# Economic Literacy and Inflation Expectations: Evidence from an Economic Experiment

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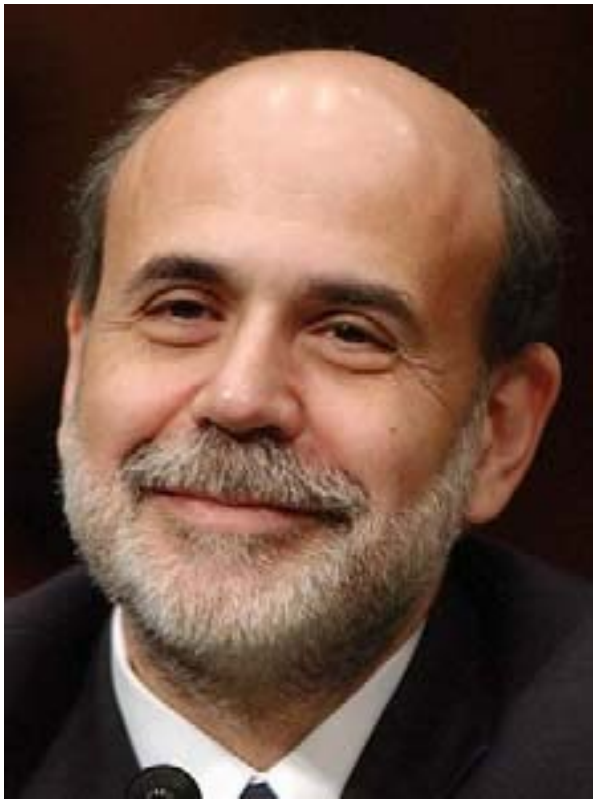
# Disclaimer: I do not speak for:

Eric Rosengren, President of Boston Fed



Ben Bernanke, Chairman of Federal Reserve

# What drives variation in inflation expectations?

- Proximate factors
  - Demographic and socioeconomic factors
    - Bryan & Venkatu (2001), Pfajfar & Santoro (2008)
  - Economic/financial literacy
    - Bruine de Bruin et al. (2010)
- Causal factors in expectation-formation
  - Reliance on different information
    - Personal experience vs. macro conditions
  - Differential use of same information
    - Sticky information (Mankiw and Reis 2002)
    - Different priors, learning rules (Giannitsarou 2003)

# Goals of experiment

- Relate IE formation to economic literacy and demographics
  - How much and why do these factors matter?
- Method: elicit prior beliefs/practices in incentivized setting
  - What information is relevant?
  - How does given data influence forecasts?
  - Analyze variation in revealed behaviors
- Access diverse subject pool
  - Experiments conducted at Harvard Decision Sciences Lab
  - 137 subjects, not just Harvard students
  - Initial run at Roxbury Community College served as test

# Need for new experimental approach

- Limitations of surveys
  - Weak Incentives
  - Can't manipulate real-world conditions
  - Must rely on introspection to reveal info use
- Previous experiments have different focus
  - Can group learn to play REE in lab?
    - Pfajfar & Zakelj (2009), Adam (2007)
  - Data chosen *for* subjects, not *by* subjects
  - Did not measure economic literacy

# Key findings

- Some demographic variation, but not as much as expected
  - Women do not systematically predict higher inflation
  - Income not an important factor for most outcomes
  - Effects of age and race not very robust
- Economic literacy matters; adds explanatory power
  - Reduces positive inflation bias
  - Improves accuracy
  - Affects both selection and use of information
  - Dominates general educational attainment
  - Effects non-linear: driven by weakness at low end
- Variation in information selection an important factor

# Contents of Experiment

- Questions about U.S. inflation
  - Past 5 years' average rate
  - Forecasts for 1- and 5-years-ahead
- Forecasting exercises in simulated economy
- Free-response questions about forecasting behavior
- Economic/financial literacy questions
- Demographic questionnaire

# Design of forecasting exercises

- Series of exercises involving simulated time-series data (within-subjects design)
  - Use data to forecast inflation (1 or 5 years ahead)
  - Each exercise involves a new scenario
- Endogenous information exercises
  - Subjects select info "sources" from list
    - Up to 3 sources from list of 7
    - Each source shows 3 recent data points in a series
- Exogenous information exercises
  - All subjects see same information
- Ordering issues and other design features
  - Endogenous exercises first to avoid bias in info choice
  - Time horizon: 1-year exercises, then 5-year; or vice-versa
  - Info sources: order randomized between subjects
  - Data overlap between 1-year and 5-year exercises

# Exercise: 3

Remaining time [sec]: 99

You have 2 minutes to make your forecast. When ready, enter a number and press Confirm. You may pick up to three information sources to view.

**Your forecast of inflation in Year 1:** [ ] Confirm

Forecast payoff: Min. $0, Max. $45.00

**Unemployment** (Years -2, -1, 0)

Percent of population that does not have a job and is looking for one. Pick

**Inflation, earlier** (Years -5, -4, -3)

Percent change in the overall price level from the previous year to the given year. Pick

**Milk price change** (Years -2, -1, 0)

Percent change in the price of milk from the previous year to the given year. Pick

**Oil price change** (Years -2, -1, 0)

Percent change in the price of a barrel of oil from the previous year to the given year. Pick

**Inflation, current and recent** (Years -2, -1, 0)

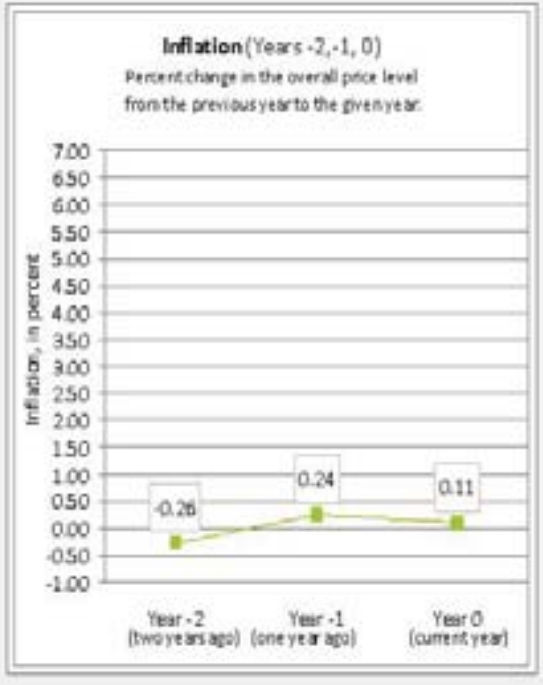
Percent change in the overall price level from the previous year to the given year. View

**Short-term interest rate** (Years -2, -1, 0)

Interest rate set by the monetary authority (annual percentage rate). Pick

**Population growth rate** (Years -2, -1, 0)

Percent change in the population from the previous year to the given year. Pick



# Exercise: 5

Remaining time [sec]: 113

You have 2 minutes to make your forecast. When ready, enter a number and press Confirm. You may pick up to three information sources to view.

**Your forecast of inflation in Year 1:**

Confirm

Forecast payoff: Min. $0, Max. $45.00

**Unemployment** (Years -2, -1, 0)

Percent of population that does not have a job and is looking for one.

Pick

**Inflation, earlier** (Years -5, -4, -3)

Percent change in the overall price level from the previous year to the given year.

Pick

**Milk price change** (Years -2, -1, 0)

Percent change in the price of milk from the previous year to the given year.

Pick

**Oil price change** (Years -2, -1, 0)

Percent change in the price of a barrel of oil from the previous year to the given year.

View

**Inflation, current and recent** (Years -2, -1, 0)

Percent change in the overall price level from the previous year to the given year.

Pick

**Short-term interest rate** (Years -2, -1, 0)

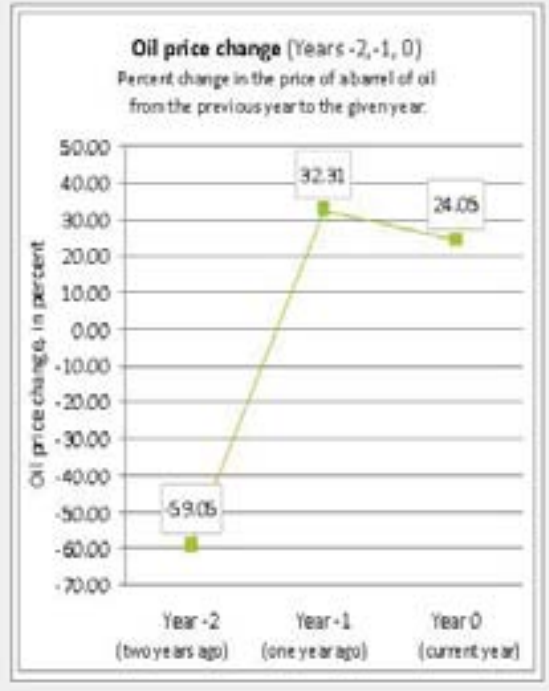
Interest rate set by the monetary authority (annual percentage rate).

Pick

**Population growth rate** (Years -2, -1, 0)

Percent change in the population from the previous year to the given year.

Pick



## Exercise: 10

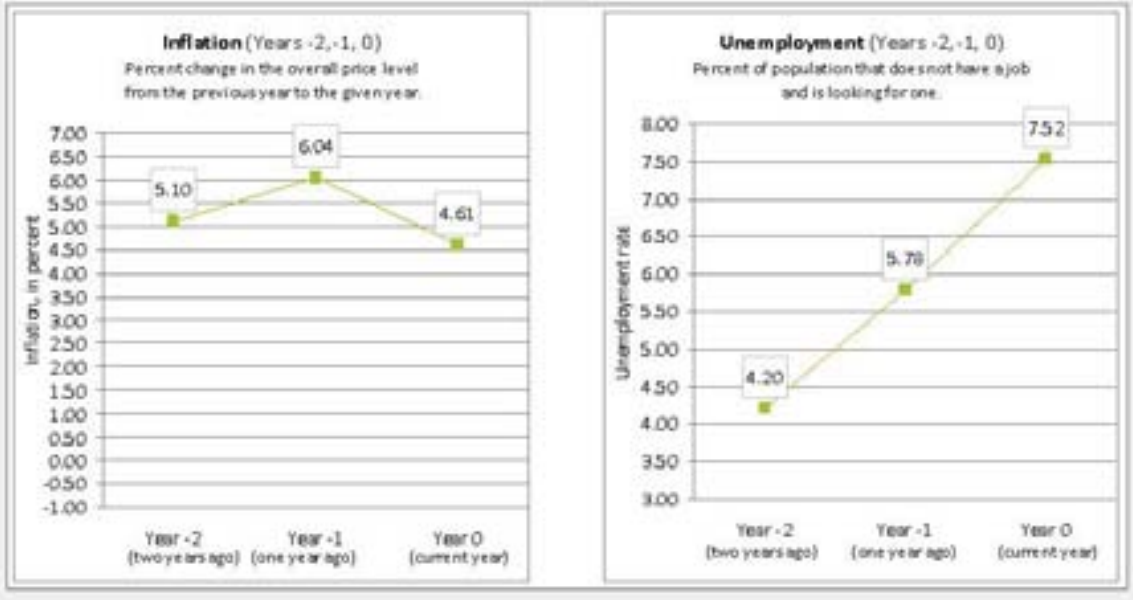
Remaining time [sec]: 99

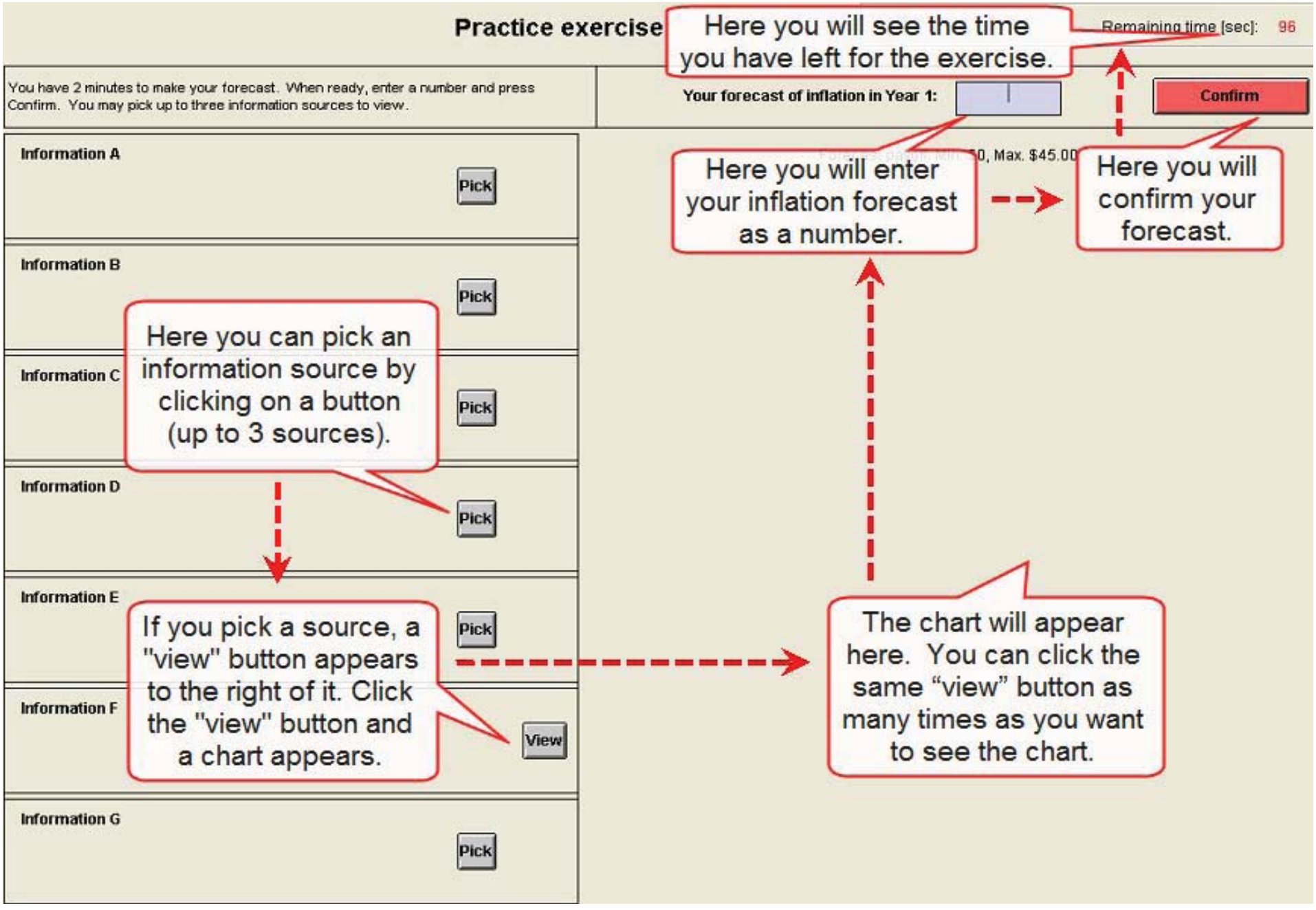
You have 2 minutes to make your forecast. When ready, enter a number and press Confirm.

**Your forecast of inflation in Year 1:**

Confirm

Forecast payoff: Min. $0, Max. $45.00



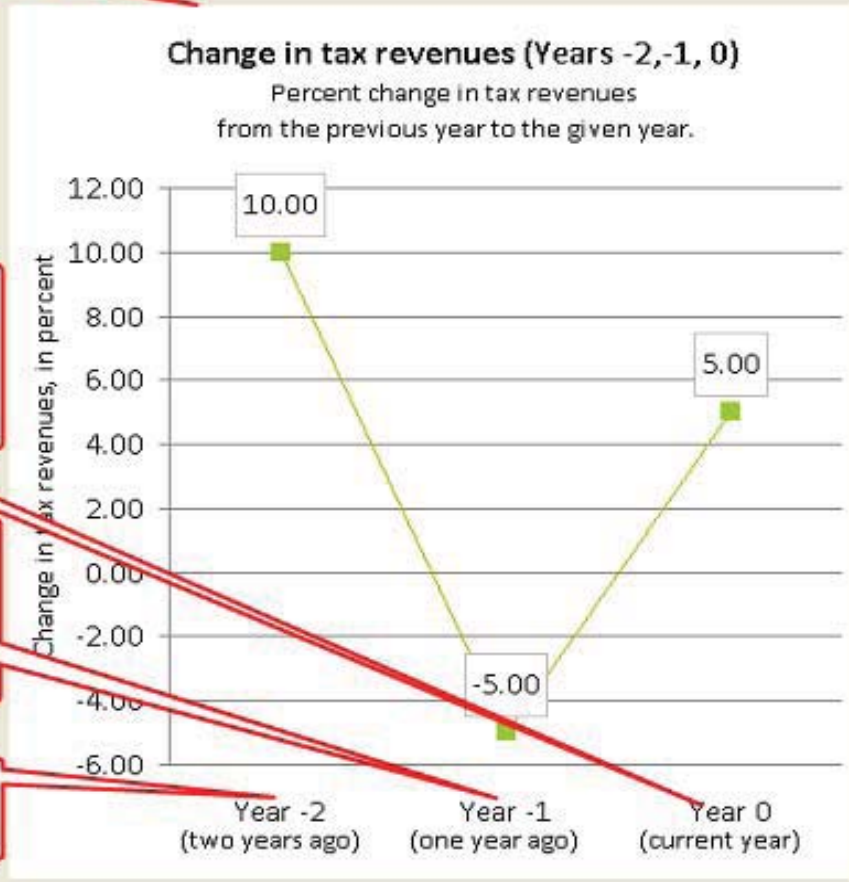

Practice exercise
Here you will see the time you have left for the exercise.
Remaining time [sec]: 96
You have 2 minutes to make your forecast. When ready, enter a number and press Confirm. You may pick up to three information sources to view.
Your forecast of inflation in Year 1:
Confirm
Here you will enter your inflation forecast as a number.
Here you will confirm your forecast.
Information A
Pick
Information B
Pick
Information C
Pick
Here you can pick an information source by clicking on a button (up to 3 sources).
Information D
Pick
Information E
Pick
If you pick a source, a "view" button appears to the right of it. Click the "view" button and a chart appears.
Information F
View
The chart will appear here. You can click the same "view" button as many times as you want to see the chart.
Information G
Pick

**Practice exercise**

Remaining time [sec]: 96

Confirm

Suppose you pick a source named "Change in tax revenues". The chart will show three values of that variable. In most cases, these will be the values for the current year and of the last two years.




"Year 0" refers to the current year, which is just ending now. In Year 0, the change in tax revenues was 5%. (Tax revenues increased by 5% compared to the previous year.)

"Year -1" refers to one year ago. In Year -1, the change in tax revenues was -5%. (Tax revenues fell by 5% compared to the previous year.)

"Year -2" refers to two years ago. In Year -2, the change in tax revenues was 10%.

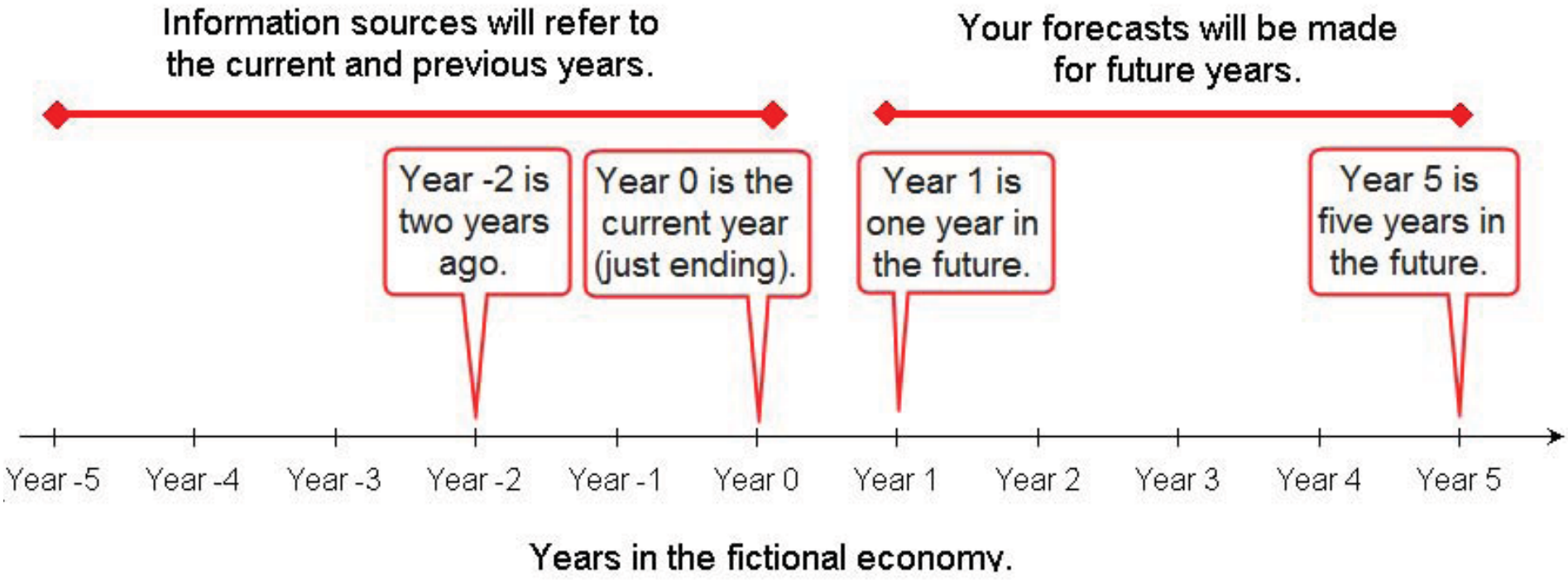
Information B

Pick

Information C

View

Pick




Years in the fictional economy.

# Payoffs, learning, and motivation

- Subjects did not see answers or payoff from individual exercises
  - Prevents learning about model
  - Yields multiple data points per individual, knowledge constant
- To maintain motivation:
  - Cumulative payoffs revealed at several junctures
  - Payoff within an exercise was potentially high
    - Total payoff = average payoff across exercises
    - Payoff per exercise truncated at zero

# Instructions for forecasting exercises

**Payoffs per exercise:** Your payoff per exercise will be between $0 and $45. **The closer your forecast is to future inflation in the fictional economy** (determined by the model), **the more you will earn.**

Keep in mind:

- If your forecast is exactly right, you get $45 for that exercise.
- If your forecast is 3 or more percentage points too high or too low, your payoff is $0.
- In between, you earn 15 cents ($0.15) more for every 0.01 percentage points you get closer to the correct forecast.

The table below shows some examples.

| Difference between your forecast and actual future inflation (in percentage points) | Your payoff |
|---|---|
| 0.00 | $45.00 |
| +1.00 or -1.00 | $30.00 |
| +1.50 or -1.50 | $22.50 |
| +2.00 or -2.00 | $15.00 |
| +2.50 or -2.50 | $7.50 |
| +3.00 or -3.00 | $0.00 |
| +10.00 or -10.00 | $0.00 |

Continue

# Model and data generation

- Reduced version of Boston Fed macro forecasting model
  - VAR on inflation, unemployment gap, output gap, real oil price, Fed Funds rate
  - Parameters estimated on U.S. for 1966-2006
- To generate simulated time series:
  - Select shocks randomly from residuals (1984–2006)
  - Select from simulated time series for desired properties (transform quarterly data to annual)
- "Correct" forecast = model-based forecast

# "Decoy" data from outside model

- Milk price inflation
  - historical CPI (whole milk), 1966–2006
- Population growth rates from U.S. history
- Matched to other data randomly
  - s.t. constraints on correlations with inflation
- Model-based rank of given sources based on predictive power
  - recent inflation
  - unemployment
  - oil price inflation
  - Fed Funds rate
  - earlier inflation

# Economic/financial literacy quiz

- Questions (total of 16) deal with
  - Inflation
  - Monetary policy
  - Interest on savings
  - General numeracy
  - Based on van Rooij et al. (2007), NY Fed instrument, other sources
- High item-rest correlations, good reliability
  - Cronbach's $\alpha$ = .74
  - Factor analysis supports single latent factor

# Sample literacy questions

**Questionnaire on economic and financial literacy**

| Question | % correct |
|---|---|
| 1. The rate of inflation in an economy is best described as the rate of increase in the<br>☐ **overall price level of goods and services.**<br>☐ overall level of money wages.<br>☐ the long term interest rate.<br>☐ value of money. | 65.7% |
| 2. A primary purpose of monetary policy today is to<br>☐ **Stabilize the price level of goods and services.**<br>☐ Stabilize the price of corporate stocks.<br>☐ Keep interest rates low and steady.<br>☐ Reduce national debt. | 84.7% |
| 3. Which of the following is a tool of monetary policy?<br>☐ Raising and lowering income taxes.<br>☐ Increasing and decreasing unemployment benefits.<br>☐ **Buying and selling government securities.**<br>☐ Increasing and decreasing government spending. | 51.8% |
| 4. Which of the following measures is most likely to lead to lower inflation?<br>☐ **Raising the short-term interest rate.**<br>☐ Lowering the short-term interest rate.<br>☐ Lowering income taxes.<br>☐ Raising the level of government spending. | 39.4% |

| Sample Characteristics N=137 | |
|---|---|
| Age | 28.533 |
| Female | 0.610 |
| White | 0.599 |
| Black | 0.109 |
| Hispanic | 0.022 |
| Asian | 0.139 |
| Other Race | 0.044 |
| Multiracial | 0.088 |
| Not US-Born | 0.175 |
| Economics Course | 0.533 |
| Income $\leq$ \$39,999 | 0.453 |
| Income \$40,000 – \$79,999 | 0.190 |
| Income \$80,000 – \$149,999 | 0.190 |
| Income $\geq$ \$150,000 | 0.153 |
| HS Diploma | 0.066 |
| Some College | 0.394 |
| Bachelor's Deg. | 0.387 |
| Advanced Deg. | 0.153 |
| Mother HS Diploma | 0.153 |
| Mother Some College | 0.080 |
| Mother Bachelor's Deg. | 0.343 |
| Mother Advanced Deg. | 0.336 |

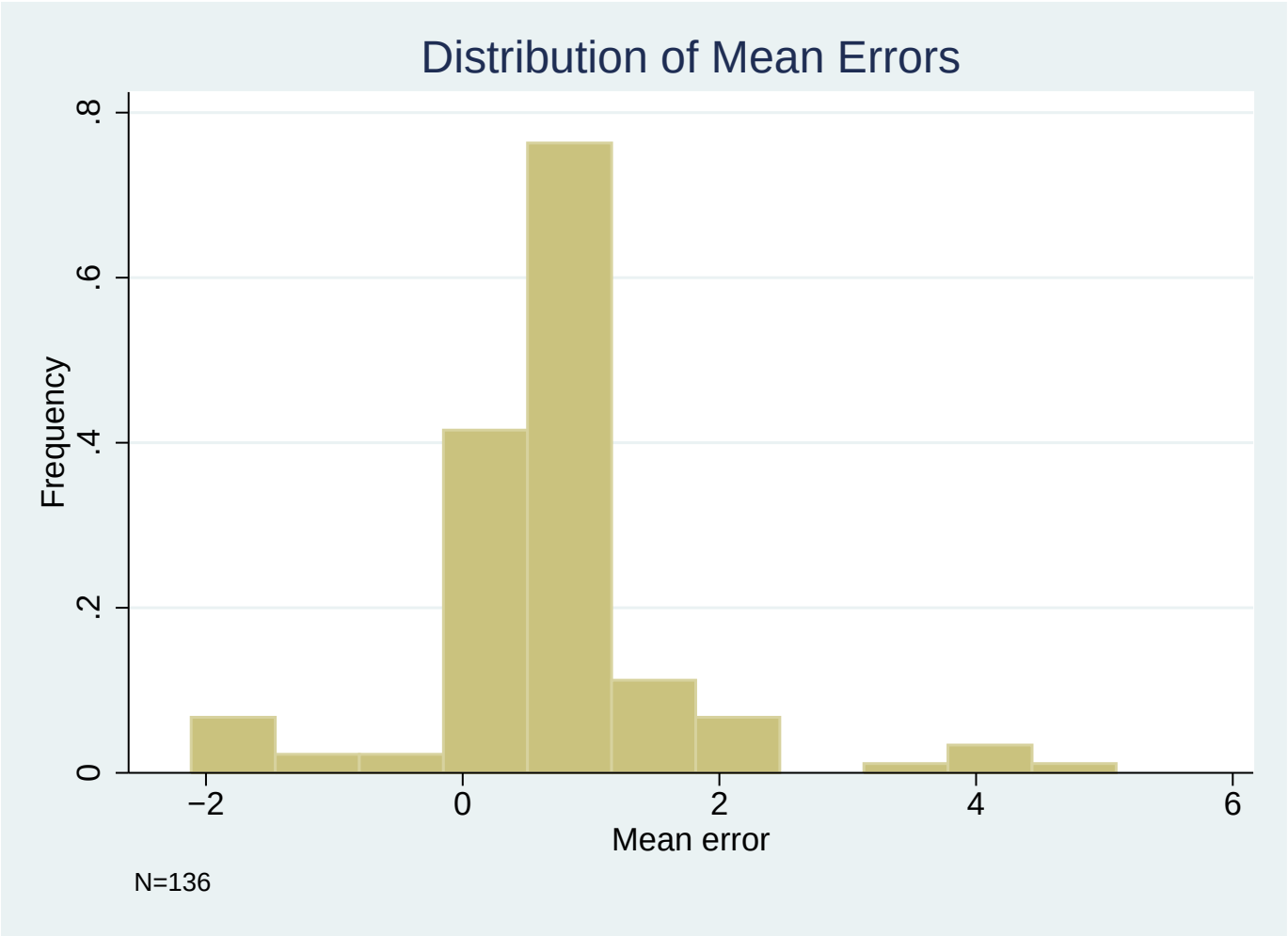
| Literacy Score Statistics | |
|---|---|
| Mean | 0.663 |
| Std. Deviation | 0.188 |
| Median | 0.690 |
| Minimum | 0.130 |
| Maximum | 1.000 |
| Cronbach's $\alpha$ | 0.740 |

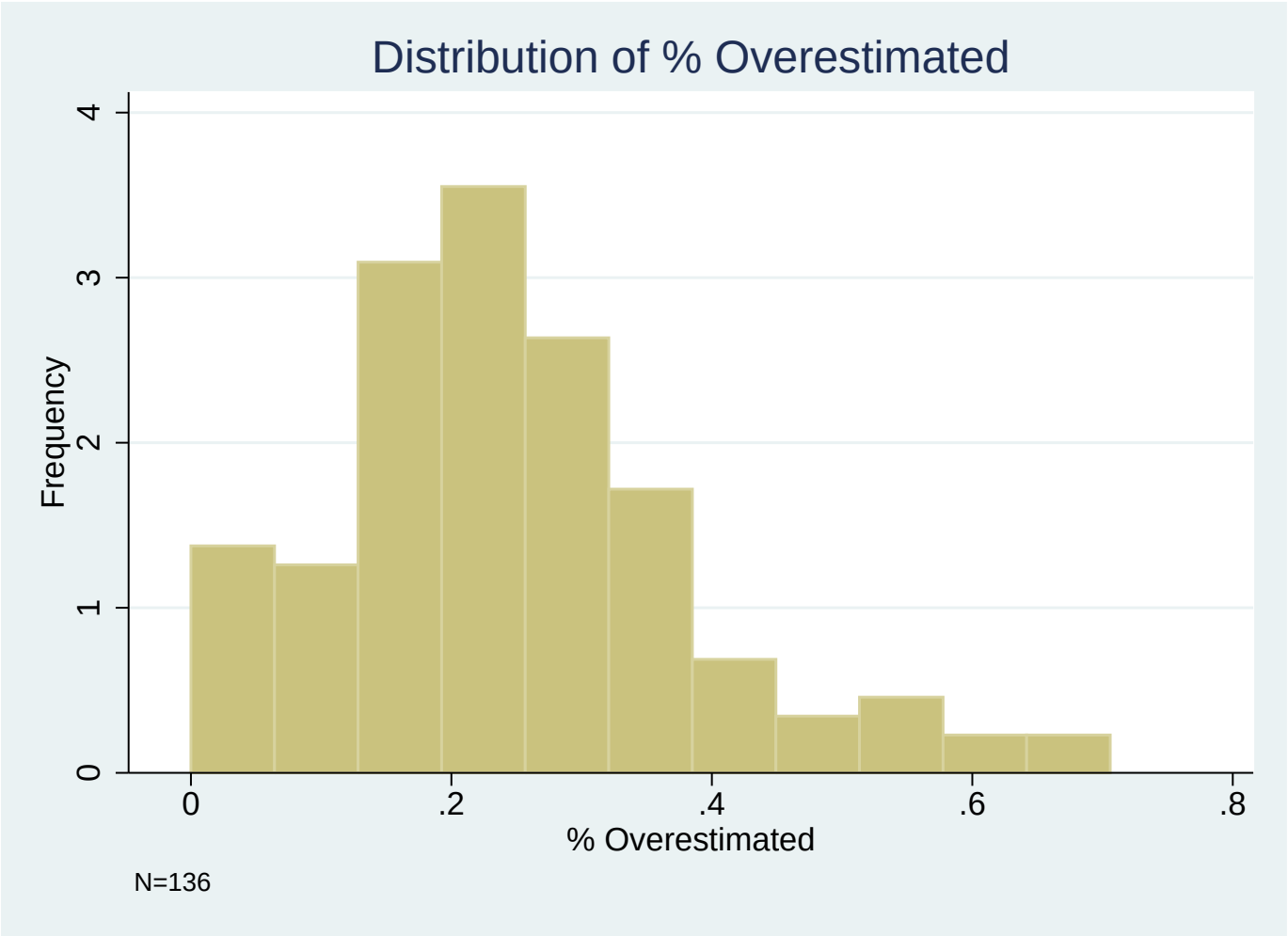
# Demographic variation in economic literacy

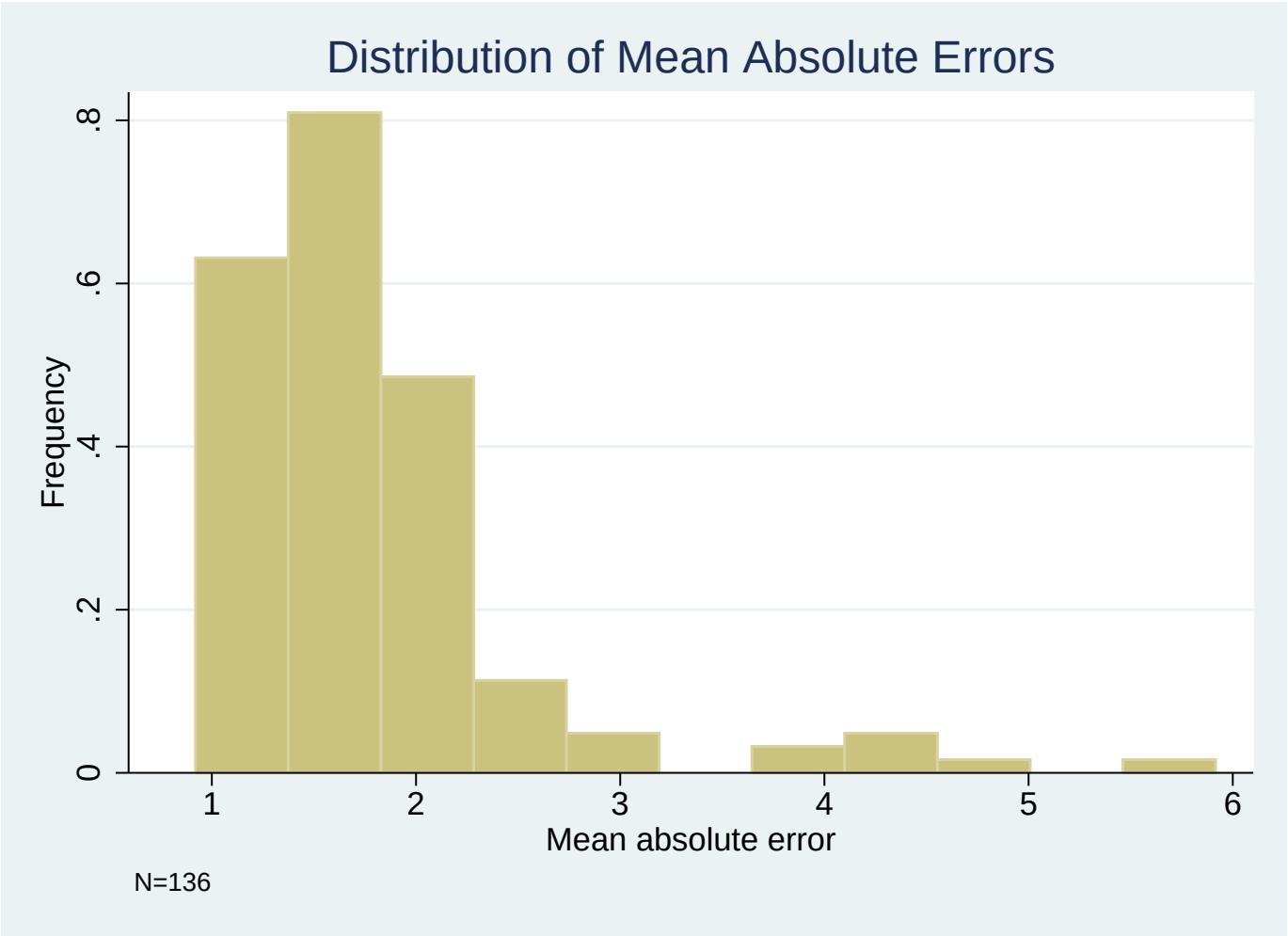
| | Literacy Scores | |
|---|---|---|
| Female | -0.078** | -0.065** |
| | (0.033) | (0.031) |
| Age | -0.002 | -0.002 |
| | (0.002) | (0.002) |
| Some College | 0.141** | 0.138** |
| | (0.070) | (0.065) |
| Bachelor's | 0.172** | 0.137** |
| | (0.069) | (0.065) |
| Advanced Degree | 0.262*** | 0.238*** |
| | (0.082) | (0.077) |
| Black | -0.106** | -0.105** |
| | (0.051) | (0.048) |
| Hispanic | -0.008 | 0.074 |
| | (0.108) | (0.102) |
| Asian | 0.005 | -0.006 |
| | (0.054) | (0.050) |
| Multiracial | 0.008 | -0.007 |
| | (0.056) | (0.053) |
| Other Race | -0.155* | -0.117 |
| | (0.079) | (0.074) |
| Not US-Born | 0.060 | 0.061 |
| | (0.047) | (0.043) |
| Income $40,000–$79,999 | 0.019 | -0.005 |
| | (0.043) | (0.040) |
| Income $80,000–$149,999 | 0.013 | -0.015 |
| | (0.045) | (0.043) |
| Income $\geq$ $150,000 | 0.021 | 0.010 |
| | (0.047) | (0.044) |
| Economics Course | | 0.139*** |
| | | (0.031) |
| Constant | 0.572*** | 0.505*** |
| | (0.087) | (0.082) |
| R Squared | .240 | .351 |
| N | 136 | 136 |

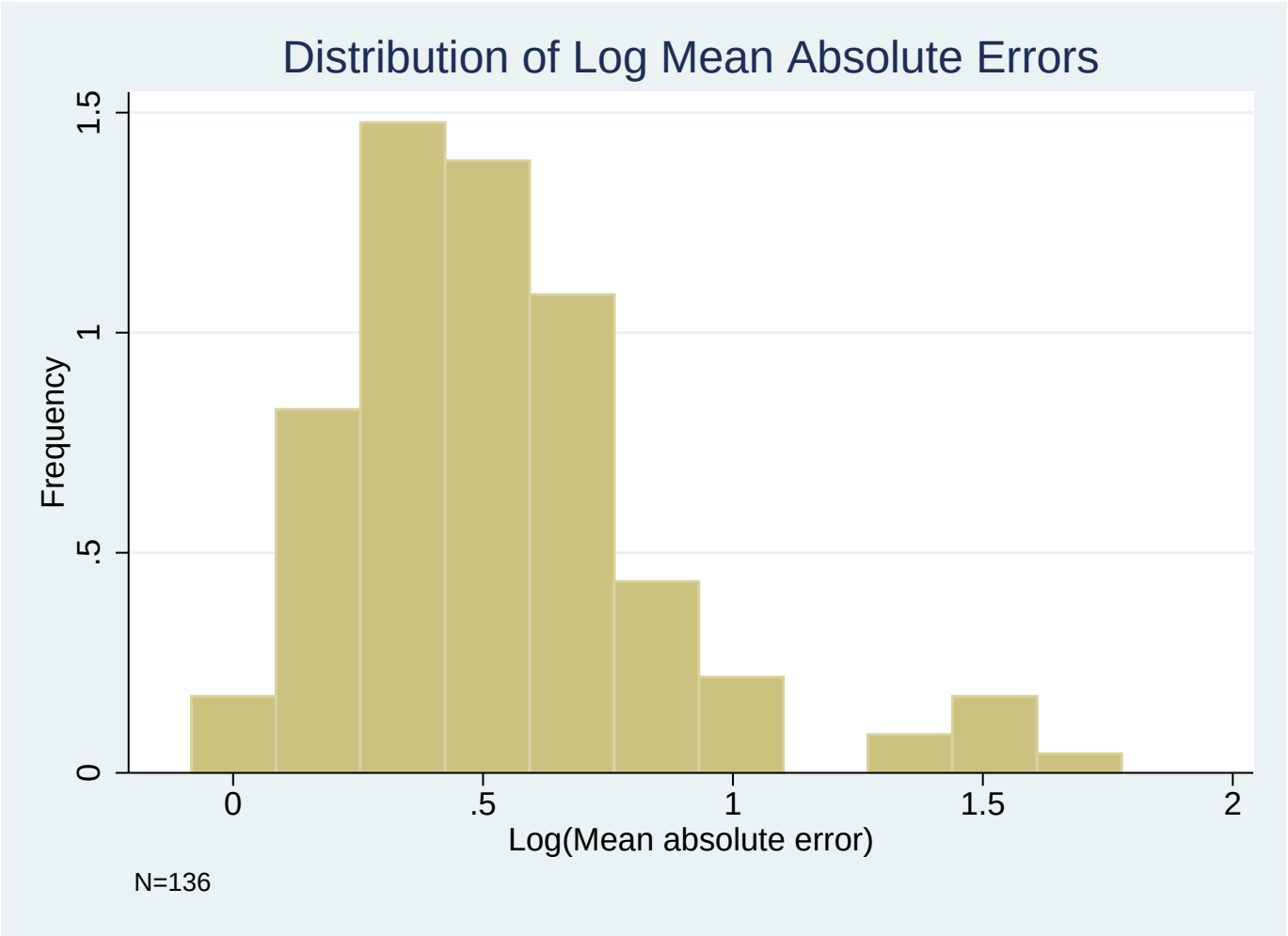
# Analysis of within-subject mean outcomes

| | Mean Error | Mean Error | % Overestimated | % Overestimated | Mean Abs. Error | Mean Abs. Error |
|---|---|---|---|---|---|---|
| Literacy Score | | -11.954*** | | -1.001*** | | -8.407*** |
| | | (3.151) | | (0.379) | | (1.814) |
| Lit. Score Squared | | 8.444*** | | 0.618** | | 5.217*** |
| | | (2.256) | | (0.281) | | (1.287) |
| Age 32 and over | 0.593* | 0.080 | 0.057 | 0.006 | 0.676*** | 0.250 |
| | (0.325) | (0.295) | (0.045) | (0.047) | (0.208) | (0.159) |
| Female | 0.102 | 0.037 | 0.007 | -0.008 | 0.097 | -0.027 |
| | (0.193) | (0.177) | (0.025) | (0.023) | (0.127) | (0.101) |
| Not US-born | 0.286 | 0.391* | -0.000 | 0.016 | 0.047 | 0.176 |
| | (0.232) | (0.221) | (0.029) | (0.027) | (0.179) | (0.154) |
| Hispanic | 1.100 | 1.143 | 0.139 | 0.141 | 1.971 | 1.991** |
| | (1.703) | (1.637) | (0.126) | (0.115) | (1.195) | (0.983) |
| Some College | 0.510 | 0.859 | 0.103* | 0.143** | 0.241 | 0.573** |
| | (0.507) | (0.549) | (0.059) | (0.060) | (0.343) | (0.262) |
| Bachelor's Deg. | 0.468 | 0.760 | 0.131 | 0.161** | 0.114 | 0.362 |
| | (0.610) | (0.582) | (0.081) | (0.071) | (0.438) | (0.283) |
| Advanced Deg. | -0.010 | 0.751 | 0.070 | 0.159** | -0.380 | 0.361 |
| | (0.531) | (0.574) | (0.059) | (0.064) | (0.369) | (0.277) |
| Black | 0.747** | 0.371 | 0.043 | 0.001 | 0.528** | 0.182 |
| | (0.299) | (0.243) | (0.045) | (0.038) | (0.263) | (0.190) |
| Asian | 0.178 | 0.252 | 0.073** | 0.079*** | 0.218 | 0.264** |
| | (0.172) | (0.157) | (0.029) | (0.027) | (0.134) | (0.124) |
| Other Race | 0.449 | 0.322 | 0.107 | 0.081 | 0.226 | 0.008 |
| | (0.519) | (0.388) | (0.070) | (0.059) | (0.459) | (0.303) |
| Multiracial | -0.103 | -0.137 | 0.011 | 0.011 | -0.139 | -0.140 |
| | (0.274) | (0.256) | (0.030) | (0.030) | (0.162) | (0.127) |
| | (0.236) | (0.219) | (0.032) | (0.029) | (0.177) | (0.161) |
| Constant | -0.123 | 3.576*** | 0.141** | 0.483*** | 1.680*** | 4.542*** |
| | (0.510) | (1.243) | (0.059) | (0.137) | (0.342) | (0.606) |
| R Squared | 0.133 | 0.280 | 0.152 | 0.261 | 0.345 | 0.570 |
| N | 135 | 135 | 135 | 135 | 135 | 135 |


Distribution of Mean Errors
Frequency
0
.2
.4
.6
.8
−2
0
2
4
6
Mean error
N=136


Distribution of % Overestimated
Frequency
0
1
2
3
4
0
.2
.4
.6
.8
% Overestimated
N=136

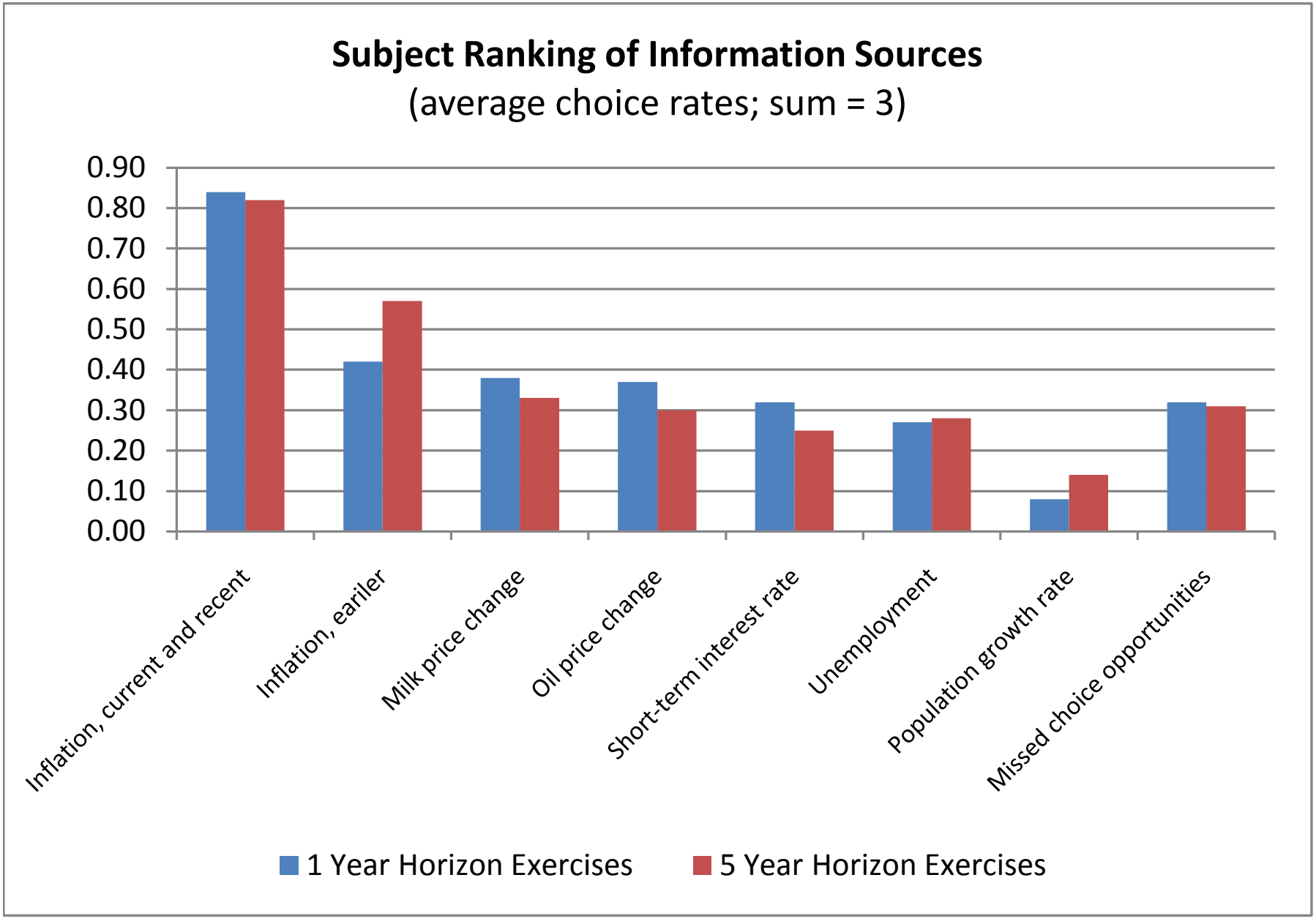

Distribution of Mean Absolute Errors
Frequency
0
.2
.4
.6
.8
1
2
3
4
5
6
Mean absolute error
N=136


Distribution of Log Mean Absolute Errors
Frequency
0
.5
1
1.5
0
.5
1
1.5
2
Log(Mean absolute error)
N=136

# Performance on exogenous vs. endogenous exercises

Mean Absolute Errors

| | Exogenous Exercises | Endogenous Exercises |
|---|---|---|
| Literacy Score | -9.492*** | -13.278*** |
| | (1.953) | (3.088) |
| Lit. Score Squared | 5.970*** | 8.281*** |
| | (1.523) | (2.408) |
| Female | 0.129 | -0.240 |
| | (0.136) | (0.215) |
| Age 22-24 | 0.073 | 0.042 |
| | (0.228) | (0.361) |
| Age 25-31 | -0.102 | 0.323 |
| | (0.252) | (0.398) |
| Age 32 and over | 0.077 | 0.537 |
| | (0.237) | (0.375) |
| Some College | 0.806*** | 0.916** |
| | (0.292) | (0.462) |
| Bachelor's Deg. | 0.423 | 0.635 |
| | (0.311) | (0.491) |
| Advanced Deg. | 0.625* | 0.592 |
| | (0.355) | (0.562) |
| Black | 0.042 | 0.704** |
| | (0.215) | (0.341) |
| Hispanic | 1.480*** | 2.589*** |
| | (0.423) | (0.669) |
| Asian | 0.234 | 0.655* |
| | (0.211) | (0.333) |
| Multiracial | -0.074 | -0.253 |
| | (0.228) | (0.361) |
| Other Race | -0.241 | 0.086 |
| | (0.318) | (0.502) |
| Not US-born | 0.236 | 0.382 |
| | (0.184) | (0.291) |
| Constant | 4.887*** | 5.774*** |
| | (0.649) | (1.026) |
| R Squared | 0.444 | 0.458 |
| N | 135 | 135 |


Subject Ranking of Information Sources
(average choice rates; sum = 3)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Inflation, current and recent
Inflation, eariler
Milk price change
Oil price change
Short-term interest rate
Unemployment
Population growth rate
Missed choice opportunities
1 Year Horizon Exercises
5 Year Horizon Exercises

# Standard deviation of choice rates

| Information source | $\sigma$ of choice rate |
|---|---|
| Current/recent inflation | .26 |
| Unemployment | .24 |
| Fed Funds rate | .27 |
| Earlier inflation | .32 |
| Milk price inflation | .30 |
| Oil price inflation | .27 |
| Population growth rate | .14 |

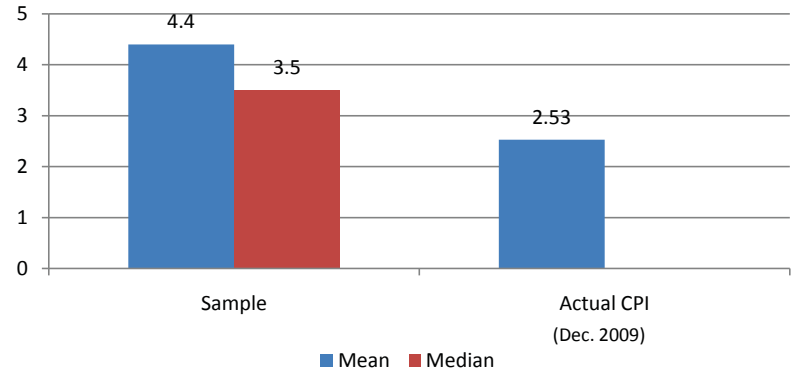
# Variation in selection-rate of “recent inflation"

| | Picked Inflation | |
|---|---|---|
| Literacy Score | | 3.123*** |
| | | (0.503) |
| Lit Score Squared | | -2.113*** |
| | | (0.393) |
| Age 22–24 | -0.189*** | -0.134** |
| | (0.070) | (0.059) |
| Age 25–31 | -0.290*** | -0.195*** |
| | (0.077) | (0.065) |
| Age 32 and over | -0.362*** | -0.212*** |
| | (0.069) | (0.061) |
| Female | -0.047 | -0.016 |
| | (0.041) | (0.035) |
| Not US-born | 0.013 | -0.020 |
| | (0.057) | (0.047) |
| Some College | 0.035 | -0.077 |
| | (0.085) | (0.073) |
| Bachelor’s Deg. | 0.236*** | 0.081 |
| | (0.089) | (0.077) |
| Advanced Deg. | 0.298*** | 0.058 |
| | (0.099) | (0.089) |
| Hispanic | -0.418*** | -0.428*** |
| | (0.131) | (0.109) |
| Black | -0.134** | -0.024 |
| | (0.063) | (0.054) |
| Asian | -0.094 | -0.114** |
| | (0.065) | (0.054) |
| Multiracial | 0.072 | 0.081 |
| | (0.071) | (0.059) |
| Other Race | -0.151 | -0.097 |
| | (0.097) | (0.082) |
| Constant | 0.878*** | -0.123 |
| | (0.091) | (0.165) |
| R Squared | 0.420 | 0.606 |
| N | 136 | 136 |

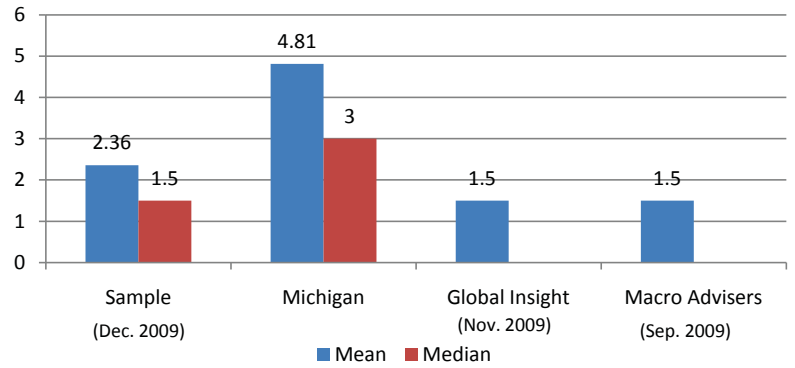
# Summary and implications

- More economically literate subjects make better forecasts
  - Select more-relevant information
  - Make better use of given information
  - Results driven by poor performance of bottom quartile
  - Modest educational interventions may be worthwhile
- Demographic variation
  - Few observed effects
  - Most effects explained by economic literacy
- Lower variance of accuracy in exogenous exercises
  - Directing subjects to relevant info helps
  - Info selection may drive large share of variation in consumers' IE

## Past 5 Years Inflation




## 1-Year Ahead Inflation




## 5-Year Ahead Inflation