United States Department of Agriculture

Clarifying the Confidence Levels of PPI and CPI Forecasts in the USDA's Food Price Outlook

David Levin, Economic Research Service

What is the Food Price Outlook?

- Monthly forecasts of annual percent changes of PPI and CPI and food series
- Forecasts given in a 1% range
  - Increase in CPI Beef of 5% to 6%
- Explanation of changes to forecasts
- Historical PPI and CPI percent changes
- Current year forecast
- From July to December, also forecast for the upcoming year

Current Forecasting Methodology

- Implemented in mid-2012
- Vertical price transmission pass-through approach
  - Sufficiently long time series of historical retail/input prices
  - Reliable measure of forecasted input prices
- Autoregressive Moving Average (ARMA) approach
  - Limited data availability
  - Relies on lagged and current values of the CPI being forecasted

Current Forecasting Methodology

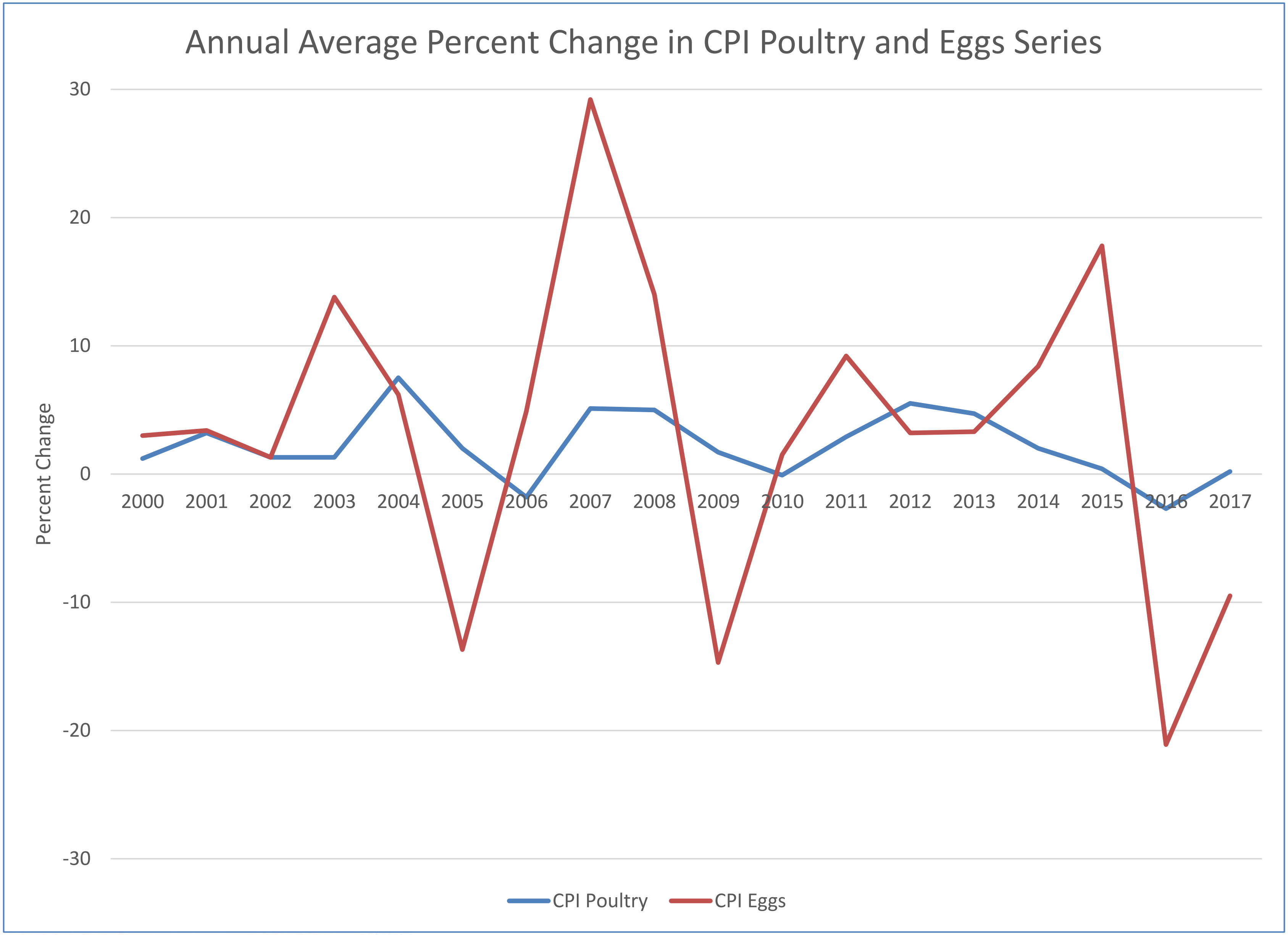
- Aggregate series forecasted using weighted average of sub-series
  - Weights from CPI relative importance shares

The Issue

- FPO forecasts given in a 1% range for all PPI and CPI series

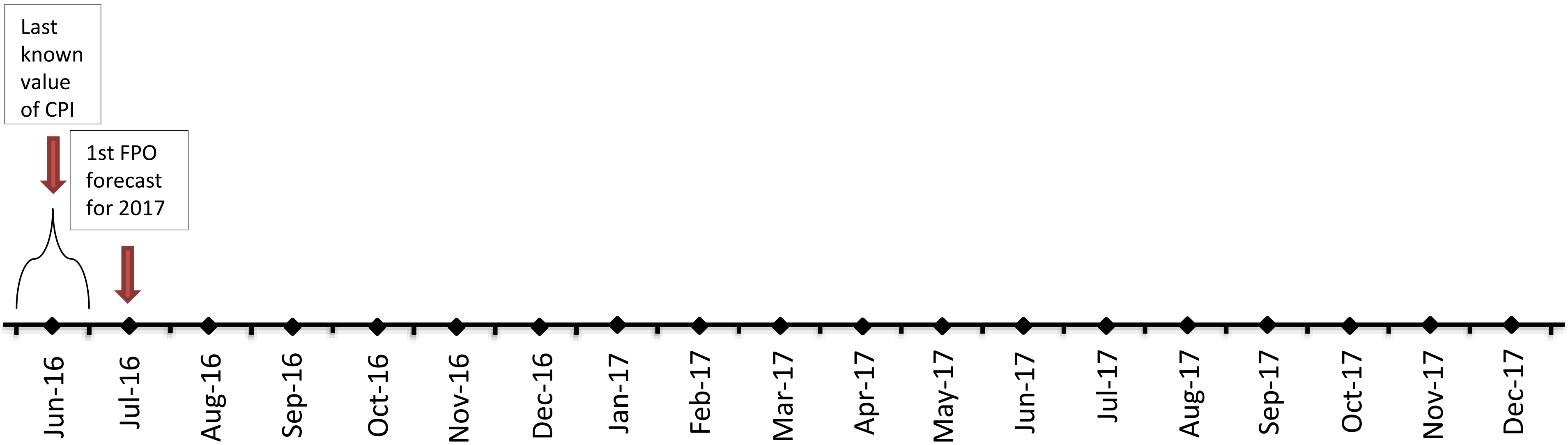
Conceptual Questions

- How can data users interpret the range?
  - Not a confidence level
  - Identical forecast range for all series
    - May imply that forecasts made with the same level of confidence across series

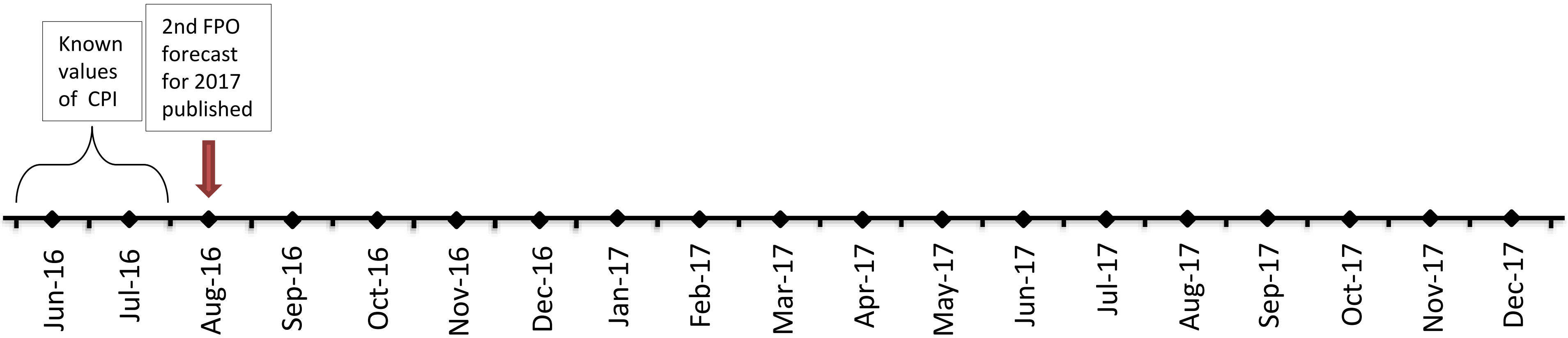


Annual Average Percent Change in CPI Poultry and Eggs Series
Percent Change
30
20
10
0
-10
-20
-30
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
CPI Poultry
CPI Eggs

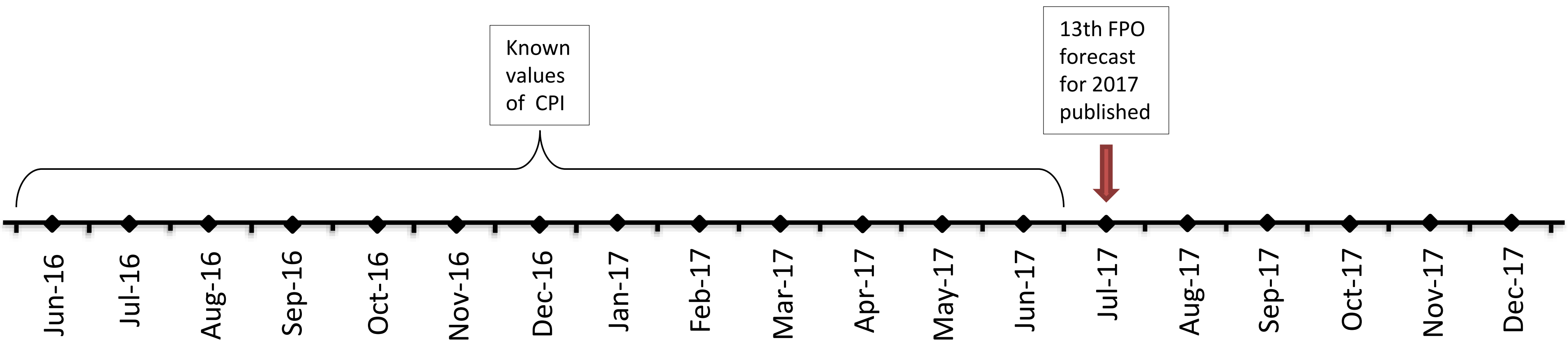
FPO Forecasts for 2017



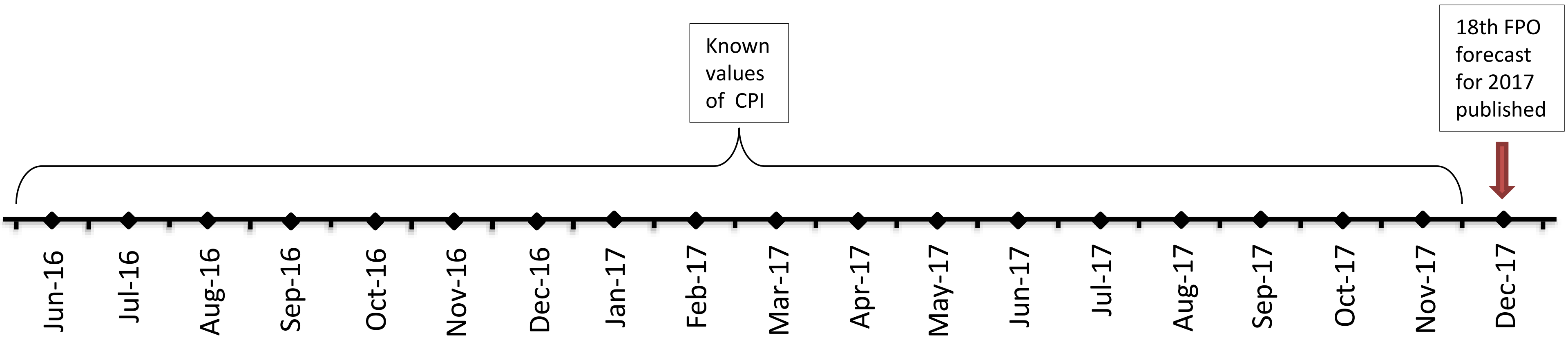
FPO Forecasts for 2017



FPO Forecasts for 2017



FPO Forecasts for 2017



Conceptual Questions

- 1% interval used for all 18 forecasts of given year
  - Might imply equal confidence in 1st and 18th forecast
  - Narrower range as more data from given year is known?
    - When and by how much should the range narrow with subsequent forecasts?

Practical Question

- How accurate are the 1% ranges?
  - ERS Technical Bulletin 1940 (Kuhns et al., 2015) evaluated FPO forecasts
    - Compared current vertical price transmission pass-through approach to previous univariate methodology
    - Used number of revisions – fewer revisions indicating greater accuracy
  - Forecast intervals traditionally evaluated using hit rates and forecast coverage
    - (Isengildina-Massa et al., 2011)

Hit Rate and Forecast Coverage

- Hit Rate
  - Proportion of times forecast intervals contain the final or ‘true’ value
  - Closer the hit rate is to stated confidence level, more accurate the forecast

- Forecast coverage
  - Is the proportion of times the forecast interval includes the true value equal to the target (stated) confidence level?
  - Likelihood ratio test (Chi-square with df=1)
  - Unconditional coverage test (Christofferson, 1998)

Hit Rate of 1% FPO Interval, 2004 through 2016

Statistic	CPI Poultry
N	234
Hit rate	28.21%
Misses above	32.48%
Misses below	38.89%

Alternatives to Fixed 1% Interval

- Food Price Forecasting Conference
  - February 2015
  - Recommendations
    - Interval forecasts
    - Forecasts based on recent volatility (backward-looking)
    - Forecasts incorporating on commodities/futures markets (forward-looking)

Forward-looking Forecasts

- Incorporate commodities/futures markets
  - Futures contracts don't exist for most PPI and CPI food series
  - Not feasible for FPO

Backward-looking Forecasts

- Prior research shows that empirical confidence intervals can be created (Isengildina-Massa et al., 2011)
  - World Agricultural Outlook Board (WAOB) season-average farm prices (SAP)
    - Corn, Soybeans, Wheat
    - 18-month cycle: May through following October
      - Final 'old crop' price published in November
    - No confidence level provided
    - Published intervals narrow over time
      - Process of narrowing opaque to public

Empirical Confidence Intervals

- Backward-looking forecast
- Use past forecast performance to estimate the level of confidence at each step of the forecast
  - Past errors from first July forecasts for confidence level of first July forecasts in the future
- Split data into two parts
  - Part 1: generate forecast error distribution to generate confidence limits
  - Part 2: use confidence limits from part 1
  - Similar to standard forecasting approach of using part 1 to estimate ‘model’ and using part 2 to test model accuracy/fit

Empirical Confidence Intervals

- Key assumption
  - Distribution of forecast errors is stable over time

Empirical Confidence Intervals

- Approach of Isengildina et al., (2011) :
  - Non-parametric
    - Histograms
    - Kernel density estimation
  - Parametric
    - Normal, logistic, extreme value, uniform, Rayleigh distributions
  - Quantile regression estimation
    - From Taylor and Bunn (1999)
    - Not based on small samples

Empirical Confidence Intervals

- Important weakness
  - Small sample sizes
- Isengildina-Massa et al., (2011)
  - 27 annual observations for each monthly forecast
  - 15-year period for part 1
  - 12-year period for part 2

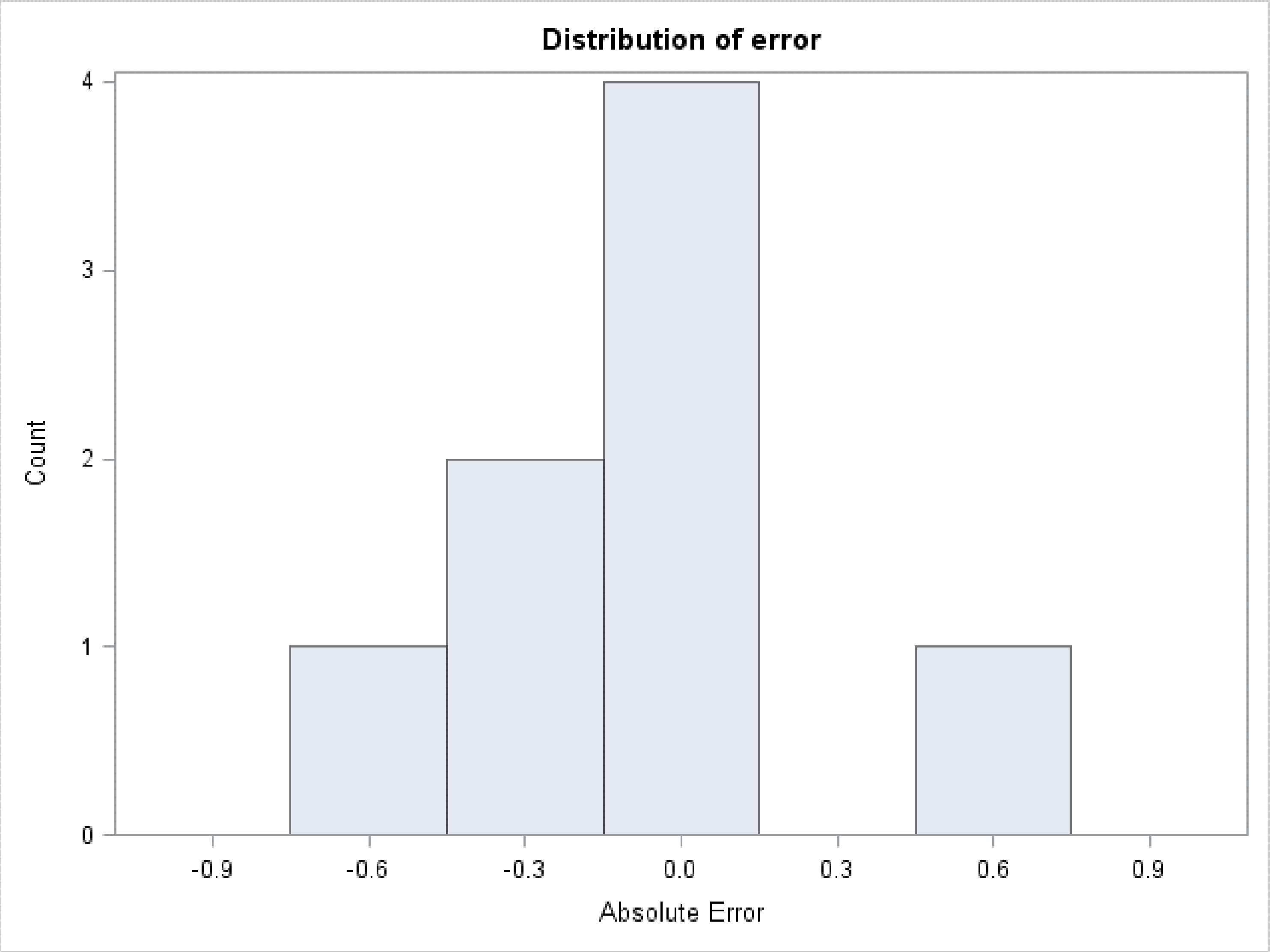
Empirical Confidence Intervals

- Food Price Outlook
  - 13 annual observations for each monthly forecast
  - 8-year period for part 1
  - 5-year period for part 2

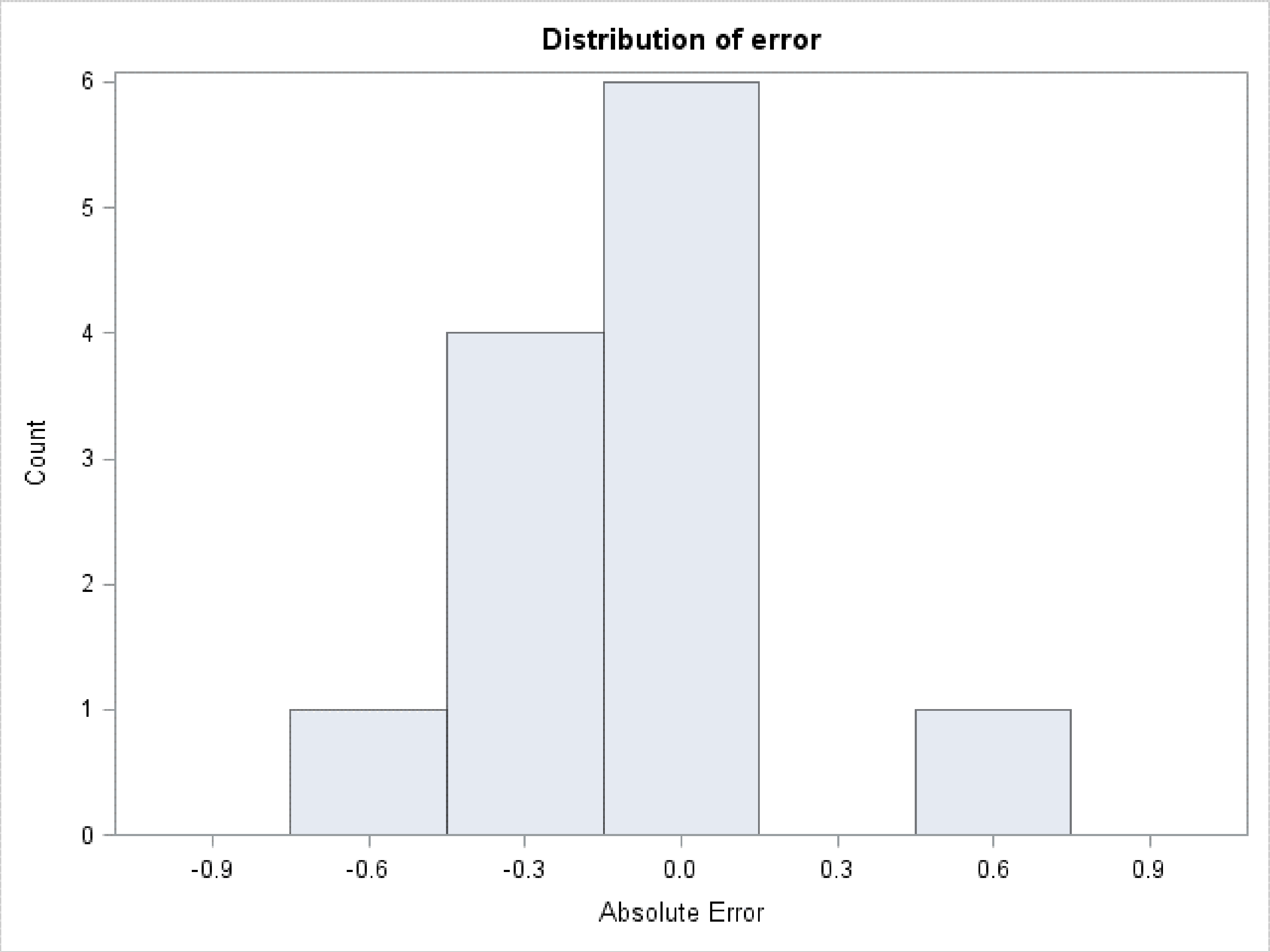
Histogram Approach

- Most simple (non-parametric) procedure for forecast error distribution
- Sort forecast errors from negative to positive
- Confidence levels approximated by dropping extreme values to achieve selected confidence level

Histogram Estimate for 18th Forecast (December) From 2004-2011 Sub-sample



Histogram Estimate for 18th Forecast (December) From 2004-2015 Sub-sample

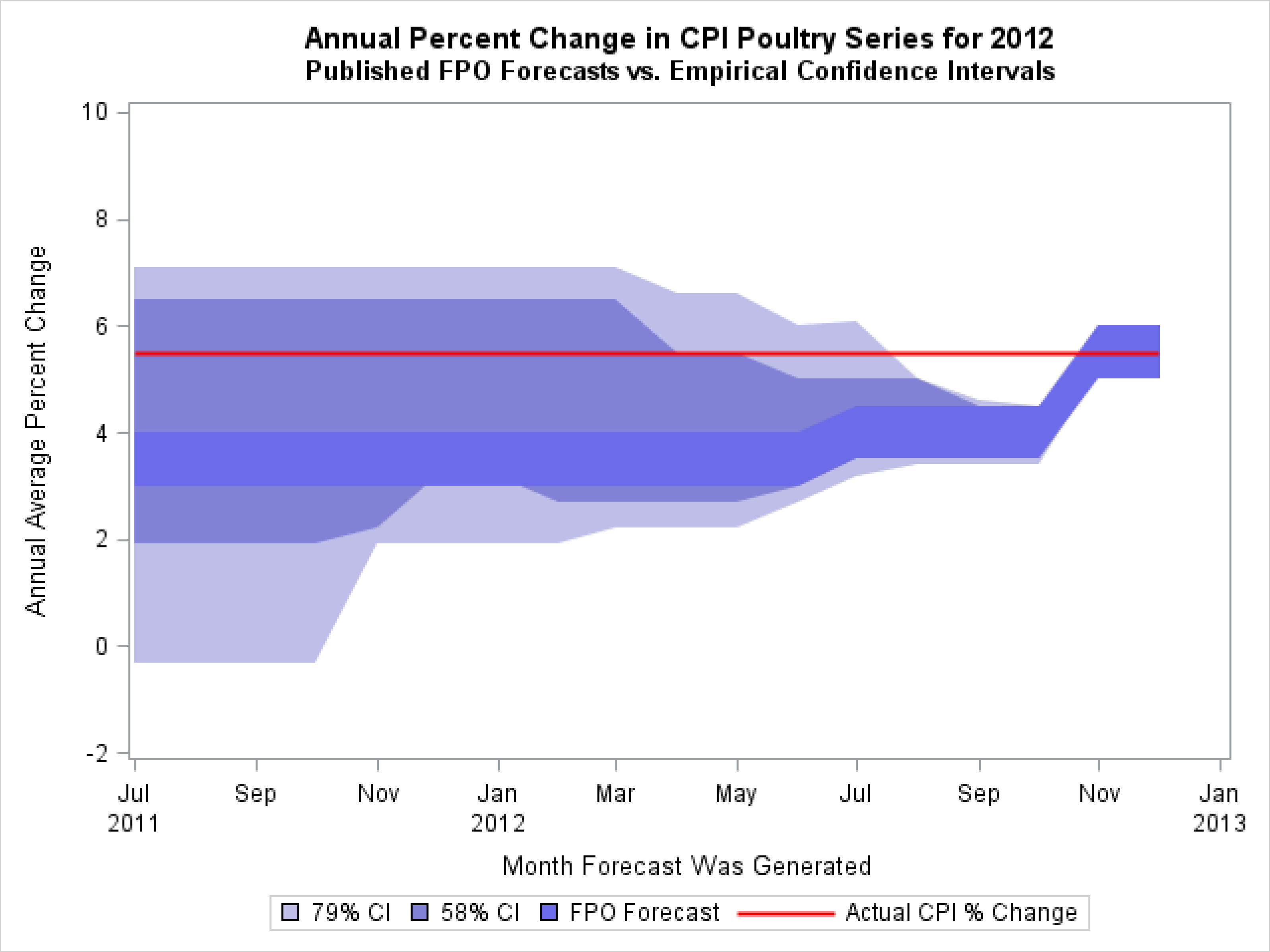


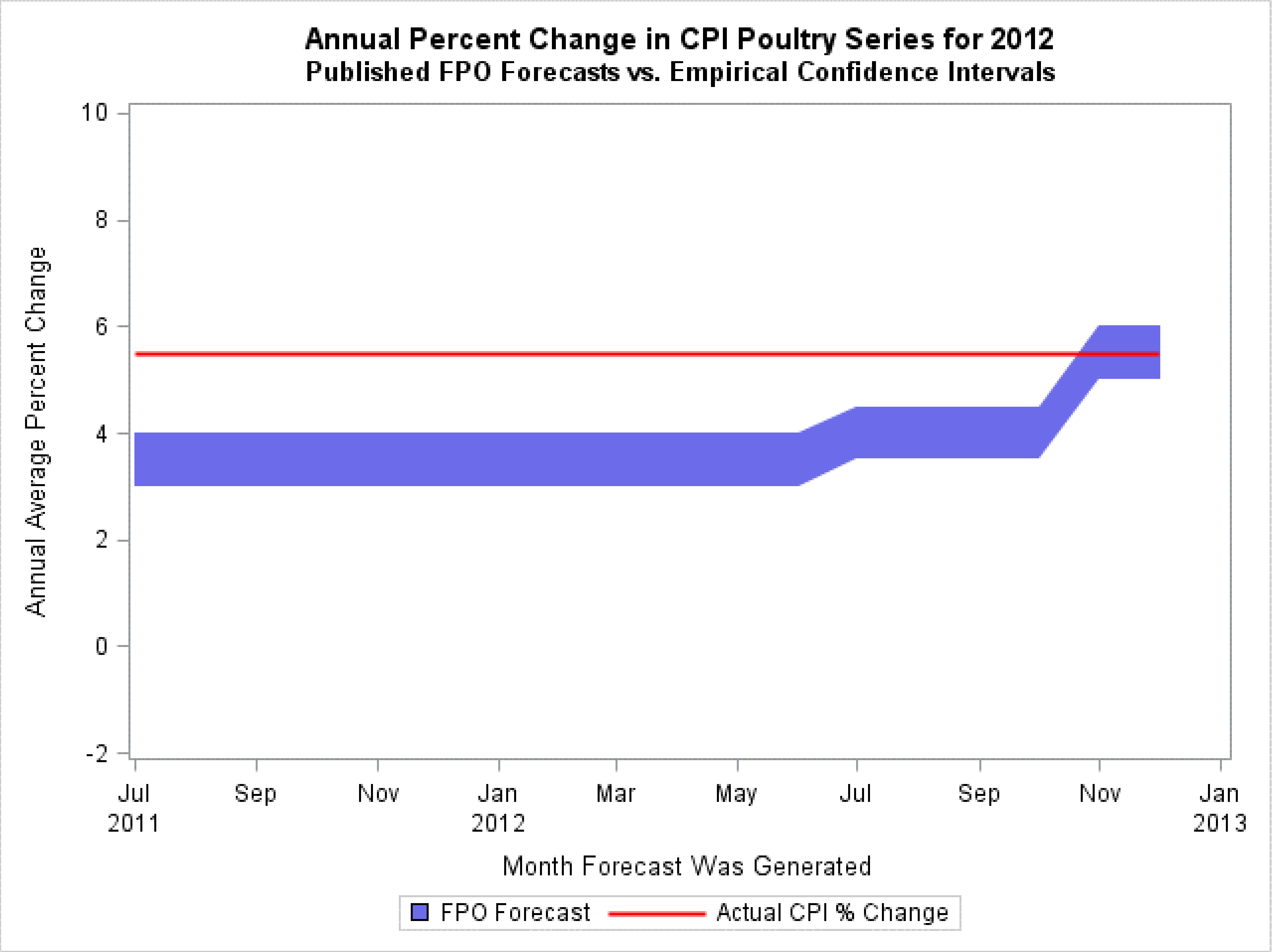
Histogram Approach

- Drop largest positive and largest negative error
  - Corresponds to confidence levels from 75% (6 out of 8 observations) to 83.3% (10 out of 12 observations)
  - Add 2nd-largest negative and positive forecast error to midpoint of forecasts in part 2
    - Approximates empirical 79.2% confidence interval

Histogram Approach

- Drop largest two positive and largest two negative errors
  - Corresponds to confidence levels from 50% (4 out of 8 observations) to 69.2% (8 out of 12 observations)
  - Add 3rd-largest negative and positive forecast error to midpoint of forecasts in part 2
    - Approximates empirical 58.3% confidence interval


Annual Percent Change in CPI Poultry Series for 2012
Published FPO Forecasts vs. Empirical Confidence Intervals
Annual Average Percent Change
10
8
6
4
2
0
-2
Jul 2011
Sep
Nov
Jan 2012
Mar
May
Jul
Sep
Nov
Jan 2013
Month Forecast Was Generated
79% CI
58% CI
FPO Forecast
Actual CPI % Change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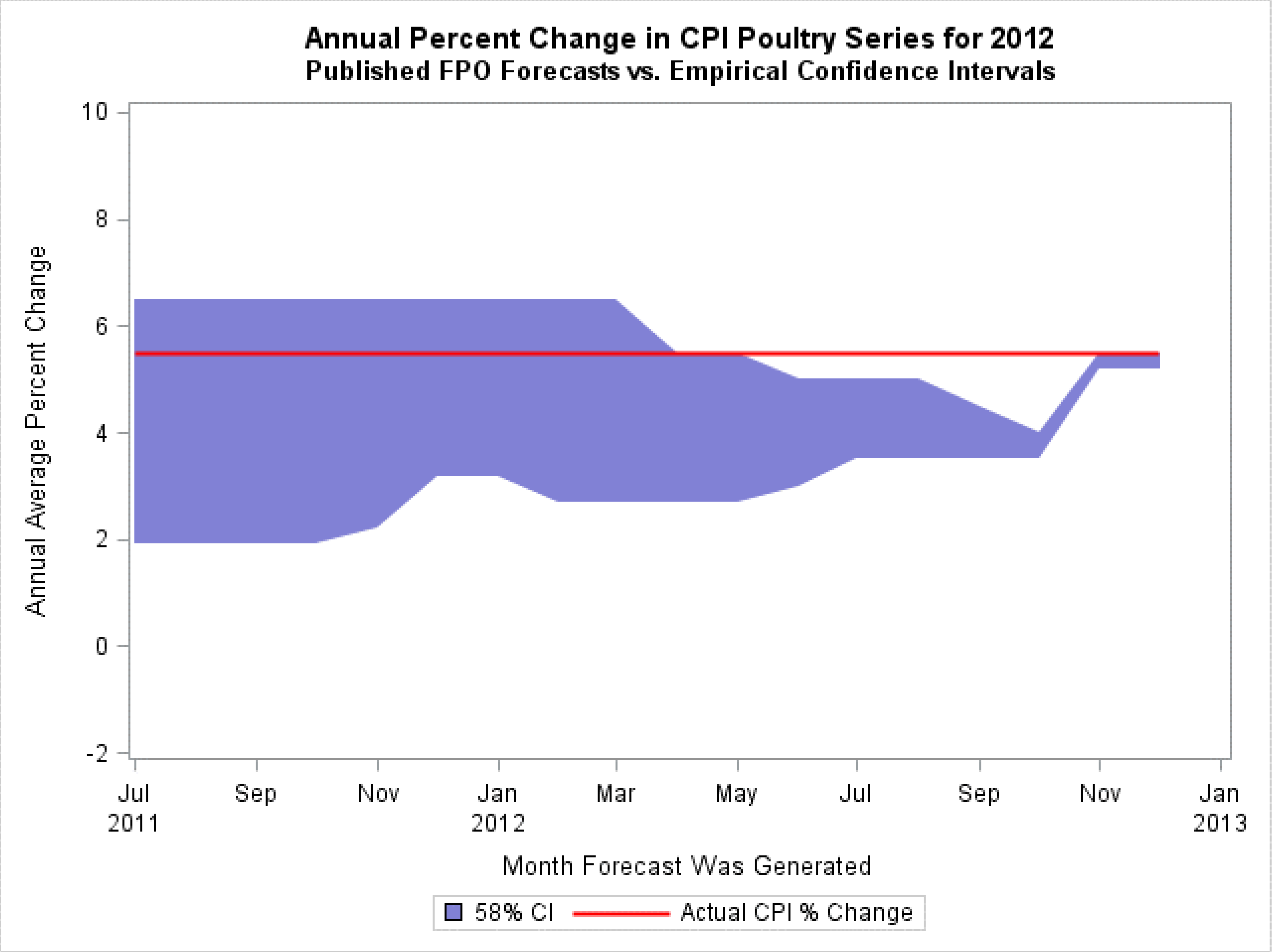
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8
6
4
2
0
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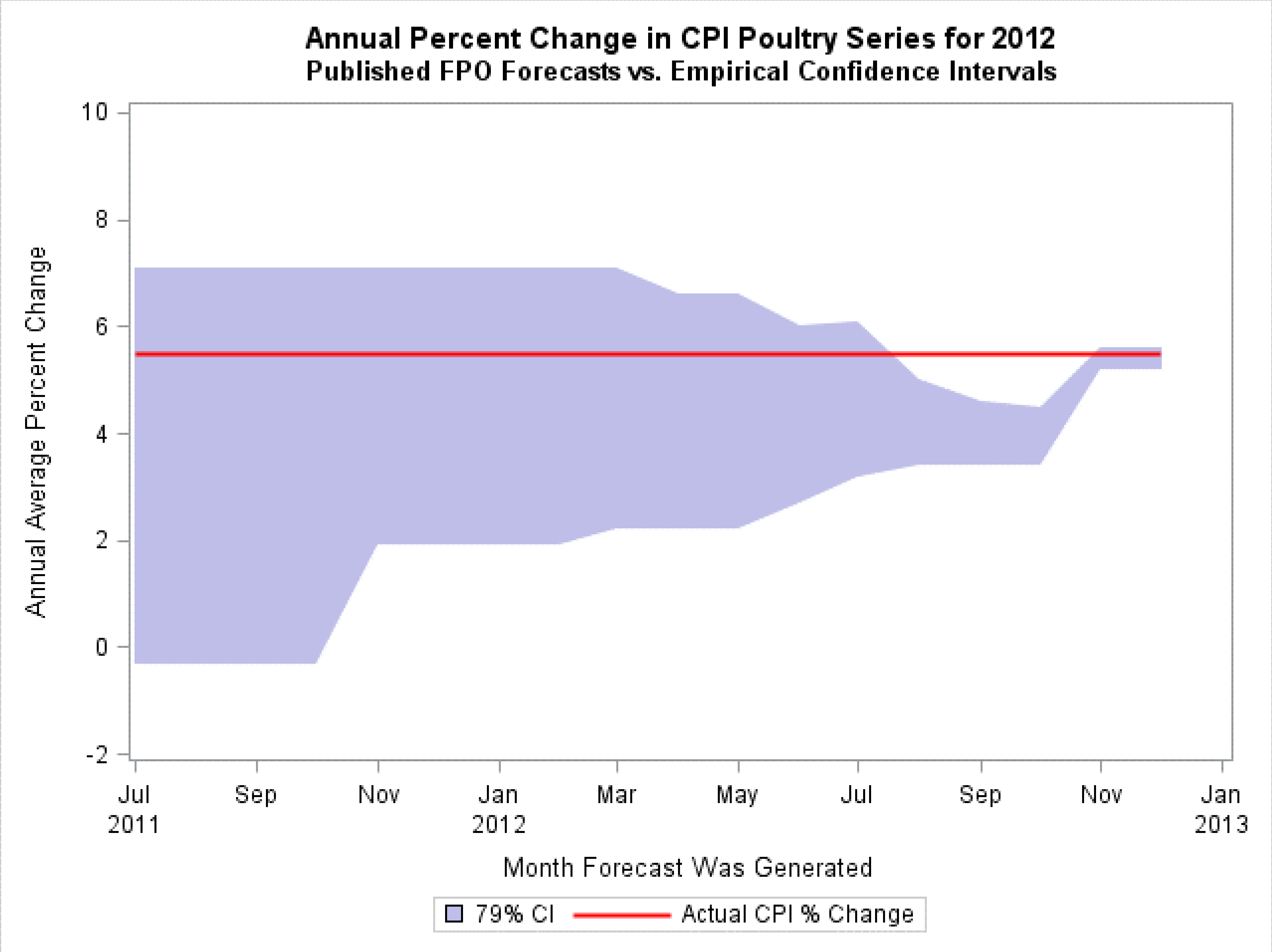
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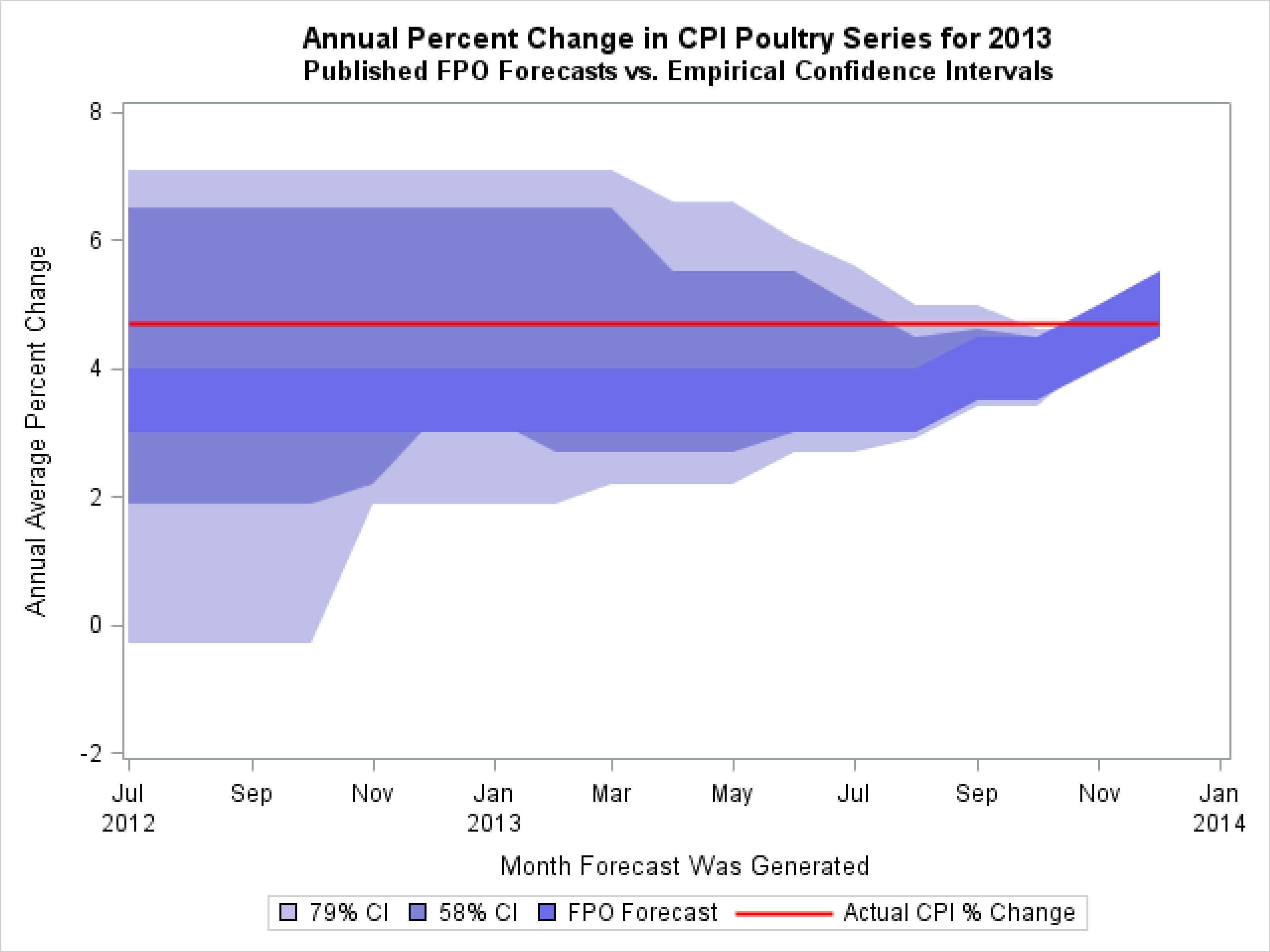

Annual Percent Change in CPI Poultry Series for 2013
Published FPO Forecasts vs. Empirical Confidence Intervals
Annual Average Percent Change
8
6
4
2
0
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Jul 2012
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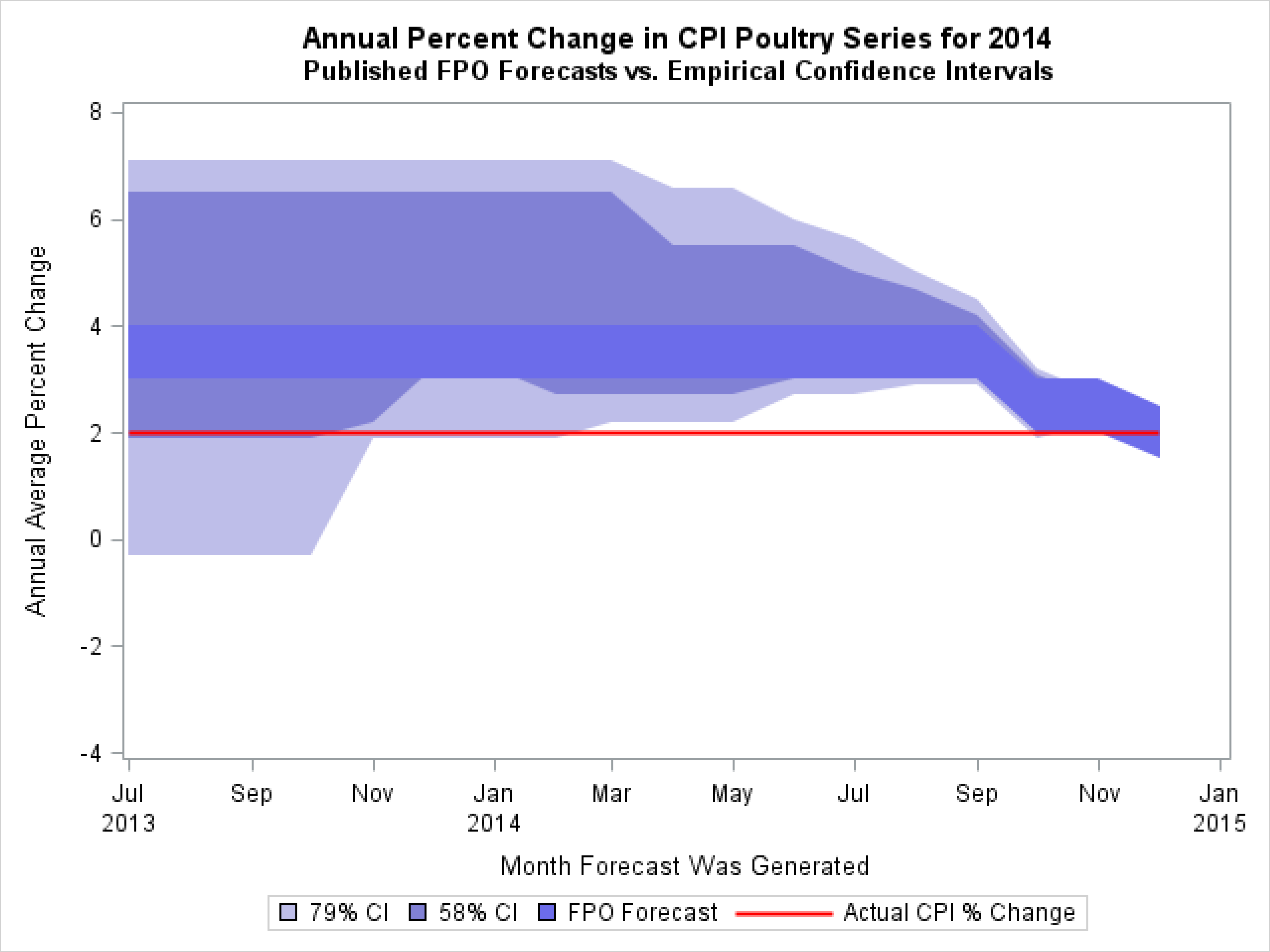
Annual Percent Change in CPI Poultry Series for 2014
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Annual Average Percent Change
8
6
4
2
0
-2
-4
Jul 2013
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Jan 2014
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May
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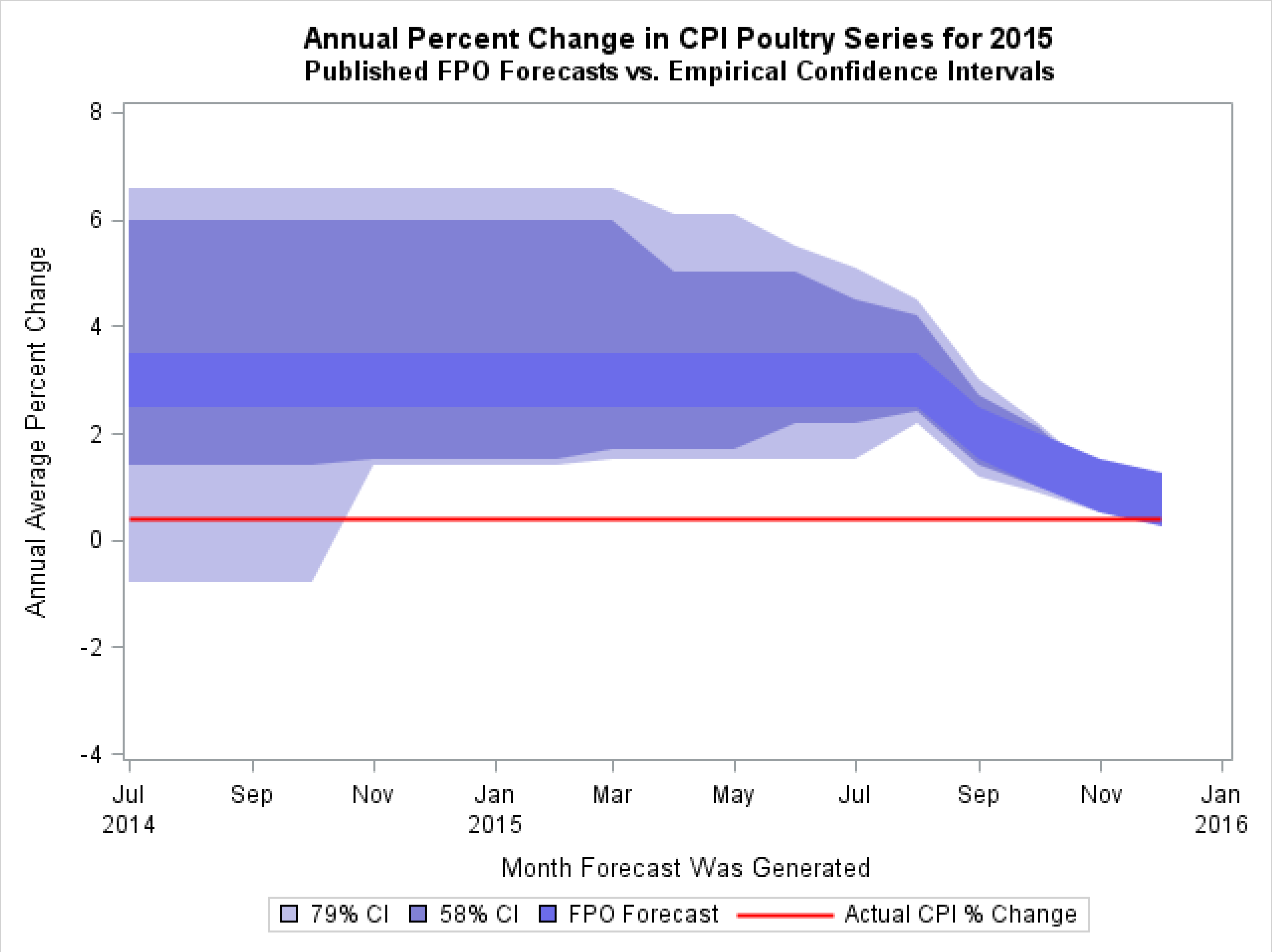
Annual Percent Change in CPI Poultry Series for 2015
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Annual Average Percent Change
8
6
4
2
0
-2
-4
Jul 2014
Sep
Nov
Jan 2015
Mar
May
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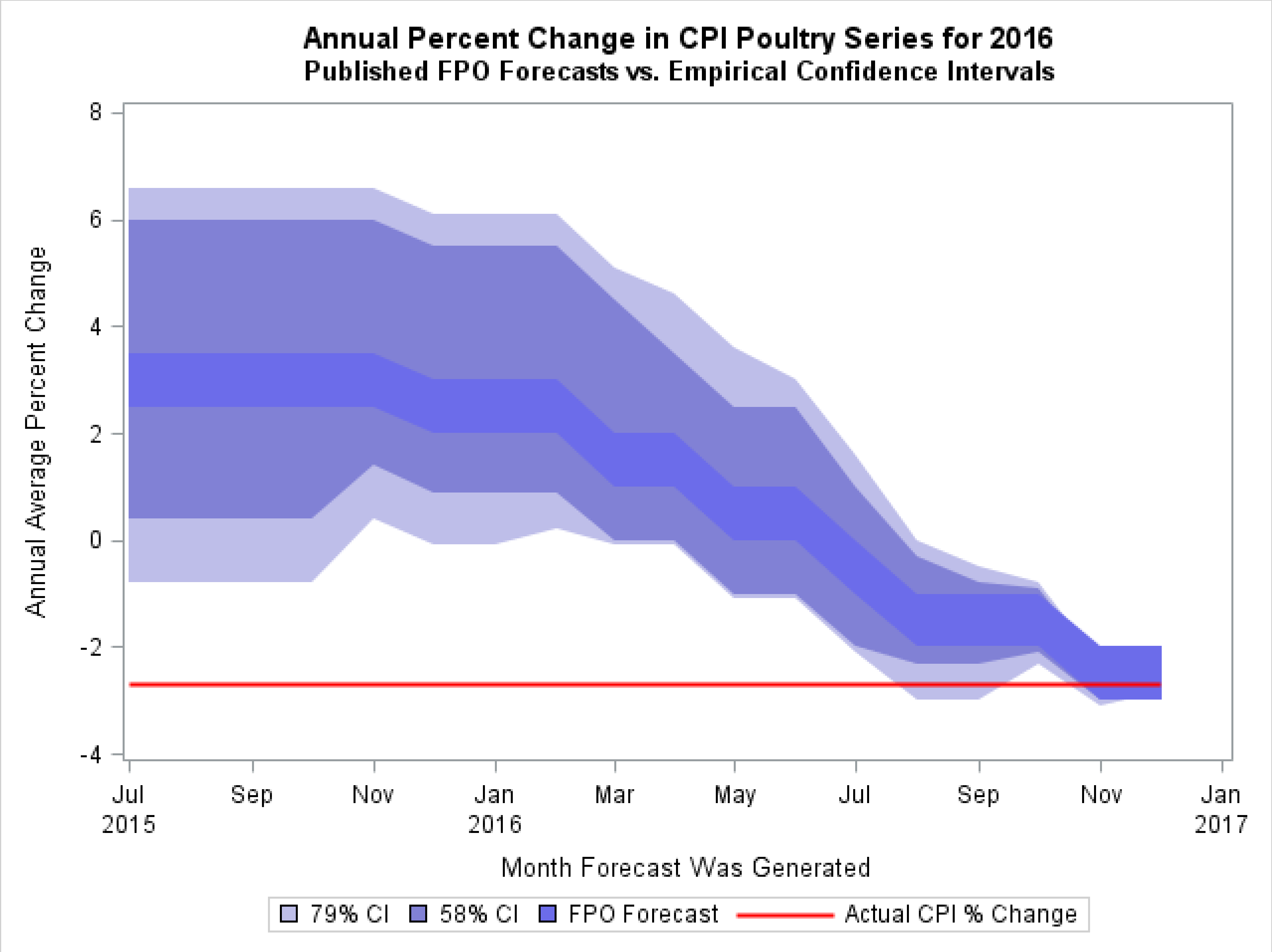

Annual Percent Change in CPI Poultry Series for 2016
Published FPO Forecasts vs. Empirical Confidence Intervals
Annual Average Percent Change
8
6
4
2
0
-2
-4
Jul 2015
Sep
Nov
Jan 2016
Mar
May
Jul
Sep
Nov
Jan 2017
Month Forecast Was Generated
79% CI
58% CI
FPO Forecast
Actual CPI % Change

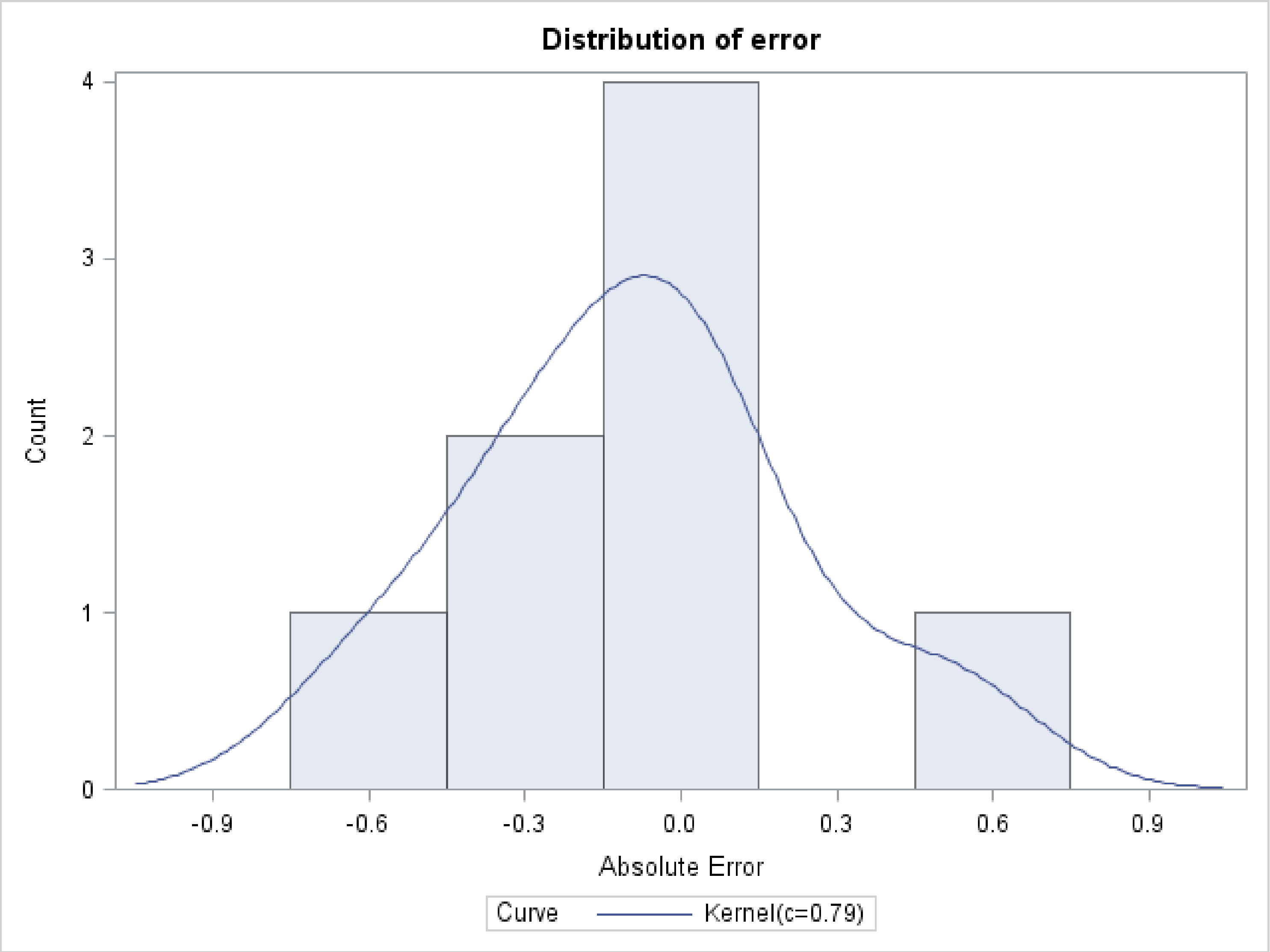
Accuracy Statistics for 2012-2016

Statistic	Published 1% FPO Interval	Histogram 58% CI	Histogram 79% CI
N	90	90	90
Hit rate	11.11%	38.89%	54.44%
Misses above	35.56%	10%	5.56%
Misses below	53.33%	51.11%	40%
Unconditional coverage test	254.77***	132.65***	20.24***
Target confidence level is 79%			
*** indicates significance at the 1% level			

Histogram Approach Limitations

- Sensitivity to choice of origin and bin width
- Choice of confidence levels limited by discrete nature
  - Number of years
  - Split point between parts one and two
- Concentration on tails of distribution
  - Namely, extreme values
  - Doesn’t take entire shape of distribution into account

Histogram Estimate for 18th Forecast (December) From 2004-2011 Sub-sample



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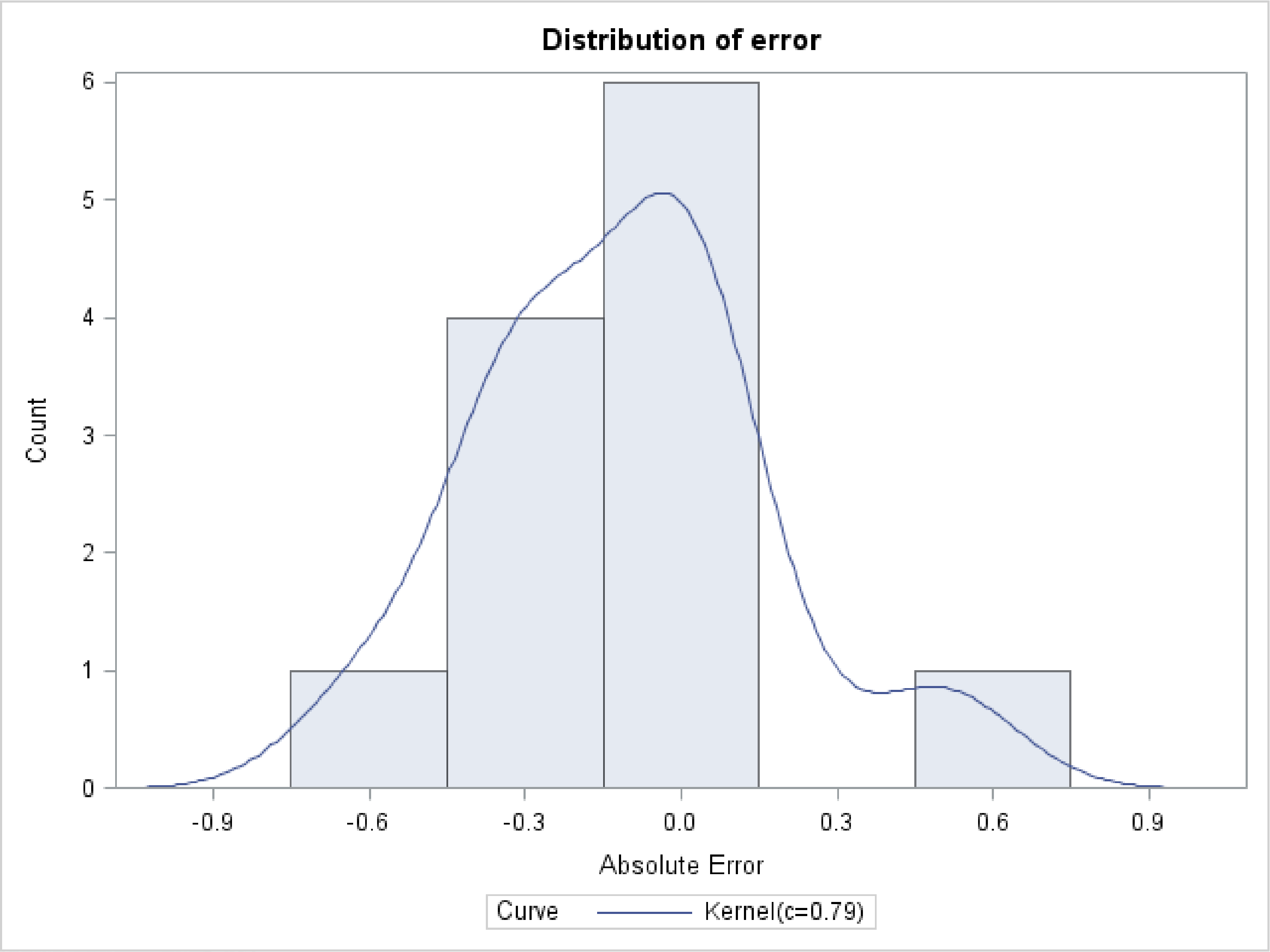

Constant Error Distribution Assumption

- Can test this assumption
  - Split sample into two parts
  - Test whether mean and variance of forecast error differed between two parts
    - Independent t-test for difference in means
    - Levene's F-statistic for difference variances

Constant Error Distribution Assumption

Statistic	CPI Poultry
N (2004-2011)	144
N (2012-2016)	90
Mean (2004-2011)	0.433333
Mean (2012-2016)	-0.85611
t-statistic	-4.15118***
Variance (2004-2011)	2.501087
Variance (2012-2016)	1.477363
Levene's *F*-Statistic	0.352198
*** indicates significance at the 1% level	

Constant Error Distribution Assumption

- Variance of forecast errors is stable over time
- Mean of forecast errors is not
- Data used by Isengildina-Massa et al. also violated this assumption
  - Mean for soybeans
  - Variance for corn and wheat
  - Violation a weakness or "fatal flaw"?

Constant Error Distribution Assumption

- Why would mean of forecast errors differ between 2004-2011 and 2012-2016?
  - Current FPO methodology – vertical price transmission - implemented in mid-2012
  - Prior methodology was simple univariate approach

Constant Error
Distribution Assumption

- Alternate indication
  - If intervals accurately reflect shape of underlying distribution
    - Expect equal probability of misses above and misses below

Accuracy Statistics for 2012-2016

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Misses above	35.56%	10%	5.56%
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Unconditional coverage test	254.77***	132.65***	20.24***

Target confidence level is 79%

*** indicates significance at the 1% level

Next Steps

- Evaluate severity of constant error distribution assumption
  - Possible solution: attempt to recreate historical FPO forecasts using current methodology for 2004 through mid-2012
    - Retest whether mean and variance of forecast errors differed between part 1 and part 2
- Add 2017 data

Next Steps

- Calculate empirical CIs using other methods
  - Non-parametric
    - Kernel density estimation
      - Most promising based on Isengildina-Massa et al.
  - Other possibilities
    - Parametric
      - Normal, logistic, extreme value, uniform, Rayleigh distributions
    - Quantile regression estimation
- Calculate empirical CIs for additional CPI series

Contact Information

David Levin

david.levin@ers.usda.gov

202-694-5353

Hit Rate

$$I_t^k = \begin{cases} 1 \;\; if \;\; y_t \;\in\; \left[l_{t/k}(\propto), u_{t/k}(\propto)\right] \\ 0 \;\; if \;\; y_t \;\notin\; \left[l_{t/k}(\propto), u_{t/k}(\propto)\right] \end{cases}$$

Where $\left[l_{t/k}(\propto), u_{t/k}(\propto)\right]$ are the lower and upper limits of the interval forecast for y_t made at time k with confidence level $\propto$

Unconditional Coverage Test

$$H_0: E\left(I_t^k\right) = \propto$$
$$H_1: E\left(I_t^k\right) \neq \propto$$

I_t^k has binomial distribution (Christofferson, 1998), so likelihood functions are:

Null hypothesis: $L_{(\propto)} = (1 - \propto)^{n_0} \propto^{n_1}$

Alt. hypothesis: $L_{(p)} = (1 - p)^{n_0} p^{n_1}$

Unconditional Coverage Test

Likelihood ratio test:

$$LR_{(c)} = -2\ln\left(\frac{L_{(\propto)}}{L_{(\hat{p})}}\right) \xrightarrow{asy} \chi^{2}(1)$$

where $\hat{p} = n_1/(n_0 + n_1)$ is maximum likelihood estimator of p

Vertical Price Transmission Pass-Through

- Incorporates input prices at each stage of production

ERS Farm Forecasts

- Steers
- Wholesale Broilers and Turkeys
- Barrows and Gilt
- Farm Eggs
- Farm Milk
- Farm Wheat
- Soybeans

- Note: There is no farm forecast for fruits or vegetables.

→

Farm and Wholesale PPI Forecasts

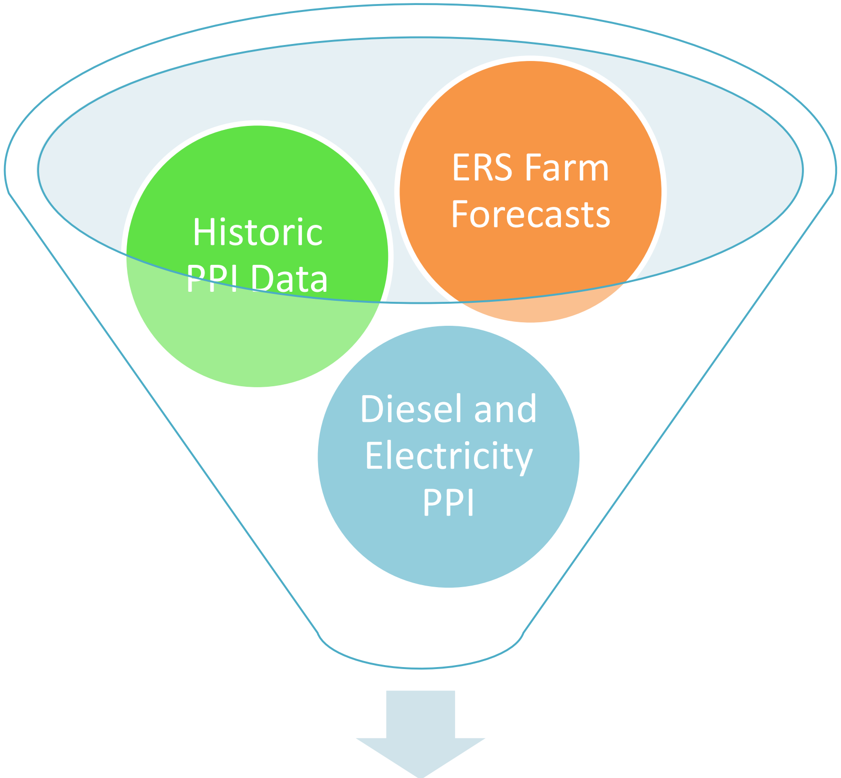
- Beef
- Processed Poultry
- Pork
- Eggs
- Processed Milk
- Wheat Flour
- Fats and Oils
- Fresh Fruits
- Fresh Vegetables

→

CPI Forecasts

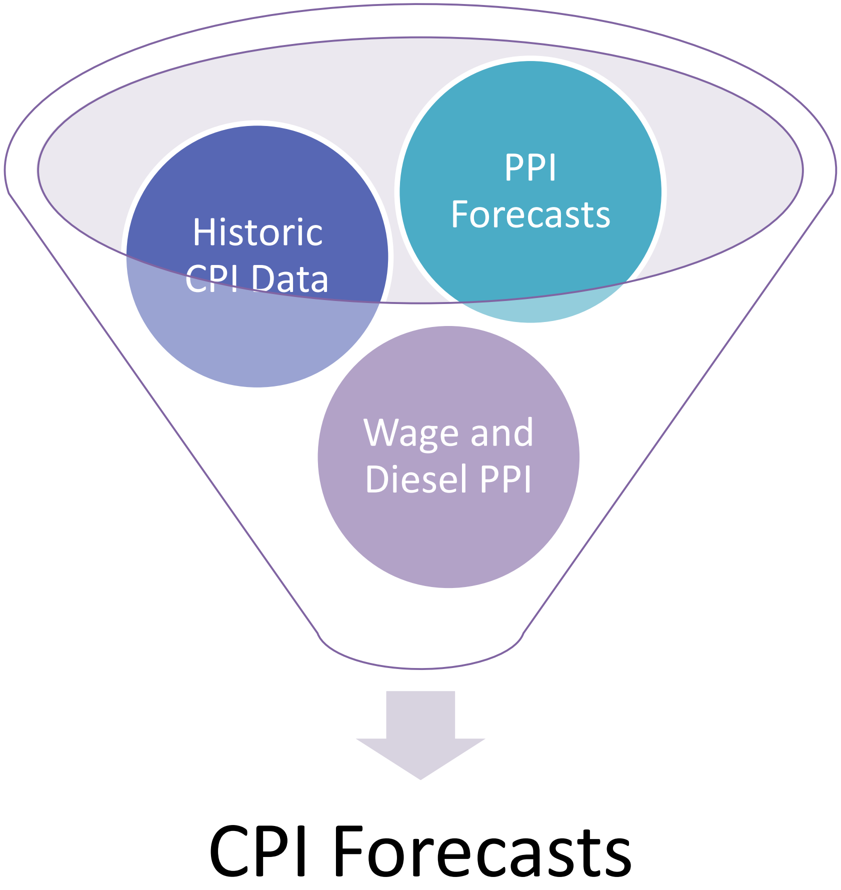
- Beef and Veal
- Poultry
- Pork
- Eggs
- Dairy
- Bread
- Fats and Oils
- Fruits
- Vegetables

First stage



Farm and Wholesale PPI Forecasts

Second stage



Vertical Price Transmission Pass-Through

- Four types of Vertical Price Transmission models
  - Threshold ECM (Error Correction Model)
  - Symmetric ECM
  - Asymmetric ECM
  - Autoregressive Distributed Lag (ARDL)