How do Macroeconomic Expectations Respond to Extreme Weather Shocks?

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Conference on Real-time Data Analysis, Methods, and Applications

Hurricanes Irma and Harvey cause Goldman Sachs to slash its outlook for the US economy

Hurricanes Irma, Harvey will have a significant negative impact on third-quarter GDP growth

Hurricane Ida: Economists foresee only modest damage US economy

Fed says Harvey and Irma will have no lasting economic impact

Katrina may curb economic growth into 2006
(AP)

Devastating storm may ultimately boost US GDP.

Katrina to boost U.S. economy in 2006

Motivation

Real-time concerns:

- FRB Governor dissented after Hurricane Katrina in September 2005:
  - **FOMC Minutes:** “Mr. Olson dissented because he preferred that the Committee defer policy action at this meeting, pending the receipt of additional information on the economic effects resulting from the severe shock of Hurricane Katrina.”

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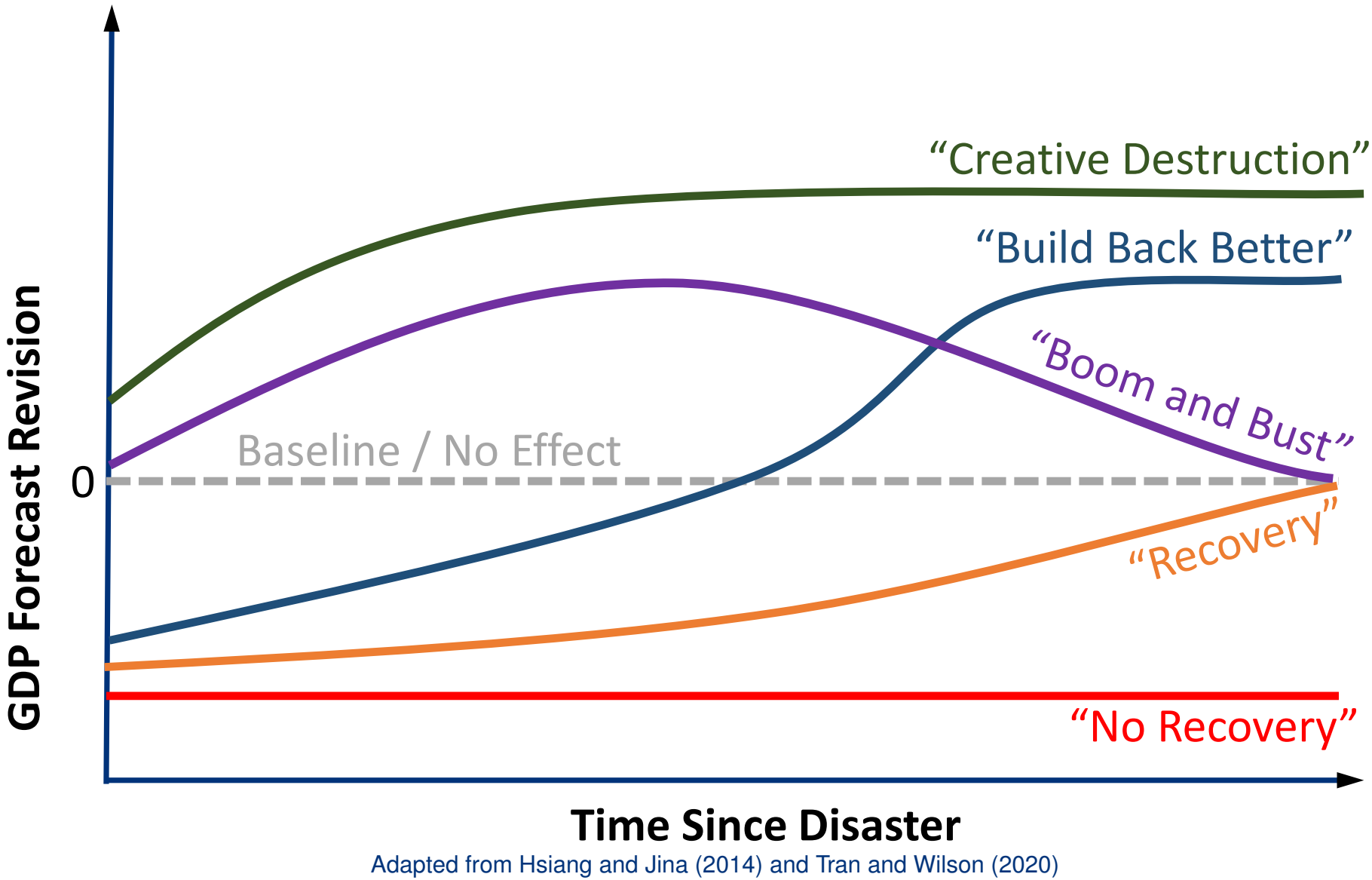
“[S]evere weather events like hurricanes do not likely have an outsized effect on growth rates in countries like the United States”

- FRB Governor Chris Waller May, 11 2023

Illustrative Pathways for Macroeconomic Expectations



Adapted from Hsiang and Jina (2014) and Tran and Wilson (2020)

Overview: This Paper

How do macroeconomic expectations react to weather shocks?

1. Construct new panel of biweekly macro forecasts
2. Construct new real-time measure of hurricane damage shocks
3. Examine individual forecast revisions following a hurricane

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What role do dynamics play?

1. Immediate (short-run) vs. Total (long-run) effect

Evidence of permanent / persistent effects?

Overview: Results

- **Katrina-sized shock has large effect on expectations:**
  - Decline in (near-term) expected output:
    - Immediate: 0.3 pp.
    - Total: 0.7 pp.
    - Slow recovery across horizons
    - Forecasters closer to hurricane expect worse
  - Rise in expected prices (0.25 percentage points); no decline
  - Decline in expected interest rates (20 basis points); full recovery

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  - GDP expectations under-react (inefficient)
    - Not forecasters in Financial Services sector / Federal Reserve Board
  - Interest rate and inflation expectations over-react

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- **No evidence of permanent effect**

Related Literature

- **Macroeconomic Effects of Extreme Weather / Climate:** Strobl (2011), Cavallo et al. (2013), Linder et al. (2013), Hsiang and Jina (2014), Tran and Wilson (2020), Kim et al. (2021), Ludvigson et al. (2021), Natoli (2022)
- **Climate and Macroeconomic Expectations:** Baker et al. (2020), Dietrich et al. (2021), Cantelmo (2022), Meinerding et al. (2023)
- **Deviations from Full-information Rational Expectations:** Nordhaus (1987), Coibion and Gorodnichenko (2015), Bordalo et al. (2020), Kohlhas and Walther (2021)
- **The Information Channel of Monetary Policy:** Campbell et al. (2012), Campbell et al. (2017), Nakamura and Steinsson (2018), Lunsford (2020), Miranda-Agrippino and Ricco (2021), Bauer and Swanson (2023)
- **High Frequency Identification:** Ghanem and Smith (2021), Chang and Levinson (2023), Jacobson et al. (2022), Buda et al. (2023)

Outline

- Motivation
- Overview
- Empirical Approach
- Data
- GDP Results
- Additional Results
- Conclusions

Empirical Approach: Static Model

Effect of an exogenous shock on individual forecast revisions:

$$\Delta f_{i,w,t,h} = \beta_{1,h} \mathrm{Shk}_{w,t} + \nu_{i,w,t,h}, \tag{1}$$

$f_{i,w,t,h}$ forecast by $i \in \{1, \ldots, N\}$ in week $w \in \{1, 3, \ldots, 11\}$ of quarter $t \in \{1, \ldots, T\}$ for horizon $h \in \{0, \ldots, 4\}$

$\Delta f_{i,w,t,h} \equiv f_{i,w,t,h} - f_{i,w-1,t,h}$ biweekly forecast revision

$\mathrm{Shk}_{w,t}$ sum of shocks between survey dates

Methodological basis: Faust and Wright (2008)

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Methodological basis: Faust and Wright (2008)

$\rightarrow$**No revision dynamics:** only an immediate effect

Empirical Approach: Revision Dynamics

Nordhaus (1987) showed that forecast revisions may not be efficient

$$\Delta f_{i,w,t,h} = \gamma_{1,h} \Delta f_{i,w-1,t,h} + u_{i,w,t,h}, \tag{2}$$

- **Consensus** ($\gamma_1 > 0$) vs. **Individual** ($\gamma_1 < 0$)

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- **Consensus** ($\gamma_1 > 0$) vs. **Individual** ($\gamma_1 < 0$)

Baker et al. (2020): state-dependent inefficiency following large shocks

$$\Delta f_{i,w,t,h} = \gamma_{1,h} \Delta f_{i,w-1,t,h} + \gamma_{2,h} (\Delta f_{i,w-1,t,h} \times Shk_{w,t}) + \tilde{u}_{i,w,t,h}, \quad (3)$$

- **Consensus:** $\gamma_1 > 0$ $\gamma_2 < 0 \rightarrow$ Large shocks attenuate rigidity

Empirical Approach: General Dynamic Model

$$\Delta f_{i,w,t,h} = \gamma_{1,h}\Delta f_{i,w-1,t,h} + \gamma_{2,h}\left(\Delta f_{i,w-1,t,h} \times Shk_{w-1,t}\right) + \sum_{j=0}^{1} \beta_{j,h} Shk_{w-j,t} + \epsilon_{i,w,t,h}, \quad (4)$$

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- **Immediate** (short-run) effect at horizon h:

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- **Total** (long-run) effect at horizon h:

$$\frac{\beta_{0,h}\left(1 + \gamma_{2,h}\text{Shk}_{w,t}\right) + \beta_{1,h}}{1 - \gamma_{1,h}}$$

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Shock-specific Test of Forecast Efficiency:

$$H_0 : \frac{\beta_{0,h}\left(1+\gamma_{2,h}Shk_{w,t}\right)+\beta_{1,h}}{1-\gamma_{1,h}} = \beta_{0,h}$$

Common factor restriction: Hendry and Mizon (1978) and Mizon and Hendry (1980).

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Shock-specific Test of Forecast Efficiency:

$$H_0 : \beta_{1,h} + \beta_{0,h}\left(\gamma_{1,h} + \gamma_{2,h} \times Shk_{w,t}\right) = 0$$

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Data: Blue Chip Surveys

Two Monthly surveys:

- Blue Chip Economic Indicators (4th-5th)
- Blue Chip Financial Forecasters (22nd - 23rd)

Average gap: 14 days (6-23 days)

Large overlap in both surveys $\approx$ 60-75% list

Focus on individual quarterly forecasts from 2001-2019

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Focus on individual quarterly forecasts from 2001-2019

Sample: 54 business economists (firms)

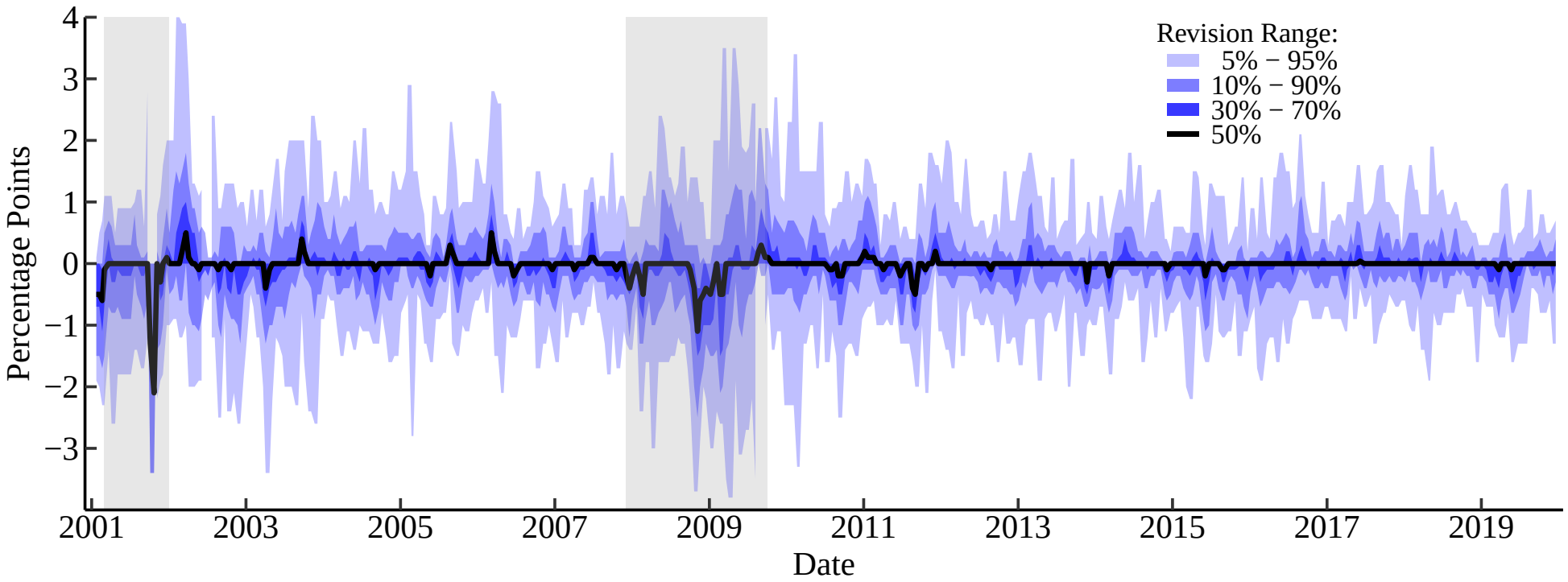
Median (mean): 324 (297)

Horizon: 0-4 quarters-ahead

Variables

1. Real GDP growth (annualized)
2. Headline CPI inflation (annualized)
3. Yield on 10 Year Treasury Notes

Data: Blue Chip Nowcast Revisions



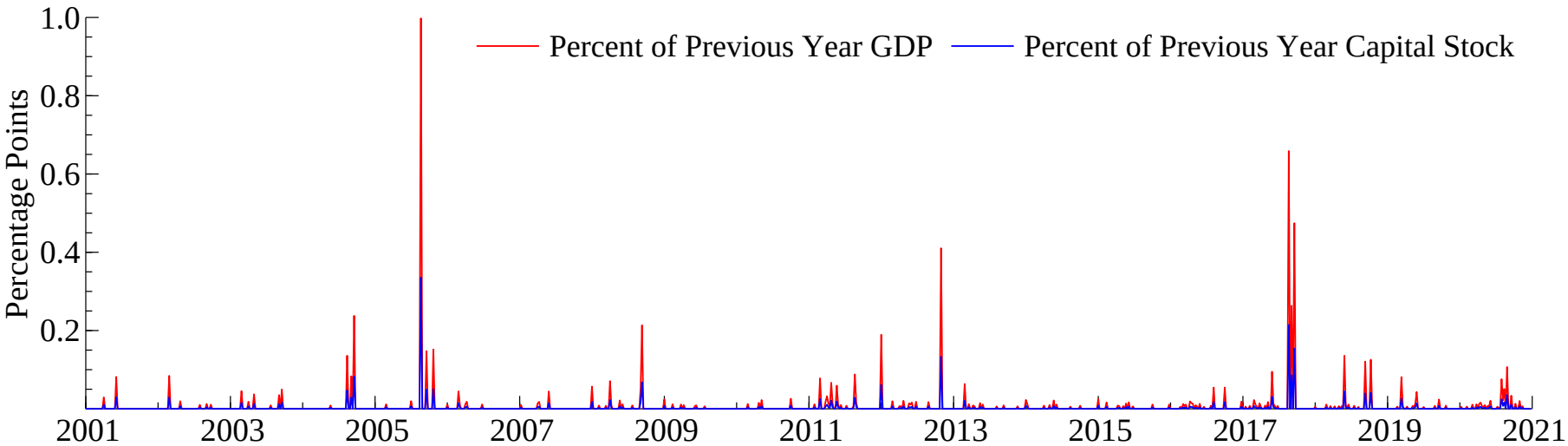
Data: Blue Chip Revision Frequency

	GDP growth			CPI inflation			10-yr T-Note yield		
h	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**
0	15	56	88	24	64	93	36	57	80
1	9	48	87	15	53	84	32	55	82
2	7	43	84	13	47	87	24	51	83
3	8	37	84	9	44	86	17	49	86
4	9	36	91	3	43	88	13	46	84

- Typically revise at higher than monthly frequency
- Longer-term forecasts revised less often
- Large amount of heterogeneity

Data: Extreme Weather and Hurricane Damages

NOAA Billion-Dollar Weather and Climate Disasters in the US:



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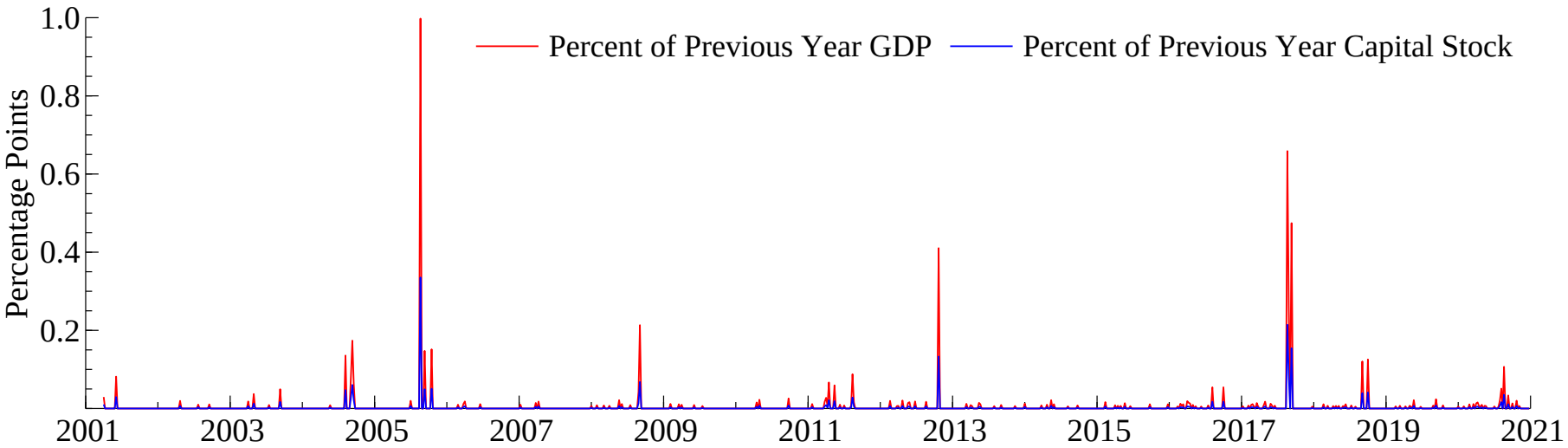

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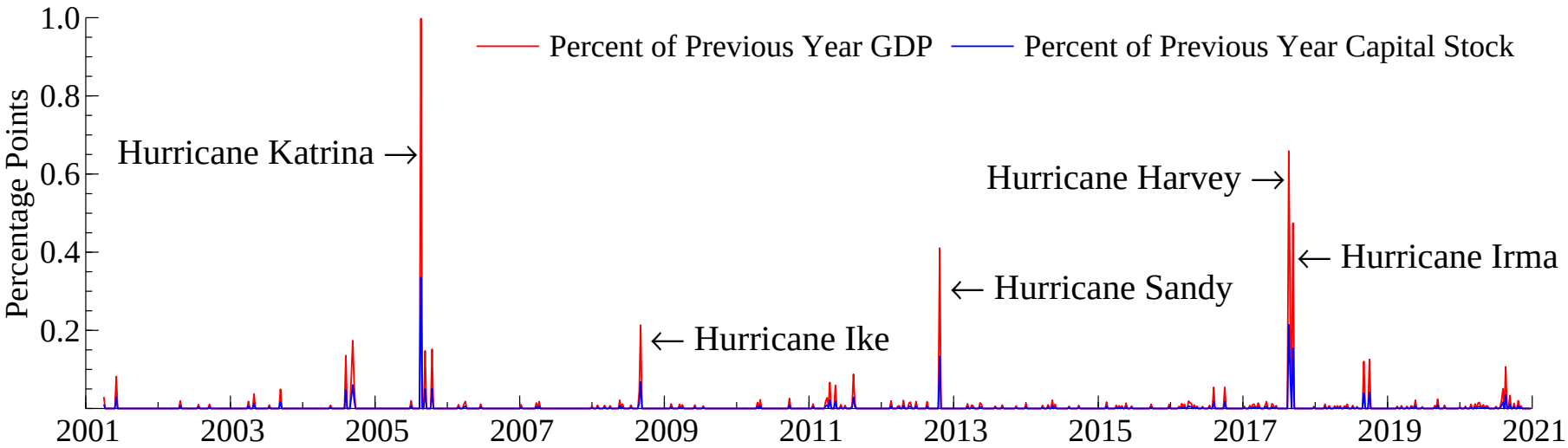

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Hurricanes: more than 73% of the real damages and 80% of the fatalities despite accounting for less than 20% of the events.

Hurricane Ian could cost US $67bn in economic damages

Published on 29/09/2022, 6:44pm

The Category 4 hurricane, one of the most powerful to ever make landfall in the US, has destroyed homes, infrastructure and citrus farms

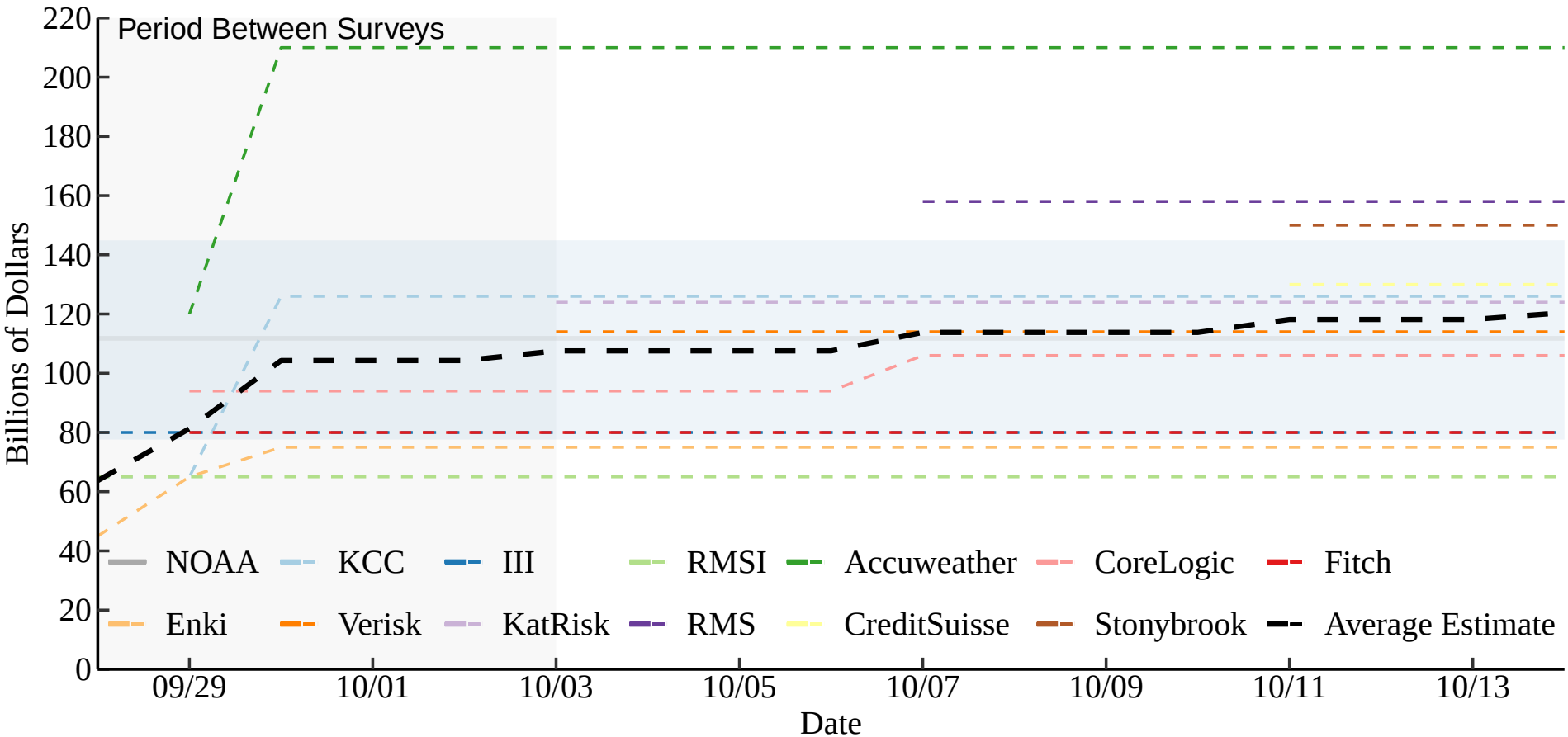
Hurricane Ian is pictured from the International Space Agency, just south of Cuba and heading to Florida. (Photo: Nasa/Flickr)

Source: Climate Home News

Data: Real-time Damage Estimates for Hurricane Ian [2022]

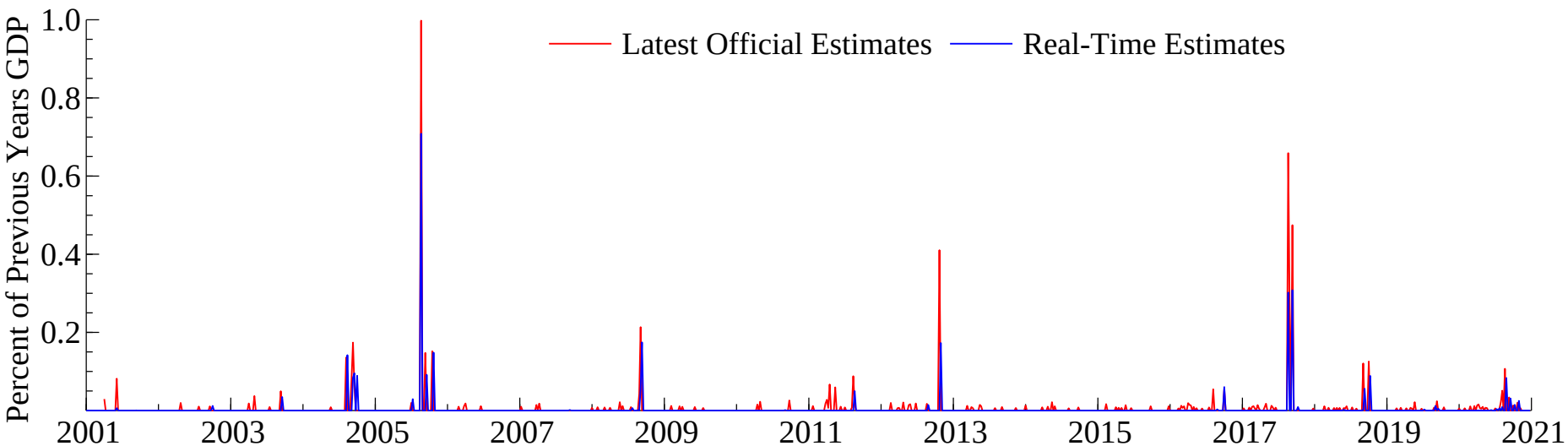
Early damage estimates up to 7 days after strike.

- From publicly available news articles / press releases



Data: Real-time Hurricane Shocks

$$\mathrm{Shk}_{w,t} = \frac{1}{M_w} \sum_{j=1}^{M_w} D_{j,w}/\mathrm{GDP}_{w,t-4} \times 100,$$



Data: Macro Surprises

Forecasters respond to macro news; Bok et al. (2018)

Caution not to over-control:

- Initial jobless claims; Aaronson et al. (2020) / Davis and Ng (2023)
- Financial variables; Kruttli et al. (2021)

Macro Controls:

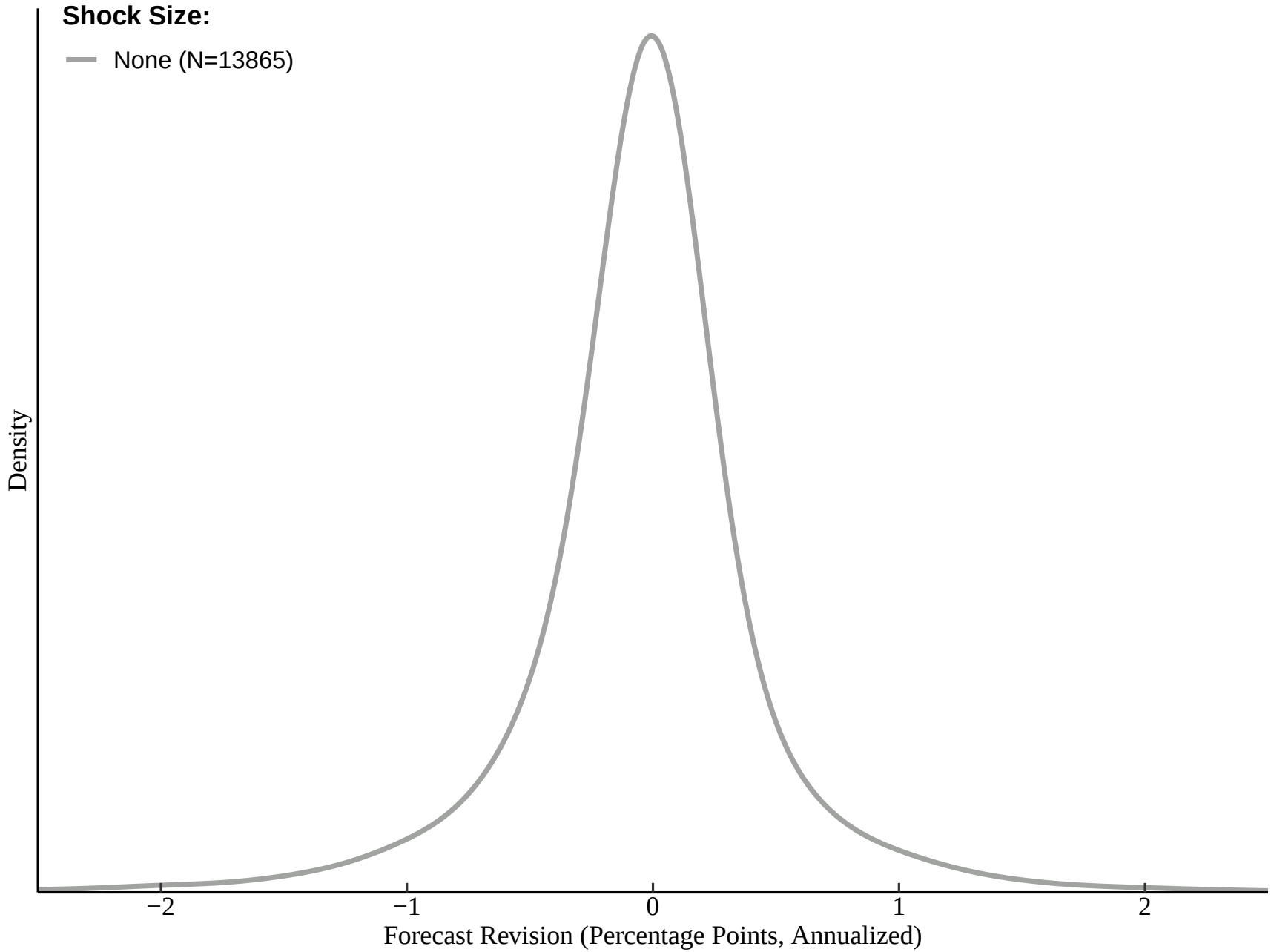
1. Bloomberg Consensus surprises; Altavilla et al. (2017)

- Continuing Jobless Claims
- Advanced Retail Sales
- Durable Goods Orders
- New Home Sales
- ISM Manufacturing
- Philadelphia Fed Business Outlook
- Monthly Budget Statement

2. Forecaster specific GDP backcast errors

3. September 11 2001

GDP Nowcast Revision Density by Shock Size



Nonparametric estimates using Gaussian kernel with bandwidth of 0.20. 14,424 observations truncated: ±2.5 pp.

Ex. Slow Updaters *Hurricane Sandy Example*

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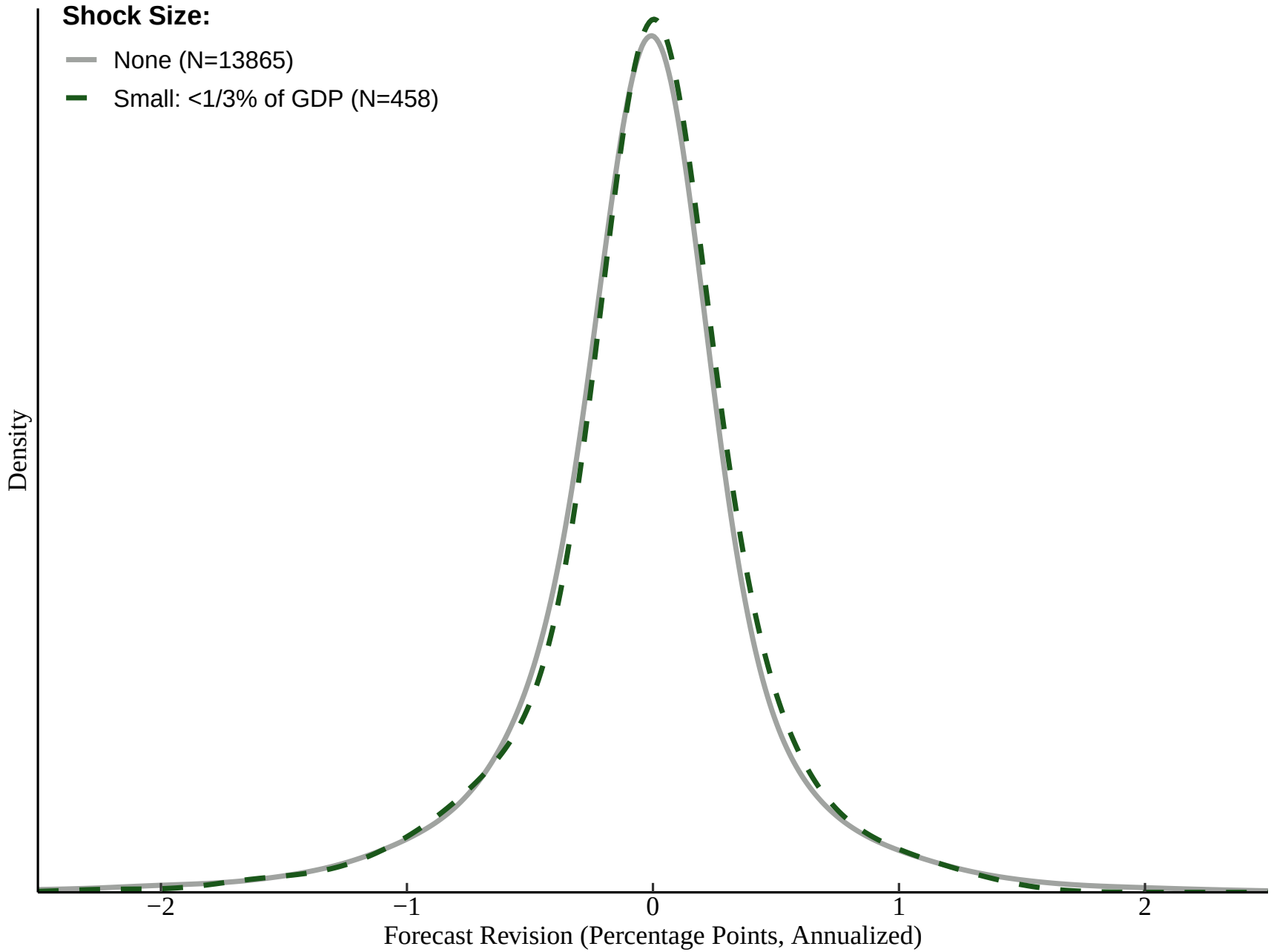

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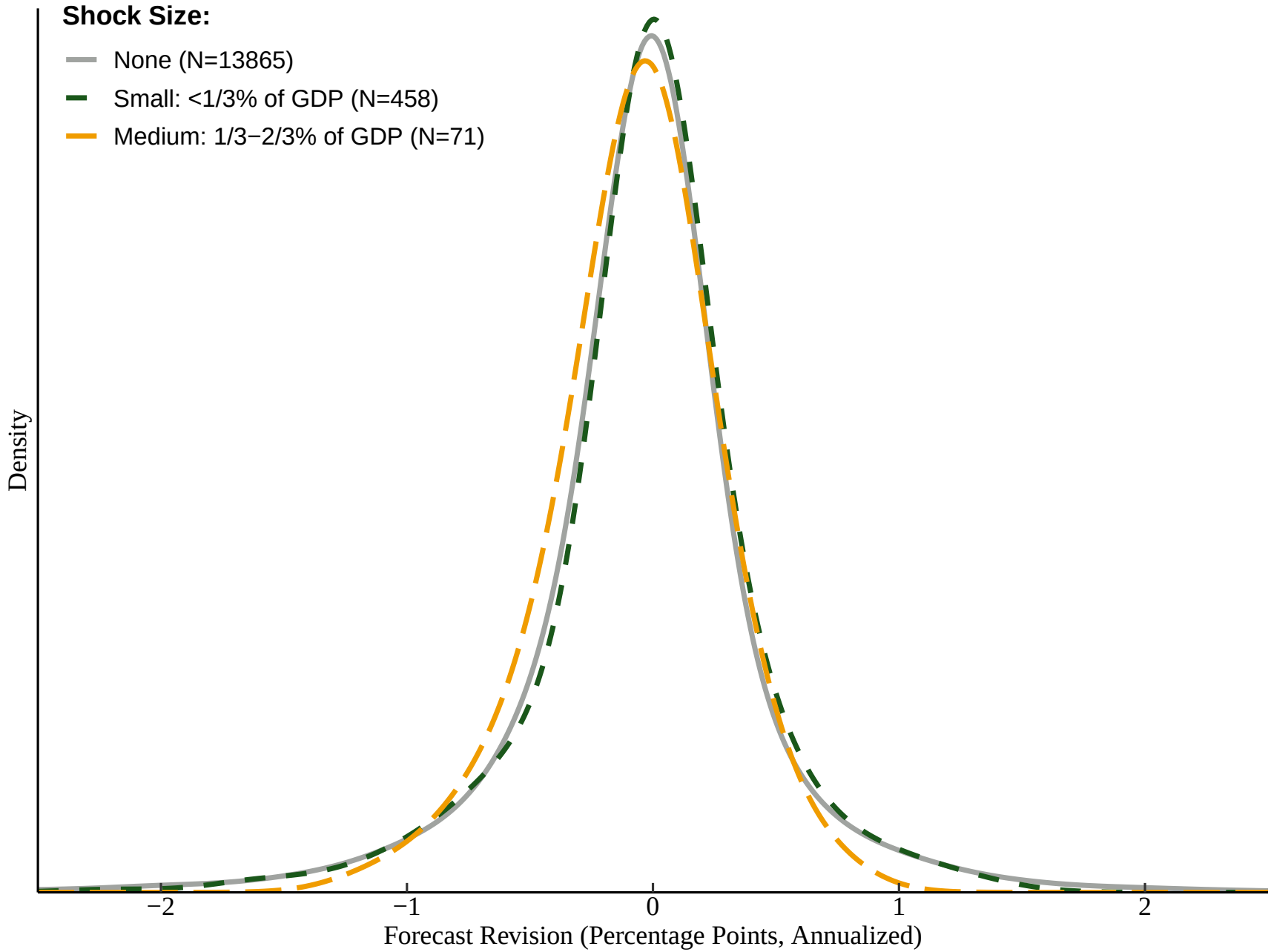

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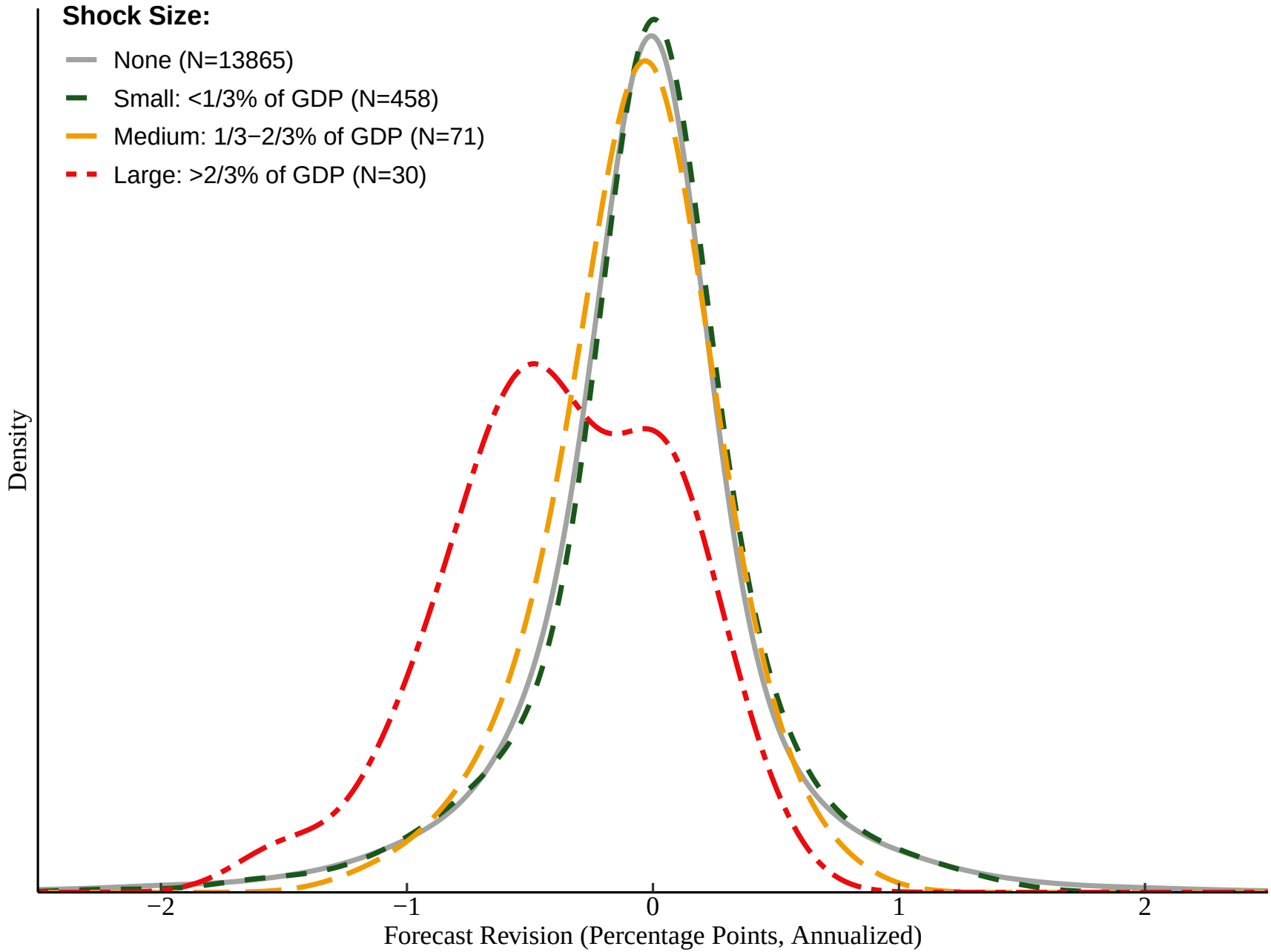

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Effect of Hurricane Katrina Shock on GDP Nowcast Revisions

	(1)
Lagged Revision:	
Lagged Revision $\times$ Lagged Shock:	
Immediate Effect:	-0.33^{*}
	(0.19)
Lagged Effect:	
Total Effect:	-0.33^{*}
	(0.19)
Tests of Efficiency, $\chi^2(1)$:	n.a.
Macro News Surprises:	Yes
Time Fixed Effects:	Yes
Firm Fixed Effects:	Yes
Observations (N$\times$T):	13,747
Forecasters (N):	54
$\hat{\sigma}$:	0.45
R^2 :	0.23

*Notes: Macro News Surprises include a single lag. Time fixed effects include both month-year fixed effects and week of quarter seasonal effects. Estimated standard errors in parentheses are clustered two-ways by firm and time following Thompson (2011) and Cameron et al. (2011), where * and ** and *** indicate that the estimated coefficient is statistically different from zero with a p-value of less than 10%, 5%, or 1%, respectively.* Disagreement Outliers Winsorizing Heterogeneity Efficiency by Shock Size

Effect of Hurricane Katrina Shock on GDP Nowcast Revisions

	(1)	(2)
Lagged Revision:		−0.27***
		(0.02)
Lagged Revision × Lagged Shock:		
Immediate Effect:	−0.33*	
	(0.19)	
Lagged Effect:		
Total Effect:	−0.33*	0
	(0.19)	
Tests of Efficiency, $\chi^2(1)$:	n.a.	126.7***
		[0.000]
Macro News Surprises:	Yes	Yes
Time Fixed Effects:	Yes	Yes
Firm Fixed Effects:	Yes	Yes
Observations (N×T):	13,747	13,747
Forecasters (N):	54	54
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Effect of Hurricane Katrina Shock on GDP Nowcast Revisions

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Lagged Revision:		−0.27***	−0.27***
		(0.02)	(0.02)
Lagged Revision × Lagged Shock:			
Immediate Effect:	−0.33*		−0.47***
	(0.19)		(0.17)
Lagged Effect:			−0.38***
			(0.13)
Total Effect:	−0.33*	0	−0.67***
	(0.19)		(0.16)
Tests of Efficiency, $\chi^2(1)$ **:**	n.a.	126.7***	3.18*
		[0.000]	[0.074]
Macro News Surprises:	Yes	Yes	Yes
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Disagreement | Outliers | Winsorizing | Heterogeneity | Efficiency by Shock Size

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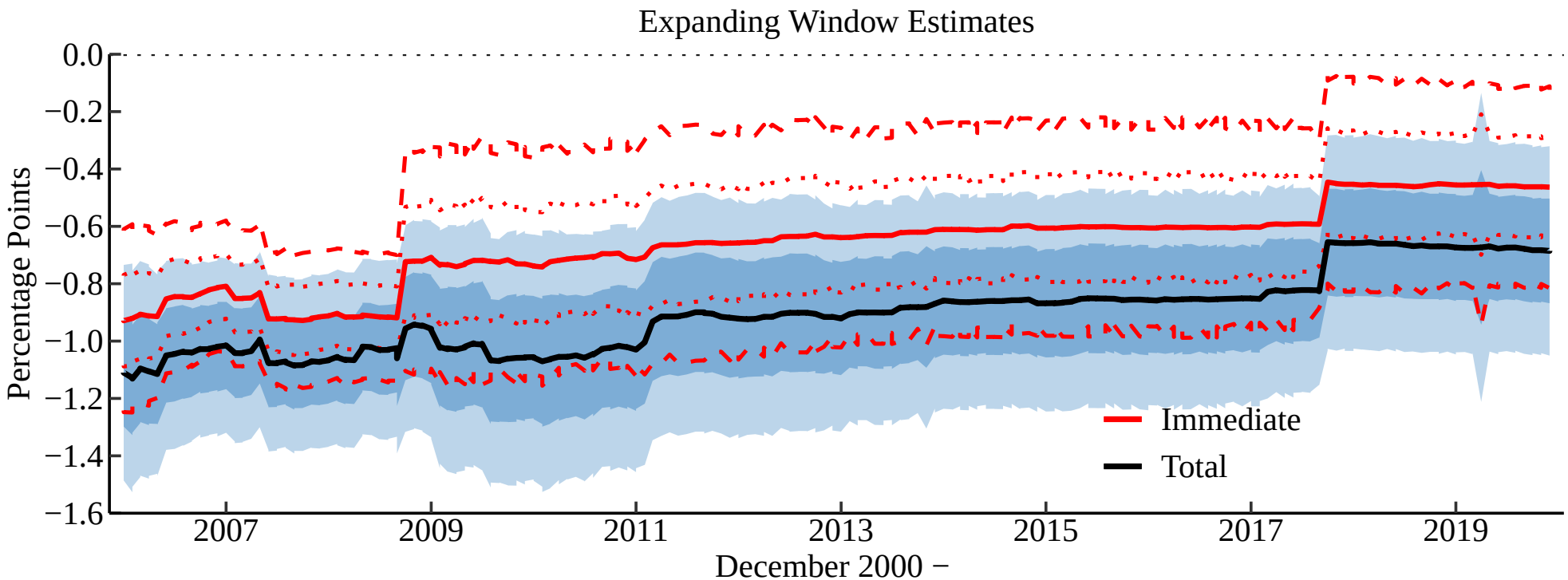
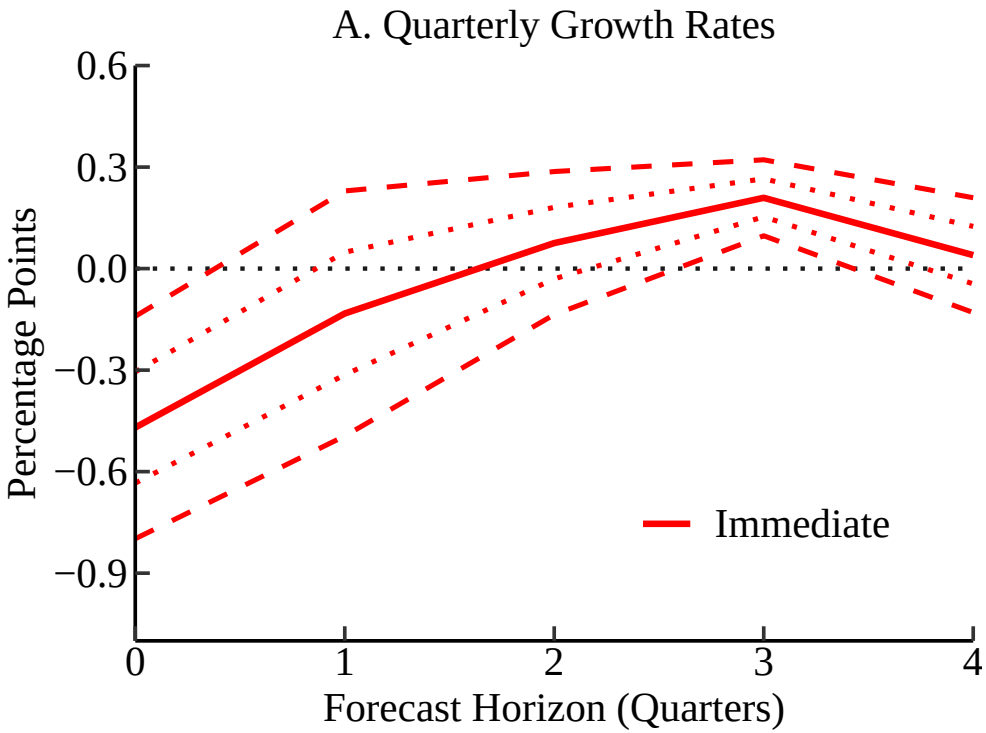
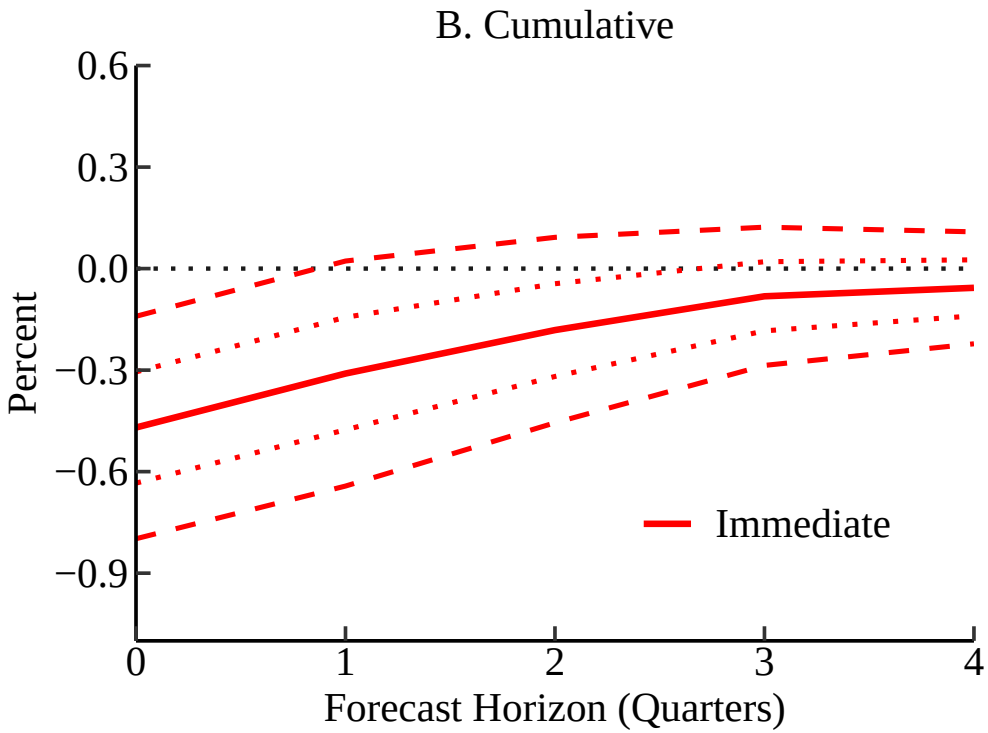
Recursive Estimates

- Effect size declining over time after Hurricane Katrina
- Total effect consistently larger than immediate effect



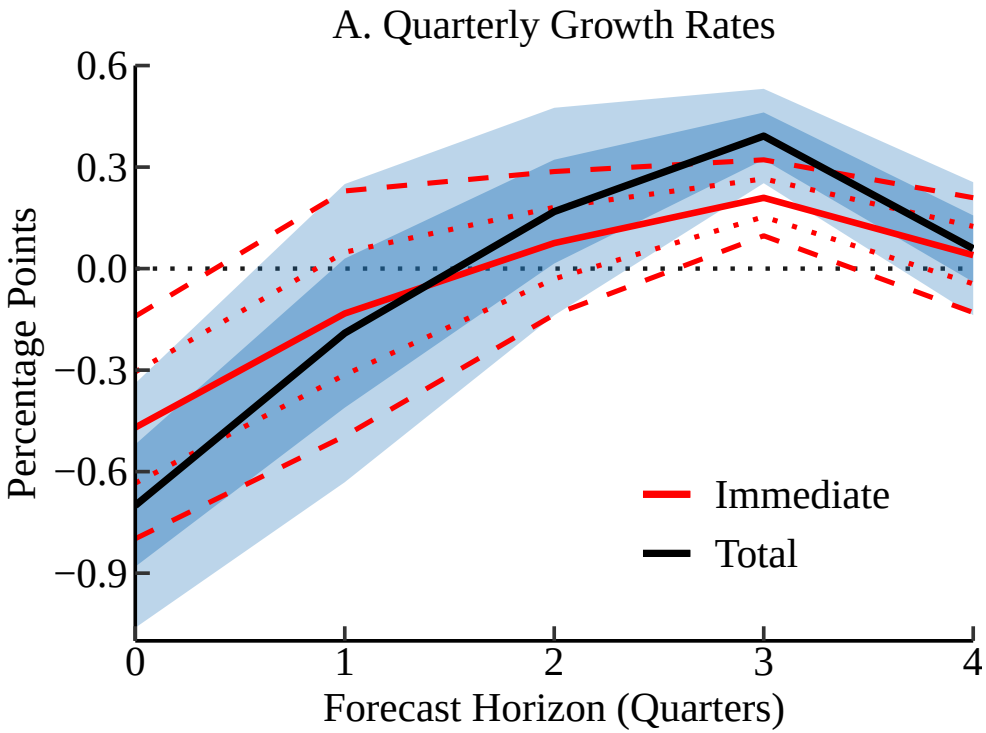
Dynamic Effects of a Hurricane Katrina Shock on GDP Forecasts

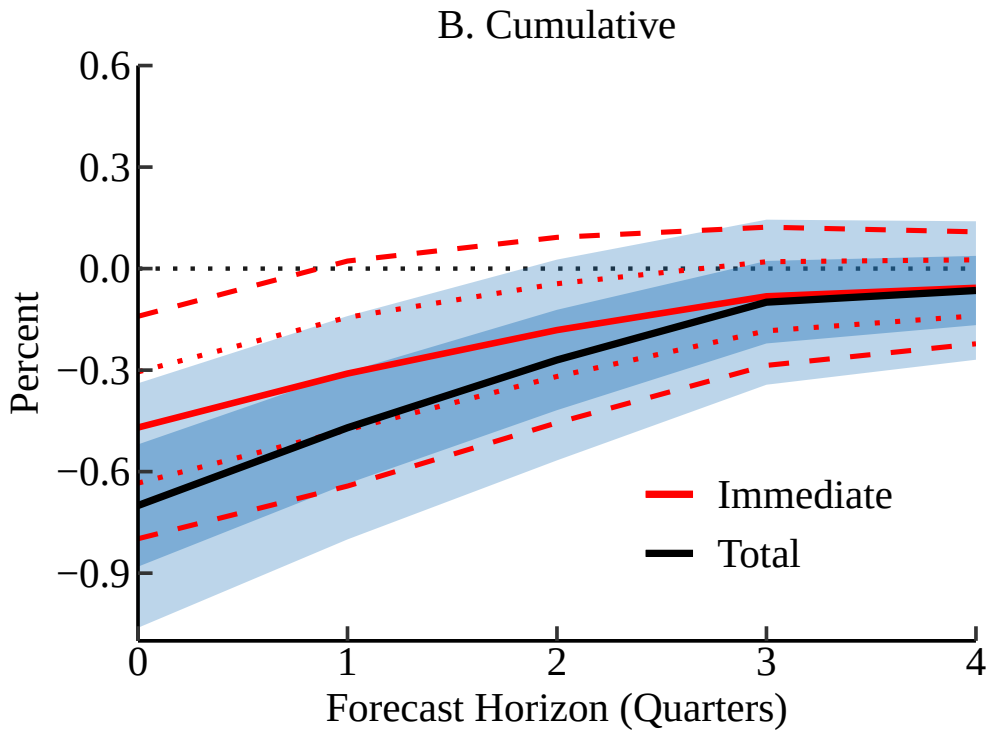




Joint Horizons

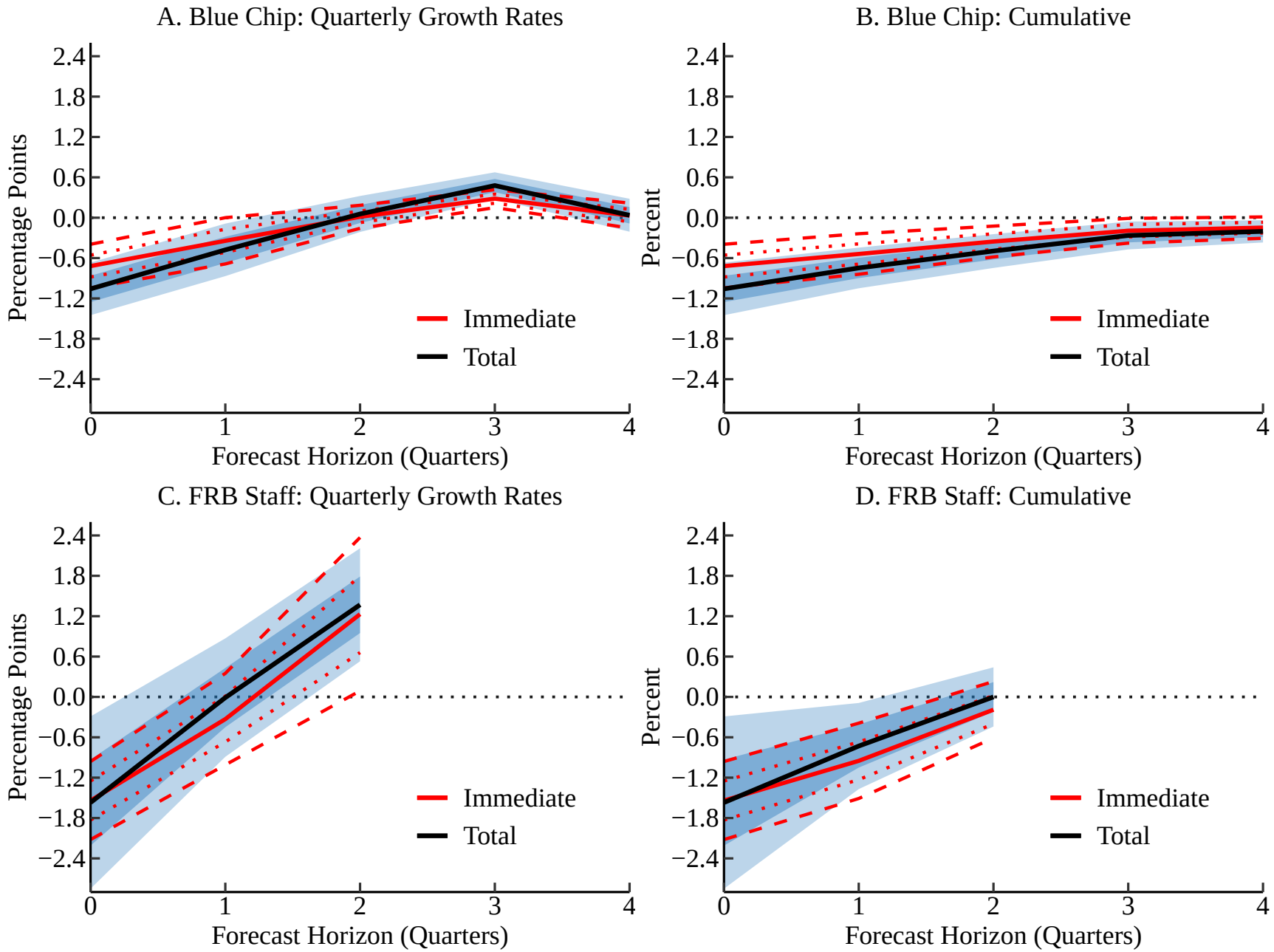
Dynamic Effects of a Hurricane Katrina Shock on GDP Forecasts





Joint Horizons

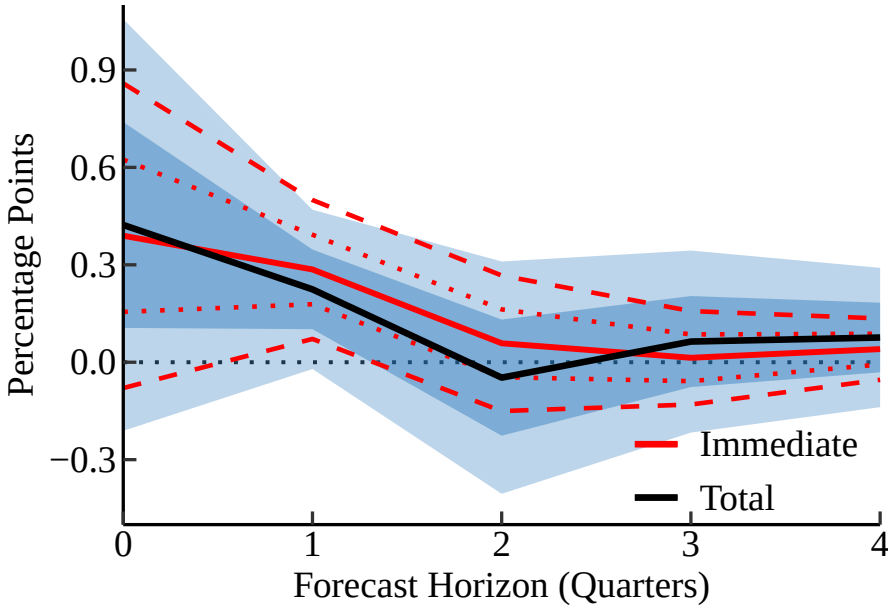
Comparing Against High Frequency FRB Staff Forecasts (2001-11)



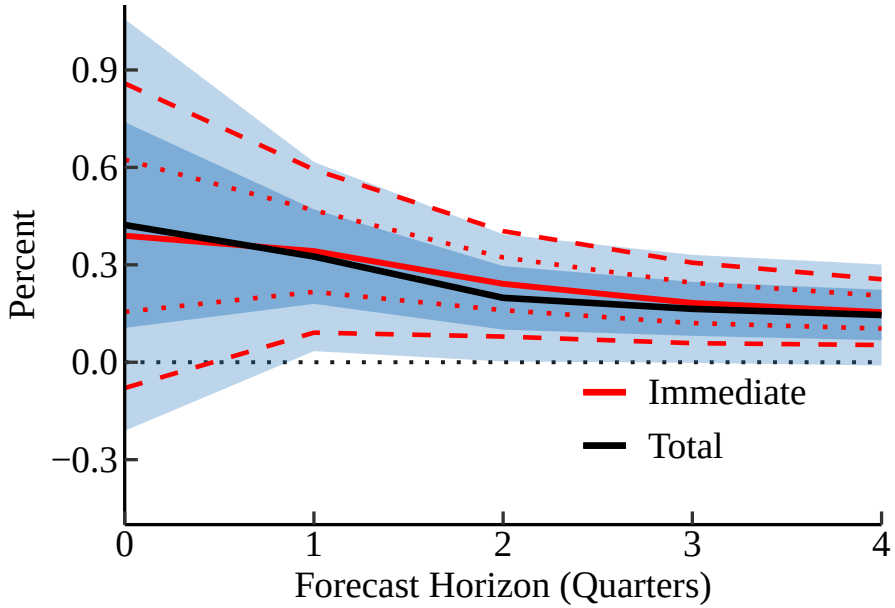
Notes: FRB Staff results calculated using data from Chang and Levinson (2023).

Effect of a Hurricane Katrina Shock on Forecasts of Other Variables

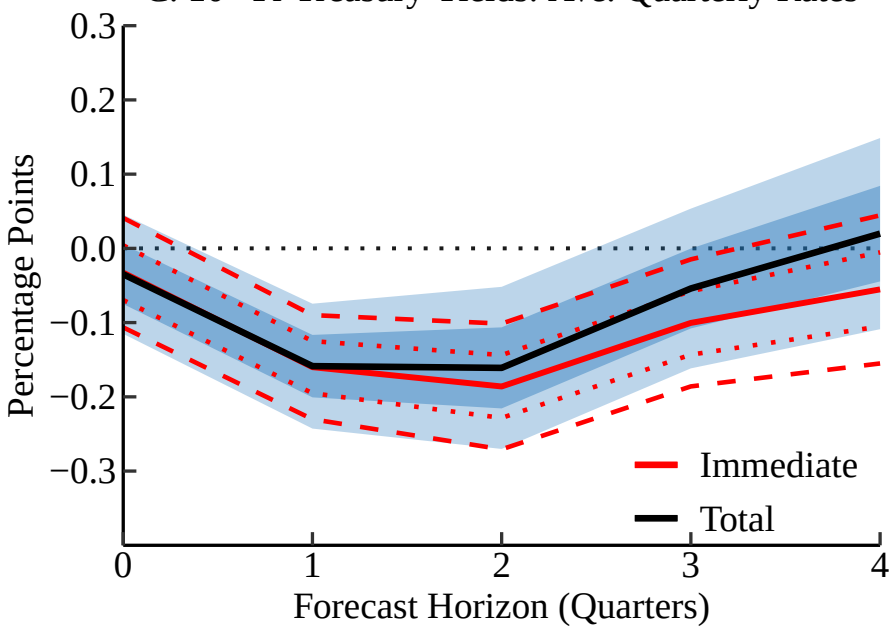
A. CPI Inflation: Quarterly Growth Rates



B. CPI Inflation: Cumulative



C. 10−Yr Treasury Yields: Ave. Quarterly Rates



System of Revisions

Conclusions

- **Large and persistent effects on expectations:**
  - Decline in (near-term) expected output:
    - Immediate: 0.3 pp.
    - Total: 0.7 pp.
    - Slow recovery across horizons
    - Forecasters closer to hurricane expect worse
  - Rise in expected prices (0.25); no offsetting decline
  - Decline in expected interest rates (20 basis points); full recovery

- **Shock-specific Dynamics are important**:
  - GDP expectations under-react and slow recovery
    - But not Fed Board staff or Financial Services
  - Interest rate expectations over-react

THANK YOU

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Data: Individual Blue Chip Forecasters

■ OCTOBER 1, 2019

Blue Chip Financial Forecasts Panel Members

NatWest Markets
DePrince & Assoc.
Action Economics
Amherst Pierpont Securities
Bank of America Merrill Lynch
Daiwa Capital Markets America
Economist Intelligence Unit
MacroFin Analytics & Rutgers Bus School
MUFG Union Bank
Naroff Economic Advisors
RDQ Economics
The Northern Trust Company
ACIMA Private Wealth
Chan Economics
Chmura Economics & Analytics
Comerica Bank
Georgia State University
Grant Thornton/Diane Swonk
J.P. Morgan Chase
Regions Financial Corporation
S&P Global
Scotiabank Group
Swiss Re
Via Nova Investment Mgt.
Cycledata Corp.
GLC Financial Economics
High Frequency Economics
Moody's Capital Markets Group
Oxford Economics
PNC Financial Services Corp.
Societe Generale
Wells Fargo
AIG
Barclays
BMO Capital Markets
BNP Paribas Americas
Fannie Mae
Goldman Sachs & Co.
Loomis, Sayles & Company
Mizuho Research Institute
Nomura Securities, Inc.
TS Lombard
ING
Moody's Analytics

32/44=0.73

■ BLUE CHIP ECONOMIC INDICATORS
■ OCTOBER 10, 2019

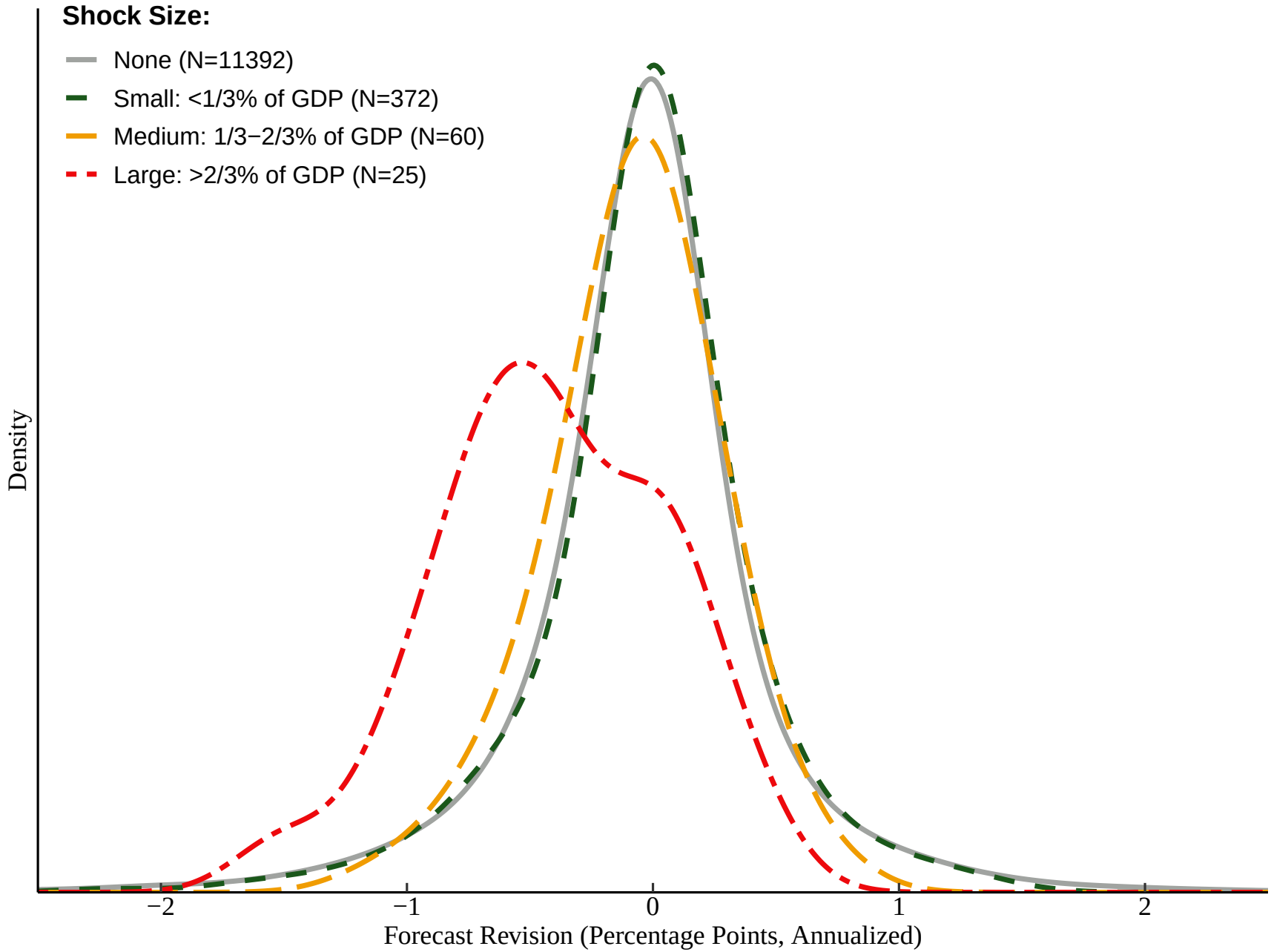
OCTOBER 2019

Amherst Pierpont Securities
Action Economics
Econoclast
MUFG Union Bank
ACT Research*
Bank of America-Merrill Lynch, US**
BMO Capital Markets*
Credit Suisse
Daiwa Capital Markets America
Eaton Corporation
Fannie Mae
FedEx Corporation, US
Ford Motor Company*
General Motors Corporation, US
Goldman Sachs & Co.**
High Frequency Economics
Inforum - Univ. of Maryland
Macroeconomic Advisers by IHS Markit**
MacroFin Analytics & Rutgers Bus School
Moody's Analytics, US
Morgan Stanley, US**
Naroff Economic Advisors*
National Assn. of Home Builders
National Retail Federation
NatWest Markets
Nomura Securities, US
PNC Financial Services Group
Point72 Asset Management*
RBC Capital Markets
RDQ Economics
Regions Financial Corporation
S&P Global, US*
Societe Generale
SOM Economics, Inc.
Swiss Re
UBS
UCLA Business Forecasting Proj.*
Visa
AIG
Barclays, US*
Comerica**
Economist Intelligence Unit, UK
Georgia State University*
Grant Thorton/Diane Swonk
JP MorganChase, US
Moody's Capital Markets, US*
Northern Trust Company*
Oxford Economics, US
U.S. Chamber of Commerce
Wells Fargo, US
ACIMA Private Wealth, US

32/51=0.63

back

GDP Nowcast Revision Density by Shock Size ex-slow updaters



Nonparametric estimation with a Gaussian kernel and a bandwidth of 0.20. 11,849 observations

back

Survey Results: Hurricane Sandy in 2012

The Blue Chip Survey in November 2012 asked: “Have you trimmed your estimate of Q4 2012 real GDP growth due to the effects of Hurricane Sandy?”

- 40% of respondents indicated that they had
- Typical change was 0.2 percentage points

back

Hurricane Katrina Shock on GDP Nowcast Revisions (Disagreement)

	(1)	(2)	(2b)	(3)	(4)
Lagged Revision:		−0.18***	−0.18***	−0.18***	−0.18***
		(0.03)	(0.03)	(0.03)	(0.03)
Lagged Revision × Lagged Shock:				0.27*	0.13
				(0.15)	(0.17)
Immediate Effect:	−0.33*		−0.45**		−0.45**
	(0.19)		(0.17)		(0.17)
Lagged Effect:			−0.30**		−0.26
			(0.14)		(0.16)
Lagged Disagreement:		−0.20***	−0.20***	−0.20***	−0.20***
		(0.02)	(0.02)	(0.02)	(0.02)
Total Effect:	−0.33*	0	−0.64***	0	−0.65***
	(0.19)		(0.17)		(0.19)
Tests of Efficiency, $\chi^2(1)$:	n.a.	48.66***	2.39	0.37	2.79*
		[0.000]	[0.123]	[0.541]	[0.095]
Macro News Surprises:	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Observations (N×T):	13,747	13,747	13,747	13,747	13,747
Forecasters/Firms (N):	54	54	54	54	54
$\hat{\sigma}$:	0.45	0.42	0.42	0.42	0.42
R^2 :	0.23	0.34	0.34	0.34	0.34

*Notes: Macro News Surprises include a lag. Time fixed effects include both month-year fixed effects and week of quarter seasonal effects. Estimated standard errors in parentheses are clustered two-ways by firm and time following Thompson (2011) and Cameron et al. (2011), where * and ** and *** indicate that the estimated coefficient is statistically different from zero with a p-value of less than 10%, 5%, or 1%, respectively.*

back

Hurricane Katrina Shock on GDP Nowcast Revisions (1% Outliers)

	(1)	(2)	(2b)	(3)	(4)
Lagged Revision:		-0.19^{***}	-0.19^{***}	-0.19^{***}	-0.19^{***}
		(0.02)	(0.02)	(0.02)	(0.02)
Lagged Revision × Lagged Shock:				0.21	0.30
				(0.22)	(0.18)
Immediate Effect:	-0.37^{**}		-0.46^{***}		-0.49^{***}
	(0.15)		(0.13)		(0.15)
Lagged Effect:			-0.21^{*}		-0.22^{*}
			(0.13)		(0.13)
Total Effect:	-0.37^{**}	0	-0.57^{***}	0	-0.80^{***}
	(0.15)		(0.15)		(0.25)
Tests of Efficiency, $\chi^2(1)$:	n.a.	111.6^{***}	0.94	0.00	4.15^{**}
		[0.000]	[0.333]	[0.940]	[0.042]
Macro News Surprises:	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Observations (N×T):	13,472	13,472	13,472	13,472	13,472
Forecasters (N):	54	54	54	54	54
$\hat{\sigma}$:	0.36	0.35	0.35	0.35	0.35
R^2 :	0.51	0.53	0.53	0.53	0.53

*Notes: Macro News Surprises include a single lag. Time fixed effects include both month-year fixed effects and week of quarter seasonal effects. Estimated standard errors in parentheses are clustered two-ways by firm and time following Thompson (2011) and Cameron et al. (2011), where * and ** and *** indicate that the estimated coefficient is statistically different from zero with a p-value of less than 10%, 5%, or 1%, respectively.* back

Hurricane Katrina Shock on GDP Nowcast Revisions (Winsorized 5%)

	(1)	(2)	(2b)	(3)	(4)
Lagged Revision:		−0.24***	−0.24***	−0.24***	−0.24***
		(0.02)	(0.02)	(0.02)	(0.02)
Lagged Revision × Lagged Shock:				0.15	0.01
				(0.15)	(0.06)
Immediate Effect:	−0.39***		−0.48***		−0.48***
	(0.13)		(0.11)		(0.11)
Lagged Effect:			−0.22**		−0.22*
			(0.10)		(0.11)
Total Effect:	−0.39***	0	−0.56***	0	−0.56***
	(0.13)		(0.12)		(0.13)
Tests of Efficiency, $\chi^2(1)$:	n.a.	119.2***	1.04	0.35	1.00
		[0.000]	[0.308]	[0.555]	[0.318]
Macro News Surprises:	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects:	Yes	Yes	Yes	Yes	Yes
Observations (N×T):	13,747	13,747	13,747	13,747	13,747
Forecasters (N):	54	54	54	54	54
$\hat{\sigma}$:	0.34	0.33	0.33	0.33	0.33
R^2 :	0.17	0.22	0.22	0.22	0.22

*Notes: Macro News Surprises include a single lag. Time fixed effects include both month-year fixed effects and week of quarter seasonal effects. Estimated standard errors in parentheses are clustered two-ways by firm and time following Thompson (2011) and Cameron et al. (2011), where * and ** and *** indicate that the estimated coefficient is statistically different from zero with a p-value of less than 10%, 5%, or 1%, respectively.* back

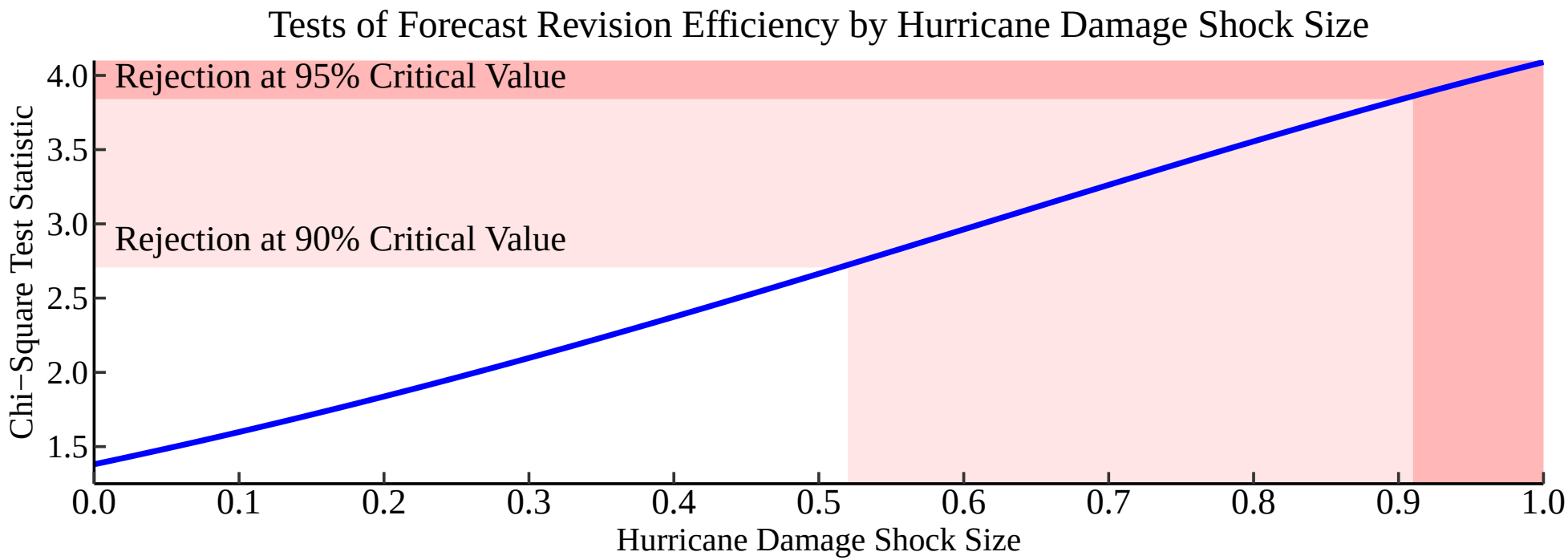
Forecaster Heterogeneity

	Publicly Traded	>1000 Employees	Financial Services	Primary Dealers	Dist. ($\leqslant$700mi)	Obs. Shr. ($\geqslant$0.70)	Rev. Shr. ($\geqslant$0.65)
Lagged Revision:	−0.31***	−0.31***	−0.29***	−0.30***	−0.28***	−0.29***	−0.27***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Lagged Revision × Lagged Shock:	0.38	0.46*	0.51	0.38*	-0.15	0.64*	-0.02
	(0.28)	(0.25)	(0.33)	(0.23)	(0.25)	(0.38)	(0.22)
Immediate Effect:	−0.29**	−0.33**	−0.60***	−0.45**	−0.42**	−0.29*	−0.40**
	(0.15)	(0.15)	(0.18)	(0.18)	(0.18)	(0.17)	(0.19)
Lagged Effect:	−0.17	−0.20	0.01	−0.22	−0.65***	−0.18	−0.37**
	(0.13)	(0.13)	(0.17)	(0.15)	(0.23)	(0.19)	(0.18)
Total Effect:	−0.87***	−0.81***	−0.67***	−0.73***	−1.12***	−0.83**	−0.91***
	(0.22)	(0.21)	(0.21)	(0.20)	(0.24)	(0.21)	(0.21)
	Other Firms	**$\leqslant$1000 Employees**	**Other Industries**	**Other Firms**	**Dist ($>$700mi)**	**Obs. Shr. ($<$0.70)**	**Rev. Shr. ($<$0.65)**
Lagged Revision:	−0.25***	−0.25***	−0.26***	−0.22***	−0.09	−0.26***	−0.28***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.06)	(0.03)	(0.03)
Lagged Revision × Lagged Shock:	−0.08	−0.07	0.03	−0.31	0.19	−0.13	0.42*
	(0.28)	(0.28)	(0.25)	(0.37)	(0.19)	(0.27)	(0.24)
Immediate Effect:	−0.61***	−0.57***	−0.38**	−0.49**	−0.99***	−0.59**	−0.62***
	(0.23)	(0.22)	(0.18)	(0.20)	(0.15)	(0.25)	(0.22)
Lagged Effect:	−0.52**	−0.48**	−0.46**	−0.55**	−0.04	−0.53***	−0.29*
	(0.24)	(0.24)	(0.20)	(0.29)	(0.16)	(0.20)	(0.15)
Total Effect:	−0.44**	−0.52***	−0.70***	−0.65***	−0.79***	−0.50**	−0.60***
	(0.18)	(0.18)	(0.26)	(0.20)	(0.19)	(0.23)	(0.18)
Test of Homogeneity; $\chi^2(4)$:	8.84*	7.81*	11.85**	7.59	44.8***	10.6**	9.82**
	[0.065]	[0.099]	[0.019]	[0.108]	[0.000]	[0.031]	[0.044]

Notes: Each column represents a single equation. The cutoff values for distance for the hurricane (Dist.), Observation share and and Revision share roughly correspond to the 66th percentile. back

Tests of Forecast Revision Efficiency

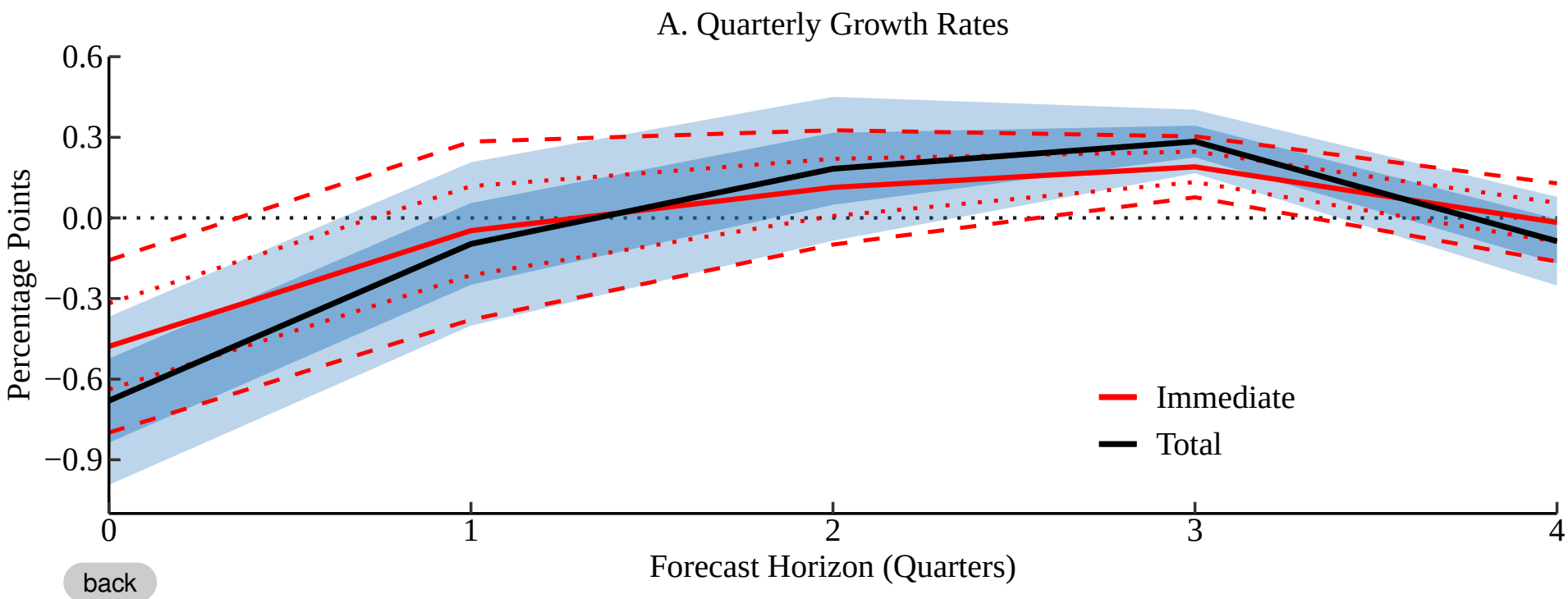
- Forecast efficiency rejected at larger shock sizes:



back

Joint Dynamic Effects of Hurricane Katrina Shock

- Are individual horizons independent?
  - Test for diagonal structure in system: No! $\chi^2(30)$=259.4 [0.000]
- Limited cross-horizon dependence:
  - One horizon lead / lag relationship
  - Not rejected: $\chi^2(22)$=24.3 [0.331]



back

Empirical Approach: General Dynamic System

Allow for dependence across variables

$$\mathbf{A}_h \Delta \mathbf{F}_{i,w,t,h} = \sum_{k=1}^{3} \Gamma_{1,k,h} \Delta \mathbf{F}_{i,w-k,t,h} + \sum_{j=0}^{1} \beta_j \text{Shk}_{w-j,t} + \boldsymbol{e}_{i,w,t,h}, \quad (5)$$

$$\mathbf{F}_{i,w,t,h} \equiv \{ \ \text{GDP}_{i,w,t,h} \quad \text{CPI}_{i,w,t,h} \quad \text{T10}_{i,w,t,h} \ \}'$$

Empirical Approach: General Dynamic System

Allow for dependence across variables

$$\mathbf{A}_h \Delta \mathbf{F}_{i,w,t,h} = \sum_{k=1}^{3} \Gamma_{1,k,h} \Delta \mathbf{F}_{i,w-k,t,h} + \sum_{j=0}^{1} \beta_j \mathrm{Shk}_{w-j,t} + \boldsymbol{e}_{i,w,t,h}, \quad (5)$$

$$\mathbf{F}_{i,w,t,h} \equiv \{ \ \mathrm{GDP}_{i,w,t,h} \quad \mathrm{CPI}_{i,w,t,h} \quad \mathrm{T10}_{i,w,t,h} \ \}'$$

Assume a Choleski ordering

$$\mathbf{A}_h = \begin{pmatrix} 1 & 0 & 0 \\ -\delta_{cg,h} & 1 & 0 \\ -\delta_{tg,h} & -\delta_{tc,h} & 1 \end{pmatrix}$$

Implicit (could impose):

1. Okun's Law / Phillips curve to predict inflation: $\delta_{cg,h} > 0$
2. Talyor-rule to forecast interest rates: $\delta_{tg,h} > 0$ and $\delta_{tc,h} > 0$

Long-run estimates: multivariate extension from Doornik and Hendry (2018)

Empirical Approach: General Dynamic System

Allow for dependence across variables

$$\mathbf{A}_h \Delta \mathbf{F}_{i,w,t,h} = \sum_{k=1}^{3} \Gamma_{1,k,h} \Delta \mathbf{F}_{i,w-k,t,h} + \sum_{j=0}^{1} \beta_j \mathrm{Shk}_{w-j,t} + \boldsymbol{e}_{i,w,t,h}, \quad (5)$$

$$\mathbf{F}_{i,w,t,h} \equiv \{ \ \mathrm{GDP}_{i,w,t,h} \quad \mathrm{CPI}_{i,w,t,h} \quad \mathrm{T10}_{i,w,t,h} \ \}'$$

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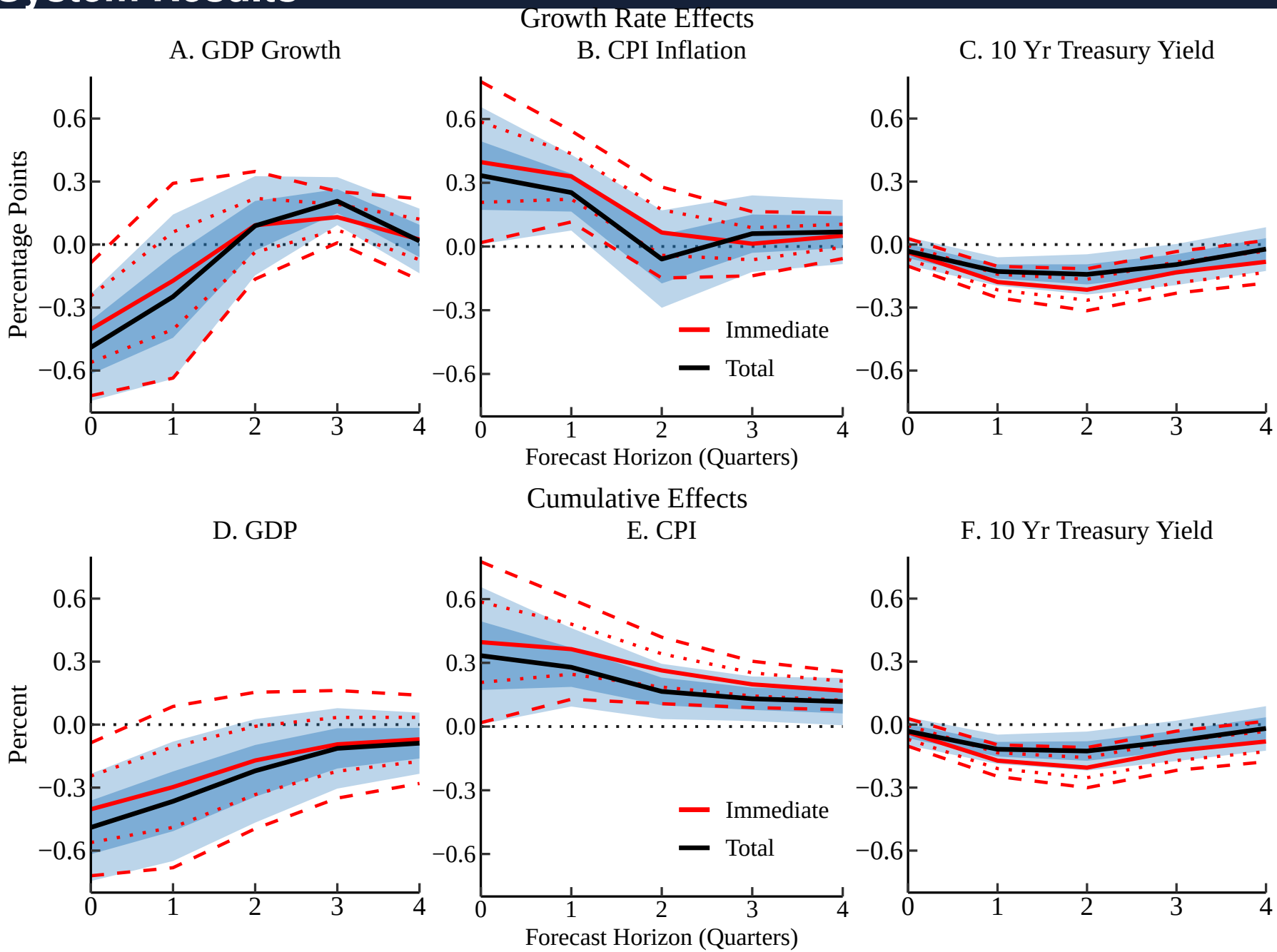
Long-run estimates: multivariate extension from Doornik and Hendry (2018)

Restrictions

- No cross-equation lagged relationships
- No nonlinearities

System Results



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