Measuring Market Expectations

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Motivation

- Expectations are key
  - decision-making under uncertainty
  - forward-looking models in macro and finance

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  ⇨ forecast efficiency regressions: futures prices are <u>not</u> unbiased predictors of future spot prices

- But financial market participants demand compensation for risk: asset price = market expectation + risk premium

Asset Pricing

- The absence of profitable arbitrage opportunities implies:

$$E_t(M_{t+h}(S_{t+h} - F_t^h)) = 0$$

where

M_{t+h} is the stochastic discount factor

$(S_{t+h} - F_t^h)$ is the random payoff of a long position

- Solving for the futures price yields:

$$F_t^h = E_t(S_{t+h}) + \frac{cov_t(M_{t+h}S_{t+h})}{E_t(M_{t+h})}$$

where the latter term refers to the time-varying risk premium

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⇨ unifying perspective (Dai & Singleton, 2002; Hamilton & Wu, 2014):

$$f_{t+1}^{h-1} - f_t^h = \kappa_{h-1} + \delta_{h-1}' x_t + \varepsilon_{t+1}^{h-1}$$

where

- $f_{t+1}^{h-1} - f_t^h$ is the payoff on a long position in an h-period futures contract
- x_t are observed or latent risk pricing factors
- in term structure models: $\kappa_{h-1} = \beta_{h-1}'\lambda - \frac{1}{2}\beta_{h-1}'\Sigma\Sigma'\beta_{h-1}$

  $\delta_{h-1}' = \beta_{h-1}'\Lambda$
- in return regressions: $\kappa_{h-1} = \hat{\kappa}_{h-1}^{OLS}$

  $\delta_{h-1} = \hat{\delta}_{h-1}^{OLS}$

Key Differences

- Return regressions
  - unrestricted least squares
  - observed proxies for relevant risk factors:
    - common factors across asset classes
    - asset-specific factors
  - easy to pinpoint source(s) of risk

⇨ fitted value is estimate of time-varying risk premium

- Affine term structure models
  - cross-equation restrictions to rule out arbitrage
  - latent factors inferred from behavior of asset prices
  - additional observable determinants to help with interpretability and link to macroeconomic dynamics

⇨ difference between observed futures price and rational expectation is estimate of time-varying risk premium

Illustration for the Oil Market

Article	Model	Monthly Predictors for WTI Futures Payoff
Bessembinder (1992)	B1	CRSP value-weighted equity index returns
	B2	CRSP value-weighted equity index returns
		Unexpected CPI inflation
		Change in expected CPI inflation
		Change in 3-month T-bill rate
		Change in the term structure (20YGB – 3-month T-bill)
		Change in default premium (BAA – 20YGB)
		Unexpected change in U.S. industrial production
Bessembinder and Chan (1992)	BC	Dividend yield on CRSP value-weighted equity index
		3-month T-bill rate
		Junk bond premium (BAA – AAA)
Bessembinder and Seguin (1993)	BS	Ratio of trading volume of oil futures contracts to open interest by horizon
De Roon, Nijman, and Veld (2000)	DNV1	Returns on S&P 500 stock price index
		Own-market hedging pressure
		Cross-market hedging pressure for gold, silver, platinum, heating oil
	DNV2	DNV1 + own-market price pressure

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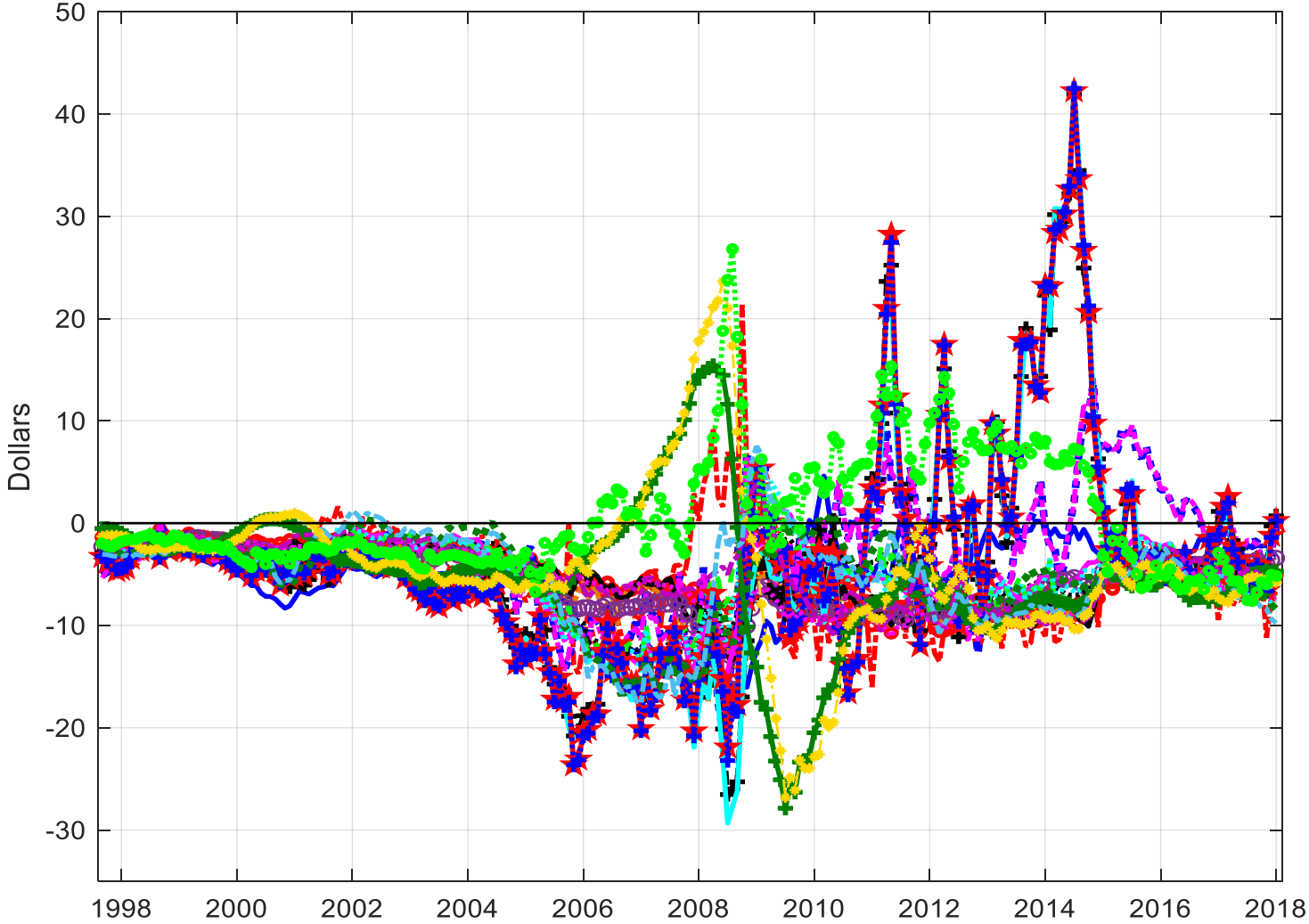
Article	Model	Monthly Predictors for WTI Futures Payoff
Gorton, Hayashi, and Rouwenhorst (2013)	GHR1	Normalized U.S. crude oil commercial inventories
	GHR2	Own-market hedging pressure
Hong and Yogo (2012)	HY1	1-month T-bill rate
		Yield spread (AAA – 1MTbill)
		Horizon-specific basis
	HY2	HY1 + growth rate of dollar open interest for oil futures
	HY3	HY1 + CFNAI
	HY4	HY3 + growth rate of dollar open interest for oil futures
	HY5	HY1 + futures market imbalance
	HY6	HY5 + growth rate of dollar open interest for oil futures
	HY7	HY5 + CFNAI
	HY8	HY7 + growth rate of dollar open interest for oil futures
Pagano and Pisani (2009)	PP1	Degree of capacity utilization in U.S. manufacturing
	PP2	Term spreads
	PP3	Composite leading indicator for OECD + 6 NMEs
Pagano and Pisani (2009) Extensions	PPE1	GECON from Baumeister, Korobilis, and Lee (2020)
	PPE2	PP2 + GECON
	PPE3	PP3 + GECON

Heterogeneity of Risk Premium Estimates

There will be as many risk premium estimates as there are models

⇨ imply different market expectations (shown for the 1-year horizon)



A Model Selection Criterion

- Set of spot price expectations: $E_t(S_{t+h}) = F_t^h - RP_t^h$
- Baumeister and Kilian (2017): to identify the most plausible market-based expectation measure, assess accuracy of price expectations in terms of their mean-squared prediction error (MSPE): $E[S_{t+h} - E_t(S_{t+h})]^2$
- Key insight:

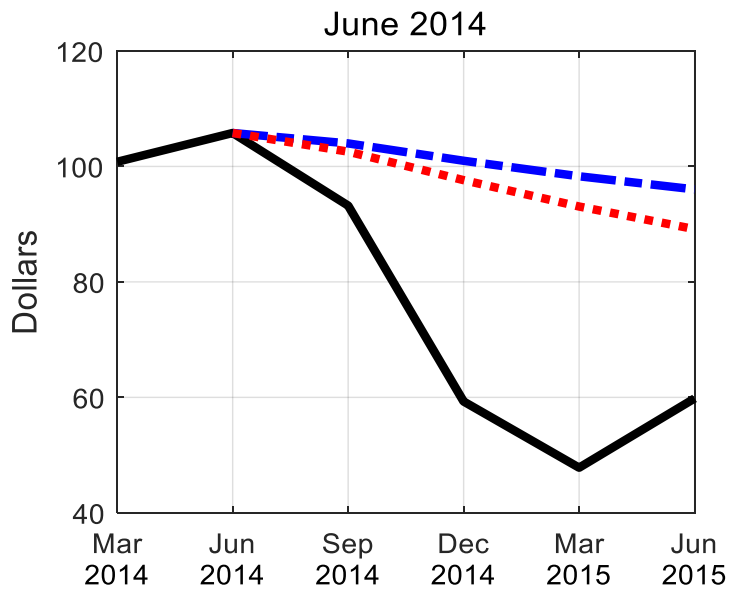
  The conditional expectation minimizes the MSPE under quadratic loss (Granger, 1969; Granger & Newbold, 1986)
- Select market expectation that delivers the largest MSPE reduction

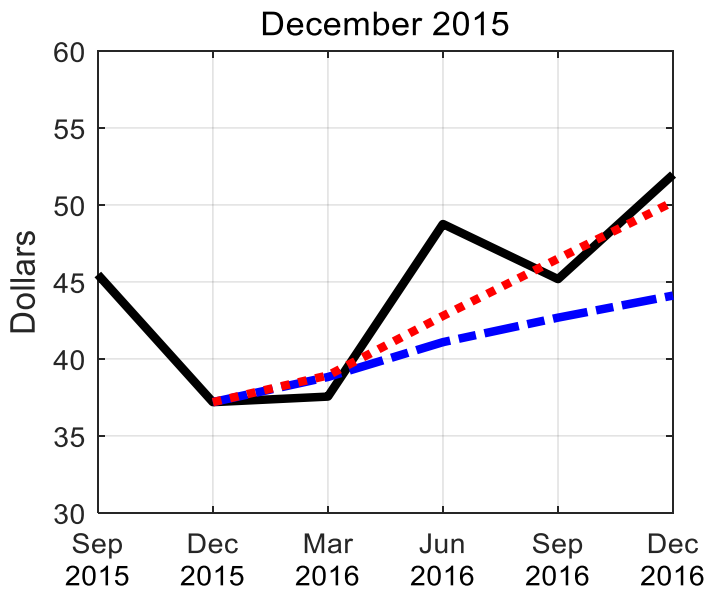
⇨ general methodology to recover unique market expectation

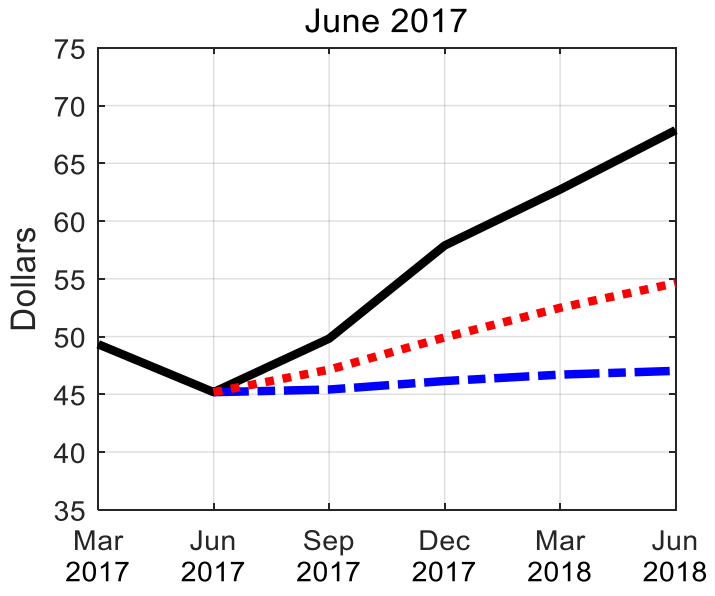
Oil Price Expectations

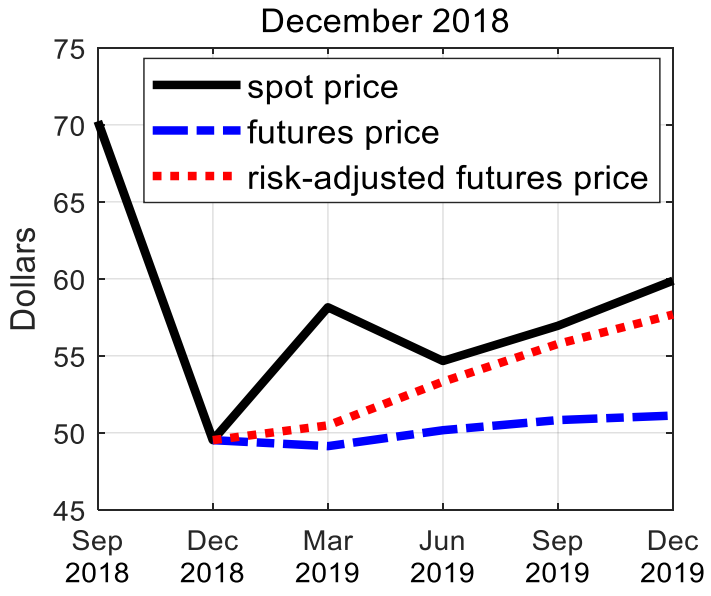
Models	Monthly horizon h			
	3	6	9	12
F_t^h	**0.976***	**0.965****	**0.923****	**0.859****
Basis Regressions				
FF1	1.013	1.037	1.027	**0.985***
FF2	1.015	1.036	1.029	**0.987***
Payoff Regressions				
B1	**0.984***	1.022	1.017	**0.975***
B2	**0.899***	**0.930****	**0.931****	**0.865****
BC	**0.994**	1.020	1.005	**0.959***
BS	1.003	1.004	1.055	1.016
DNV1	**0.925****	**0.978**	**0.938***	**0.853****
DNV2	**0.925****	**0.969**	**0.939***	**0.850****
GHR1	**0.957****	**0.989***	1.031	**0.994***
GHR2	1.011	1.037	1.015	**0.980***
HY1	**0.977****	**0.992**	**0.989**	**0.938***
HY2	**0.975***	**0.995**	**0.993**	**0.947***
HY3	**0.909****	**0.955****	**0.963****	**0.915****
HY4	**0.912****	**0.954****	**0.963****	**0.926****
HY5	**0.970***	**0.954**	**0.906***	**0.848****
HY6	**0.972***	**0.957**	**0.908***	**0.861****
HY7	**0.887****	**0.894****	**0.849****	**0.794****
HY8	**0.892****	**0.888****	**0.838****	**0.801****
PP1	1.003	1.031	1.032	**0.997***
PP2	**0.979***	**0.989***	**0.981***	**0.960***
PP3	1.012	1.013	**0.949****	**0.865****
PPE1	**0.953***	**0.995***	**0.986***	**0.942****
PPE2	**0.926****	**0.945****	**0.943****	**0.930****
PPE3	**0.954***	**0.973****	**0.907****	**0.825****
Term Structure Model				
HW	**0.896***	**0.829****	**0.762****	**0.697****

Oil Price Expectations at Different Points in Time







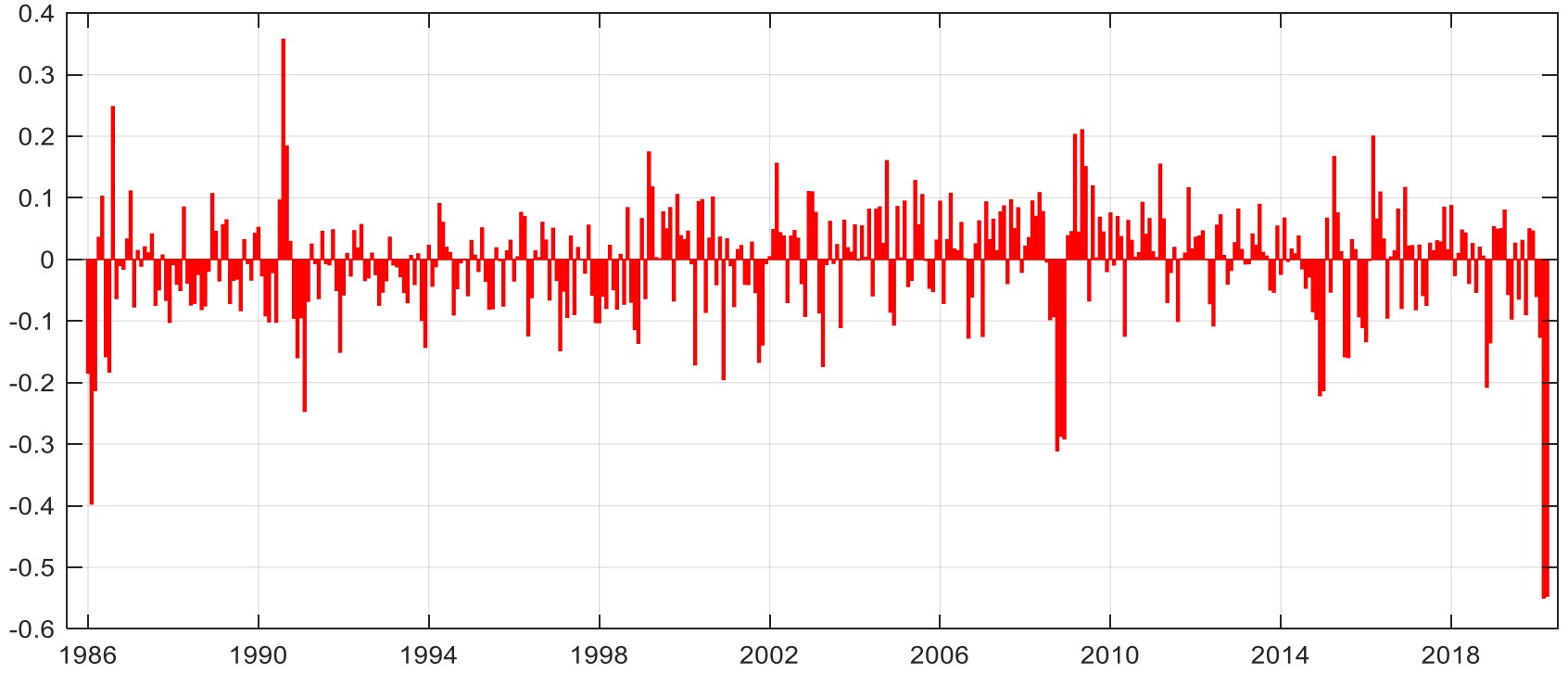


Deriving Shock Measures

- Market-based oil price shocks:

(1) Oil price surprises computed as log difference between actual oil price and what market participants expected the price to be last month

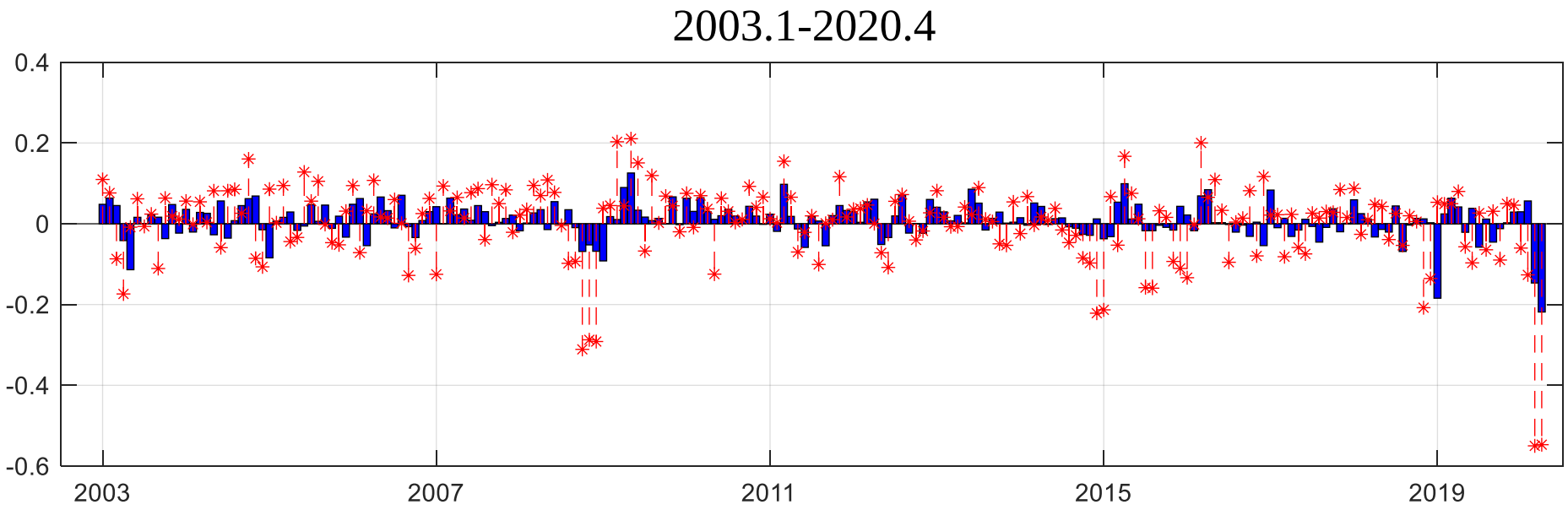
1986.1-2020.4



Deriving Shock Measures

- Market-based oil price shocks:

  (2) 'Pure' expectation shocks driven by market beliefs (orthogonal to fundamental oil supply and demand shocks)



Modeling Applications

- Evaluation of economic models
  - Testing hypotheses: test for bubbles (Pavlidis et al., 2017); test for financialization of commodity markets (Baumeister et al., 2017)
  - Modeling agents' decisions: vehicle purchases (e.g. Allcott and Wozny, 2014); inventory build-up (Baumeister et al., 2017); investment in resource extraction (Anderson et al., 2018; Gilje et al., 2020)
- Input for policy analysis
  - Regulation and government policies
    - Management of the Strategic Petroleum Reserve (Newell and Prest, 2017)
    - Changes in gasoline taxes vs fuel-economy regulations (Busse et al., 2013)
  - Economic outlook
    - Feed oil price expectations into macroeconomic projections

Implications for Out-of-Sample Forecasting

- Does risk adjustment translate into out-of-sample forecasting success?

  ⇨ Baumeister and Kilian (2017) provided encouraging results BUT weakened over extended evaluation period

  ⇨ Way forward: add to forecast combinations

Recursive MSPE Ratios Relative to No-Change Forecast of the WTI Oil Price
Evaluation Period: 2009.1-2020.7

Monthly horizon h	F_t^h	HW	HW + daily price change
3	**0.890****	1.066	**0.901****
6	**0.840****	**0.972***	**0.935****
9	**0.781****	**0.945****	**0.909****
12	**0.739****	**0.916****	**0.894****

NOTES: Boldface indicates improvements on the monthly no-change forecast.

Monetary Policy Expectations

- Common measure: Fed funds futures
  - risk-adjusted expectation measure (Piazzesi and Swanson, 2008)

- Many other financial instruments can be used to infer market-based expectations about future changes in Fed policy
  - differ in their characteristics which means different risk premia
  - Gürkaynak, Sack & Swanson (2007) investigate their forecasting performance but ignore risk premia

- Additional challenges:
  - Zero lower bound: shadow-rate model (Bauer & Rudebusch, 2016)
  - Heterogeneous beliefs influence size and variation of risk premia (Kelly & Pruitt, 2013; Barillas & Nimark, 2017, 2019; Cao, Crump, Eusepi & Moench, 2020)

Inflation Expectations

- Common measure: breakeven inflation rates
  - difference between yields on nominal Treasuries and inflation-protected Treasuries
  - derived from **two** markets with differing characteristics, in particular liquidity during periods of financial stress
- In addition to risk premium: adjust for liquidity premium
- Existence of inflation-linked assets not a precondition for deriving market-based measure of inflation expectations
  - model joint dynamics of nominal rates and actual inflation in a state-space framework where inflation and real rates are unobserved states (Hamilton, 1985; Burmeister et al., 1986)
  - use futures prices of agricultural commodities and relationship between commodity and consumer prices to back out overall inflation expectations (Hamilton, 1992)

Conclusion

- Long list of assets traded on financial, forward, and futures markets whose prices incorporate expectations about key macroeconomic variables

  ⇨ inflation, house prices, freight costs, commodity prices, interest rates, foreign exchange, emission allowances (carbon price), …

- Same general methodology can be applied to select the most plausible market-based expectation measure

  ⇨ important: account for specific features of each market in deriving the relevant set of expectations for evaluation

- Useful for many economic applications and policy decisions