Measuring Uncertainty Based on Rounding: New Method and Application to Inflation Expectations

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Inflation's Uncertainty Haunts Consumers

By SOMA GOLDEN

If consumers were certain that substantial inflation, of say 6 per cent annually, were here to stay, they would go out and spend money faster than the experts are predicting for this year.

But so far, consumers lack a consensus. Some expect inflation to disappear entirely this year; others think the price indexes will speed ahead at a rate of 10 per cent or so.

In this environment of enormous price uncertainty, the standard forecast calls for weak consumption outlays, rising savings, and a drop in "real" retail sales—deflated to take price increases into consideration.

Thinking and Doing

The complex interplay between what consumers think and what they do was discussed yesterday by F. Thomas Juster, a University of Michigan Professor and program director of the uni-

The New York Times

F. Thomas Juster

versity's Survey Research Center. Visiting New York to introduce a new quarterly publication, Economic Outlook USA, which will draw heavily from the center's consumer surveys, Mr. Juster painted a generally gloomy picture of the consumer sector for the first half of 1974.

How much consumers will actually "pull in their horns" and hold back spending, said Mr. Juster, will depend on what consumers think about future inflation. He argued that there was an even bigger scattering now than a year ago in peoples' expectations on the subject.

To Mr. Juster, this lack of unanimity means "people can't make sensible plans about future spending." If people were certain that prices would be up 8 per cent, 5 per cent, or zero, then they could go ahead and do their spending.

Savings Gain Seen

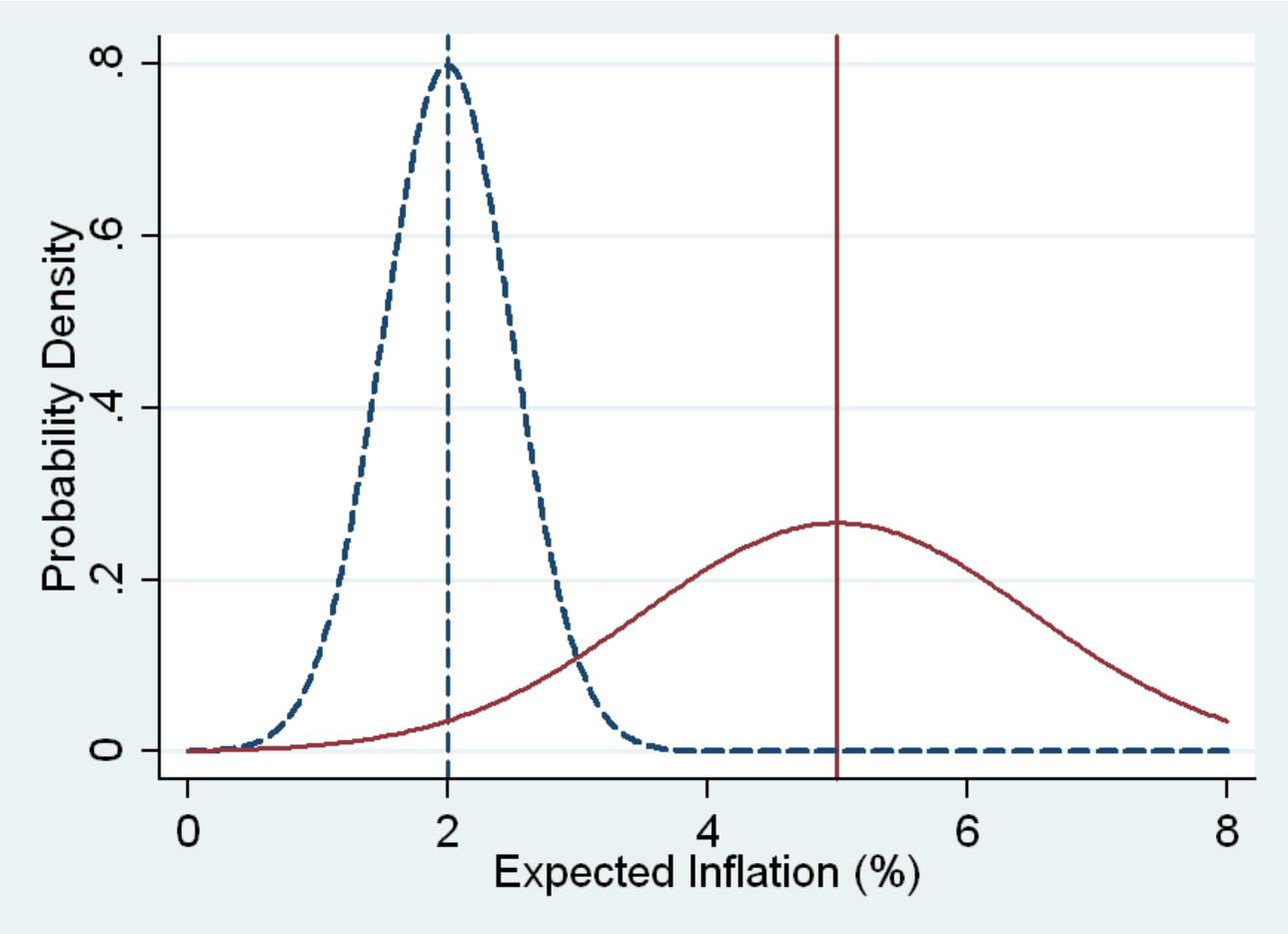
Actually, if consumers follow the Juster scenario and raise the savings rate from the fourth quarter's 6.9 per cent over the next few months, few economic analysts would be surprised. Most of the profession is predicting that consumers will do just that—although few have the rate climbing as high as 8.7 per cent in the second quarter of 1974, which is Mr. Juster's prediction.

More noteworthy is Mr. Juster's contention that American consumers could learn to live with a high rate of inflation—if they could see it coming. Once consumers are sure of the rate, he said, they can figure out what their real income will be and make spending plans accordingly.

Mr. Juster could not estimate how long inflation must continue at high rates before consumers give up hope that it will subside. Since the current six-year period of rapidly rising prices is the longest in post-world War II United States history, economists have little to guide them in making such guesses.

To confuse matters further, Mr. Juster conceded that prices are not the only thing causing consumers serious uncertainty. Rising unemployment, in the cards for this year, will raise a question for many about their ability to take on added consumption outlays.

Uncertainty: a feature of individuals' beliefs



Challenge: how to measure?

Round Numbers and Uncertainty

85th Year ··· No. 334

50 Million Expected to Go to Polls

Turnout of 80,000 Seen in Race for 10th District Seat

By Harry Gabbett
Staff Reporter

- Cognition and communication researchers have studied how people express imprecise approximations.
- Multiples of 5 are used to convey imprecise or uncertain estimates (Zelnick 1961, Sigurd 1988, Jansen 2001, Dechow and You 2012).

RNRI Principle (Krifka 2002)

Round numbers suggest round interpretations.

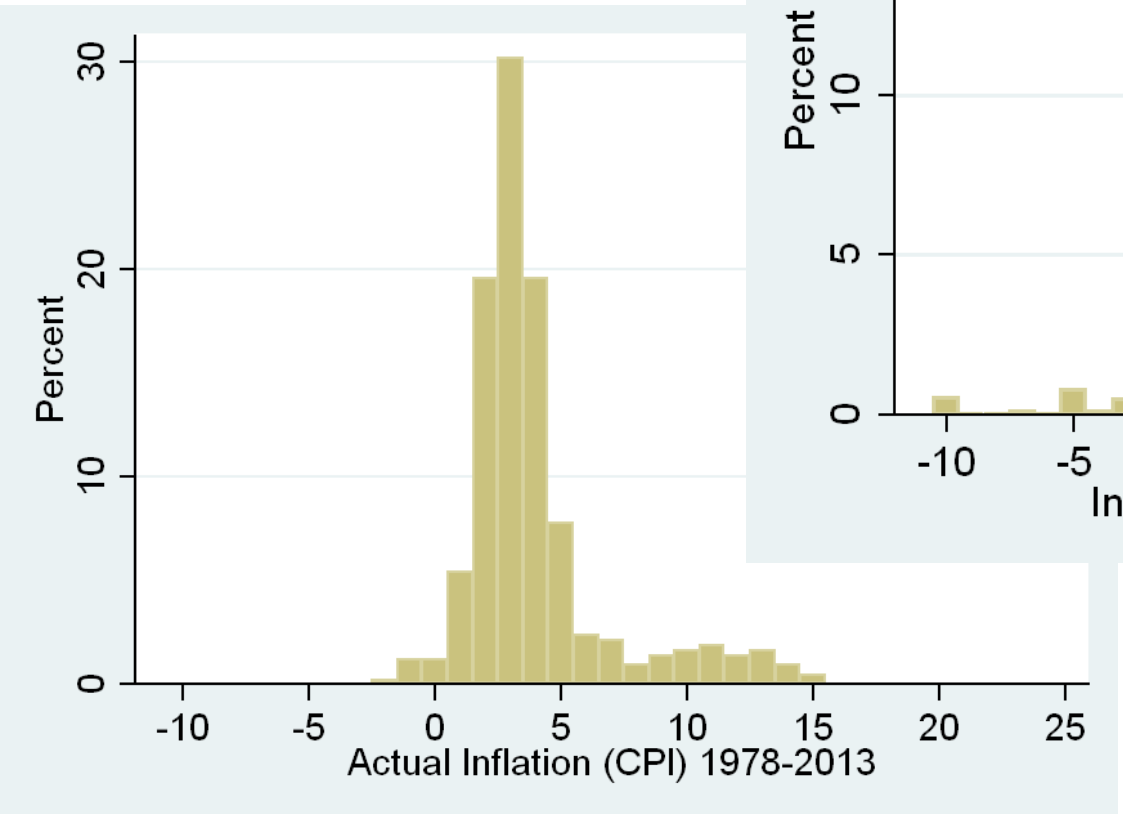
Inflation Expectations Survey Data

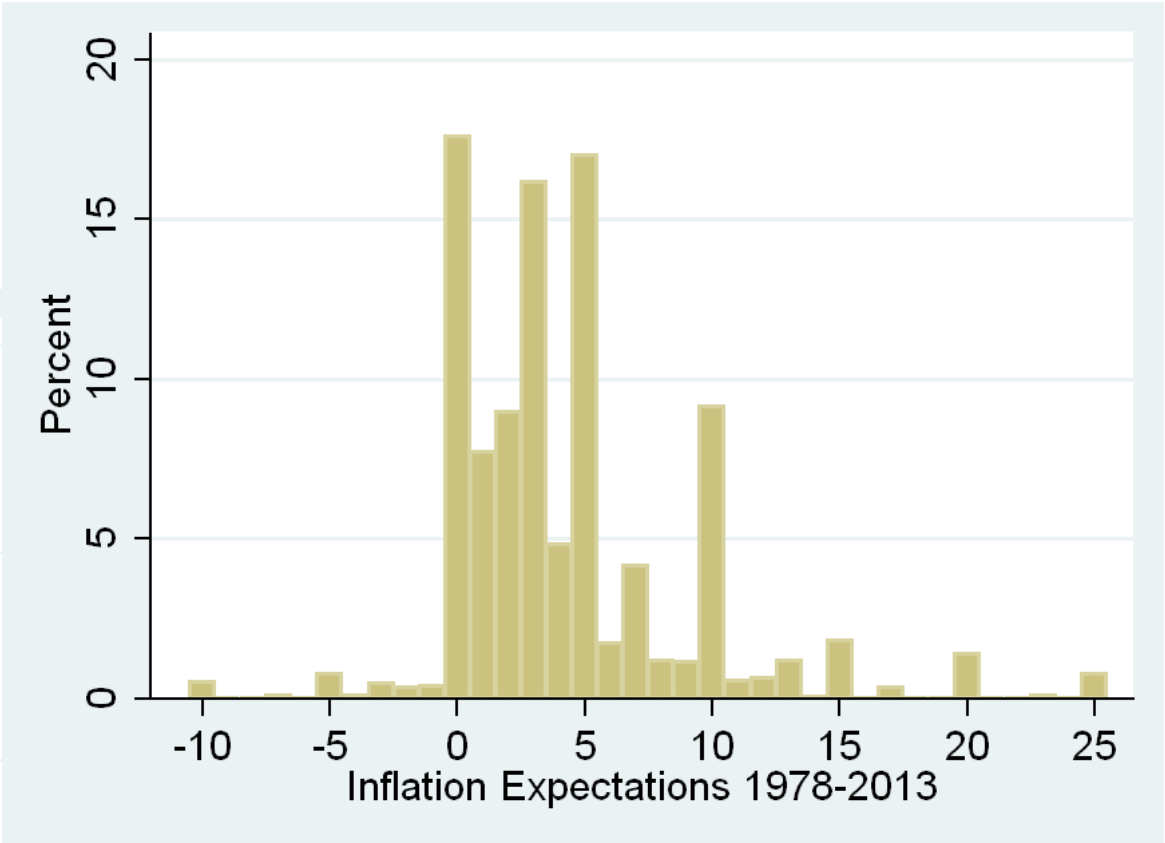
Michigan Survey of Consumers (MSC)

- Monthly since 1978
- Nationally representative sample of about 500 households
- Expectations, spending attitudes, demographics

Response Heaping at Round Numbers

Multiples of 5: 10% of inflation realizations vs. 49% of forecasts.





Quantifying the Uncertainty of Round Numbers

- Not all round responses are equally likely to indicate high uncertainty.
- Example: In 1990, when inflation was near 5%, many respondents chose 5% forecast.

Quantifying the Uncertainty of Round Numbers

Suppose each consumer i has inflation forecast f_{it} and uncertainty v_{it}.

- If v_{it} is sufficiently *high*, i rounds to nearest multiple of 5 (M5) to convey uncertainty. Response R_{it} is nearest M5 to f_{it}. (Type h)
- If v_{it} is sufficiently *low*, then R_{it} is nearest integer to f_{it}. (Type l)

Quantifying the Uncertainty of Round Numbers

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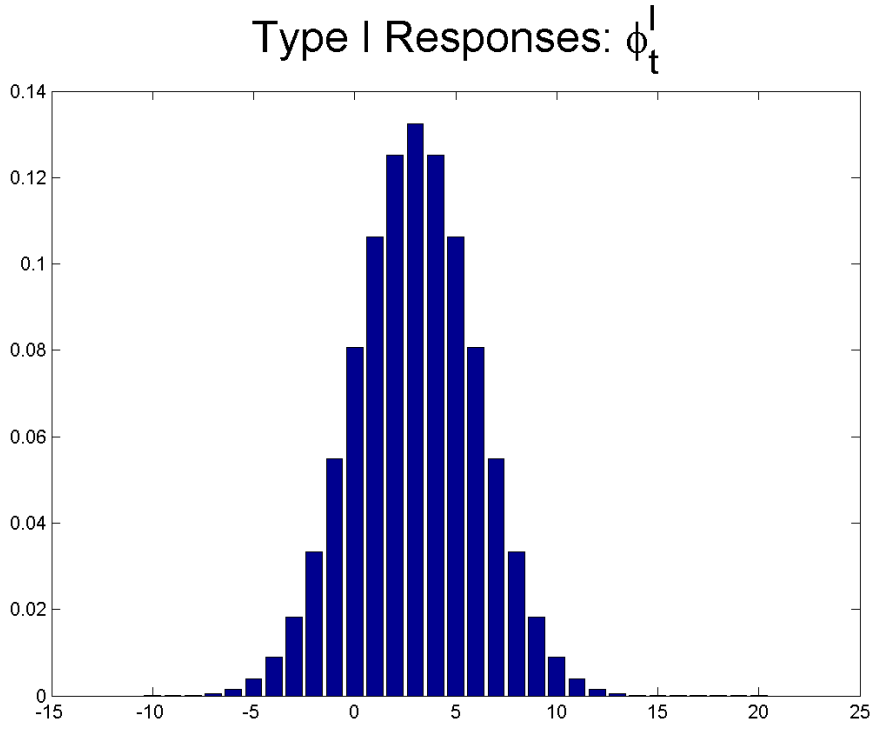
What is the probability that i is type h, given her response R_{it}?

- 0, if R_{it} is not M5
- Between 0 and 1, if R_{it} is M5

Distribution of Survey Responses



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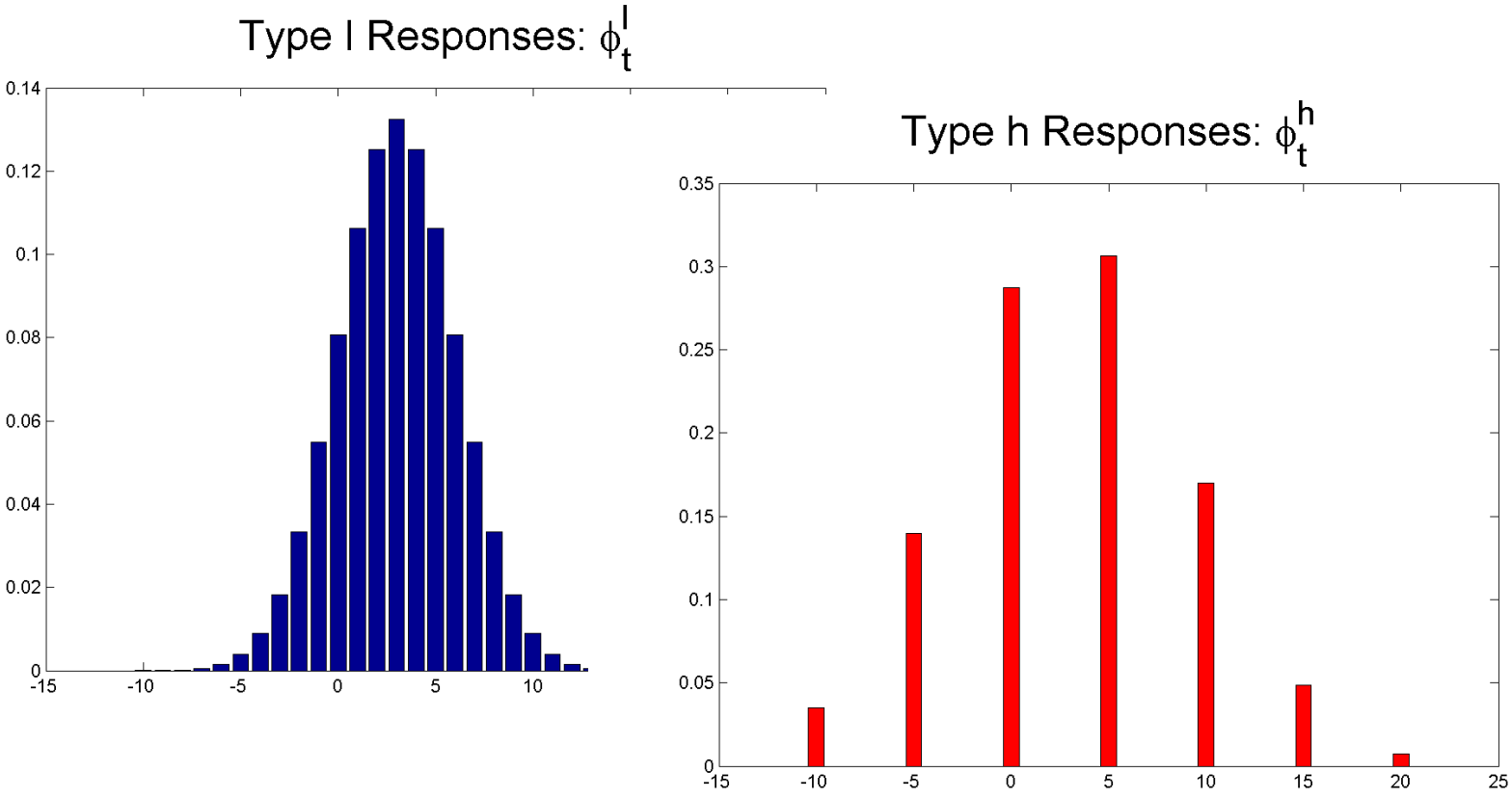

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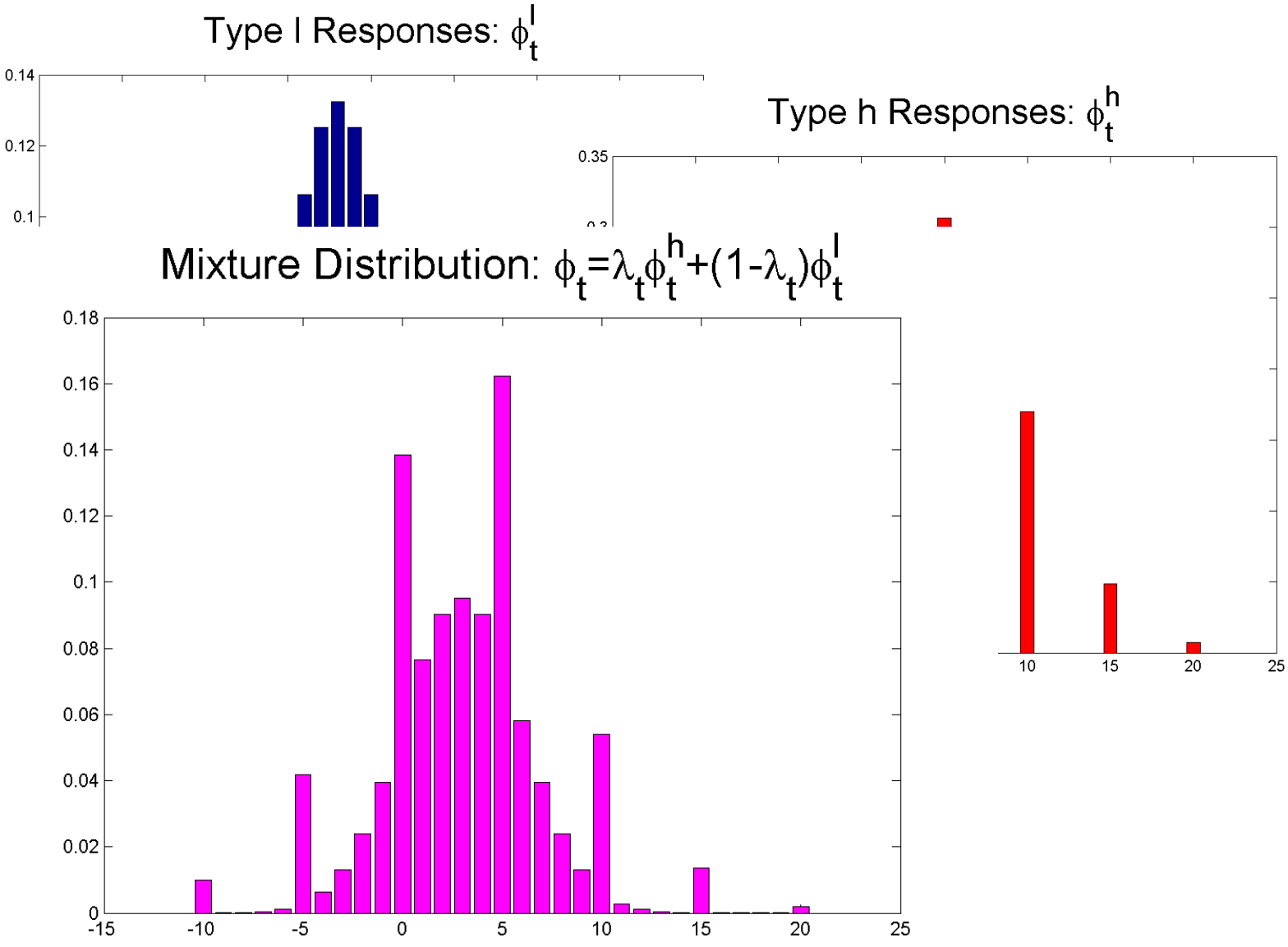
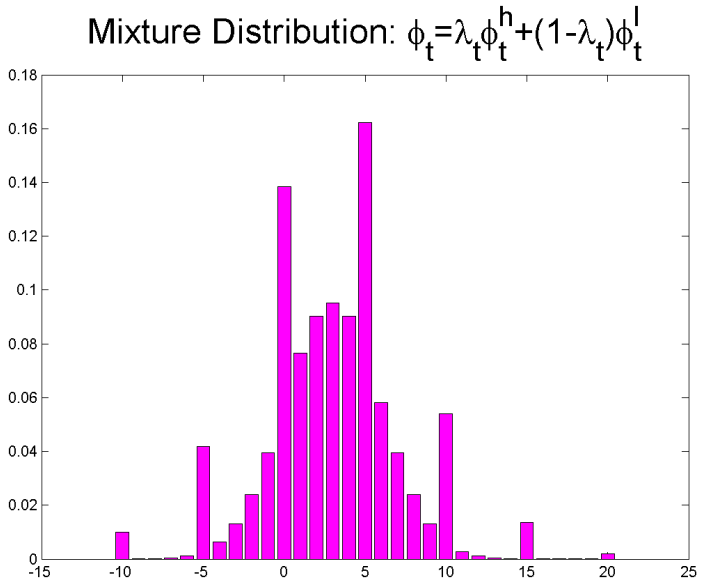


Estimating Probability

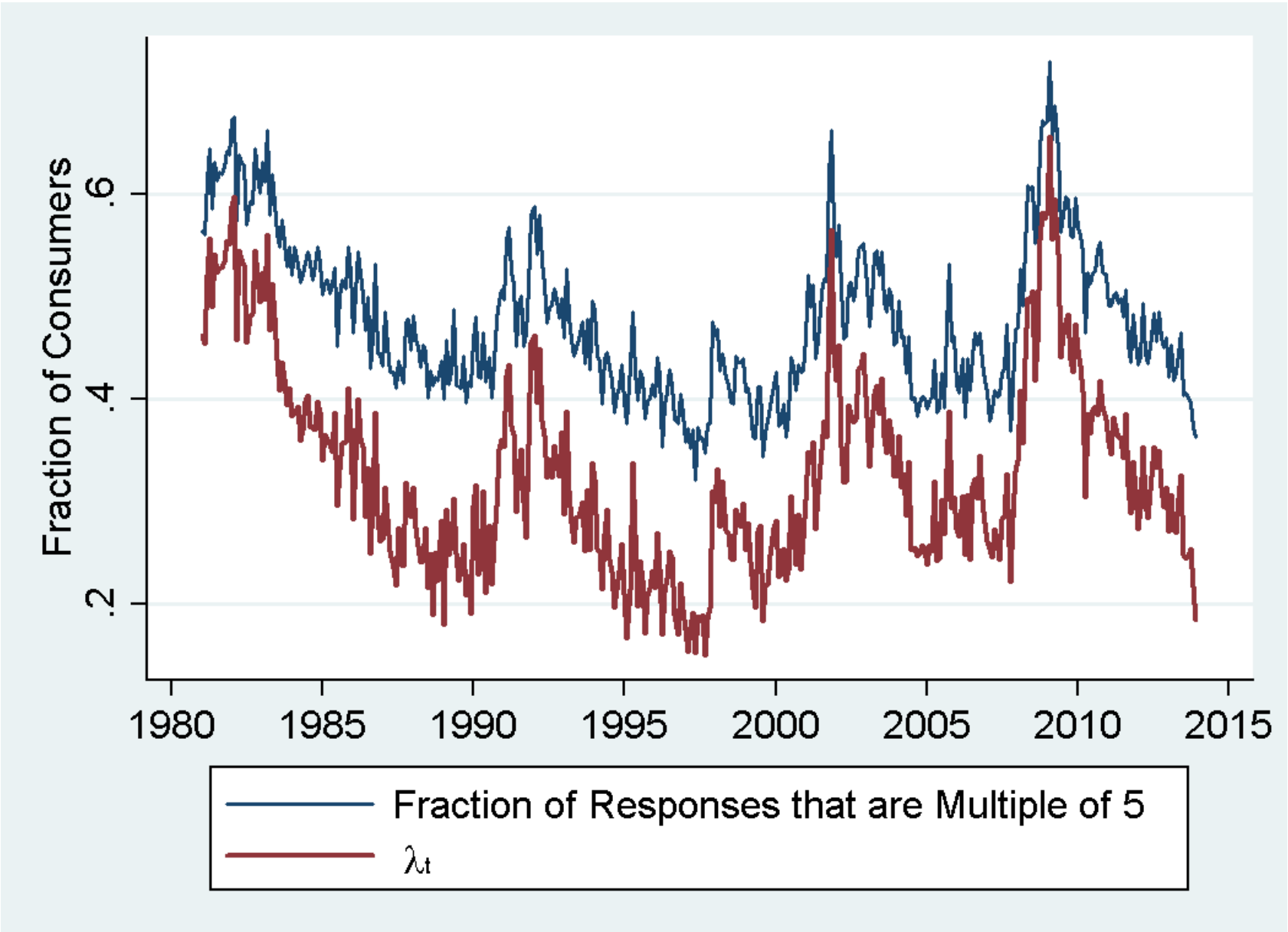


I estimate parameters of mixture distribution $(\mu_{ht}, \mu_{lt}, \sigma_{ht}, \sigma_{lt}, \lambda_t)$ by maximum likelihood.

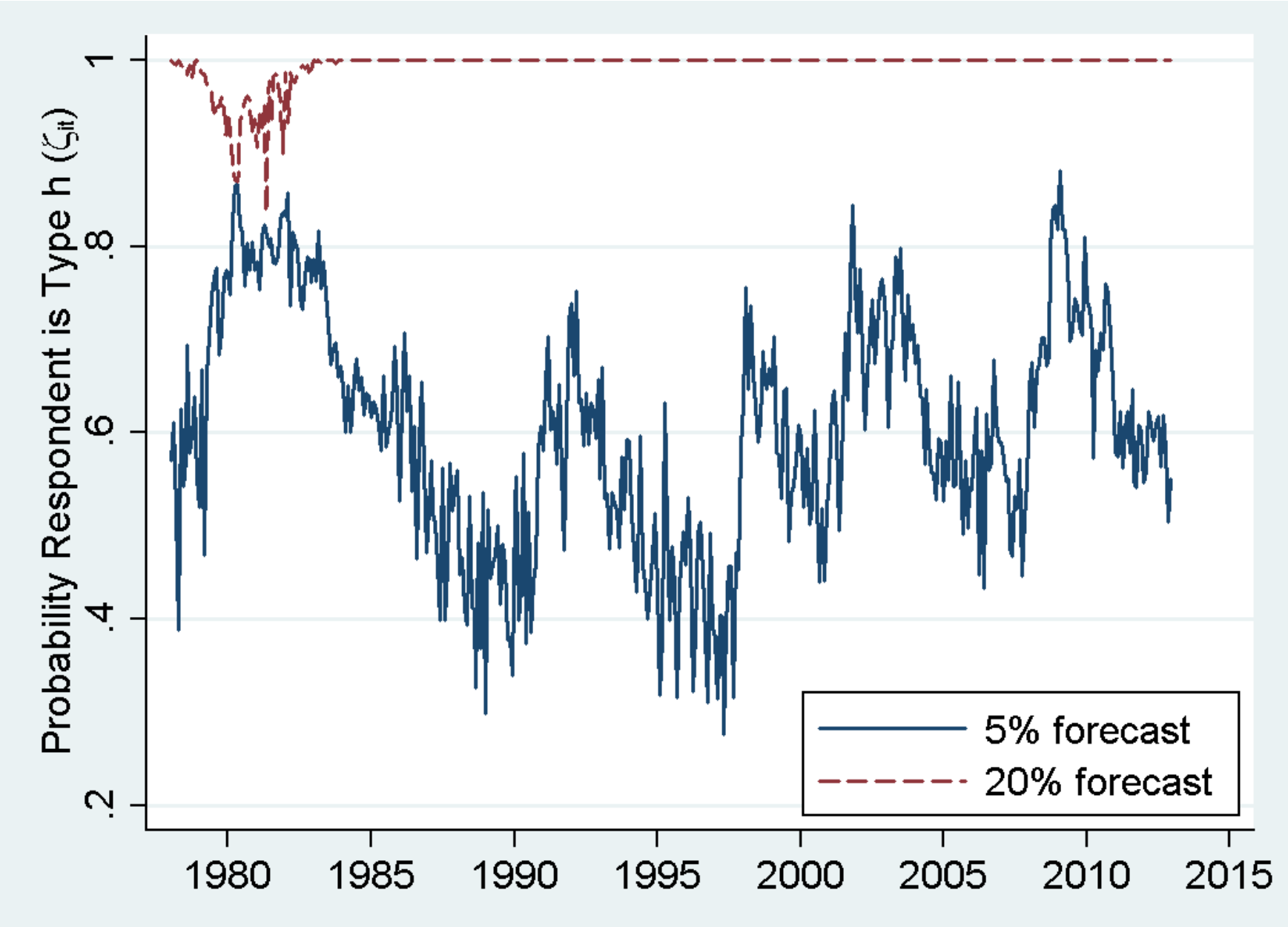
- Mixture weight λ_t is the fraction of type-h consumers.
- Probability ζ_{it} that respondent i is type h:

$$\zeta_{it} = \zeta_t(R_{it}) = \begin{cases} 0, \text{ if } R_{it} \notin M5 \\ \frac{\lambda_t \phi_t^h(R_{it})}{\lambda_t \phi_t^h(R_{it}) + (1-\lambda_t)\phi_t^l(R_{it})} \text{ if } R_{it} \in M5 \end{cases}$$

Estimates


Fraction of Consumers
.2
.4
.6
1980
1985
1990
1995
2000
2005
2010
2015
Fraction of Responses that are Multiple of 5
λ_t

Estimates

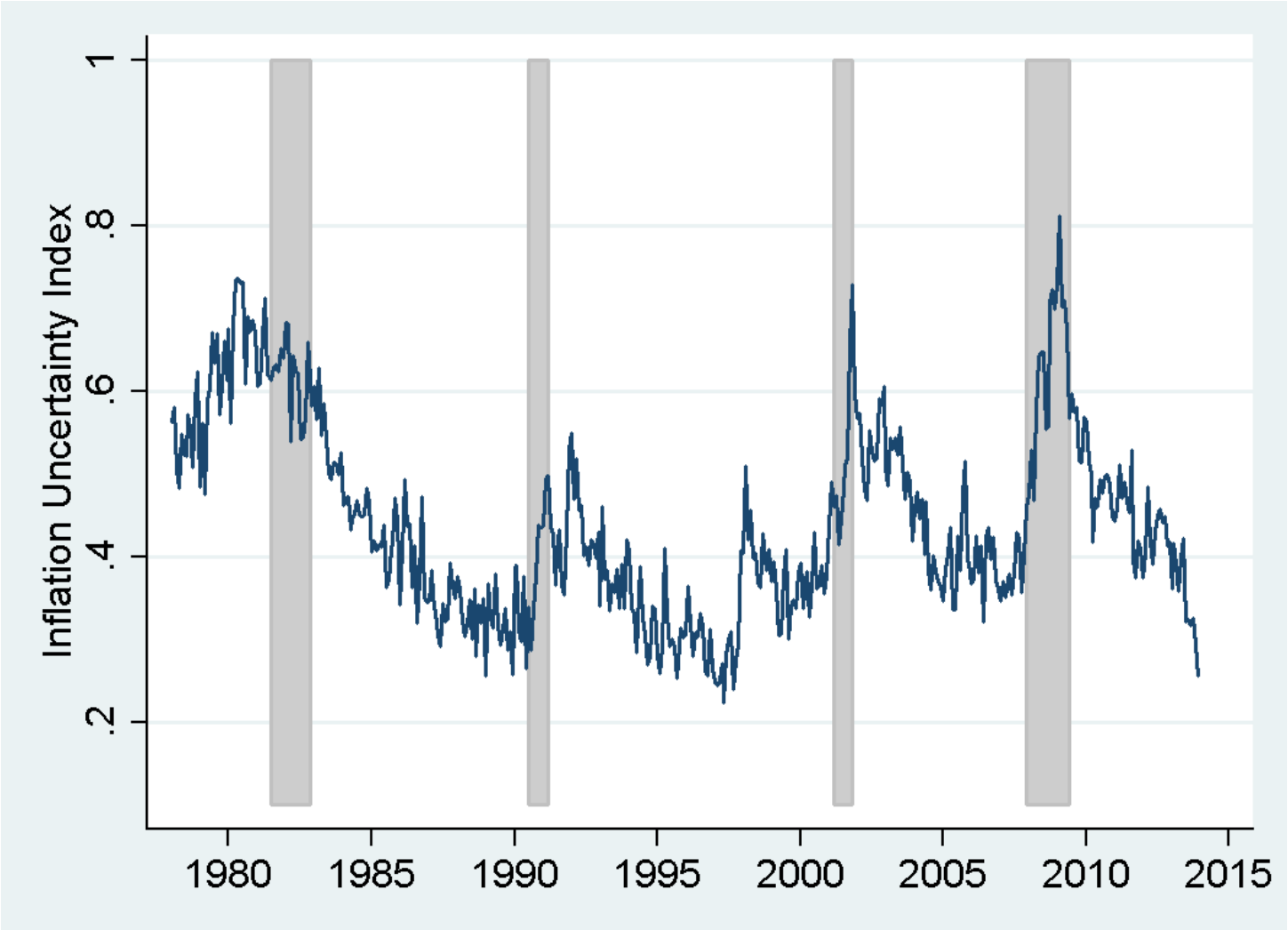

Probability Respondent is Type h (ζ_{it})
.2
.4
.6
.8
1
1980
1985
1990
1995
2000
2005
2010
2015
5% forecast
20% forecast

Properties of Uncertainty Measure ζ_{it}

- Mean=0.42
- Std. dev.=0.41
- Demographic patterns:

	Mean of ζ
No High School Degree	0.56
High School but No College Degree	0.43
College Grad	0.34
Lowest Income Tercile	0.49
Middle Income Tercile	0.39
Top Income Tercile	0.34
No Stock Investments	0.49
Stock Investments	0.36

Inflation Uncertainty Index



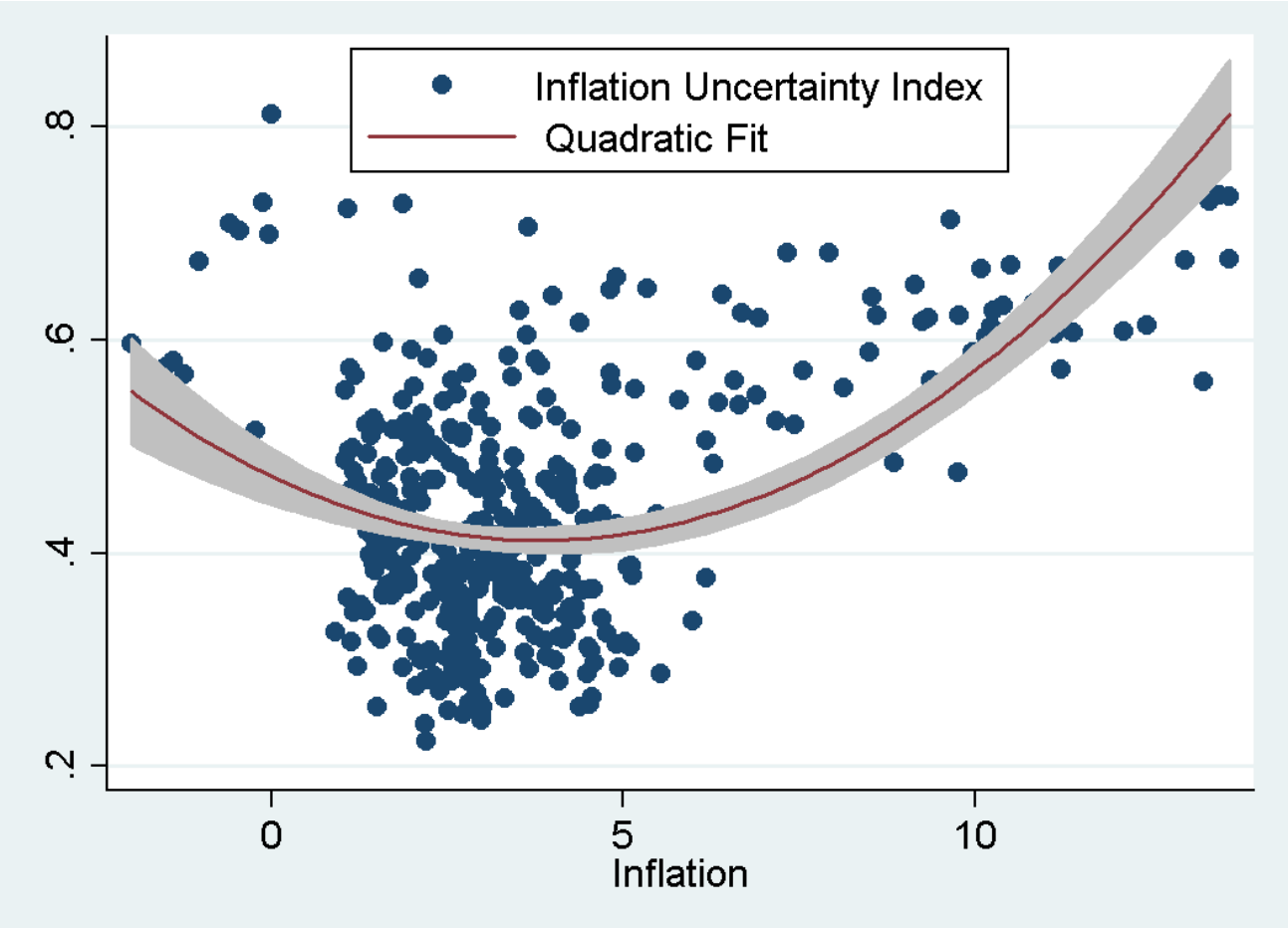
Max=0.81 in February 2009, min=0.22 in May 1997, countercyclical

Inflation Uncertainty Index

Correlation with inflation uncertainty index	
Inflation	0.44
Unemployment	0.45
Inflation Disagreement	0.76
Inflation Volatility	0.68
Economic Policy Uncertainty	0.49

Inflation Uncertainty and Inflation

Time Period	Correlation π_t and U_t
1978-1996	0.75
1997-2013	-0.25



Applications

1. Durables consumption
   - Consumers who are more uncertain about inflation are less likely to say it is a good time to buy a home, car, or durables
2. Inflation dynamics
   - Mean inflation expectations of "low uncertainty" type more useful in Phillips Curve estimation than expectations of all consumers or of professional forecasters
3. Monetary policy evaluation
   - Also construct index at 5-10 year horizon to evaluate monetary policy credibility and expectations anchoring
   - Since 1990s, long-run uncertainty lower than short-run

Conclusions

Inflation Uncertainty and Durables Consumption

Slump in Auto Sales Laid To Economic Uncertainty

By WALTER RUGABER
Special to The New York Times

DETROIT, May 14—The sharp decline in automobile sales this month appears to be attributable more to economic factors than to the current controversy over vehicle safety. A number of retail dealers and some leading manufacturers have blamed public concern over safety for the slump reported Thursday.

The industry announced that sales for the first 10 days of May were off 15.4 per cent in comparison with the same period a year ago.

The early May decline followed a smaller drop in April, and there has been speculation that charges of unsafe vehicle design, made in Congress and elsewhere, have had an effect on business.

Inflation a Factor

A survey by eight correspondents of The New York Times showed that many consumers were indeed aware of the growing argument over the safety of American cars.

But interviews in major metropolitan areas indicated that prospective car buyers were far more concerned with economic factors such as the recent inflationary trend.

This economic concern has also been noted by some "respected analysts such as those at the University of Michigan's Survey Research Center.

PARLEYS PRESSED IN NURSING CRISIS

City Seeks Pact to Avoid Resignations and Keep Hospital Clinics Open

By MURRAY SCHUMACH

City officials and nurses will meet today to try to avert the threatened resignation of 1,400 nurses and the closing of outpatient clinics at the 21 municipal hospitals.

George Moskowitz, the mediator in the dispute, said last night: "I have indicated, and there is an awareness, that a solution must be found in time to avert a catastrophe in the hospitals."

The sense of urgency became apparent when, after six hours, negotiations ended at 5:45 P.M., to be resumed today at 2 P.M. Hope was expressed that the crisis would impel the city and the nurses to work out an agree-

	Correlation with U_t
PCE on Durables (Annual % Change)	-0.40
Lightweight Vehicle Sales	-0.52
New One Family Houses Sold	-0.24

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Michigan Survey Spending Attitude Variables

- DUR: About the big things people buy for their homes–such as furniture, a refrigerator, stove, television, and things like that. Generally speaking, do you think now is a good or a bad time for people to buy major household items? (Mean=0.71)
- CAR: Do you think the next 12 months or so will be a good time or a bad time to buy a vehicle, such as a car, pickup, van or sport utility vehicle? (Mean=0.64)
- HOM: Generally speaking, do you think now is a good time or a bad time to buy a house? (Mean=0.67)

I regress (probit) the spending attitude variables on inflation uncertainty and control variables.

Expected Inflation, Uncertainty, and Consumption

Marginal effect: change in probability that i thinks it's a good time to spend when ζ_{it} increases from 0 to 1

Marginal Effects	**DUR**	**CAR**	**HOM**
Inflation uncertainty	-3.1%***	-2.0%***	-4.7%***
	(0.37%)	(0.34%)	(0.37%)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

In the Great Recession, the increase in inflation uncertainty accounts for about 4-6% of the total decline in durables consumption. back

Conclusions

- New way to construct micro-level and time series uncertainty proxies from point estimates
- Applicable to other survey data (earnings, gas prices, home prices, etc.)
- Will be useful for testing models of expectations formation, for monetary policy analysis, and for forecasting
- https://sites.google.com/site/inflationuncertainty

Appendix Slides

Expected Inflation, Uncertainty, and Consumption

	(1) DUR	(2) CAR	(3) HOM
ζ_{it}	-9.8e-02***	-5.6e-02***	-1.4e-01***
π^e_{it}	-7.3e-04	-8.1e-03***	-4.9e-03***
INEX	1.5e-03***	1.8e-03***	3.0e-03***
PAGO	1.4e-01***	7.7e-02***	8.4e-02***
PEXP	4.1e-02***	6.6e-02***	5.7e-02***
BEXP	9.1e-02***	1.3e-01***	1.2e-01***
RATEX	7.7e-02***	-1.2e-02**	1.9e-02**
UNEMP	-1.5e-01***	-1.1e-01***	-1.2e-01***
Opinion of Government	1.4e-01***	1.3e-01***	1.2e-01***
Unemployment	-1.1e-01***	-2.4e-02***	-3.7e-02***
Fed Funds Rate	1.9e-02***	-1.3e-02***	-7.7e-02***
Inflation	-5.7e-02***	-5.4e-02***	-5.6e-02***
ZLB	3.5e-02	-1.3e-01***	-2.0e-01***
Observations	164621	165248	169258
Pseudo R^2	6.6e-02	5.9e-02	1.4e-01

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Inflation Uncertainty in the Great Recession

$$\ln(\text{Car Spending}_t) = \alpha + \beta CAR_t + \gamma t$$

	DUR	CAR	HOM
Spending attitudes and aggregate spending			
Coefficient $\hat{\beta}$	0.71***	1.01***	1.03***
	(0.03)	(0.07)	(0.12)
Observations	432	432	432
R^2	0.90	0.40	0.15
Spending attitudes, inflation uncertainty, and expected inflation			
Inflation uncertainty	-3.1%***	-2.0%***	-4.7%***
	(0.37%)	(0.34%)	(0.37%)
Expected inflation	-0.02%	-0.29%***	-0.16%***
	(0.03%)	(0.03%)	(0.03%)

During the Great Recession, inflation uncertainty increased by about 0.25. Marginal effects imply that the mean of DUR declines 0.8%, CAR 0.5%, and HOM 0.2%, so aggregate spending on durables, cars, and homes decline 0.5% to 1.2%, or about 5% of the actual decline.

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Control Function Approach

Two-stage instrumental variable method for non-linear models (Rivers and Vuong 1988, Imbens and Woolridge 2007) to address potential omitted variable bias and measurement error.

1. First stage: regress uncertainty from second survey on uncertainty from first survey and all exogenous control variables
   - Coefficient on lagged inflation uncertainty is 0.24***, R^2=0.14, std. err. of residuals=0.36.
2. Second stage: estimate baseline probit including residual from first stage as an additional control variable
   - Small coefficient on residual $\Rightarrow$ endogeneity concerns not too severe
   - Marginal effects of inflation uncertainty are still negative

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Phillips Curve

$$\pi_t = \beta \pi_t^e + \alpha X_t + \epsilon_t$$

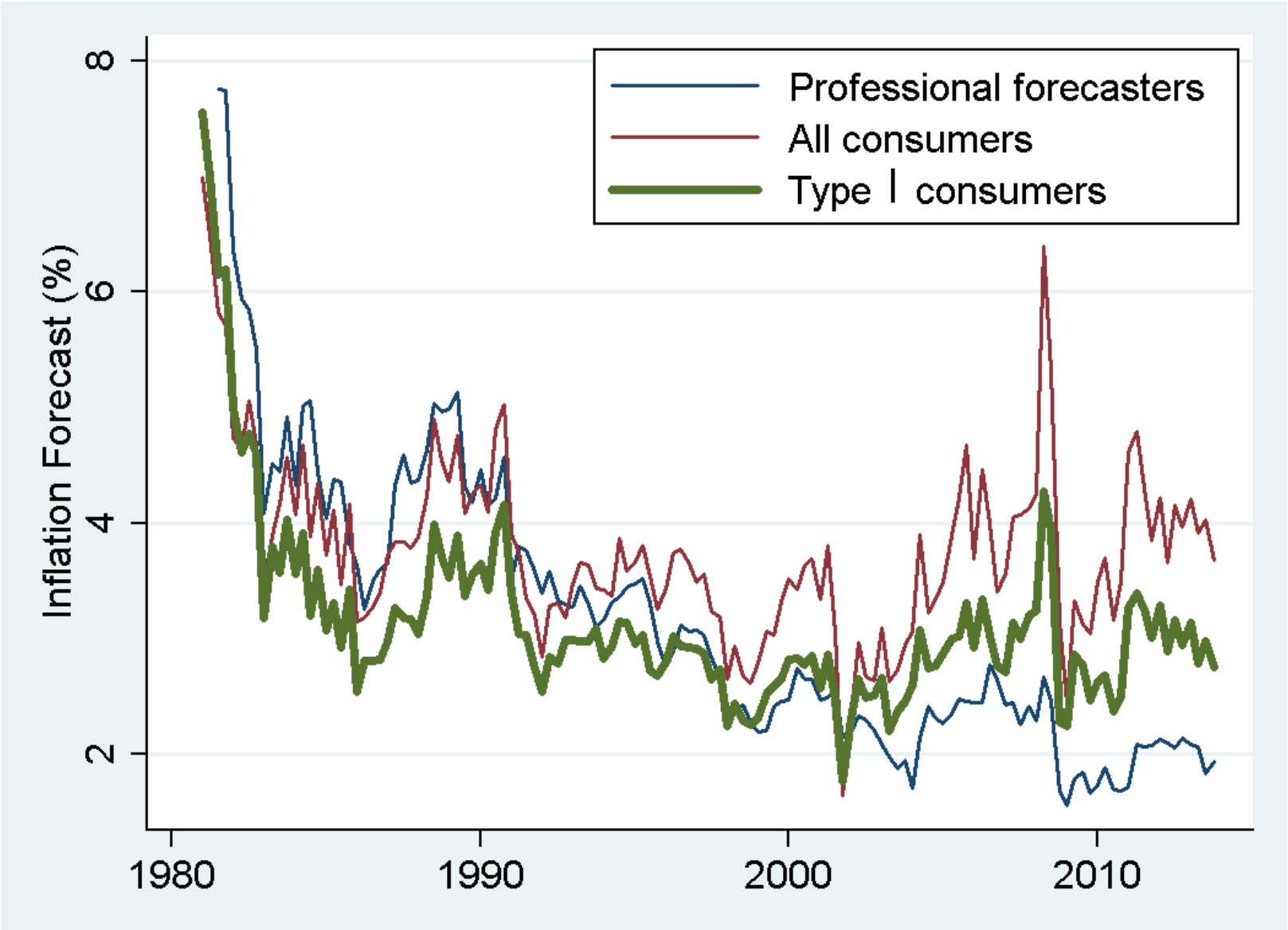
Bernanke (2007): "On which measure or combination of measures should central bankers focus to assess inflation developments?"

Phillips Curve

$$\pi_t = \beta \pi_t^e + \alpha X_t + \epsilon_t$$

- Expectations of professional forecasters typically used as proxy for price setters' expectations.
- **Coibion and Gorodnichenko (2013)**: "Given that many prices are set by small and medium-sized enterprises who do not have professional forecasters on staff... it seems a priori as likely for their inflation expectations to be well-proxied by household forecasts as by professional forecasts."
- *Hypothesis*: Since price setters are likely more informed than the typical household, type-I forecasts should be even better proxy.

Phillips Curve



Phillips Curve

$$\pi_t = \beta\pi^e_{lt} + (1-\beta)\pi^e_{\text{other},t} + \alpha\text{Unemployment}_t + \epsilon_t.$$

	(1)	(2)	(3)
π^e_l	1.24***	0.57***	1.76***
	(0.23)	(0.19)	(0.65)
π^e_h	-0.24		
	(0.24)		
π^e_{SPF}		0.43**	
		(0.19)	
π_{MSC}			-0.76*
			(0.65)
Unemployment	-0.25**	-0.19**	-0.21**
	(0.12)	(0.08)	(0.10)
N	144	130	144
R^2	0.04	0.07	0.04

Newey-West std. errs. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

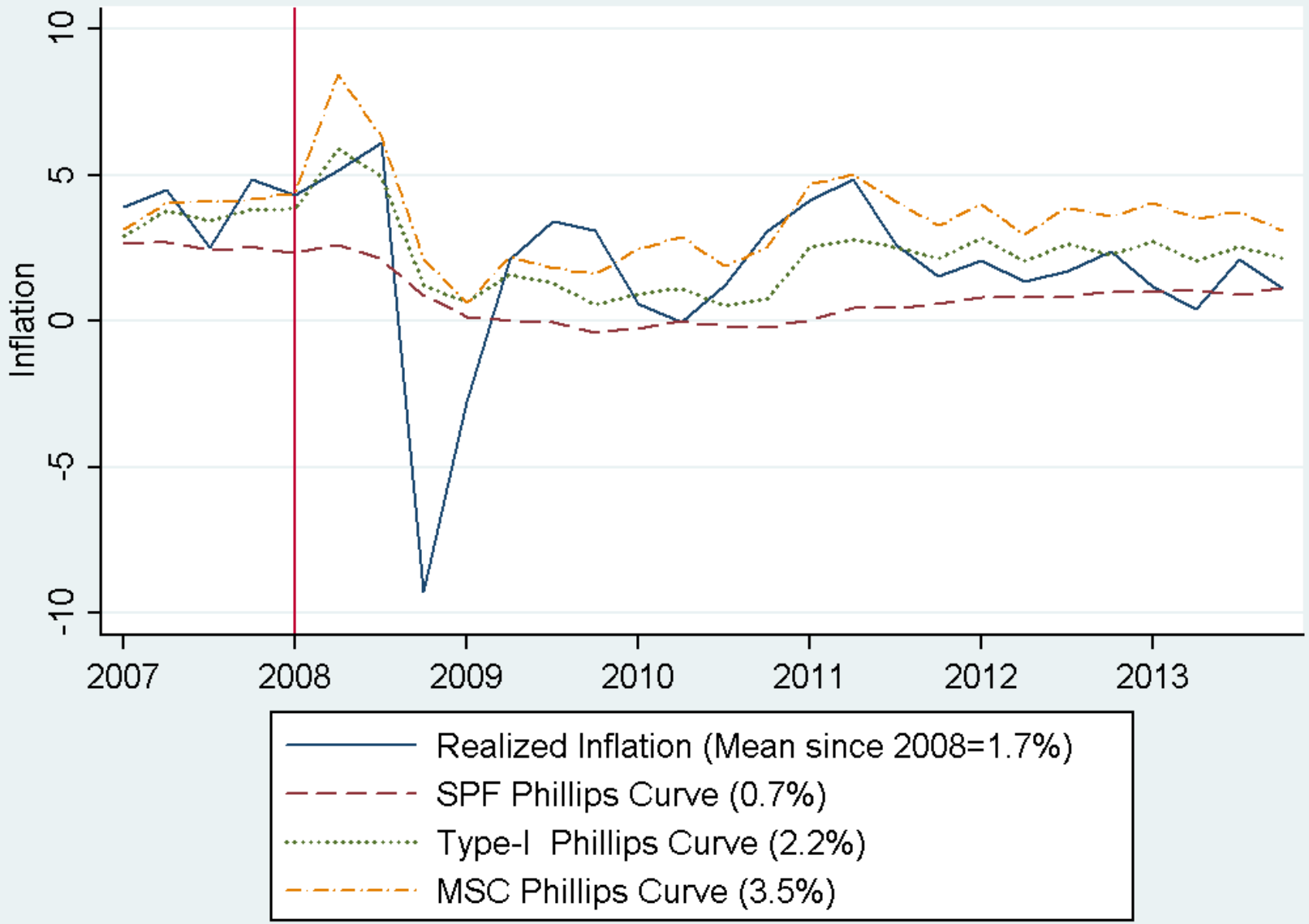
Robustness

Phillips Curve

$$\pi_t = \beta \pi^e_{lt} + (1-\beta)\pi^e_{\text{other},t} + \alpha \text{Unemployment}_t + \epsilon_t.$$

- Type-*l* consumers' expectations best proxy for price-setters expectations.

Actual and Predicted Inflation



Control Variables

- Demographics: income, years of schooling, sex, marital status, age, age squared, geographic region, race
- Expectations/attitudes: family income expectations, evaluation and expectations of personal financial situation, expectations of business conditions, interest rates, and unemployment, and opinion of government policy
- Macroeconomic: unemployment rate, inflation, federal funds rate, zero lower bound dummy

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Central Bank Credibility

- *"An increase in uncertainty about future inflation outcomes may be used as an early warning system of any erosion in central bank credibility."* (-NY Fed Staff: van der Klaauw et al. 2008)
- High inflation uncertainty in household sector linked to reduced interest-rate sensitivity (hence reduced monetary policy potency)
- Improved communication strategy could reduce inflation uncertainty especially among lower income/education groups (see my paper "Fed Speak on Main Street").

Inflation Uncertainty and Monetary Policy

Monetary policymakers interested in monitoring not only the level but also the uncertainty of inflation expectations:

"An increase in uncertainty about future inflation outcomes may be used as an early warning system of any erosion in central bank credibility."
—NY Fed Staff: van der Klaauw et al. 2008

Inflation Uncertainty and Monetary Policy

Monetary policymakers interested in monitoring not only the level but also the uncertainty of inflation expectations:

"Starting in the mid-1960s...the public grew less certain of the central bank's commitment to fighting inflation. This uncertainty led expectations of future inflation to become 'unanchored' and more likely to react to economic developments"
—Yellen 2013

Inflation Uncertainty and Monetary Policy

Monetary policymakers interested in monitoring not only the level but also the uncertainty of inflation expectations:

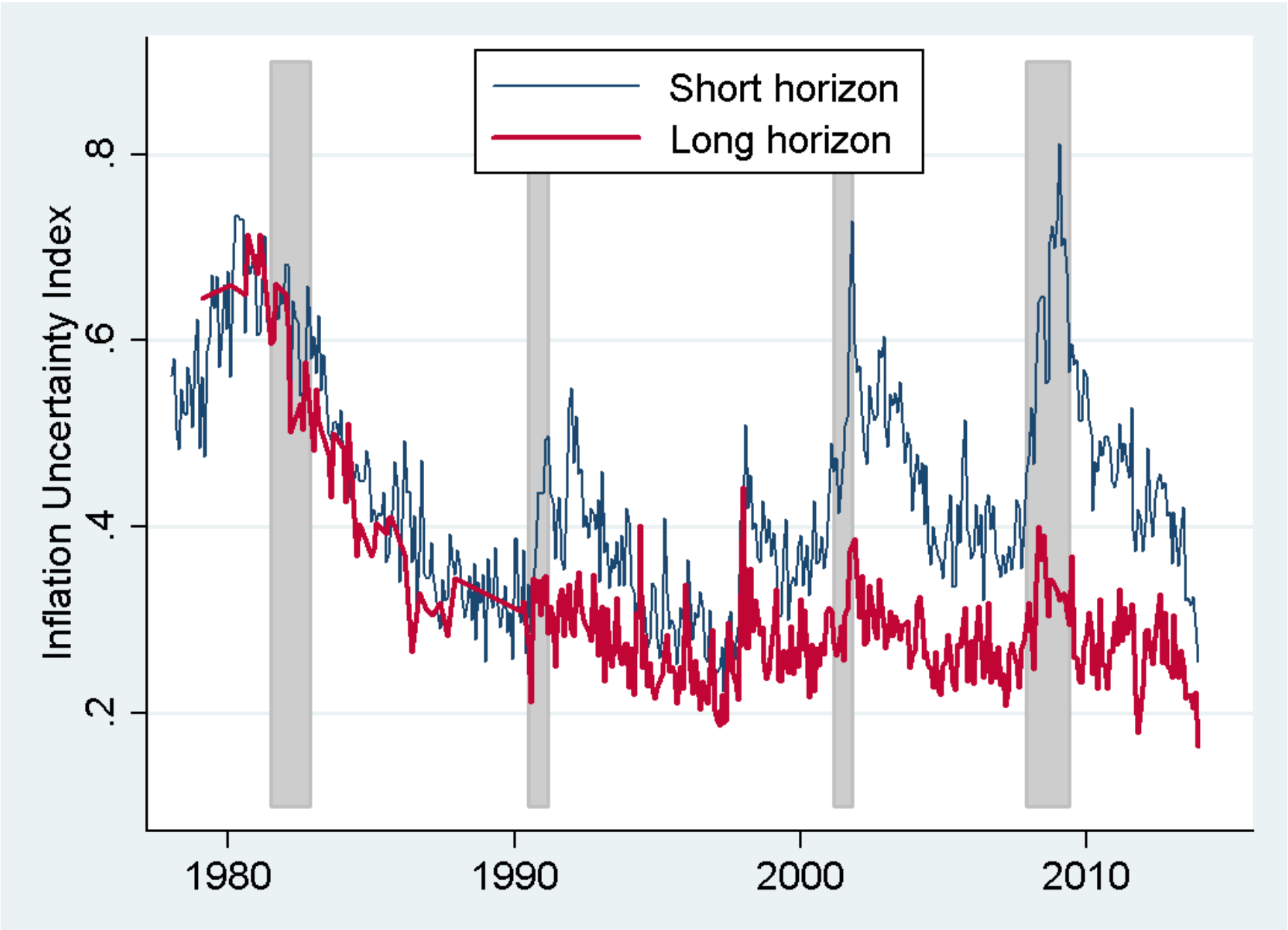
"People are pretty confident we're not going to let it get away from 2%. I like that."
—Richmond Fed President Lacker 2013

Inflation Uncertainty and Monetary Policy

Monetary policymakers interested in monitoring not only the level but also the uncertainty of inflation expectations:

- Monetary policy impacts inflation uncertainty at longer horizons (Ball and Cecchetti 1990, Erceg and Levin 2002).
- Consumers' imprecise knowledge of the real interest rate can explain slow, "hump-shaped" response of consumption to monetary policy (Mackowiak and Wiederholt 2011).
- Can construct analogous inflation uncertainty measure for 5- to 10-year horizon inflation.

Inflation Uncertainty by Horizon



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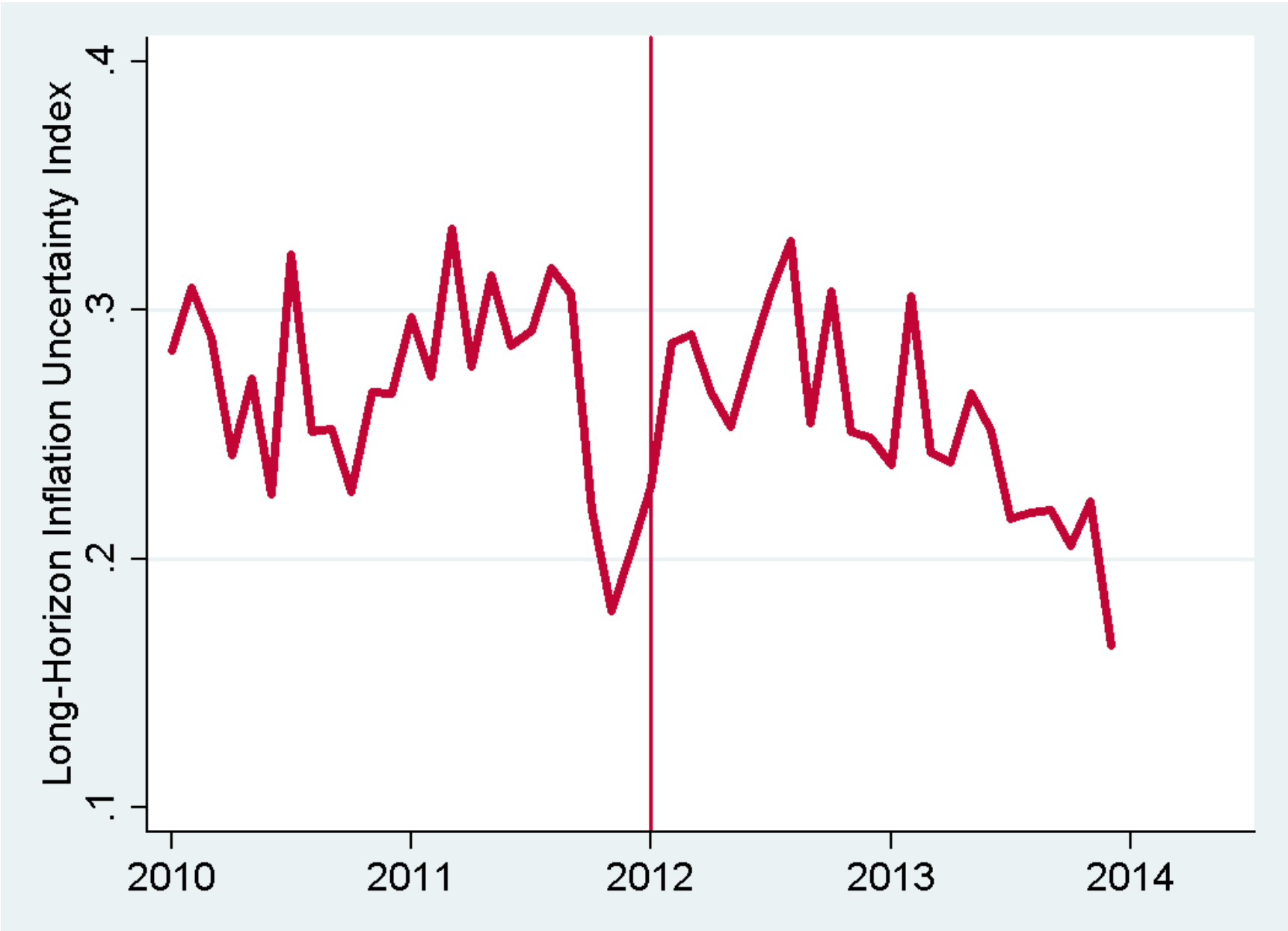

Let R_{it} be the sum of consumer i's mentions of high interest rates minus the sum of her mentions of low interest rates. Let rt_t be some measure of the interest rate at time t and consider a regression of the form:

$$\Delta R_{it} = \beta_0 + \beta_1 \Delta \text{rt}_t + \beta_2 \Delta \text{rt} * \zeta_{it} + \beta_3 \zeta_{it}$$

We expect β_1 to be positive: consumers should be more likely to mention high rates when rates increase and to mention low rates when rates decrease. If β_2 is negative, then interest sensitivity is lower for more uncertain consumers.

	ΔR	ΔR	ΔR
ζ	0.004	-0.060***	-0.006
	(0.013)	(0.022)	(0.017)
Δ Fed funds rate	0.152***		
	(0.017)		
Δ Fed funds rate * ζ	-0.063***		
	(0.010)		
Δ Real rate		0.009***	
		(0.002)	
Δ Real rate * ζ		-0.011***	
		(0.002)	
MP Shock			0.199***
			(0.034)
MP Shock * ζ			-0.070***
			(0.027)
Observations	88553	75797	76763
R^2	0.024	0.001	0.007

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Long-Horizon Inflation Uncertainty

Consumers with higher long-horizon inflation uncertainty:

- Make larger and more frequent revisions to long-run inflation expectations
- Revise long-run expectations more when they revise short-run expectations

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Inflation Uncertainty in Theory

- Role in inflation dynamics:
  - High inflation $\Rightarrow$ high inflation uncertainty (Okun 1971, Ball 1992, Fountas and Karanasos 2007)
  - High inflation uncertainty $\Rightarrow$ high inflation (Cukierman and Meltzer 1986)
- Role in real economy:
  - A real cost of inflation (Friedman 1977)
  - Ambiguous effects on output (Cechetti 1993)
  - Consumption and saving (Kantor 1983, Dotsey and Sarte 2000, Knotek and Khan 2011)
- Indicator of monetary policy credibility and transparency (Erceg and Levin 2003, van der Klaauw et al. 2008)
- Reflects agents' information environment (Sims 2003, Mackowiak and Wiederholt 2011)

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- Reflects agents' information environment (Sims 2003, Mackowiak and Wiederholt 2011)

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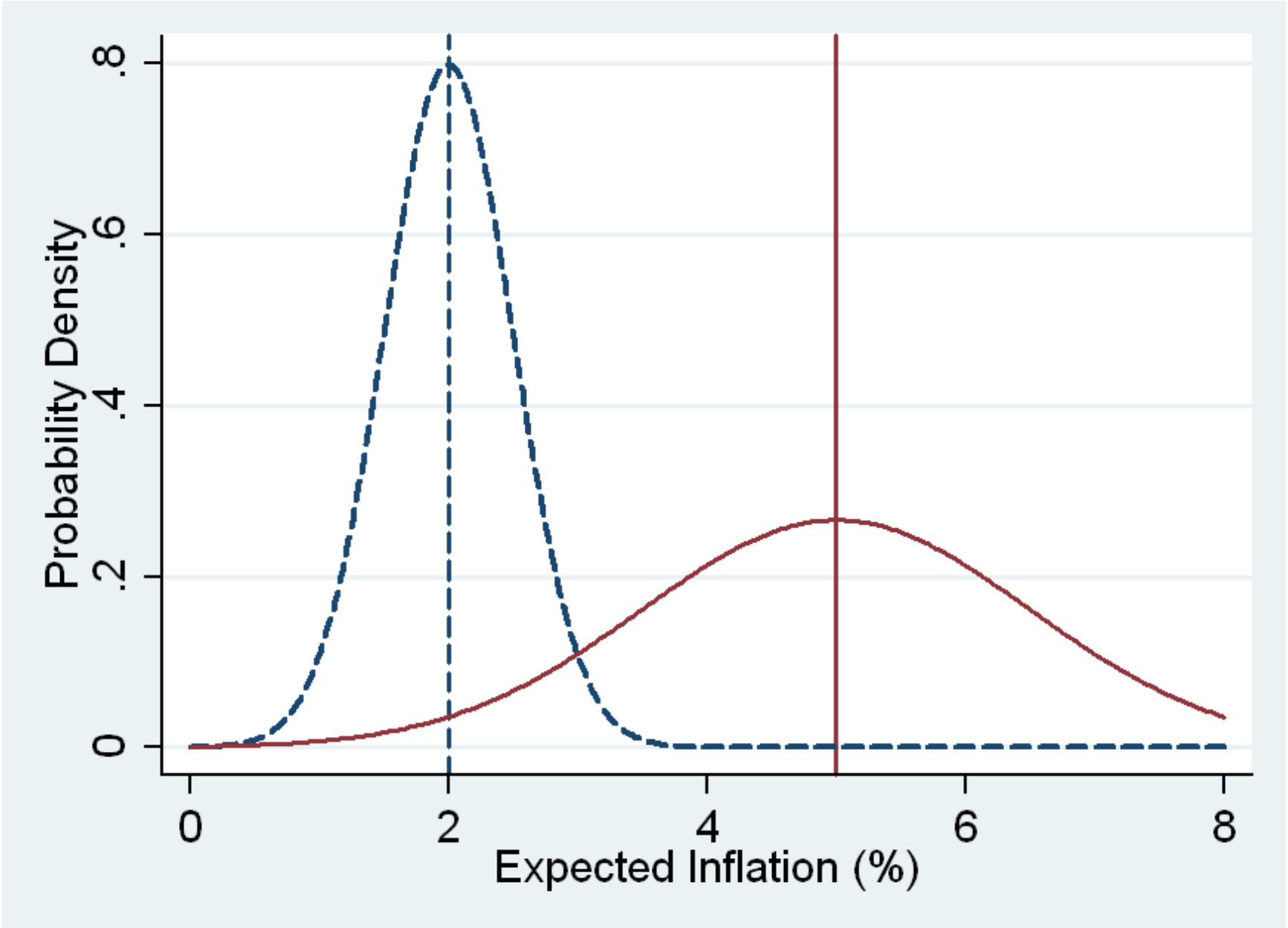

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Rounding and Uncertainty

- Multiples of 5 prevalent in estimates of area, length, or time (Baird et al. 1970, Huttenlocher et al. 1990)
- Stock traders' bids and offers cluster at multiples of 5, particularly when volatility is high (Harris 1991)
- Financial forecasts cluster at multiples of 5, especially for less informed forecasters (Herrmann and Thomas 2005, Dechow and You 2012)
- Age heaping (Zelnick 1961, A'Hearn and Baten 2009)
- Example: BLS Occupational Outlook Handbook lists expected employment change for economists for 2012-22 to be 2,300.

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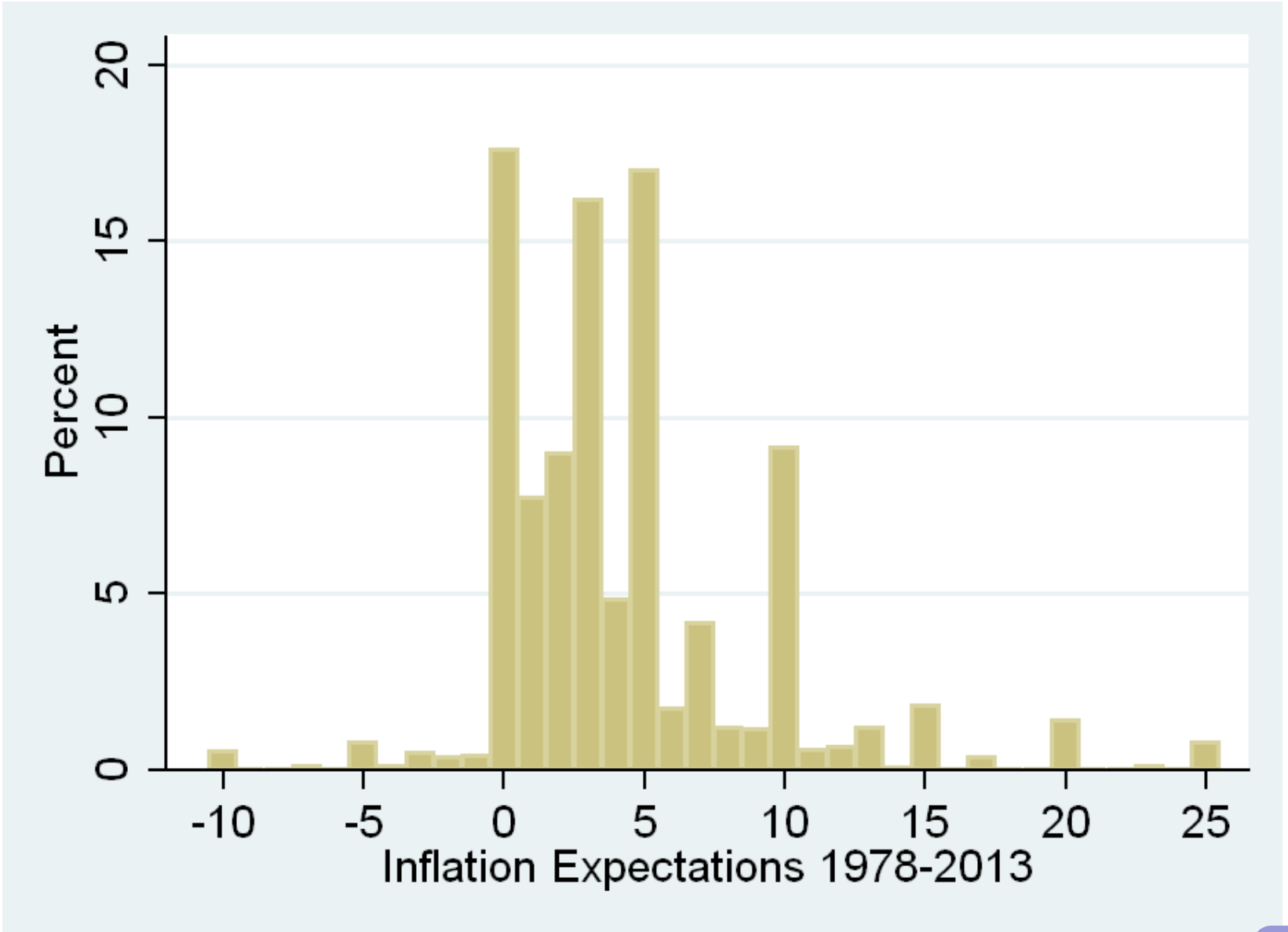
Histogram of Inflation Expectations



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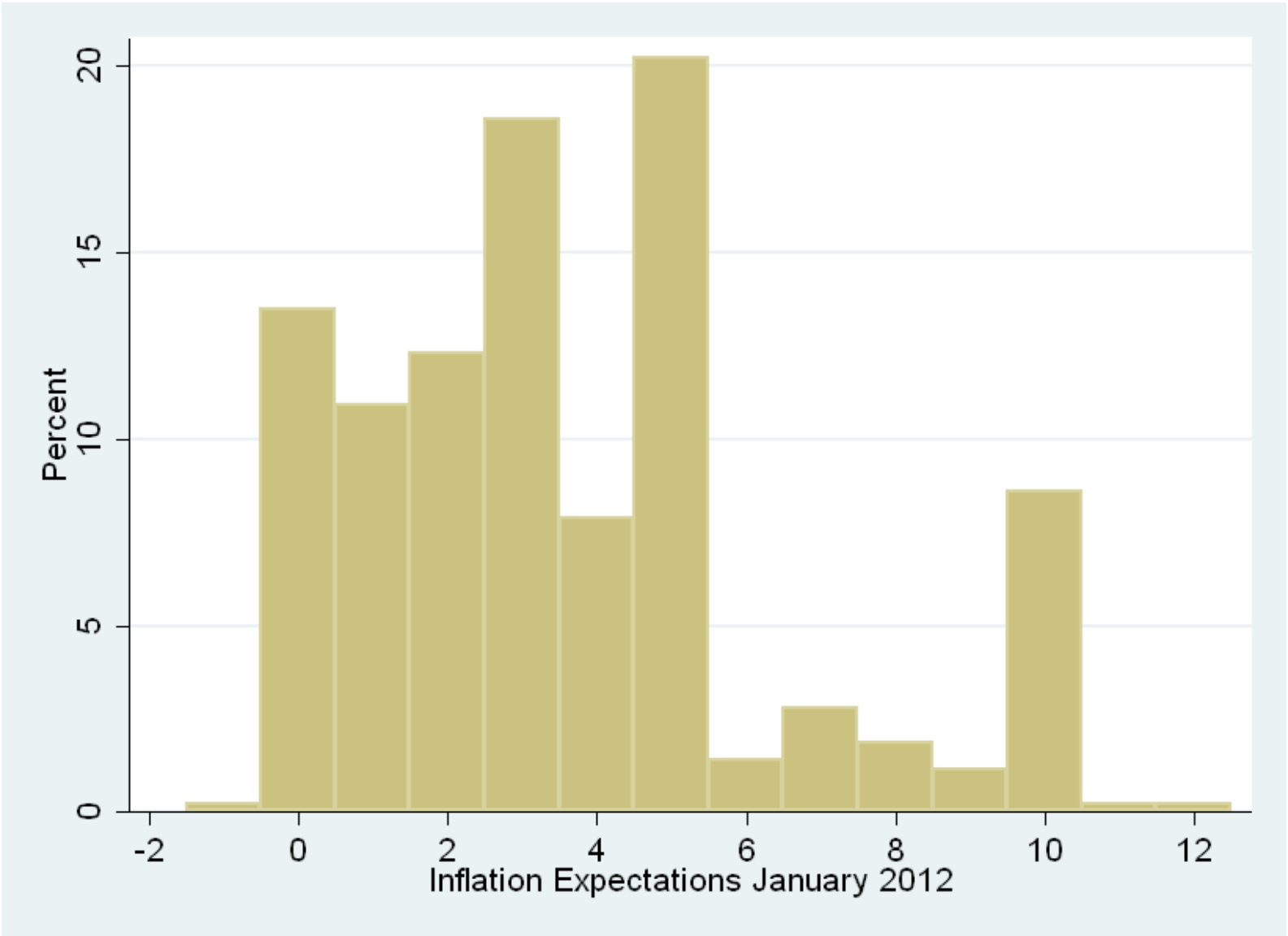
Histogram of Inflation Expectations, Jan 2012



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Whipple Index

Developed by demographers to detect response heaping.

Suppose we have T observations of realized inflation. Let M_j be the number of inflation realizations in $[j - 0.5, j + 0.5)$ and N_j be the number of inflation expectations of value j. Then the digit-specific Whipple Index for j is:

$$\hat{W}_j = \frac{N_j}{N_{-10} + N_{-9} + ... + N_{24} + N_{25}} \frac{T}{M_j} \tag{1}$$

The highest values of $\hat{W}_j$ occur at multiples of 5. No response heaping detected at other values.

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Rounding and Uncertainty

	Non-round	**Round**	***t*-stat for difference**
RMSE (p.pts.)	3.5	6.1	46***
Mean abs. revision (p. pts.)	2.5	3.9	43***
DK on second survey	4.0%	6.6%	15***

t-statistics computed using standard errors clustered by time period.

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Rounding Behavior of Rotating Panel

	Change in Absolute Error
Nonround → Nonround	-0.09
Nonround → Round	1.15
Round → Nonround	-1.72
Round → Round	-0.41

	Non-Round	Round	t-stat
Revision Frequency	0.78	0.72	20
Mean Absolute Revision	2.4	4.0	56
Mean Absolute Nonzero Revision	3.1	5.5	77

	Non Round	Round	DK
Initial Non Round	0.62	0.33	0.04
Initial Round	0.39	0.54	0.07
Initial DK	0.27	0.40	0.33

Maximum Likelihood Estimation

Cross-sectional distributions of f_{it} from types $\tau \in \{l, h\}$:

$$f_{it}|\text{type } \tau \sim N(\mu_{\tau t}, \sigma^2_{\tau t}),$$

Cross-sectional distributions of R_{it} by type:

$$\phi^l_t = P(R_{it} = j|\text{type l}) = \int_{j-.5}^{j+.5} \frac{1}{\sigma_{lt}\sqrt{2\pi}} e^{\frac{(x-\mu_{lt})^2}{2\sigma^2_{lt}}} dx, j = ..., -1, 0, 1, ...$$

$$\phi^h_t = P(R_{it} = j|\text{type h}) = \int_{j-2.5}^{j+2.5} \frac{1}{\sigma_{ht}\sqrt{2\pi}} e^{\frac{(x-\mu_{ht})^2}{2\sigma^2_{ht}}} dx, \ j = ... - 5, 0, 5, ...$$

Mixture distribution:

$$\phi_t(R_{it}) = P(R_{it} = j) = (1 - \lambda_t)\phi^l_t + \lambda_t\phi^h_t$$

Likelihood:

$$L(\{R_{it}\}_{i=1}^{N^l_t+N^h_t}|\lambda_t, \mu_{lt}, \mu_{ht}, \sigma_{lt}, \sigma_{ht}) = \Pi_{j=1}^{N^l_t+N^h_t} \phi_t(R_{it}|\mu_{lt}, \mu_{ht}, \sigma_{lt}, \sigma_{ht}, \lambda_t)$$

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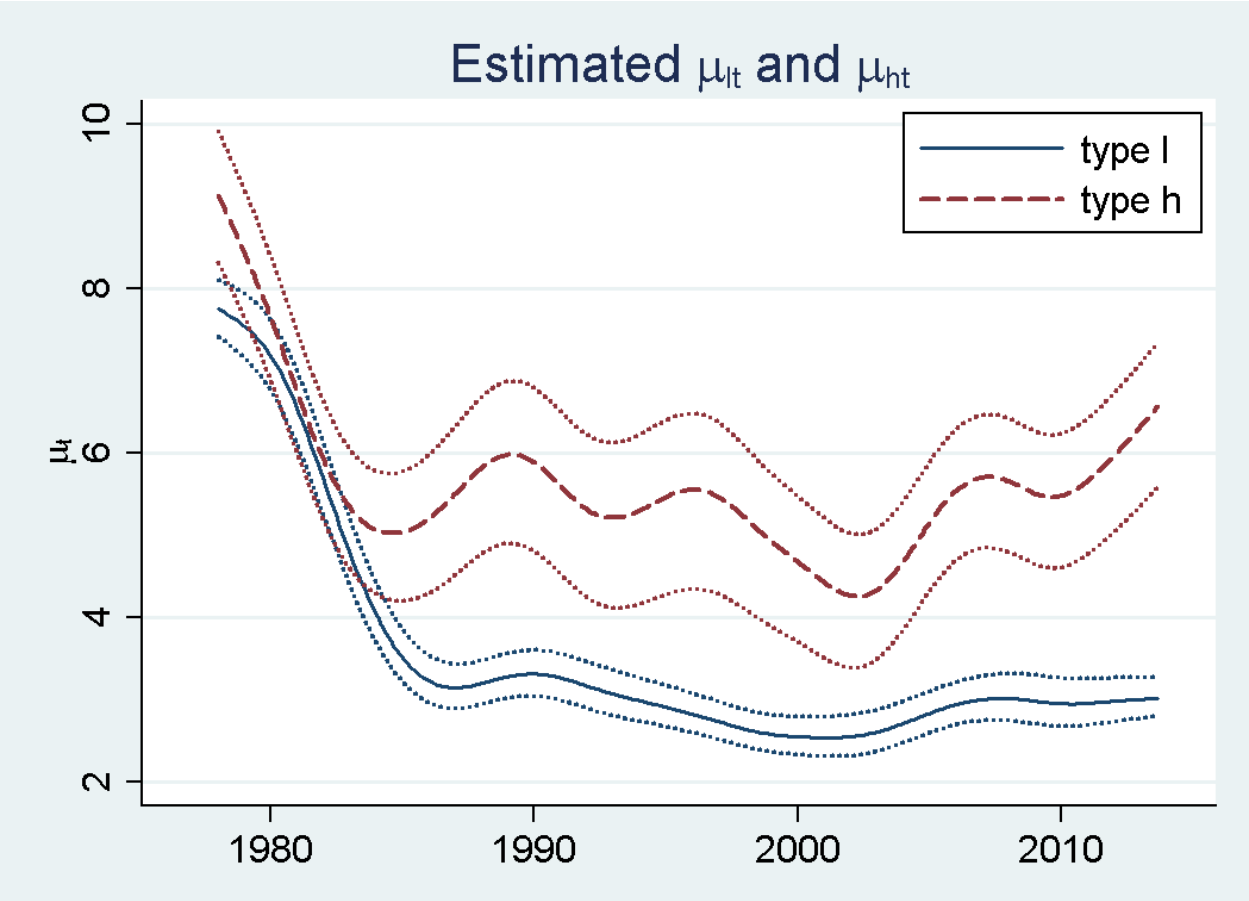
Maximum Likelihood Estimates

$$\Big(\underbrace{\mu_{lt}, \quad \mu_{ht}}_{\text{mean forecast by type}} \;,\; \underbrace{\sigma^2_{lt}, \quad \sigma^2_{ht}}_{\text{cross-sectional variance by type}} \;,\; \underbrace{\lambda_t}_{\text{share of type r}} \;, \Big)$$



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Maximum Likelihood Estimates

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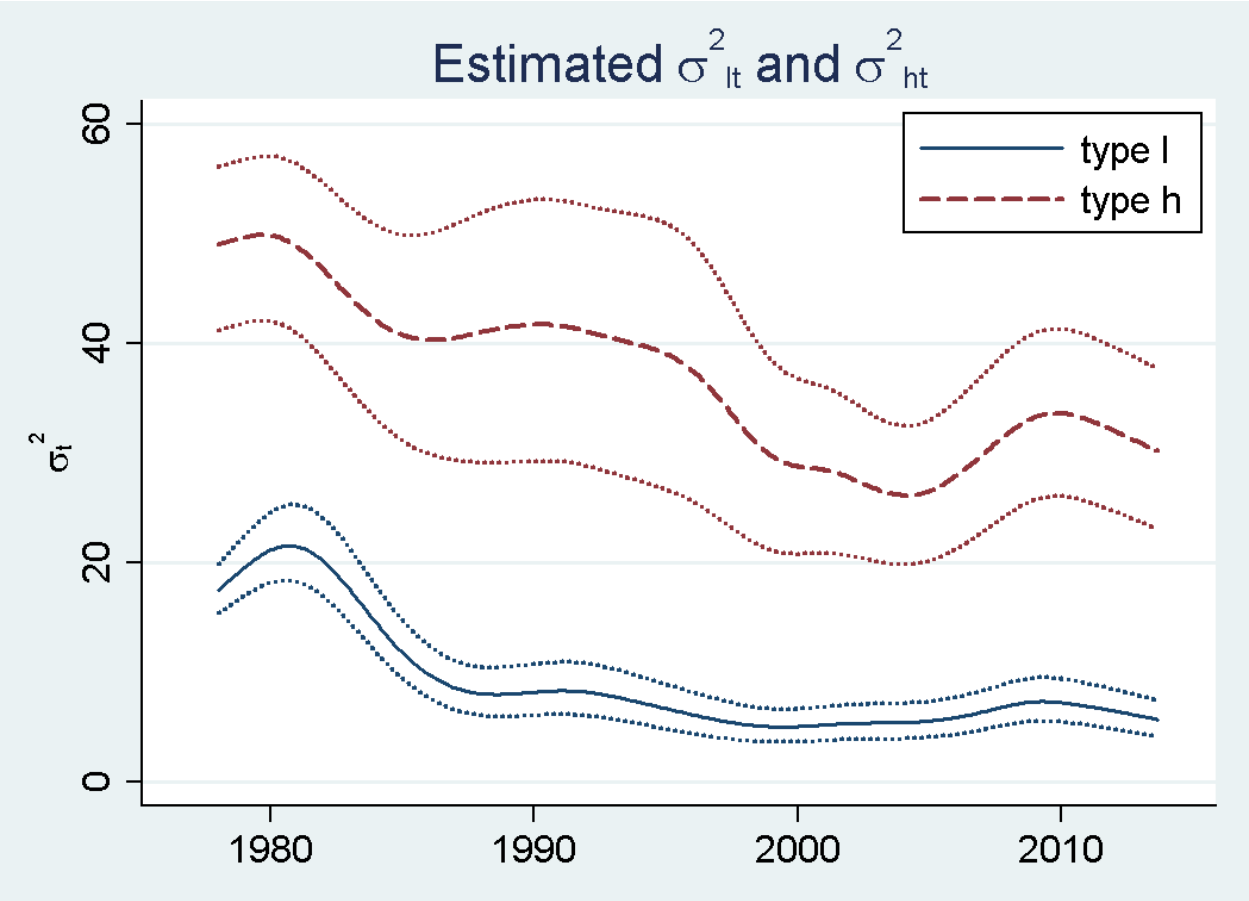

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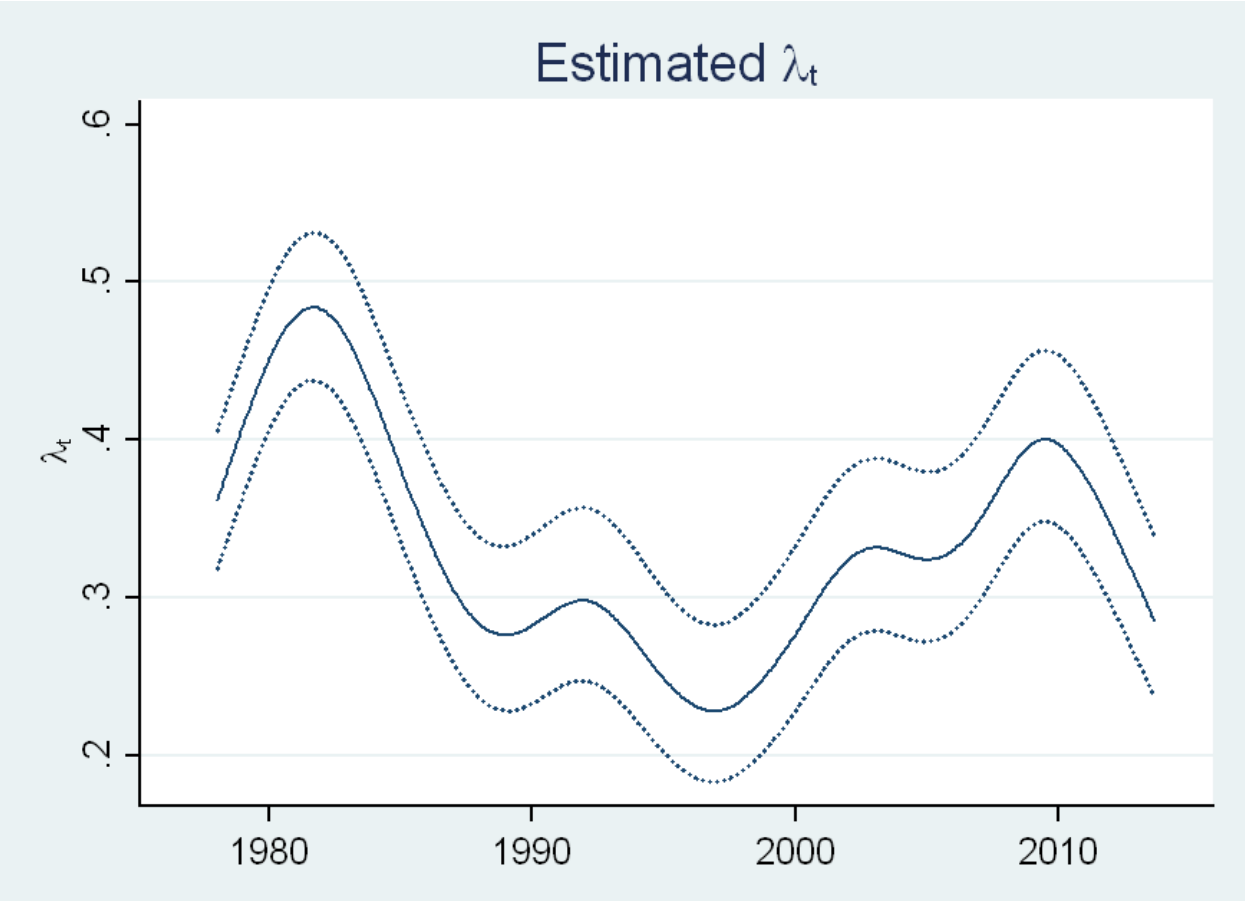
Maximum Likelihood Estimates

$$\Big(\underbrace{\mu_{lt}, \quad \mu_{ht}}_{\text{mean forecast by type}} \;,\; \underbrace{\sigma^2_{lt}, \quad \sigma^2_{ht}}_{\text{cross-sectional variance by type}} \;,\; \underbrace{\lambda_t}_{\text{share of type r}} \;, \Big)$$



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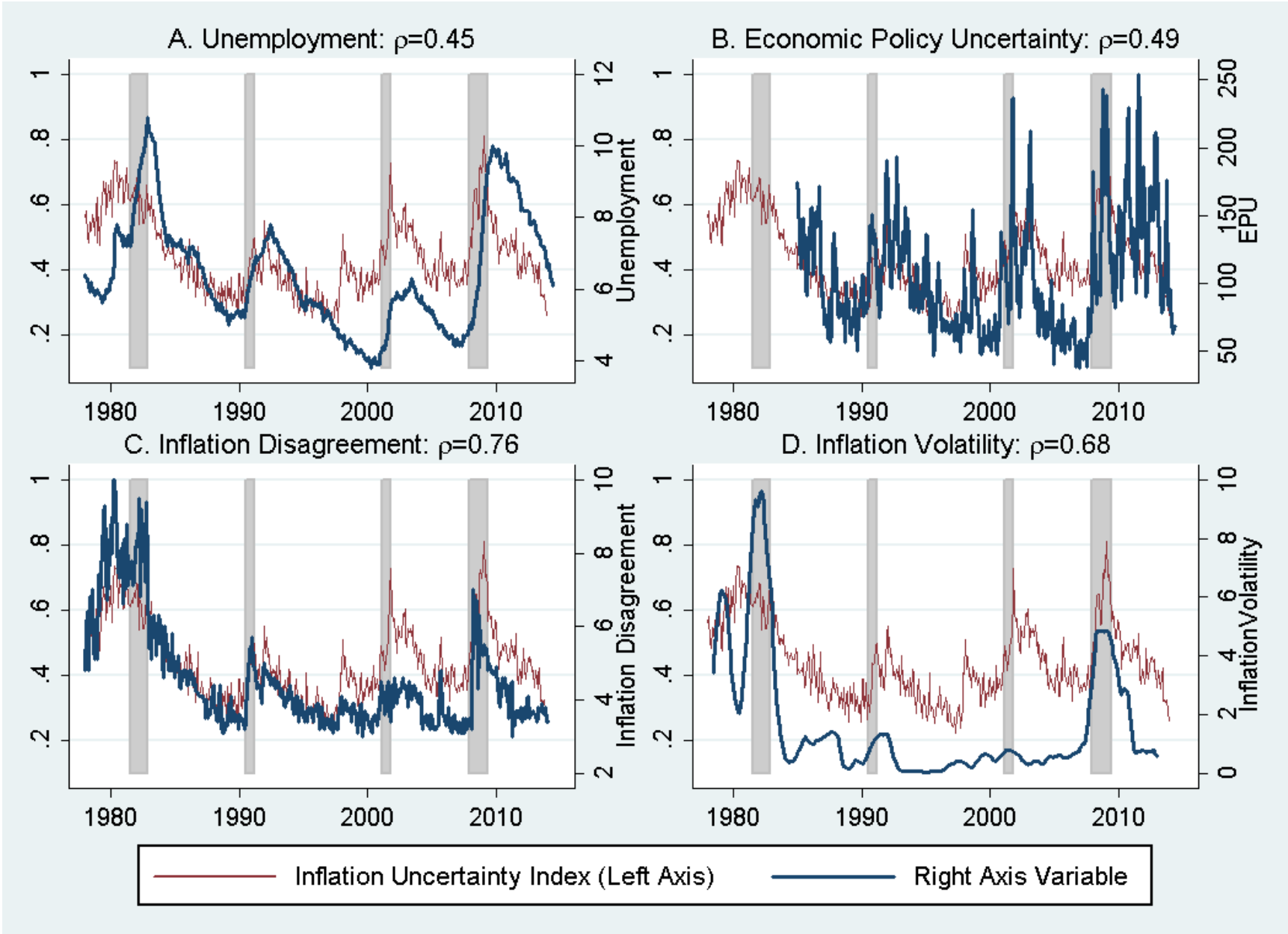
A. Unemployment: ρ=0.45
B. Economic Policy Uncertainty: ρ=0.49
C. Inflation Disagreement: ρ=0.76
D. Inflation Volatility: ρ=0.68
Unemployment
EPU
Inflation Disagreement
InflationVolatility
1980
1990
2000
2010
Inflation Uncertainty Index (Left Axis)
Right Axis Variable

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Phillips Curve Robustness Checks

Alternative measures of real activity:

	(1)	(2)	(3)	(4)	(5)	(6)
π^e_I	0.64***	0.82***	0.84***	1.83***	1.84***	1.47***
	(0.19)	(0.20)	(0.19)	(0.66)	(0.60)	(0.65)
π^e_{SPF}	0.36*	0.18	0.16			
	(0.19)	(0.20)	(0.19)			
π^e_{MSC}				-0.83*	-0.84**	-0.47
				(0.66)	(0.60)	(0.65)
Unemp. Gap	0.27**			0.41***		
	(0.10)			(0.14)		
Capacity Ut.		0.13***			0.21***	
		(0.06)			(0.06)	
GDP Gap ($ Tr.)			-1.48***			-1.92***
			(0.64)			(0.68)
Observations	128	128	128	141	141	141
R^2	0.11	0.13	0.14	0.16	0.24	0.18

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Newey-West standard errors in parentheses.

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Phillips Curve Robustness Checks

Restricted time samples/ relaxation of constraint on coefficients:

	(1)	(2)	(3)
π_I^e	0.72***	0.53**	2.23***
	(0.21)	(0.22)	(0.33)
π_{SPF}^e	0.28	0.47*	0.03
	(0.21)	(0.22)	(0.16)
Unemployment	-0.22**	-0.19*	-0.33***
	(0.11)	(0.11)	(0.10)
Observations	114	106	128
R^2	0.10	0.15	0.46
Time Sample	After 1984	Before 2008	Unrestricted
Regression Type	Constrained	Constrained	Unconstrained

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Newey-West standard errors in parentheses.
Specification: $\pi_t = \beta_n \pi_{nt}^e + \beta_{SPF} \pi_{SPFt}^e + \alpha \text{Unemployment}_t + \epsilon_t$, where constraint $\beta_n + \beta_{SPF} = 1$ is imposed in (1) and (2) but not in (3).

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Phillips Curve Robustness Checks

Restricted time samples/ relaxation of constraint on coefficients:

	(1)	(2)	(3)	(4)
π_I^e	1.78***	1.43***	0.85***	1.86***
	(0.67)	(0.30)	(0.08)	(0.17)
π_{MSC}^e	-0.78*	0.43		
	(0.67)	(0.31)		
π_{t-1}			0.15**	0.01
			(0.08)	(0.05)
Unemployment	-0.21**	-0.266***	-0.21**	-0.30***
	(0.10)	(0.08)	(0.10)	(0.08)
Observations	141	141	135	135
R^2	0.11	0.76	0.58	0.69
Regression Type	Constrained	Unconstrained	Constrained	Unconstrained

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Newey-West standard errors in parentheses.

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