BIC).

	REV-Total		REV-Own		EXP-Total	
	$h = 1$	$h = 2$	$h = 1$	$h = 2$	$h = 1$	$h = 2$
Panel A: RMSFEs Relative to Random Walk						
MIDAS ($j = 0$)	0.65	0.61	0.73	0.64	0.69	0.69
	(0.53,0.84)	(0.51,0.75)	(0.58,0.96)	(0.47,0.87)	(0.50,1.01)	(0.44,0.94)
ADL	0.75	0.65	0.88	0.79	0.77	0.73
	(0.59,1.61)	(0.48,1.40)	(0.78,1.03)	(0.68,1.03)	(0.64,0.94)	(0.55,0.91)
AR	0.71	0.77	0.78	0.72	0.78	0.68
	(0.58,1.07)	(0.61,0.96)	(0.70,0.95)	(0.59,0.88)	(0.64,0.97)	(0.56,0.88)
Panel B: Panel DM tests relative to MIDAS ($j = 0$)						
ADL	-2.03	-1.52	-3.40	-2.78	-2.33	-1.19
	(0.02)	(0.06)	(0.00)	(0.00)	(0.01)	(0.12)
AR	-1.60	-1.10	-1.00	-0.58	-1.59	-0.52
	(0.06)	(0.13)	(0.16)	(0.28)	(0.06)	(0.30)
Panel C: RMSFEs Relative to MIDAS ($j = 0$)						
MIDAS ($j = 1$)	0.98	0.98	0.95	1.03	1.01	0.97
	(0.90,1.11)	(0.93,1.06)	(0.78,1.11)	(0.85,1.15)	(0.93,1.18)	(0.84,1.15)
MIDAS ($j = 2$)	0.92	0.97	0.87	1.02	1.01	0.96
	(0.72,1.07)	(0.87,1.06)	(0.66,1.05)	(0.84,1.18)	(0.78,1.24)	(0.83,1.18)
MIDAS ($j = 3$)	0.86	0.98	0.89	0.99	1.03	0.97
	(0.72,1.04)	(0.88,1.12)	(0.71,1.05)	(0.84,1.21)	(0.90,1.25)	(0.79,1.22)

Table OA.2.5: Mincer and Zarnowitz (1969) tests of forecast performance by model using the Bayesian information criterion (BIC)

The table reports the out-of-sample forecast performance of forecasting models as determined using the Mincer and Zarnowitz (1969) (MZ) regressions outlined in Section II.B. For a given model, budget series, forecast horizon, and state, we test and null hypothesis of the MZ test, and report the proportion of states for which the null hypothesis of this test is rejected. The first six columns of the table report the percentage of states for which a particular model rejects the MZ test for a given combination of budget series and forecast horizon. The final column, labeled "Overall," displays the combined rejection rate across both budget series and forecast horizons. "RW," "AR," and "ADL" refer to the random walk, autoregressive, and autoregressive distributed lag models, represented by equations (2), (3), and (4), respectively. The "MIDAS ($j = 0$)" model refers to the ADL-MIDAS model from equation (1), which does not contain any additional quarter's worth of high-frequency data. The "MIDAS ($j = x$)" models, for $x \in \{1, 2, 3\}$, refer to forecasts obtained via ADL-MIDAS models that are estimated using an additional x quarter's worth of high-frequency data, as outlined by equation (6). Finally, all models are estimated following the procedures described in Section III, and lag lengths for all models (except the RW) are selected using the Bayesian information criterion (BIC).

	REV-Total		REV-Own		EXP-Total		Overall
	$h = 1$	$h = 2$	$h = 1$	$h = 2$	$h = 1$	$h = 2$	
RW	100.00	100.00	100.00	100.00	97.92	100.00	99.65
AR	72.92	95.83	60.42	56.25	25.00	39.58	58.33
ADL	62.50	68.75	100.00	97.92	31.25	58.33	69.79
MIDAS ($j = 0$)	43.75	68.75	25.00	31.25	29.17	54.17	42.01
MIDAS ($j = 1$)	27.08	58.33	14.58	35.42	31.25	43.75	35.07
MIDAS ($j = 2$)	18.75	43.75	4.17	45.83	25.00	50.00	31.25
MIDAS ($j = 3$)	16.67	58.33	16.67	39.58	33.33	56.25	36.81

OA.3 Additional out-of-sample forecast results

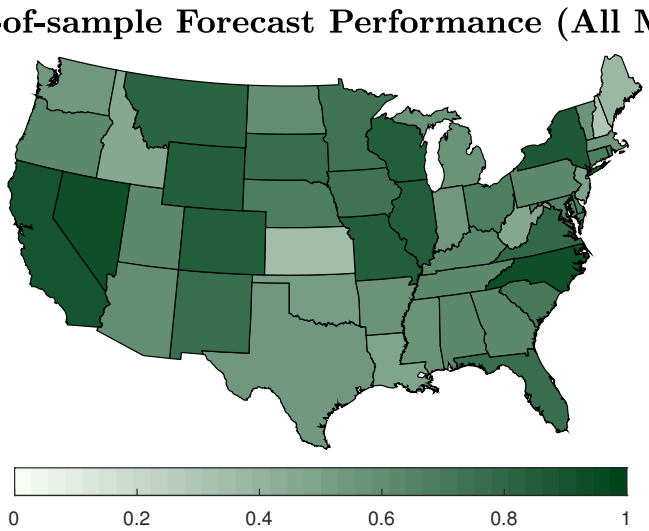


Figure OA.3.2: Out-of-sample forecast performance by state

The figure displays the average out-of-sample forecast performance associated with the nine models we consider (summarized in Table 4) at the state level. Here, out-of-sample forecast performance is determined by Mincer and Zarnowitz (1969) (MZ, hereafter) tests. For a given state, we forecast each budget series (3) at each forecast horizon (2) using each model under consideration (7) and conduct a total of $3 \times 2 \times 7 = 42$ state-specific MZ tests. The figure then displays the proportion of these MZ tests that are rejected on a state-by-state basis. The scale ranges from a rejection rate of zero percent, represented by the lightest color, to a rejection rate of 100 percent, represented by the darkest color.

OA.4 Additional results on economic heterogeneity of forecasts

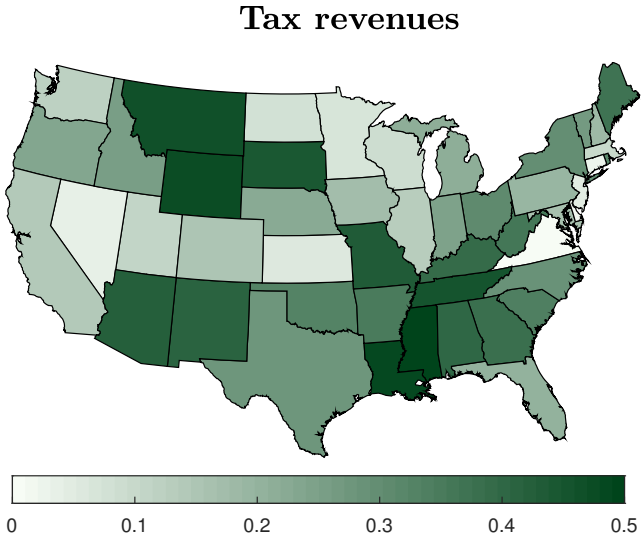


Figure OA.4.3: Sources of state general revenues: taxation
The figure displays the proportion of total state and local government general revenues that are collected from taxation. In each year between 2004 and 2018, data from the U.S. Census Bureau's annual survey of State & Local Government Finance is used to compute the proportion of each state's general revenues derived collectively from six different types of taxes. This annual proportion is then averaged across all years and reported in the figure. The scale ranges from a proportion of zero, represented by the lightest color, to a proportion of 0.50, represented by the darkest color.

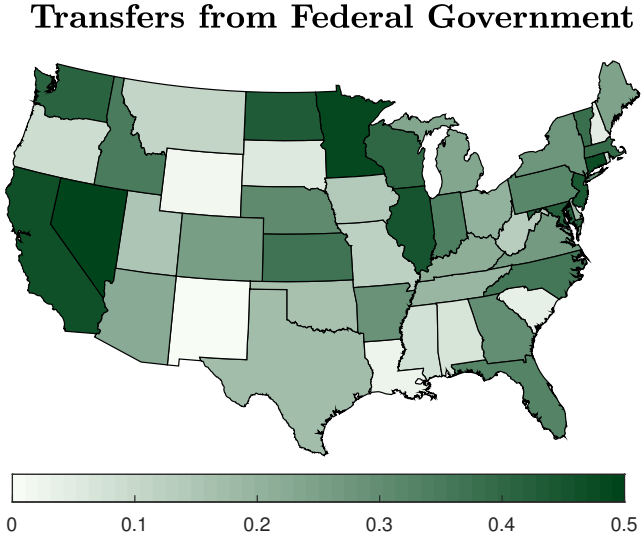


Figure OA.4.4: Sources of state general revenues: transfers
The figure displays the proportion of total state and local government general revenues that are obtained from transfers from the Federal Government. In each year between 2004 and 2018, data from the U.S. Census Bureau's annual survey of State & Local Government Finance is used to compute the proportion of each state's general revenues derived from transfers from the Federal Government. This annual proportion is then averaged across all years and reported in the figure. The scale ranges from a proportion of zero, represented by the lightest color, to a proportion of 0.50, represented by the darkest color.

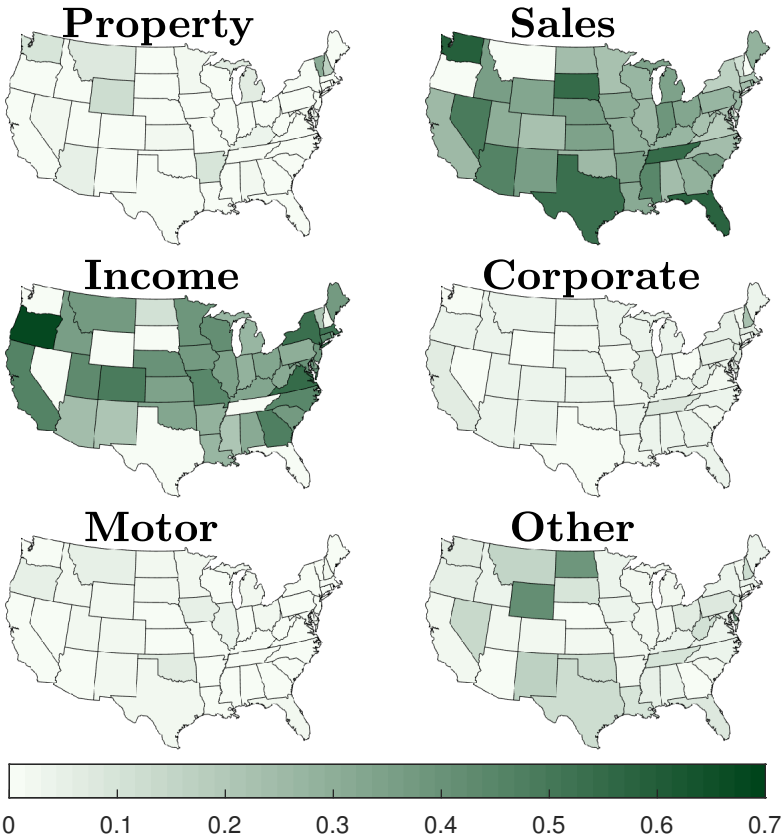


Figure OA.4.5: Sources of state and local tax revenues

The figure displays the proportion of total state and local government tax revenues that are collected from each of six different categories of taxes: property, sales, individual income, corporate income, motor vehicle licenses, and other. In each year between 2004 and 2018, data from the U.S. Census Bureau's annual survey of State & Local Government Finance is used to compute the proportion of each state's tax revenues derived from each of the six sources. This annual proportion is then averaged across all years and reported in the figure. The scale ranges from a proportion of zero, represented by the lightest color, to a proportion of 0.70, represented by the darkest color.

OA.5 State & local government budgets

Table OA.5.6: Summary statistics for state & local government budgets

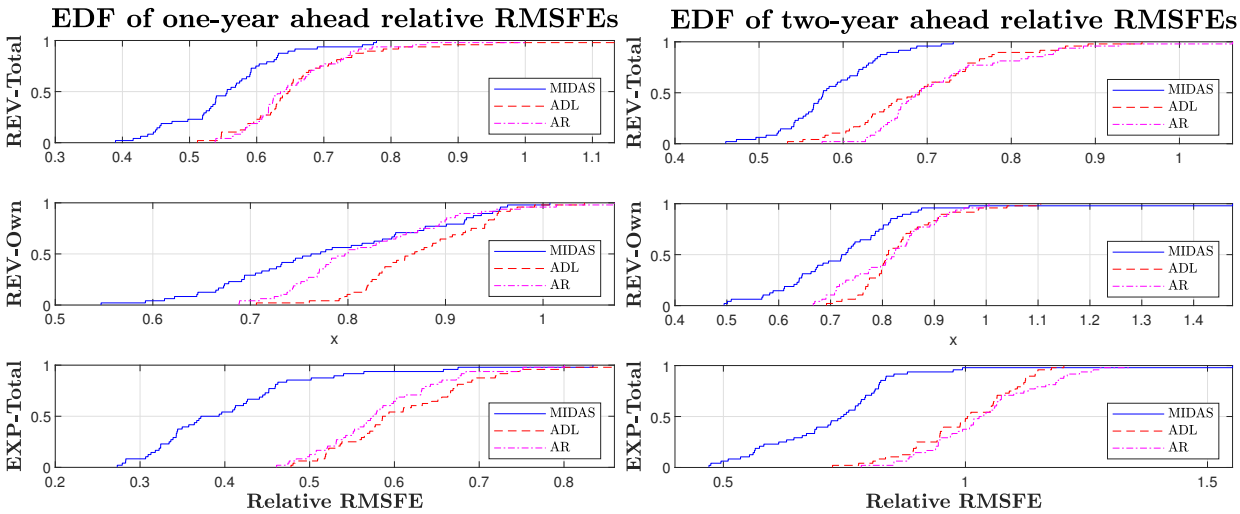
The table reports the summary statistics for each variable used in this paper. Variables are transformed to induce stationarity and are denoted by the mnemonics reported in Table 1. The mean, median, volatility, 5^{th} and 95^{th} percentiles (denoted by $P5$ and $P95$, respectively), skewness, and first-order autocorrelation reported for state-specific variables are obtained by calculating each statistic on a state-by-state basis, and then reporting the equal-weighted average statistic across all states. The dispersion of each state-specific time series is obtained by first computing the cross-sectional standard deviation of each time series, and then reporting the time-series mean of this statistic. The summary statistics are computed using data that ranges from 1955 to 2018.

Time series	Mean	Median	Volatility	Dispersion	$P5$	$P95$	Skew.	ACF(1)
REV-Total	3.038	2.872	9.893	4.498	-5.660	10.894	0.947	-0.300
REV-Own	2.263	2.421	6.935	4.009	-3.572	8.878	-1.321	-0.015
EXP-Total	2.589	2.145	5.953	3.249	-3.261	9.046	0.609	-0.286

Table OA.5.7: Forecast results for state & local government budgets

The table reports the forecast performance of the ADL-MIDAS models for predicting the growth rates of total revenues (denoted by "REV-Total"), own source revenues (denoted by "REV-Own"), and total expenditures (denoted by "EXP-Total)") for each state's combined state & local governments. Panel A reports the median value of the root mean squared forecast error (RMSFE) from the ADL-MIDAS model, represented by equation (1) and denoted by "MIDAS ($j = 0$)," relative to the RMSFE of a random walk (RW), represented by equation (2), for the one- and two-year ahead forecasts of each fiscal variable. Panel A also reports the RMSFEs of the autoregressive distributed lag (denoted by "ADL") and autoregressive (denoted by "AR") models relative to the RMSFEs of a RW. Panel B compares the forecast performance of the MIDAS ($j = 0$) model to the forecast performance of each of the ADL and AR models, represented by equations (3) and 4, respectively, using the panel Diebold-Mariano test proposed by Pesaran *et al.* (2009). The panel reports both the test statistic and the p-value associated with this test statistic in parentheses. Panel C reports the median value of the RMSFEs from one-, two-, and three-quarter ahead nowcasts of the fiscal variables from three ADL-MIDAS models from equation (6) relative to the RMSFEs of the MIDAS ($j = 0$) model, which is estimated without using any additional quarters worth of high-frequency data. Depending on the value of j, an additional 0, 1, 2, or 3 quarters worth of intra-year high-frequency data are used to produce each forecast. Each model is estimated following the procedure described in Section III, and in Panels A and C the 5^{th} and 95^{th} percentiles of the distribution of relative RMSFEs across states are reported in parentheses. Finally, each model is estimated using the procedure described in Section III.

	REV-Total		REV-Own		EXP-Total	
	$h = 1$	$h = 2$	$h = 1$	$h = 2$	$h = 1$	$h = 2$
Panel A: RMSFEs Relative to Random Walk						
MIDAS ($j = 0$)	0.56	0.58	0.77	0.73	0.38	0.75
	(0.43,0.76)	(0.49,0.69)	(0.61,0.96)	(0.51,0.88)	(0.28,0.66)	(0.49,0.98)
ADL	0.65	0.69	0.87	0.81	0.59	1.01
	(0.55,0.89)	(0.57,0.87)	(0.79,0.98)	(0.72,0.99)	(0.48,0.75)	(0.81,1.15)
AR	0.64	0.69	0.80	0.82	0.57	1.03
	(0.56,0.83)	(0.63,0.89)	(0.71,0.98)	(0.68,0.96)	(0.48,0.75)	(0.85,1.27)
Panel B: Panel DM tests relative to MIDAS ($j = 0$)						
ADL	-3.14	-2.97	-2.32	-2.39	-8.75	-4.25
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
AR	-4.11	-2.23	-0.91	-2.16	-8.24	-5.23
	(0.00)	(0.01)	(0.18)	(0.02)	(0.00)	(0.00)
Panel C: RMSFEs Relative to MIDAS ($j = 0$)						
MIDAS ($j = 1$)	0.99	0.99	0.98	1.02	1.05	1.02
	(0.93,1.10)	(0.90,1.10)	(0.84,1.06)	(0.84,1.18)	(0.78,1.30)	(0.71,1.28)
MIDAS ($j = 2$)	0.93	0.95	0.88	1.05	1.04	1.01
	(0.81,1.13)	(0.87,1.06)	(0.73,1.00)	(0.89,1.25)	(0.74,1.37)	(0.66,1.34)
MIDAS ($j = 3$)	0.96	0.96	0.88	1.00	1.15	1.06
	(0.77,1.07)	(0.88,1.08)	(0.68,1.08)	(0.89,1.18)	(0.72,1.47)	(0.73,1.35)



(a) One-year ahead relative RMSFEs **(b)** Two-year ahead relative RMSFEs

Figure OA.5.6: Empirical distribution function of the relative RMSFEs from the forecasts for state & local government budgets

The figure displays the empirical distribution function (EDF) of the root mean squared forecast error (RMSFE) of the MIDAS model from equation (1), as well as the autoregressive model (denoted by "AR" and represented by equation (3)) and the autoregressive distributed lag model (denoted by "ADL" and represented by equation (4)), relative to the RMSFE of a random walk (RW) model, represented by equation (2), for the one- and two-year ahead forecasts of state & local government revenues and expenditures. Here, each model is estimated following the procedure described in Section III. The figures on the lefthand side report the results for one-year ahead forecasts, while the figures on the righthand side report the results for two-year ahead forecasts. The top row displays the results for total revenue growth (denoted by "REV-Total"), the middle row displays the results for own source revenue growth (denoted by "REV-Own"), and the bottom row displays the results for total expenditure growth (denoted by "EXP-Total"). Points in each figure represent the state-specific relative RMSFEs associated with each model (ordered from the smallest relative RMSFE to the largest relative RMSFE), and the horizontal axis in each figure presents the percentiles of each empirical distribution function.

Table OA.5.8: Forecast results by state for state & local government budgets

The table reports the forecast performance of the ADL-MIDAS models for predicting the growth rates of the total revenues (denoted by "REV-Total"), own source revenues (denoted by "REV-Own"), and total expenditures (denoted by "EXP-Total") of each state's combined state & local governments on a state-by-state basis. Panel A reports the median value of the root mean squared forecast error (RMSFE) from the ADL-MIDAS model, represented by equation (1) and denoted by "MIDAS," relative to the RMSFE of a random walk (RW), represented by equation (2), for the one- and two-year ahead forecasts of each fiscal variable. Panel A also reports the RMSFEs of the autoregressive distributed lag (denoted by "ADL") and autoregressive (denoted by "AR") models relative to the RMSFEs of a RW. In Panel B, $p5$, $p10$, $p25$, $p75$, $p90$, and $p95$ refer to the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles of the distribution of relative RMSFEs across states, respectively. Here, each model is estimated following the procedure for single-equation models described in Section III.

	REV-Total						REV-Own						EXP-Total					
	MIDAS		ADL		AR		MIDAS		ADL		AR		MIDAS		ADL		AR	
$h=$	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Panel A: RMSFEs Relative to Random Walk																		
Alabama	0.46	0.67	0.58	0.89	0.54	0.86	0.74	0.68	0.86	0.80	0.73	0.87	0.45	0.81	0.80	0.99	0.68	0.88
Arizona	0.56	0.57	0.64	0.75	0.62	0.69	0.80	0.81	0.93	0.91	0.83	0.80	0.35	0.69	0.53	0.94	0.52	1.07
Arkansas	0.52	0.61	0.63	0.70	0.62	0.65	0.85	0.73	0.92	0.77	0.80	0.86	0.34	0.56	0.57	1.06	0.54	1.01
California	0.63	0.62	0.74	0.70	0.74	0.67	0.85	0.58	0.91	0.79	0.78	0.84	0.33	0.79	0.58	1.00	0.57	1.12
Colorado	0.54	0.58	0.60	0.66	0.61	0.71	0.84	0.50	0.80	0.71	0.83	0.86	0.37	0.55	0.59	0.73	0.64	0.88
Connecticut	0.54	0.56	0.64	0.63	0.64	0.68	0.85	0.75	0.89	0.83	0.87	0.77	0.41	0.77	0.66	1.05	0.67	1.19
Delaware	0.54	0.61	0.65	0.64	0.62	0.64	0.88	0.84	0.86	0.80	0.91	0.75	0.36	0.58	0.52	1.00	0.50	1.20
Florida	0.57	0.55	0.62	0.58	0.63	0.66	0.88	0.72	0.95	0.86	0.83	0.71	0.31	0.78	0.54	1.20	0.51	1.28
Georgia	0.43	0.55	0.59	0.73	0.60	0.84	0.73	0.72	0.95	0.79	0.84	0.71	0.47	0.85	0.58	0.95	0.58	1.21
Idaho	0.52	0.64	0.61	0.75	0.70	0.67	0.71	0.61	0.92	0.80	0.86	0.83	0.32	0.72	0.52	1.05	0.52	1.19
Illinois	0.69	0.54	0.81	0.66	0.83	0.78	0.96	0.51	0.94	0.81	0.94	0.85	0.32	0.69	0.72	0.89	0.63	0.95
Indiana	0.52	0.72	0.58	0.96	0.58	0.81	0.90	0.97	0.85	0.76	0.78	0.77	0.34	0.74	0.58	1.14	0.55	1.24
Iowa	0.63	0.57	0.69	0.76	0.72	0.74	0.67	0.57	0.82	0.81	0.74	0.72	0.39	1.55	0.59	1.12	0.53	0.99
Kansas	0.45	0.56	0.51	0.69	0.54	0.63	0.55	0.79	0.71	0.80	0.69	0.76	0.45	0.47	0.52	0.90	0.57	0.97
Kentucky	0.59	0.54	0.65	0.63	0.66	0.57	0.65	0.63	0.81	0.80	0.78	0.81	0.42	0.72	0.67	1.11	0.75	0.94
Louisiana	0.57	0.54	0.63	0.60	0.59	0.67	1.01	0.88	0.94	0.93	0.79	0.90	0.66	0.82	0.70	0.89	0.75	1.04
Maine	0.59	0.47	0.67	0.53	0.68	0.73	0.75	0.67	0.85	0.77	0.77	0.75	0.44	0.57	0.75	0.99	0.68	0.92
Maryland	0.53	0.54	0.63	0.55	0.68	0.73	0.73	0.80	0.81	0.77	0.74	0.78	0.31	0.61	0.67	1.10	0.63	1.04
Massachusetts	0.50	0.52	0.65	0.57	0.64	0.67	0.92	0.78	0.94	0.84	0.98	0.82	0.28	0.47	0.64	0.82	0.66	0.94
Michigan	0.47	0.60	0.55	0.75	0.59	0.93	0.67	0.64	0.87	0.76	0.77	0.68	0.41	0.88	0.73	1.15	0.54	0.95
Minnesota	0.63	0.63	0.71	0.75	0.64	0.68	0.69	0.65	0.84	0.77	0.80	0.82	0.46	0.82	0.69	1.07	0.68	1.13
Mississippi	0.46	0.58	0.58	0.70	0.62	0.63	0.59	0.64	0.83	0.77	0.75	0.82	0.41	0.69	0.62	1.07	0.58	0.99
Missouri	0.65	0.58	0.71	0.62	0.69	0.67	0.76	0.72	0.90	0.83	0.90	0.91	0.28	0.79	0.65	1.06	0.57	1.07
Montana	0.53	0.53	0.63	0.65	0.61	0.63	0.66	0.83	0.82	0.84	0.69	0.69	0.45	0.54	0.58	0.95	0.61	1.07
Nebraska	0.57	0.51	0.67	0.63	0.65	0.70	0.96	0.82	0.95	0.98	1.01	1.01	0.56	0.82	0.63	0.90	0.64	1.06
Nevada	0.55	0.69	0.64	0.78	0.61	0.69	0.87	1.47	0.95	0.91	0.89	0.94	0.43	0.63	0.56	1.05	0.53	1.10

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Table OA.5.8 – Continued from the previous page

	REV-Total						REV-Own						EXP-Total					
	MIDAS		ADL		AR		MIDAS		ADL		AR		MIDAS		ADL		AR	
$h =$	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
New Hampshire	0.42	0.64	0.55	0.74	0.57	0.71	0.72	0.73	0.76	0.75	0.74	0.72	0.28	0.57	0.52	0.95	0.53	0.97
New Jersey	0.39	0.57	0.65	0.83	0.63	0.74	0.61	0.57	0.88	0.77	0.78	0.71	0.34	0.74	0.61	0.89	0.60	0.89
New Mexico	0.59	0.59	0.65	0.68	0.67	0.65	0.62	0.64	0.82	0.83	0.81	0.89	0.37	0.78	0.54	1.12	0.47	1.14
New York	0.59	0.62	0.73	0.69	0.72	0.66	0.83	0.67	0.83	0.75	0.87	0.85	0.34	0.81	0.59	0.94	0.60	1.26
North Carolina	0.58	0.64	0.62	0.69	0.62	0.65	0.71	0.78	0.89	0.90	0.90	0.81	0.34	0.76	0.58	1.18	0.50	1.19
North Dakota	0.61	0.56	0.65	0.63	0.66	0.72	0.69	0.59	0.85	1.04	0.77	1.00	0.46	0.83	0.56	0.95	0.59	1.06
Ohio	0.78	0.62	0.95	0.78	0.85	0.85	0.95	0.70	1.04	0.89	1.07	0.96	0.40	0.75	0.72	1.12	0.63	1.01
Oklahoma	0.53	0.46	0.55	0.61	0.56	0.68	0.92	0.66	0.80	0.85	0.77	0.93	0.50	0.51	0.59	1.00	0.56	0.94
Oregon	0.76	0.57	0.88	0.73	0.74	0.82	0.69	0.49	0.79	0.69	0.75	0.85	0.54	0.84	0.67	1.01	0.55	0.85
Pennsylvania	0.63	0.56	0.76	0.66	0.74	0.75	0.78	0.81	0.89	0.85	0.89	0.69	0.37	0.72	0.57	0.90	0.57	1.02
Rhode Island	0.58	0.64	0.72	0.63	0.73	0.72	0.77	0.61	0.89	0.72	0.91	0.71	0.31	0.75	0.56	0.95	0.55	0.89
South Carolina	0.56	0.63	0.65	0.76	0.62	0.66	0.81	0.85	0.82	0.87	0.71	0.81	0.32	0.67	0.67	1.14	0.60	1.02
South Dakota	0.66	0.56	0.74	0.65	0.75	0.69	0.67	0.74	0.82	0.88	0.85	0.67	0.32	0.77	0.48	0.83	0.48	1.03
Tennessee	0.56	0.59	0.68	0.65	0.68	0.64	0.93	0.87	0.99	0.91	0.78	0.87	0.43	0.81	0.61	1.06	0.58	1.06
Texas	0.45	0.73	0.61	0.86	0.58	1.06	0.65	0.69	0.87	0.81	0.72	0.92	0.34	0.50	0.66	1.01	0.65	0.85
Utah	0.45	0.65	0.55	0.68	0.58	0.64	0.78	0.64	0.87	0.81	0.76	0.67	0.68	0.83	0.48	0.86	0.60	0.94
Vermont	0.54	0.52	0.63	0.77	0.62	0.78	0.73	0.74	0.83	0.81	0.76	0.73	0.27	0.78	0.66	1.13	0.58	1.02
Virginia	0.60	0.58	0.68	0.61	0.69	0.75	0.96	0.79	0.94	0.84	0.95	0.85	0.53	0.97	0.52	1.09	0.48	1.34
Washington	0.52	0.50	0.60	0.59	0.62	0.67	0.75	0.73	0.84	0.80	0.74	0.85	0.36	0.56	0.48	0.78	0.46	1.17
West Virginia	0.60	0.62	0.67	0.73	0.67	0.89	0.92	0.79	0.97	1.11	0.85	0.90	0.83	0.65	0.86	0.81	0.80	0.78
Wisconsin	0.77	0.68	1.13	0.86	1.00	0.85	0.68	0.80	0.84	0.82	0.80	0.91	0.46	0.66	0.68	1.06	0.56	1.07
Wyoming	0.44	0.58	0.79	0.73	0.77	0.69	0.94	0.76	0.97	0.99	0.89	0.82	0.44	0.99	0.51	1.12	0.51	1.05
Panel B: Summary Statistics for Relative RMSFE																		
Minimum	0.39	0.46	0.51	0.53	0.54	0.57	0.55	0.49	0.71	0.69	0.69	0.67	0.27	0.47	0.48	0.73	0.46	0.78
$p5$	0.43	0.49	0.55	0.57	0.56	0.63	0.61	0.51	0.79	0.72	0.71	0.68	0.28	0.49	0.48	0.81	0.48	0.85
$p10$	0.45	0.52	0.56	0.59	0.58	0.64	0.65	0.57	0.80	0.76	0.73	0.70	0.31	0.54	0.52	0.84	0.50	0.89
$p25$	0.52	0.55	0.61	0.63	0.61	0.66	0.69	0.64	0.83	0.77	0.76	0.74	0.34	0.62	0.55	0.92	0.53	0.95
Median	0.56	0.58	0.65	0.69	0.64	0.69	0.77	0.73	0.87	0.81	0.80	0.82	0.38	0.75	0.59	1.01	0.57	1.03
$p75$	0.60	0.63	0.70	0.75	0.70	0.75	0.88	0.80	0.93	0.86	0.88	0.87	0.45	0.81	0.67	1.10	0.63	1.13
$p90$	0.65	0.66	0.78	0.82	0.75	0.85	0.94	0.85	0.95	0.92	0.93	0.93	0.54	0.85	0.72	1.14	0.68	1.21
$p95$	0.76	0.69	0.89	0.87	0.83	0.89	0.96	0.88	0.98	0.99	0.98	0.96	0.66	0.98	0.75	1.15	0.75	1.27
Maximum	0.78	0.73	1.13	0.96	1.00	1.06	1.01	1.47	1.04	1.11	1.07	1.01	0.83	1.55	0.86	1.20	0.80	1.34

Table OA.5.9: Mincer and Zarnowitz (1969) tests of forecast performance by model for state & local government budgets

The table reports the out-of-sample forecast performance of forecasting models as determined using the Mincer and Zarnowitz (1969) (MZ) regressions outlined in Section II.B. For a given model, budget series, forecast horizon, and state, we test and null hypothesis of the MZ test, and report the proportion of states for which the null hypothesis of this test is rejected. The first six columns of the table report the percentage of states for which a particular model rejects the MZ test for a given combination of budget series and forecast horizon. The final column, labeled "Overall," displays the combined rejection rate across both budget series and forecast horizons. "RW," "AR," and "ADL" refer to the random walk, autoregressive, and autoregressive distributed lag models, represented by equations (2), (3), and (4), respectively. The "MIDAS ($j = 0$)" model refers to the ADL-MIDAS model from equation (1), which does not contain any additional quarter's worth of high-frequency data. The "MIDAS ($j = x$)" models, for $x \in \{1, 2, 3\}$, refer to forecasts obtained via ADL-MIDAS models that are estimated using an additional x quarter's worth of high-frequency data, as outlined by equation (6). Finally, all models are estimated following the procedures described in Section III.

	REV-Total		REV-Own		EXP-Total		Overall
	$h = 1$	$h = 2$	$h = 1$	$h = 2$	$h = 1$	$h = 2$	
RW	100.00	100.00	100.00	100.00	100.00	68.75	94.79
AR	56.25	81.25	79.17	79.17	35.42	87.50	69.79
ADL	64.58	66.67	97.92	97.92	50.00	60.42	72.92
MIDAS ($j = 0$)	25.00	6.25	50.00	47.92	22.92	14.58	27.78
MIDAS ($j = 1$)	27.08	10.42	39.58	43.75	33.33	16.67	28.47
MIDAS ($j = 2$)	4.17	4.17	18.75	54.17	6.25	14.58	17.01
MIDAS ($j = 3$)	20.83	6.25	27.08	47.92	27.08	12.50	23.61

OA.6 Forecast combination weights

OA.6.1 Plots

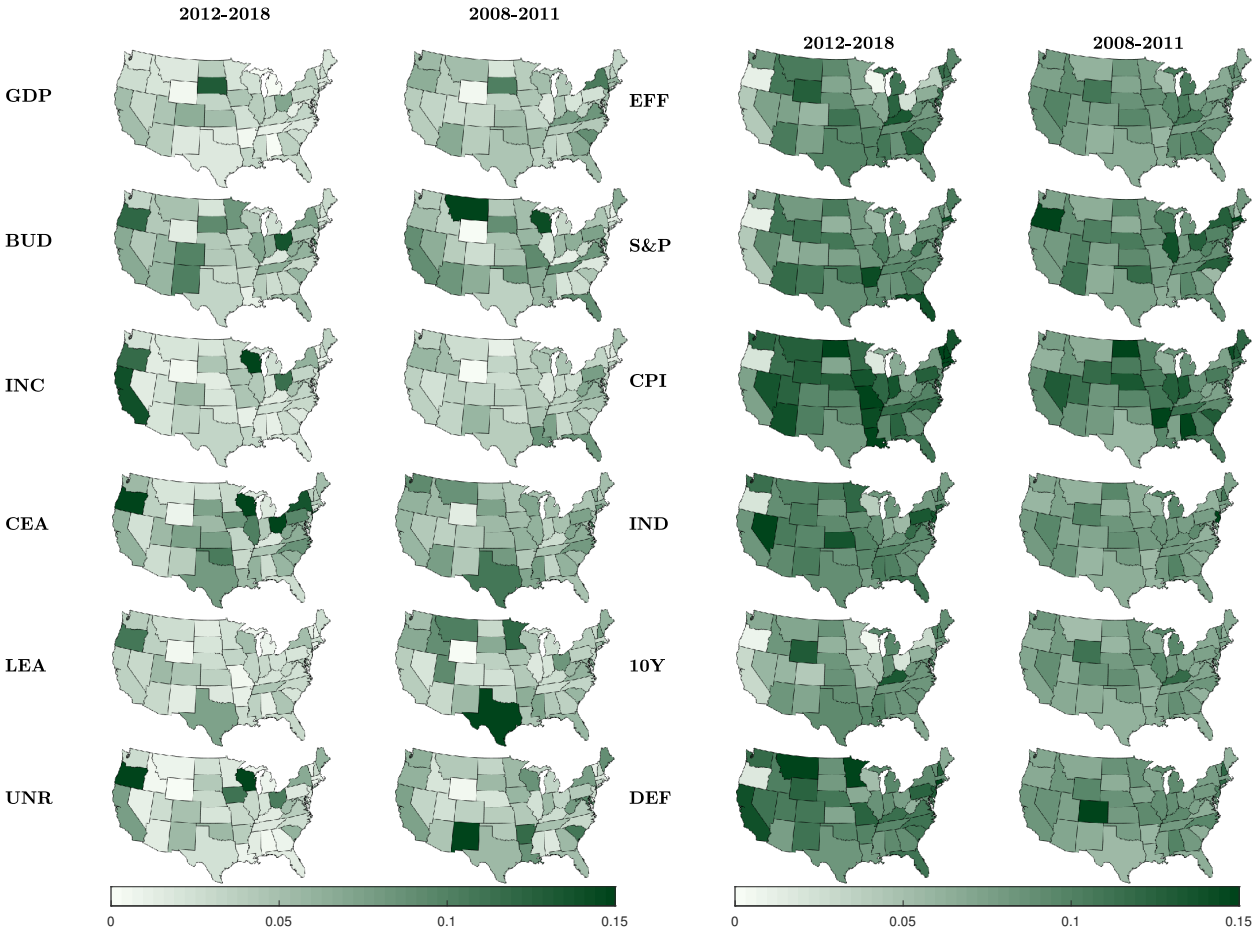

Figure OA.6.7: Forecast combination weights for total revenue growth

The figure shows the average forecast combination weight placed on each predictor when combining one-year ahead forecasts of the annual growth rate of each state's real total revenues per capita (REV-Total). The average forecast combination weights are obtained as follows. First, the ADL-MIDAS regression from equation (1) is estimated for each combination of state, high-frequency predictor, and weight function, using data from 1958 to 1998. Next, a rolling window forecast scheme is used to generate forecasts from each model that span 1999 to 2018. The forecast combination weights displayed in this figure are based on the squared discounted mean square forecast errors (dMSFE) associated with each model from equation (5). The color associated with each pair of (i) state, and (ii) high-frequency predictor becomes progressively darker as more weight is placed on a particular predictor when determining the overall forecast for total revenue growth). The maps under the columns entitled "2004 - 2007" ("2008 - 2011") display the average forecast combination weight for each state-predictor pair over the 2004 to 2007 (2008 to 2011) periods. The scale ranges from a weight of 0% for the lightest color to a weight of 15% for the darkest color. All independent variables are referred to by a mnemonic as detailed in Table 1.

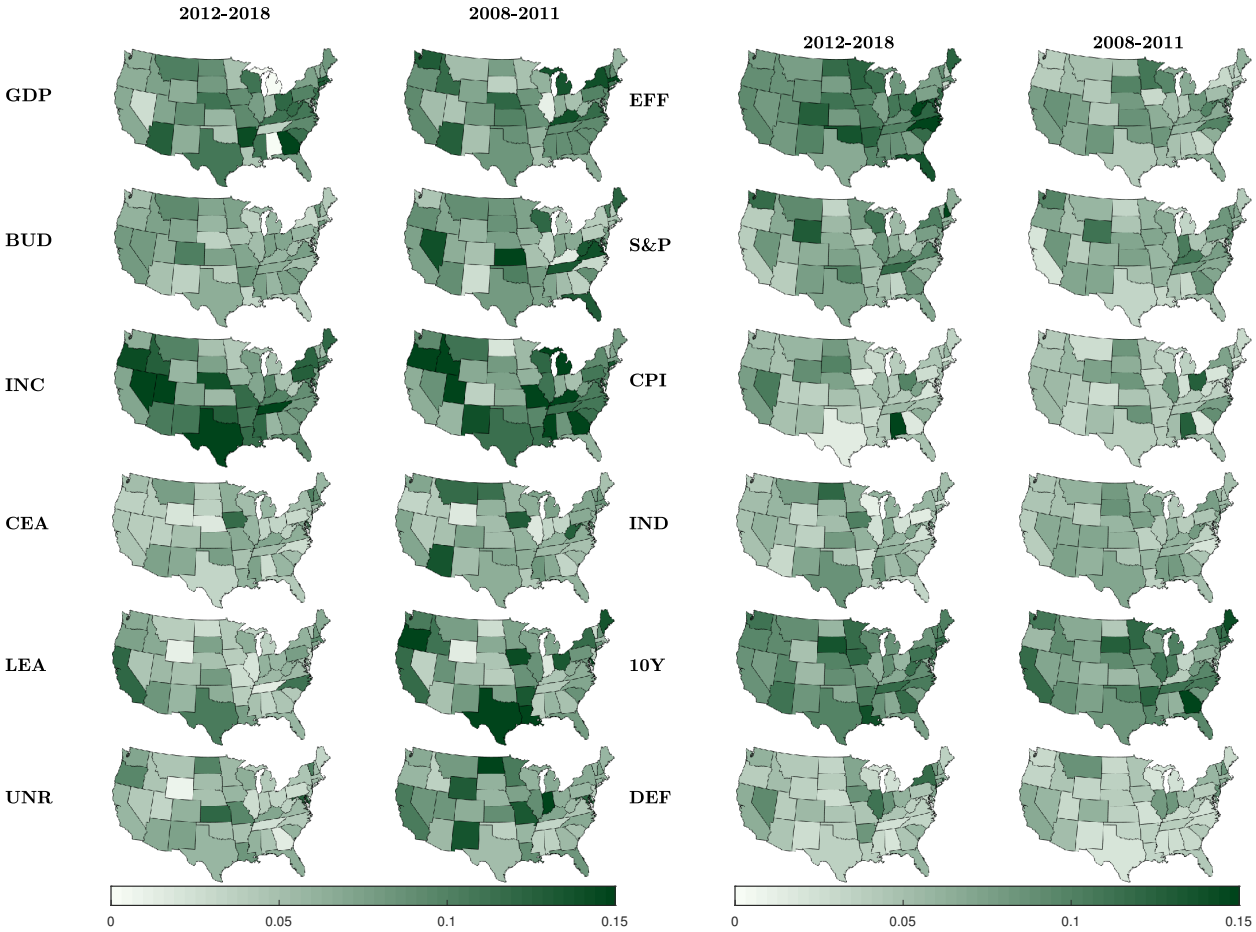

Figure OA.6.8: Forecast combination weights for own source revenue growth

The figure shows the average forecast combination weight placed on each predictor when combining one-year ahead forecasts of the annual growth rate of each state's real own source per capita (REV-Own). The average forecast combination weights are obtained as follows. First, the ADL-MIDAS regression from equation (1) is estimated for each combination of state, high-frequency predictor, and weight function, using data from 1958 to 1998. Next, a rolling window forecast scheme is used to generate forecasts from each model that span 1999 to 2018. The forecast combination weights displayed in this figure are based on the squared discounted mean square forecast errors (dMSFE) associated with each model from equation (5). The color associated with each pair of (i) state, and (ii) high-frequency predictor becomes progressively darker as more weight is placed on a particular predictor when determining the overall forecast for own source revenue growth. The maps under the columns entitled "2004 - 2007" ("2008 - 2011") display the average forecast combination weight for each state-predictor pair over the 2004 to 2007 (2008 to 2011) periods. The scale ranges from a weight of 0% for the lightest color to a weight of 15% for the darkest color. All independent variables are referred to by a mnemonic as detailed in Table 1.

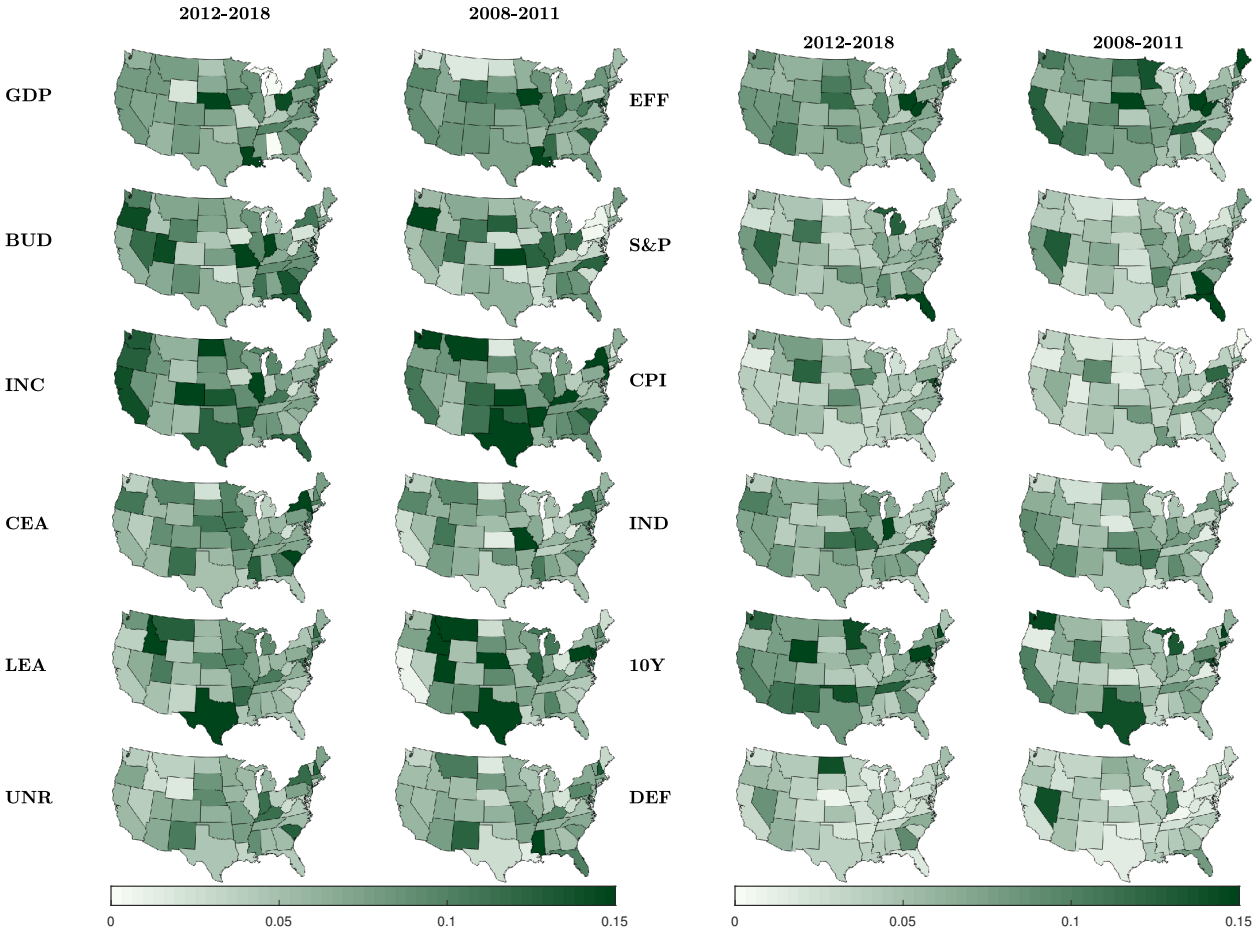

Figure OA.6.9: Forecast combination weights for total expenditure growth

The figure shows the average forecast combination weight placed on each predictor when combining one-year ahead forecasts of the annual growth rate of each state's real total expenditures per capita (EXP-Total). The average forecast combination weights are obtained as follows. First, the ADL-MIDAS regression from equation (1) is estimated for each combination of state, high-frequency predictor, and weight function, using data from 1958 to 1998. Next, a rolling window forecast scheme is used to generate forecasts from each model that span 1999 to 2018. The forecast combination weights displayed in this figure are based on the squared discounted mean square forecast errors (dMSFE) associated with each model from equation (5). The color associated with each pair of (i) state, and (ii) high-frequency predictor becomes progressively darker as more weight is placed on a particular predictor when determining the overall forecast for total expenditure growth). The maps under the columns entitled "2004 - 2007" ("2008 - 2011") display the average forecast combination weight for each state-predictor pair over the 2004 to 2007 (2008 to 2011) periods. The scale ranges from a weight of 0% for the lightest color to a weight of 15% for the darkest color. All independent variables are referred to by a mnemonic as detailed in Table 1.

OA.6.2 Forecast combination weights and state-level taxes

In this section we examine the extent to which the forecast combination weights for each state, obtained by estimating equation (5), are related to state-level tax policies and transfers from the Federal government. While our analysis only includes a parsimonious set of high-frequency regressors that may not fully or *explicitly* capture some of the structural differences between states (e.g., the fact that Texas tends to derive revenues through property taxes, while Washington largely raises tax revenues through sales taxes), some of these structural differences may *implicitly* be captured by differences in forecast combination weights. To this end, we examine whether the weight attributed to high-frequency regressor i for forecasting the revenues or expenditures of state s depends on the state's sources of income via the following cross-sectional regression

$$\omega_{i,s} = \beta_0 + \beta_1 Property_s + \beta_2 Sales_s + \beta_3 Income_s + \beta_4 FedTrans_s + \varepsilon_{i,s}. \quad (1)$$

Here, $\omega_{i,s}$ denotes the forecast combination weight associated with variable i in state s that is obtained by estimating equation (5).[1] $Property_s$, $Sales_s$, and $Income_s$ denote the proportion of general revenues in state s that are derived from property, sales, and personal income taxes, respectively. Similarly, $FedTrans_s$ denotes the proportion of general revenues in state s that are obtained by transfers from the Federal government. We obtain these details on tax revenues and Federal transfers for each state from the U.S. Census Bureau's annual survey of State & Local Government Finance. Finally, the data underlying equation (1) are related to year 2018, the final year of our sample period, and we estimate a separate regression for each variable, budget series (revenues or expenditures), and forecast horizon (one-year ahead or two-years ahead).

The results of the analysis described above are reported in Table OA.6.10 to Table OA.6.15. The results show that the forecast combination weights underlying the ADL-MIDAS model are in fact related, at least in part, to the extent to which generates various types of taxes and receives transfers from the Federal government. This suggests that many of the structural differences between states that the ADL-MIDAS model does not account for *explicitly* (e.g., the fact that some states rely on transfers from the Federal government more than others) are *implicitly* captured by the data-driven forecast combination weights.

For instance, focusing on Table OA.6.10, which shows the results of equation (1) for one-year ahead total revenue growth, delivers a number of takeaways. For instance, the corporate default spread and S&P 500 returns are more important predictors of state revenues in states that rely more on transfers from the Federal government, whereas the state's coincident economic activity index is a less important predictor of revenues in these states. This could, perhaps, suggest that the Federal government tends to provide more support to states with revenues more closely aligned with aggregate business conditions. Moreover, oil prices are a more useful predictor of revenues in states that rely more on property taxes, such as Texas, and sales taxes. Looking across the remaining tables in this section yields similar takeaways, and suggests that the forecast combination weights underlying the ADL-MIDAS models are at least partially capturing some of the structural differences between state-level economies.

[1] Since we treat each MIDAS polynomial underlying equation (1) as a separate model, for a fixed regressor i, we sum the weights represented by equation (5) across all six models associated with the HF regressor.

Table OA.6.10: Heterogeneity in forecast weights: one-year ahead total revenues

The table reports the results of cross-sectional regressions in which the forecast combination weights from forecasts of one-year ahead state government total revenue growth are projected on the extent to which a state derives general revenues from property, sales, and income taxes, as well as transfers from the Federal government. The forecast combination weights associated with each variable are obtained in three steps. First, for a given high-frequency regressor and weight function, the ADL-MIDAS model represented by equation (1) is estimated using data that spans 1958 to 2018. Next, the forecast combination weight represented by equation (5) is computed. Finally, the forecast weights associated with each high-frequency regressor are summed across the six different weight functions before estimating regression 1. Parentheses report t-statistics that are computed using heteroskedasticity-consistent standard errors, and the adjusted $\bar{R}^2$ of each regression is reported in the final column.

Regressor	Constant	Property	Sales	Income	Fed. Trans.	R^2
EFF	0.04	0.32	0.06	-0.01	0.08	0.07
	(0.74)	(1.88)	(0.57)	(-0.16)	(0.65)	
3MO	0.05	0.24	0.05	-0.03	0.06	0.03
	(0.87)	(1.43)	(0.50)	(-0.33)	(0.48)	
10Y	0.05	0.23	-0.01	-0.05	0.10	0.08
	(0.82)	(1.45)	(-0.06)	(-0.56)	(0.79)	
DEF	0.04	0.23	0.10	0.12	0.25	-0.03
	(0.59)	(1.22)	(0.95)	(1.24)	(1.70)	
S&P	-0.03	0.11	0.19	0.09	0.25	0.04
	(-0.40)	(0.64)	(1.91)	(1.00)	(1.79)	
OIL	-0.01	0.22	0.17	0.11	0.15	0.05
	(-0.31)	(1.72)	(2.37)	(1.63)	(1.51)	
CPI	0.07	0.42	0.07	0.02	0.24	0.09
	(1.06)	(2.21)	(0.65)	(0.24)	(1.63)	
IP	0.11	0.10	0.08	-0.04	0.02	0.00
	(2.17)	(0.63)	(0.90)	(-0.56)	(0.15)	
CEA	0.22	-0.61	-0.24	-0.12	-0.44	0.15
	(2.65)	(-2.50)	(-1.75)	(-0.97)	(-2.34)	
LEA	0.01	-0.14	0.01	0.05	-0.01	0.01
	(0.25)	(-1.36)	(0.12)	(0.87)	(-0.11)	
UR	0.19	-0.52	-0.24	-0.07	-0.34	0.02
	(1.54)	(-1.49)	(-1.23)	(-0.38)	(-1.26)	
MUNI	0.00	-0.02	-0.01	-0.01	-0.01	-0.02
	(0.40)	(-1.07)	(-1.15)	(-0.66)	(-0.73)	
INC	0.07	-0.34	-0.08	0.08	-0.08	0.02
	(0.78)	(-1.26)	(-0.50)	(0.59)	(-0.39)	
GDP	0.10	-0.18	-0.09	-0.09	-0.07	0.10
	(3.24)	(-2.05)	(-1.84)	(-1.89)	(-1.01)	
BUD	0.08	-0.06	-0.05	-0.06	-0.20	-0.05
	(1.33)	(-0.35)	(-0.54)	(-0.65)	(-1.47)	

Table OA.6.11: Heterogeneity in forecast weights: one-year ahead total revenues

The table reports the results of cross-sectional regressions in which the forecast combination weights from forecasts of two-year ahead state government total revenue growth are projected on the extent to which a state derives general revenues from property, sales, and income taxes, as well as transfers from the Federal government. The forecast combination weights associated with each variable are obtained in three steps. First, for a given high-frequency regressor and weight function, the ADL-MIDAS model represented by equation (1) is estimated using data that spans 1958 to 2018. Next, the forecast combination weight represented by equation (5) is computed. Finally, the forecast weights associated with each high-frequency regressor are summed across the six different weight functions before estimating regression 1. Parentheses report t-statistics that are computed using heteroskedasticity-consistent standard errors, and the adjusted $\bar{R}^2$ of each regression is reported in the final column.

Regressor	Constant	Property	Sales	Income	Fed. Trans.	R^2
EFF	0.06	0.12	0.10	-0.03	0.11	0.03
	(1.18)	(0.76)	(1.11)	(-0.33)	(0.92)	
3MO	0.03	0.14	0.16	0.04	0.17	0.05
	(0.69)	(0.98)	(1.96)	(0.50)	(1.50)	
10Y	0.07	0.13	0.02	-0.05	0.05	-0.01
	(1.44)	(0.88)	(0.19)	(-0.65)	(0.46)	
DEF	0.10	0.14	-0.03	-0.09	0.07	0.04
	(1.87)	(0.94)	(-0.38)	(-1.10)	(0.57)	
S&P	0.07	0.14	0.08	-0.02	0.07	-0.01
	(1.45)	(0.94)	(0.96)	(-0.27)	(0.58)	
OIL	0.05	0.11	0.04	-0.02	0.08	-0.04
	(1.08)	(0.80)	(0.47)	(-0.30)	(0.72)	
CPI	0.16	0.20	-0.11	-0.16	-0.20	0.05
	(2.45)	(1.06)	(-1.07)	(-1.65)	(-1.43)	
IP	0.08	0.10	0.01	-0.08	0.10	0.05
	(1.49)	(0.67)	(0.07)	(-1.02)	(0.85)	
CEA	0.08	-0.07	-0.04	0.11	-0.13	-0.01
	(0.83)	(-0.25)	(-0.27)	(0.73)	(-0.59)	
LEA	0.06	-0.22	-0.11	-0.06	-0.10	0.00
	(1.26)	(-1.67)	(-1.51)	(-0.88)	(-1.01)	
UR	-0.02	-0.01	0.09	0.16	0.04	-0.02
	(-0.25)	(-0.03)	(0.80)	(1.53)	(0.26)	
MUNI	0.06	-0.05	-0.09	-0.06	-0.02	0.11
	(2.67)	(-0.80)	(-2.53)	(-1.98)	(-0.37)	
INC	0.13	-0.42	-0.11	0.07	-0.18	0.08
	(1.48)	(-1.61)	(-0.76)	(0.48)	(-0.88)	
GDP	0.02	-0.00	-0.03	0.15	-0.07	0.05
	(0.31)	(-0.02)	(-0.22)	(1.31)	(-0.40)	
BUD	0.03	-0.32	0.04	0.05	0.02	-0.05
	(0.32)	(-1.26)	(0.29)	(0.41)	(0.09)	

Table OA.6.12: Heterogeneity in forecast weights: one-year ahead own source revenues

The table reports the results of cross-sectional regressions in which the forecast combination weights from forecasts of one-year ahead state government own source revenue growth are projected on the extent to which a state derives general revenues from property, sales, and income taxes, as well as transfers from the Federal government. The forecast combination weights associated with each variable are obtained in three steps. First, for a given high-frequency regressor and weight function, the ADL-MIDAS model represented by equation (1) is estimated using data that spans 1958 to 2018. Next, the forecast combination weight represented by equation (5) is computed. Finally, the forecast weights associated with each high-frequency regressor are summed across the six different weight functions before estimating regression 1. Parentheses report t-statistics that are computed using heteroskedasticity-consistent standard errors, and the adjusted $\bar{R}^2$ of each regression is reported in the final column.

Regressor	Constant	Property	Sales	Income	Fed. Trans.	R^2
EFF	0.01	-0.27	-0.05	-0.01	0.08	-0.04
	(0.05)	(-0.88)	(-0.31)	(-0.08)	(0.34)	
3MO	0.02	-0.28	-0.10	-0.01	0.04	-0.02
	(0.21)	(-1.19)	(-0.74)	(-0.09)	(0.23)	
10Y	0.11	-0.18	0.02	-0.08	-0.04	-0.08
	(1.30)	(-0.71)	(0.13)	(-0.58)	(-0.20)	
DEF	0.02	0.28	0.14	0.12	0.13	-0.07
	(0.20)	(1.05)	(0.91)	(0.86)	(0.63)	
S&P	0.12	0.36	-0.03	-0.06	0.02	-0.03
	(1.31)	(1.35)	(-0.21)	(-0.43)	(0.11)	
OIL	0.12	0.00	0.09	-0.09	-0.02	-0.02
	(1.41)	(0.02)	(0.69)	(-0.69)	(-0.12)	
CPI	-0.03	-0.10	0.12	0.00	0.16	-0.02
	(-0.31)	(-0.42)	(0.90)	(0.04)	(0.87)	
IP	0.08	-0.05	-0.05	-0.06	0.14	0.01
	(1.37)	(-0.29)	(-0.52)	(-0.65)	(1.05)	
CEA	0.11	0.19	-0.08	-0.04	-0.11	-0.05
	(1.59)	(1.00)	(-0.71)	(-0.44)	(-0.75)	
LEA	0.04	0.18	-0.01	0.06	-0.00	-0.08
	(0.50)	(0.85)	(-0.05)	(0.59)	(-0.02)	
UR	0.12	0.27	-0.01	-0.01	-0.08	-0.03
	(1.47)	(1.16)	(-0.04)	(-0.06)	(-0.48)	
MUNI	0.04	-0.18	-0.05	-0.07	-0.11	-0.09
	(0.52)	(-0.81)	(-0.37)	(-0.60)	(-0.61)	
INC	0.07	-0.60	0.13	0.04	-0.06	0.07
	(0.71)	(-2.07)	(0.76)	(0.25)	(-0.29)	
GDP	0.08	0.12	-0.14	0.16	-0.11	-0.00
	(0.57)	(0.31)	(-0.63)	(0.79)	(-0.37)	
BUD	0.10	0.26	0.01	0.04	-0.04	-0.03
	(1.33)	(1.22)	(0.09)	(0.40)	(-0.25)	

Table OA.6.13: Heterogeneity in forecast weights: one-year ahead own source revenues

The table reports the results of cross-sectional regressions in which the forecast combination weights from forecasts of two-year ahead state government own source revenue growth are projected on the extent to which a state derives general revenues from property, sales, and income taxes, as well as transfers from the Federal government. The forecast combination weights associated with each variable are obtained in three steps. First, for a given high-frequency regressor and weight function, the ADL-MIDAS model represented by equation (1) is estimated using data that spans 1958 to 2018. Next, the forecast combination weight represented by equation (5) is computed. Finally, the forecast weights associated with each high-frequency regressor are summed across the six different weight functions before estimating regression 1. Parentheses report t-statistics that are computed using heteroskedasticity-consistent standard errors, and the adjusted $\bar{R}^2$ of each regression is reported in the final column.

Regressor	Constant	Property	Sales	Income	Fed. Trans.	R^2
EFF	0.11	-0.72	0.10	0.17	-0.03	-0.04
	(0.51)	(-1.21)	(0.30)	(0.54)	(-0.05)	
3MO	0.09	-0.18	-0.06	0.16	0.04	0.04
	(1.00)	(-0.69)	(-0.41)	(1.13)	(0.21)	
10Y	0.36	-0.46	-0.28	-0.01	-0.62	0.01
	(1.68)	(-0.76)	(-0.79)	(-0.03)	(-1.31)	
DEF	0.01	0.10	0.03	-0.02	0.13	-0.05
	(0.19)	(0.48)	(0.28)	(-0.20)	(0.80)	
S&P	0.11	-0.08	-0.04	-0.14	-0.14	-0.01
	(2.03)	(-0.51)	(-0.52)	(-1.74)	(-1.23)	
OIL	-0.03	0.60	0.12	0.09	0.23	0.28
	(-0.60)	(4.39)	(1.50)	(1.24)	(2.20)	
CPI	0.04	-0.24	0.01	-0.04	-0.10	-0.03
	(0.66)	(-1.31)	(0.11)	(-0.45)	(-0.70)	
IP	0.08	0.03	0.03	-0.03	-0.18	0.04
	(1.71)	(0.23)	(0.33)	(-0.47)	(-1.76)	
CEA	0.18	-0.31	-0.27	-0.22	-0.11	0.01
	(2.15)	(-1.31)	(-2.03)	(-1.74)	(-0.60)	
LEA	-0.03	-0.07	0.15	0.10	0.16	-0.02
	(-0.47)	(-0.38)	(1.58)	(1.08)	(1.19)	
UR	0.12	-0.15	-0.07	-0.14	0.25	0.20
	(1.77)	(-0.74)	(-0.61)	(-1.28)	(1.57)	
MUNI	-0.18	0.36	0.08	-0.01	0.36	0.04
	(-0.98)	(0.67)	(0.25)	(-0.05)	(0.86)	
INC	0.06	0.58	-0.01	-0.02	-0.06	-0.05
	(0.44)	(1.39)	(-0.04)	(-0.09)	(-0.18)	
GDP	-0.03	0.39	0.25	0.16	0.07	-0.04
	(-0.30)	(1.26)	(1.44)	(0.98)	(0.30)	
BUD	0.11	0.17	-0.03	-0.04	0.01	0.03
	(2.10)	(1.15)	(-0.40)	(-0.49)	(0.08)	

Table OA.6.14: Heterogeneity in forecast weights: one-year ahead total expenditures

The table reports the results of cross-sectional regressions in which the forecast combination weights from forecasts of one-year ahead state government total expenditure growth are projected on the extent to which a state derives general revenues from property, sales, and income taxes, as well as transfers from the Federal government. The forecast combination weights associated with each variable are obtained in three steps. First, for a given high-frequency regressor and weight function, the ADL-MIDAS model represented by equation (1) is estimated using data that spans 1958 to 2018. Next, the forecast combination weight represented by equation (5) is computed. Finally, the forecast weights associated with each high-frequency regressor are summed across the six different weight functions before estimating regression 1. Parentheses report t-statistics that are computed using heteroskedasticity-consistent standard errors, and the adjusted $\bar{R}^2$ of each regression is reported in the final column.

Regressor	Constant	Property	Sales	Income	Fed. Trans.	R^2
EFF	0.16	0.01	0.01	-0.11	-0.18	-0.08
	(1.32)	(0.03)	(0.04)	(-0.59)	(-0.67)	
3MO	0.13	-0.31	-0.11	-0.13	-0.28	-0.02
	(1.38)	(-1.20)	(-0.72)	(-0.93)	(-1.40)	
10Y	0.19	-0.04	-0.14	-0.20	0.40	0.26
	(2.12)	(-0.16)	(-0.96)	(-1.48)	(2.00)	
DEF	-0.01	0.23	0.05	0.11	0.05	-0.01
	(-0.29)	(1.61)	(0.65)	(1.45)	(0.44)	
S&P	0.06	0.30	0.04	-0.07	0.05	0.02
	(0.78)	(1.40)	(0.35)	(-0.65)	(0.32)	
OIL	0.07	0.28	-0.14	-0.06	-0.11	0.00
	(0.83)	(1.10)	(-0.98)	(-0.46)	(-0.59)	
CPI	0.08	0.15	0.08	-0.07	0.02	-0.02
	(1.10)	(0.70)	(0.63)	(-0.65)	(0.14)	
IP	-0.07	-0.10	0.16	0.17	0.11	0.00
	(-0.82)	(-0.45)	(1.21)	(1.39)	(0.60)	
CEA	0.04	-0.31	-0.02	0.06	-0.07	0.00
	(0.48)	(-1.42)	(-0.15)	(0.54)	(-0.41)	
LEA	0.17	0.13	-0.11	-0.08	-0.13	-0.05
	(2.01)	(0.54)	(-0.77)	(-0.63)	(-0.68)	
UR	-0.01	-0.30	0.00	0.06	0.02	0.01
	(-0.10)	(-1.39)	(0.03)	(0.52)	(0.09)	
MUNI	-0.01	0.22	0.02	0.07	0.12	0.18
	(-0.40)	(2.87)	(0.51)	(1.76)	(2.06)	
INC	0.04	-0.04	0.19	0.17	0.36	0.22
	(0.59)	(-0.24)	(1.75)	(1.79)	(2.47)	
GDP	0.17	0.03	-0.18	-0.03	-0.15	-0.01
	(1.89)	(0.09)	(-1.22)	(-0.20)	(-0.71)	
BUD	-0.01	-0.24	0.15	0.11	-0.20	0.04
	(-0.12)	(-0.72)	(0.77)	(0.65)	(-0.77)	

Table OA.6.15: Heterogeneity in forecast weights: one-year ahead total expenditures

The table reports the results of cross-sectional regressions in which the forecast combination weights from forecasts of two-year ahead state government total expenditure growth are projected on the extent to which a state derives general revenues from property, sales, and income taxes, as well as transfers from the Federal government. The forecast combination weights associated with each variable are obtained in three steps. First, for a given high-frequency regressor and weight function, the ADL-MIDAS model represented by equation (1) is estimated using data that spans 1958 to 2018. Next, the forecast combination weight represented by equation (5) is computed. Finally, the forecast weights associated with each high-frequency regressor are summed across the six different weight functions before estimating regression 1. Parentheses report t-statistics that are computed using heteroskedasticity-consistent standard errors, and the adjusted $\bar{R}^2$ of each regression is reported in the final column.

Regressor	Constant	Property	Sales	Income	Fed. Trans.	R^2
EFF	0.23	-0.23	-0.25	-0.24	-0.31	-0.05
	(2.11)	(-0.72)	(-1.40)	(-1.47)	(-1.27)	
3MO	0.06	0.54	0.13	0.04	0.02	0.04
	(0.71)	(2.40)	(1.00)	(0.36)	(0.12)	
10Y	0.11	-0.03	-0.10	-0.12	0.10	0.02
	(1.58)	(-0.14)	(-0.88)	(-1.19)	(0.63)	
DEF	0.02	-0.07	-0.08	0.05	-0.12	0.08
	(0.43)	(-0.45)	(-0.92)	(0.61)	(-0.95)	
S&P	0.00	-0.11	0.17	0.15	0.14	-0.01
	(0.06)	(-0.50)	(1.37)	(1.34)	(0.83)	
OIL	-0.07	0.04	0.16	0.19	0.40	0.10
	(-1.11)	(0.24)	(1.67)	(2.09)	(2.97)	
CPI	0.12	-0.31	0.02	-0.20	-0.05	0.06
	(1.41)	(-1.28)	(0.17)	(-1.57)	(-0.25)	
IP	0.10	-0.06	-0.17	-0.11	-0.17	-0.00
	(1.45)	(-0.29)	(-1.51)	(-1.04)	(-1.14)	
CEA	0.04	0.44	0.11	0.14	0.21	0.06
	(0.48)	(2.08)	(0.93)	(1.24)	(1.26)	
LEA	0.04	-0.02	0.10	0.09	-0.01	-0.01
	(0.65)	(-0.11)	(1.08)	(1.06)	(-0.07)	
UR	0.06	0.34	0.08	0.12	0.06	0.04
	(0.84)	(1.81)	(0.71)	(1.18)	(0.44)	
MUNI	-0.02	-0.03	0.01	0.05	0.13	0.03
	(-0.80)	(-0.32)	(0.13)	(1.13)	(1.95)	
INC	0.24	-0.21	-0.25	-0.19	-0.43	0.05
	(3.25)	(-0.99)	(-2.07)	(-1.70)	(-2.58)	
GDP	0.11	-0.19	-0.04	-0.02	0.03	-0.10
	(1.01)	(-0.60)	(-0.23)	(-0.11)	(0.11)	
BUD	-0.04	-0.12	0.12	0.06	0.01	0.01
	(-0.42)	(-0.49)	(0.87)	(0.44)	(0.04)	

OA.7 Additional results on the application to COVID-19

Table OA.7.16: Assumptions

The table reports the assumptions underlying the real-time forecasts of how the COVID-19 pandemic is likely to affect state-level revenue and expenditure growth rates, as reported in Table 7 of the main text. The table reports the values we assume that each high-frequency predictor underlying our analysis takes on between July 2020 and October 2020. The table reports each variable we include in this analysis, denoted by its mnemonic from Table 1, the source from which these expectations are obtained, and the units in which each variable is measured. Here, "SPF" refers the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters, while "CBO" refers to the Congressional Budget Office. Since the expectations for each variable are typically updated at a quarterly, or lower, frequency, we convert convert these quarterly expectations into monthly values for each variable through a linear interpolation.

Variable	Source	Units	June	July	August	September	October
GDP	CBO	Ann. % change	-34.60	-21.70	-8.80	4.10	17.00
BUD	CBO	$b	-2778	-2719	-2660	-2601	-2542
EFF	CBO	Ann. %	0.10	0.10	0.10	0.10	0.10
CPI	CBO	Ann. % change	-3.10	-1.68	-0.25	1.18	2.60
IND	SPF	Ann. % change	-35.71	-23.70	-11.69	0.32	12.32
OIL	CBO	$ per barrel	27.57	30.83	34.09	37.34	40.60
3MO	CBO	%	0.10	0.12	0.13	0.15	0.16
10Y	CBO	%	0.70	0.70	0.70	0.70	0.70
DEF	SPF	%	1.20	1.28	1.36	1.44	1.52

Table OA.7.17: State-level forecasts of total revenue growth

The table reports the results of out-of-sample forecasts of state-level real total revenue growth rates for fiscal years 2020 and 2021. These forecasts are obtained using the ADL-MIDAS model described in equations (1) and (6). These forecasts are produced in two steps. First, we estimate an ADL-MIDAS model for each fiscal outcome in each state using data spanning 1958 to 2019. This provides us the with both the squared discounted mean squared forecast errors (dMSFE) underlying the forecast combination weights in equation (5) and the parameter estimates underlying the ADL-MIDAS model. Next, using these forecast combination weights and parameter estimates from the first step, we estimate the one- and two-year ahead fiscal outcomes for each state. In the column denoted "Dec 2019" ("Jun 2020") we construct these out-of-sample forecasts by only using data that is available as of December 2019 (June 2020). In the column denoted "Scenario" we construct these out-of-sample forecasts using a combination of (i) data that is available as of June 2020, and (ii) expectations regarding the the evolution of key high-frequency predictors between June 2020 and October 2020. The evolution of each of these high-frequency predictors in the scenario analysis is drawn from the Survey of Professional Forecasters and the Congressional Budget Office, and is summarized in Table OA.7.16 of the Online Appendix. For each set of forecasts we report the cross-sectional mean, median, and standard deviation of the estimated total revenue growth rates.

	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
AL	3.52	0.06	-	2.47	-5.07	-8.15
AZ	4.27	-3.14	-	2.53	-1.38	-7.03
AR	6.33	2.48	-	5.96	0.76	-5.71
CA	5.11	-10.46	-	4.77	-1.71	-10.34
CO	6.67	-6.42	-	6.07	-3.60	-12.54
CT	5.79	-3.31	-	2.04	-1.34	-12.08
DE	3.79	-2.83	-	3.28	-0.14	-7.41
FL	5.72	-4.51	-	5.20	-1.10	-8.07
GA	4.95	-2.34	-	2.36	-1.73	-12.30
ID	6.61	-2.48	-	5.67	-1.66	-8.24
IL	5.34	-6.25	-	6.03	-0.90	-7.66
IN	4.02	-1.47	-	3.14	-0.26	-8.07

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	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
IA	6.56	-2.60	-	3.15	-0.48	-13.16
KS	3.82	-3.08	-	4.23	-0.89	-4.70
KY	7.16	1.63	-	3.53	-1.60	-13.79
LA	6.35	0.20	-	6.70	3.07	1.16
ME	6.93	0.39	-	2.26	-3.57	-11.03
MD	5.76	-0.49	-	3.38	-2.85	-5.56
MA	4.97	-4.66	-	5.00	-4.36	-7.19
MI	5.98	-0.12	-	3.40	-1.73	-5.38
MN	5.11	-5.17	-	4.65	-1.02	-10.08
MS	7.70	2.04	-	5.98	-0.56	-4.55
MO	5.36	-5.85	-	5.87	1.73	-8.52
MT	4.39	-3.35	-	6.30	-0.67	-3.11
NE	7.12	3.01	-	4.89	-2.11	-8.18
NV	6.90	-1.81	-	2.34	-1.15	-16.28
NH	6.35	-1.12	-	5.44	0.49	-4.24
NJ	4.01	-5.08	-	4.48	-2.80	-11.43
NM	4.39	-2.47	-	1.10	-5.62	-10.21
NY	3.63	-	-	5.18	-0.62	-5.47
NC	6.21	-6.91	-	4.15	-2.65	-5.75
ND	2.33	-3.03	-	7.41	3.78	-2.11
OH	6.42	-4.62	-	5.96	-2.34	-11.79
OK	6.63	0.84	-	6.12	3.03	4.23
OR	6.08	-5.31	-	6.04	-4.86	-11.06
PA	5.51	-5.93	-	4.82	-2.03	-8.13
RI	4.82	-5.32	-	4.10	-2.23	-9.10
SC	5.75	-2.45	-	3.93	-4.35	-12.30
SD	6.37	-3.97	-	5.54	-0.40	-9.87
TN	4.95	-3.68	-	0.56	-6.83	-11.87
TX	5.40	2.09	-	4.86	0.64	-4.99
UT	5.03	-3.62	-	5.77	-1.34	-8.63
VT	5.28	0.11	-	4.68	0.81	-8.42
VA	5.95	-2.94	-	0.26	-6.70	-15.44
WA	4.68	-5.18	-	5.17	-1.51	-11.60
WV	5.30	0.56	-	5.49	3.36	1.81
WI	6.49	-3.90	-	5.13	-6.23	-7.29
WY	6.15	-4.53	-	4.23	-2.65	-9.96

Table OA.7.18: State-level forecasts of own source revenue growth

The table reports the results of out-of-sample forecasts of state-level real own source revenue growth rates for fiscal years 2020 and 2021. These forecasts are obtained using the ADL-MIDAS model described in equations (1) and (6). These forecasts are produced in two steps. First, we estimate an ADL-MIDAS model for each fiscal outcome in each state using data spanning 1958 to 2019. This provides us the with both the squared discounted mean squared forecast errors (dMSFE) underlying the forecast combination weights in equation (5) and the parameter estimates underlying the ADL-MIDAS model. Next, using these forecast combination weights and parameter estimates from the first step, we estimate the one- and two-year ahead fiscal outcomes for each state. In the column denoted "Dec 2019" ("Jun 2020") we construct these out-of-sample forecasts by only using data that is available as of December 2019 (June 2020). In the column denoted "Scenario" we construct these out-of-sample forecasts using a combination of (i) data that is available as of June 2020, and (ii) expectations regarding the the evolution of key high-frequency predictors between June 2020 and October 2020. The evolution of each of these high-frequency predictors in the scenario analysis is drawn from the Survey of Professional Forecasters and the Congressional Budget Office, and is summarized in Table OA.7.16 of the Online Appendix. For each set of forecasts we report the cross-sectional mean, median, and standard deviation of the estimated own source revenue growth rates.

	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
AL	2.97	-12.61	-	4.07	-3.51	-11.26
AZ	2.53	-6.77	-	0.81	-9.15	-15.28
AR	1.71	-2.53	-	3.03	-1.66	-13.81
CA	1.95	-5.76	-	4.96	-4.96	-16.36
CO	2.86	-7.76	-	3.95	-1.97	-10.46
CT	3.46	-4.05	-	3.92	-3.79	-10.06
DE	-0.09	-5.40	-	2.34	-1.72	-10.85
FL	2.59	-5.13	-	4.17	-7.99	-7.69
GA	1.95	-8.05	-	2.76	-4.37	-7.79
ID	3.01	-9.05	-	4.54	-9.14	-8.94
IL	4.37	-4.65	-	3.50	-2.39	-16.03
IN	1.40	-4.43	-	0.07	-7.34	-13.05
IA	3.98	-6.57	-	4.47	-5.23	-12.53
KS	2.04	-5.26	-	4.34	-1.74	-10.45
KY	2.09	-1.28	-	3.00	-4.22	-16.06
LA	1.59	-9.34	-	1.43	-6.51	-11.66
ME	1.34	-5.56	-	3.90	-5.86	-16.84
MD	1.95	-6.61	-	3.97	-6.75	-9.15
MA	2.10	-4.05	-	3.88	-5.11	-12.65
MI	1.83	-6.60	-	3.22	-3.60	-19.01
MN	3.20	-6.48	-	4.31	-2.37	-13.20
MS	3.57	-5.64	-	3.96	-7.73	-12.58
MO	2.17	-4.52	-	4.72	-6.16	-16.70
MT	0.05	-12.03	-	4.34	-5.08	-19.00
NE	2.10	-5.69	-	4.31	-1.77	-14.07
NV	1.63	-5.64	-	3.15	-4.84	-12.53
NH	4.08	-4.07	-	2.69	-8.36	-9.22
NJ	2.43	-8.23	-	2.00	-6.21	-7.80
NM	3.14	-5.65	-	3.95	-4.66	-11.59
NY	0.17	-	-	3.46	-3.78	-13.67
NC	2.46	-7.04	-	3.75	-1.93	-10.30
ND	4.40	-5.34	-	4.05	-7.16	-14.52
OH	2.25	-7.00	-	2.89	-3.55	-8.05
OK	1.12	-6.52	-	5.36	-4.75	-11.78
OR	2.42	-8.60	-	4.47	-1.62	-9.43
PA	2.32	-8.01	-	4.05	-3.25	-11.50
RI	1.49	-9.70	-	4.74	-5.54	-13.88
SC	1.70	-7.24	-	3.00	-1.90	-11.05

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	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
SD	2.14	-10.67	-	3.91	-2.74	-12.24
TN	2.96	-3.03	-	2.72	-3.02	-15.51
TX	2.18	-7.93	-	2.93	-3.72	-16.65
UT	2.89	-11.09	-	3.89	-3.69	-10.63
VT	0.47	-8.56	-	4.00	-3.64	-13.12
VA	0.76	-5.98	-	5.42	-4.42	-12.64
WA	2.85	-4.65	-	3.98	-4.70	-9.18
WV	3.17	-2.93	-	3.12	-0.28	-12.43
WI	3.00	-10.15	-	4.11	-4.17	-17.80
WY	-0.57	-11.89	-	0.93	-6.27	-14.56

Table OA.7.19: State-level forecasts of total expenditure growth

The table reports the results of out-of-sample forecasts of state-level real own source revenue growth rates for fiscal years 2020 and 2021. These forecasts are obtained using the ADL-MIDAS model described in equations (1) and (6). These forecasts are produced in two steps. First, we estimate an ADL-MIDAS model for each fiscal outcome in each state using data spanning 1958 to 2019. This provides us the with both the squared discounted mean squared forecast errors (dMSFE) underlying the forecast combination weights in equation (5) and the parameter estimates underlying the ADL-MIDAS model. Next, using these forecast combination weights and parameter estimates from the first step, we estimate the one- and two-year ahead fiscal outcomes for each state. In the column denoted "Dec 2019" ("Jun 2020") we construct these out-of-sample forecasts by only using data that is available as of December 2019 (June 2020). In the column denoted "Scenario" we construct these out-of-sample forecasts using a combination of (i) data that is available as of June 2020, and (ii) expectations regarding the the evolution of key high-frequency predictors between June 2020 and October 2020. The evolution of each of these high-frequency predictors in the scenario analysis is drawn from the Survey of Professional Forecasters and the Congressional Budget Office, and is summarized in Table OA.7.16 of the Online Appendix. For each set of forecasts we report the cross-sectional mean, median, and standard deviation of the estimated total expenditure growth rates.

	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
AL	4.91	2.84	-	2.90	-1.50	-9.27
AZ	2.78	-0.26	-	0.83	-3.34	-8.38
AR	5.16	1.03	-	2.62	-0.35	-9.81
CA	1.06	-4.95	-	-1.90	-6.80	-8.54
CO	1.90	-2.24	-	2.67	-2.30	-6.10
CT	3.15	-4.98	-	3.03	-4.85	-10.40
DE	4.61	2.92	-	1.01	-1.55	-7.46
FL	-0.57	-6.00	-	0.50	-2.87	-8.35
GA	1.19	-4.61	-	1.73	1.00	-7.76
ID	2.54	-3.00	-	4.17	-5.82	-19.50
IL	4.42	-1.88	-	0.07	-6.74	-15.62
IN	2.85	-0.42	-	3.34	-0.93	-12.76
IA	1.63	1.68	-	5.36	1.40	-9.20
KS	2.60	-1.77	-	4.25	-0.15	-7.82
KY	6.03	2.68	-	6.37	3.26	-7.72
LA	4.97	-1.30	-	1.59	-2.35	-12.89
ME	0.07	-4.36	-	1.31	-4.32	-8.25
MD	3.12	-2.37	-	4.20	-1.84	-15.33
MA	1.95	-2.30	-	3.35	-1.15	-11.27
MI	1.29	-5.05	-	1.09	-5.23	-10.57
MN	1.33	-1.04	-	1.39	-3.33	-7.47
MS	2.54	-6.29	-	3.97	-0.54	-14.22

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Table OA.7.19 – Continued from the previous page

	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
MO	2.79	-0.32	-	3.63	-1.14	-5.92
MT	3.56	-0.36	-	3.97	-3.86	-10.13
NE	-0.17	-2.75	-	5.50	2.33	-3.87
NV	1.53	-5.44	-	3.29	-2.26	-14.50
NH	3.25	-0.43	-	4.30	0.73	-4.79
NJ	2.56	-2.52	-	1.43	-7.04	-6.49
NM	5.47	0.29	-	4.30	-3.85	-16.86
NY	2.95	-	-	3.41	0.28	-6.81
NC	1.15	-4.03	-	3.98	1.74	-9.95
ND	4.65	-0.73	-	4.71	-0.98	-7.83
OH	2.67	-1.61	-	4.26	1.39	-4.49
OK	1.83	-1.99	-	3.75	-3.93	-13.27
OR	4.24	1.15	-	2.89	-1.34	-7.07
PA	2.48	-0.85	-	4.31	-2.25	-6.85
RI	2.39	-2.86	-	2.41	-1.25	-8.38
SC	2.13	-0.55	-	3.86	-2.87	-17.57
SD	4.17	-3.23	-	1.95	-2.31	-7.19
TN	1.83	-1.28	-	1.93	-0.11	-8.29
TX	3.92	-0.71	-	2.91	-0.83	-6.40
UT	1.45	-2.09	-	3.78	-2.59	-10.77
VT	6.49	2.53	-	3.16	2.06	-5.74
VA	1.85	-0.32	-	1.47	-3.38	-2.50
WA	2.85	-3.44	-	3.83	-0.93	-6.82
WV	0.30	-5.60	-	4.95	1.01	-12.73
WI	2.05	-2.21	-	2.71	-3.48	-9.82
WY	4.14	-2.26	-	4.18	-7.15	-19.10

Table OA.7.20: Real-time forecasts for fiscal years 2020 and 2021

The table reports the results of out-of-sample forecasts of state-level real revenue and expenditure growth rates for fiscal years 2020 and 2021. These forecasts are obtained using the ADL-MIDAS model described in equations (1) and (6). These forecasts are produced in two steps. First, we estimate an ADL-MIDAS model for each fiscal outcome in each state using data spanning 1958 to 2019. This provides us the with both the squared discounted mean squared forecast errors (dMSFE) underlying the forecast combination weights in equation (5) and the parameter estimates underlying the ADL-MIDAS model. Next, using these forecast combination weights and parameter estimates from the first step, we estimate the one- and two-year ahead fiscal outcomes for each state. In estimating these models and producing each out-of-sample forecast, we require the predicted values to lie within a range of $[-50\%, +50[$. In the column denoted "Dec 2019" ("Jun 2020") we construct these out-of-sample forecasts by only using data that is available as of December 2019 (June 2020). In the column denoted "Scenario" we construct these out-of-sample forecasts using a combination of (i) data that is available as of June 2020, and (ii) expectations regarding the the evolution of key high-frequency predictors between June 2020 and October 2020. The evolution of each of these high-frequency predictors in the scenario analysis is drawn from the Survey of Professional Forecasters and the Congressional Budget Office, and is summarized in Table OA.7.16 of the Online Appendix. For each set of forecasts we report the cross-sectional mean, median, and standard deviation of the estimated growth rates. Panel A reports these summary statistics for total revenue growth rates, Panel B reports these summary statistics for own source revenue growth rates, and Panel C reports these summary statistics for total expenditure growth rates.

	Fiscal year 2020			Fiscal year 2021		
	Dec 2019	Jun 2020	Scenario	Dec 2019	Jun 2020	Scenario
Panel A: Summary statistics for REV-Total						
Mean	9.85	-4.45	-	6.66	-3.47	-13.42
Median	9.52	-3.42	-	5.88	-3.24	-14.62
Std.	4.26	4.68	-	5.33	5.05	6.77
Panel B: Summary statistics for REV-Own						
Mean	2.87	-3.17	-	8.20	-3.16	-12.48
Median	3.18	-2.90	-	8.67	-4.10	-11.86
Std.	4.18	5.18	-	4.88	4.65	6.40
Panel C: Summary statistics for EXP-Total						
Mean	3.24	-2.24	-	4.48	-1.67	-10.99
Median	3.20	-2.04	-	4.44	-1.59	-9.59
Std.	3.76	4.21	-	4.22	3.95	7.09

References

Mincer, J. and Zarnowitz, V. (1969). The evaluation of economic forecasts. In *Economic Forecasts and Expectations: Analysis of Forecasting Behavior and Performance*, National Bureau of Economic Research, Inc, pp. 3–46.

Pesaran, M. H., Schuermann, T. and Smith, L. V. (2009). Forecasting economic and financial variables with global VARs. *International Journal of Forecasting*, **25** (4), 642 – 675.