

# How Much is US Labor Productivity Revised?

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Views and findings are those of the authors, and do not necessarily reflect the views of the Bureaus

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# Labor productivity definition

- Labor Productivity (LP) growth =  $\frac{\text{Output growth (BEA)}}{\text{Hours Worked growth (BLS)}}$
- We focus on U.S. nonfarm business labor productivity
  - About 75% of GDP, excluding general government and nonprofits
  - Hours worked by matching workforce
- The data sources are revised over time.
  - Mostly “transitory uncertainty,” as more information becomes available
  - Some is definitional or change in methods
  - Related studies: Aruoba (2008), Sinclair and Stekler (2013), Manski (2015), Jacobs and van Norden (2010, 2016), Fixler et al (2018), Galvao et al (2019), our new Asher et al (2021)



# Definitions and notation

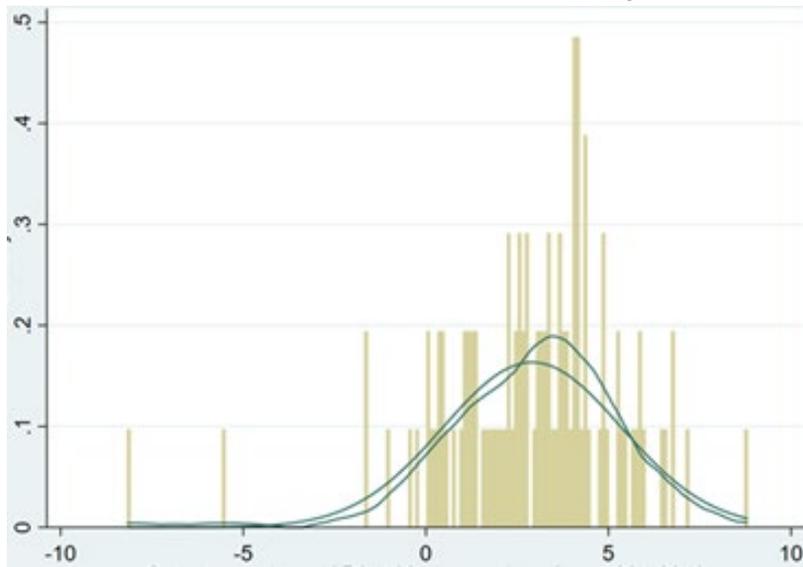
- Key variables: **Hours worked, output, and labor productivity (LP)**
  - A figure for Q1 is a change from the previous Q4
  - Measured as quarter-to-quarter growth rate, annualized
  - Overall hours grew at a bit under 1% rate, LP around 2%, and output at almost 3%
- We have data as of each LP news releases: 8 per year, 1994-2020
  - *Estimates* from releases R0, R1, R2, . . . R40, are shown with subscripts **0, 2, 40**
  - Previous quarters are updated at the time of each release (available: [bls.gov/lpc](https://bls.gov/lpc))
- **Revisions** are *changes in estimates* between releases. Release # is subscript
  - So if LP growth is revised from  $LP_0 = 1.8$  to  $LP_2 = 2.0$ , that *revision* is .2

# Growth rates as of first releases (R0)

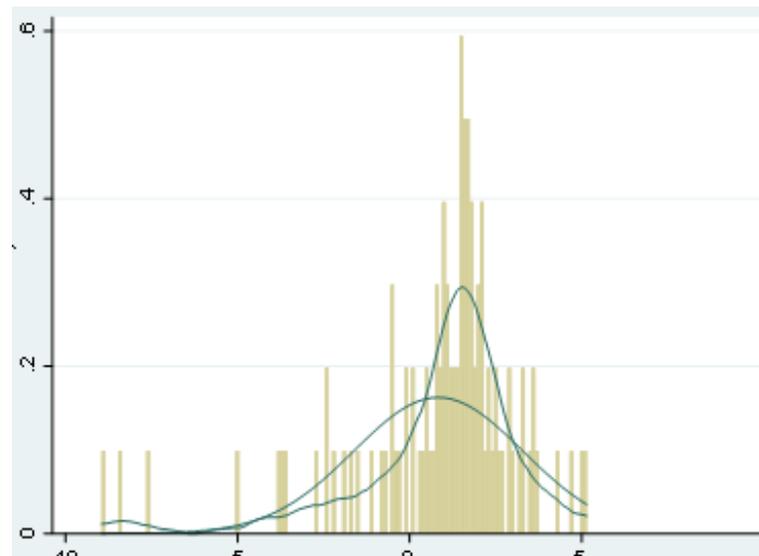
Charts show distributions at R0, before revisions, as annualized growth rates

- Reference quarters 1994-2019, missing one because of government shutdown in 2018: N=103
- Test for normal distribution rejects it for all three
- Output growth shows some skew and downward tail. Mean = 2.91%
- Hours-worked is peaked, tightly clustered. Mean = .96%
- Resulting Labor Productivity growth distribution is slightly peaked. Mean = 1.93%

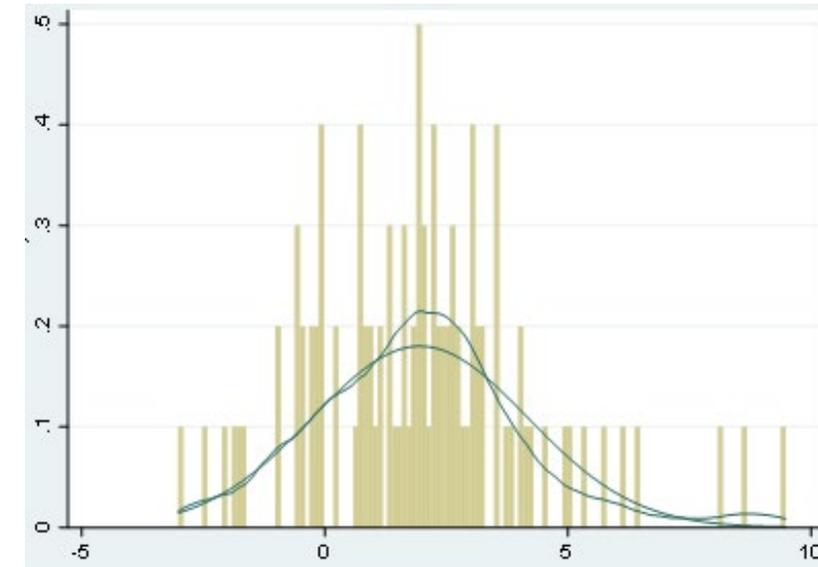
Output growth ( $\text{Output}_{R0}$ )



Hours-worked growth ( $\text{Hours}_{R0}$ )



Labor productivity growth ( $\text{LP}_{R0}$ )



# Summary statistics of variables across releases

## ➤ These are averages of growth rates

- Reference quarters 1995 Q1 – 2016 Q2

## ➤ Effects of revisions

- Slightly raise then lower output and labor productivity estimates
- Hours estimates drift down
- The distributions spread out; their standard deviation goes up

|           | <b>LP<sub>R0</sub></b> | <b>LP<sub>R2</sub></b> | <b>LP<sub>R40</sub></b> |
|-----------|------------------------|------------------------|-------------------------|
| Mean      | 2.07                   | 2.26                   | 1.96                    |
| Std. dev. | 2.28                   | 2.53                   | 2.68                    |
| Min       | -3.02                  | -4.45                  | -3.39                   |
| Max       | 9.45                   | 9.50                   | 10.34                   |

|           | <b>Output<sub>R0</sub></b> | <b>Output<sub>R2</sub></b> | <b>Output<sub>R40</sub></b> |
|-----------|----------------------------|----------------------------|-----------------------------|
| Mean      | 2.84                       | 2.97                       | 2.63                        |
| Std. dev. | 2.62                       | 3.02                       | 3.35                        |
| Min       | -8.19                      | -8.84                      | -12.03                      |
| Max       | 8.80                       | 10.40                      | 11.01                       |

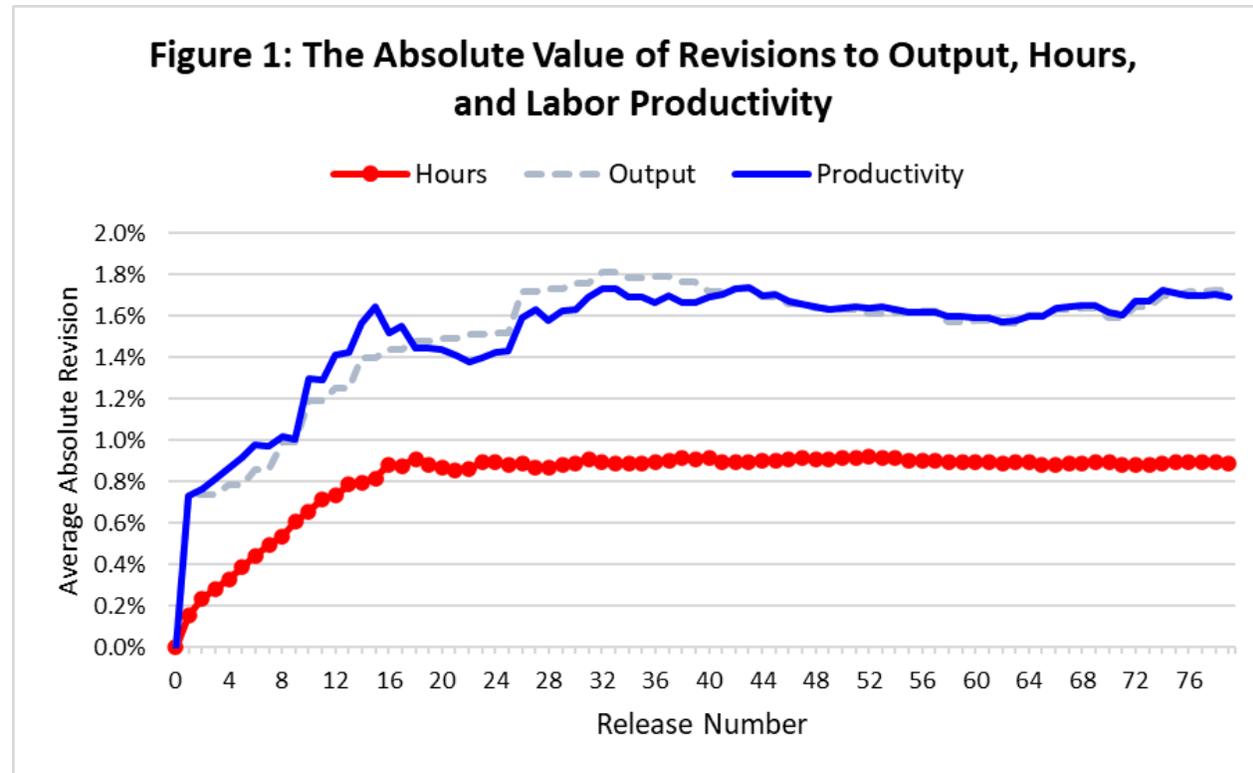
|           | <b>Hours<sub>R0</sub></b> | <b>Hours<sub>R2</sub></b> | <b>Hours<sub>R40</sub></b> |
|-----------|---------------------------|---------------------------|----------------------------|
| Mean      | .78                       | .72                       | .67                        |
| Std. dev. | 2.57                      | 2.53                      | 2.81                       |
| Min       | -8.95                     | -9.04                     | -10.15                     |
| Max       | 5.06                      | 4.88                      | 4.56                       |

# Magnitude of revisions over time

Chart shows absolute values of revisions averaged over reference quarters for which we have ten years of data

- Hours-worked estimates avg change: .85%
- Output and LP estimates avg change: 1.7%

After two years, revisions to hours are small  
After 3-5 years, revisions to output and labor productivity are small.





# Data flow for hours-worked estimates



Here we'll focus on statistical properties of the aggregate.



# Sources of Revisions

- Additional data in sources (GDP and CES)
- Benchmarking (CES to QCEW)
- Updating of seasonal adjustment in GDP, CES, CPS
- Annual revisions to GDP data
- Methodology changes to all sources

Largest revisions occur on regular annual schedules.

- March incorporates the CES benchmark revision of previous year
- August release incorporates the annual NIPA/GDP benchmark revisions, and Comprehensive Revisions to GDP every 5 years



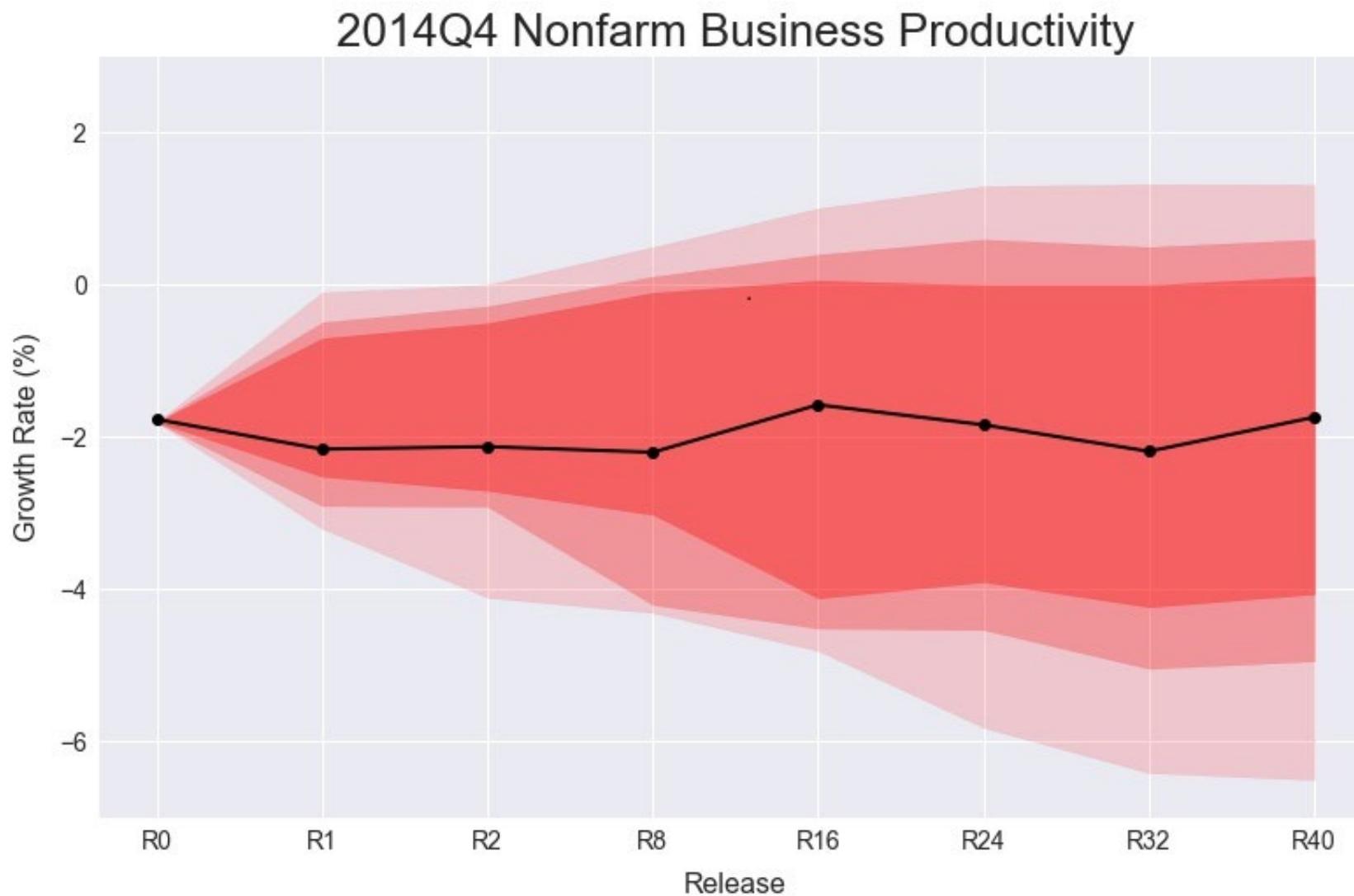
# Prediction intervals for LP: 70, 80 and 90% ranges

The leftmost point is first estimate of labor productivity for 2014Q4 ( $LP_{R0}$ )

The dark region is 70% prediction interval based on 20 years of historical data.

The fan shows ranges of likely estimates for that reference quarter for the next five years.

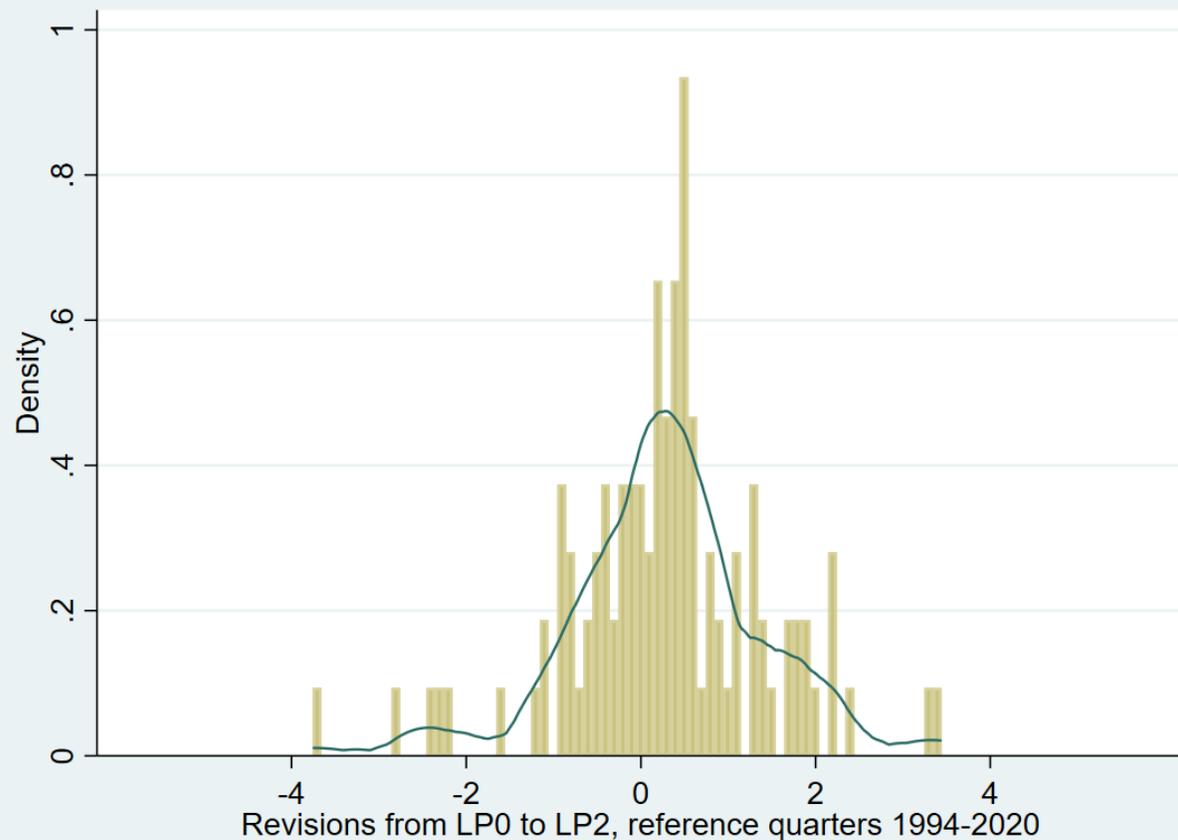
The downward range spreads more than the upward range.



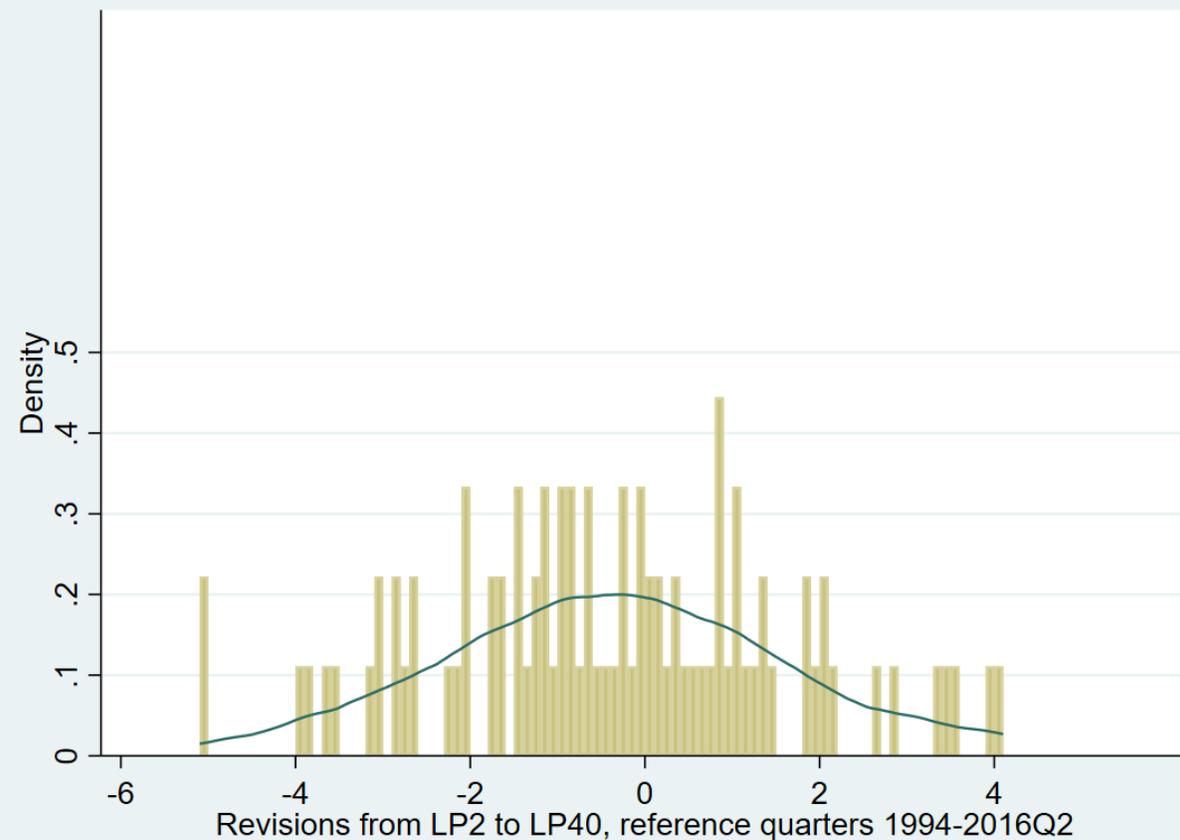
Prediction intervals are shown at 70%, 80% and 90% confidence. Period used is 1995Q1 through 2014Q3.

# Distributions of productivity revisions

Revisions to LP growth in the first 3 months are peaked, with small positive mean



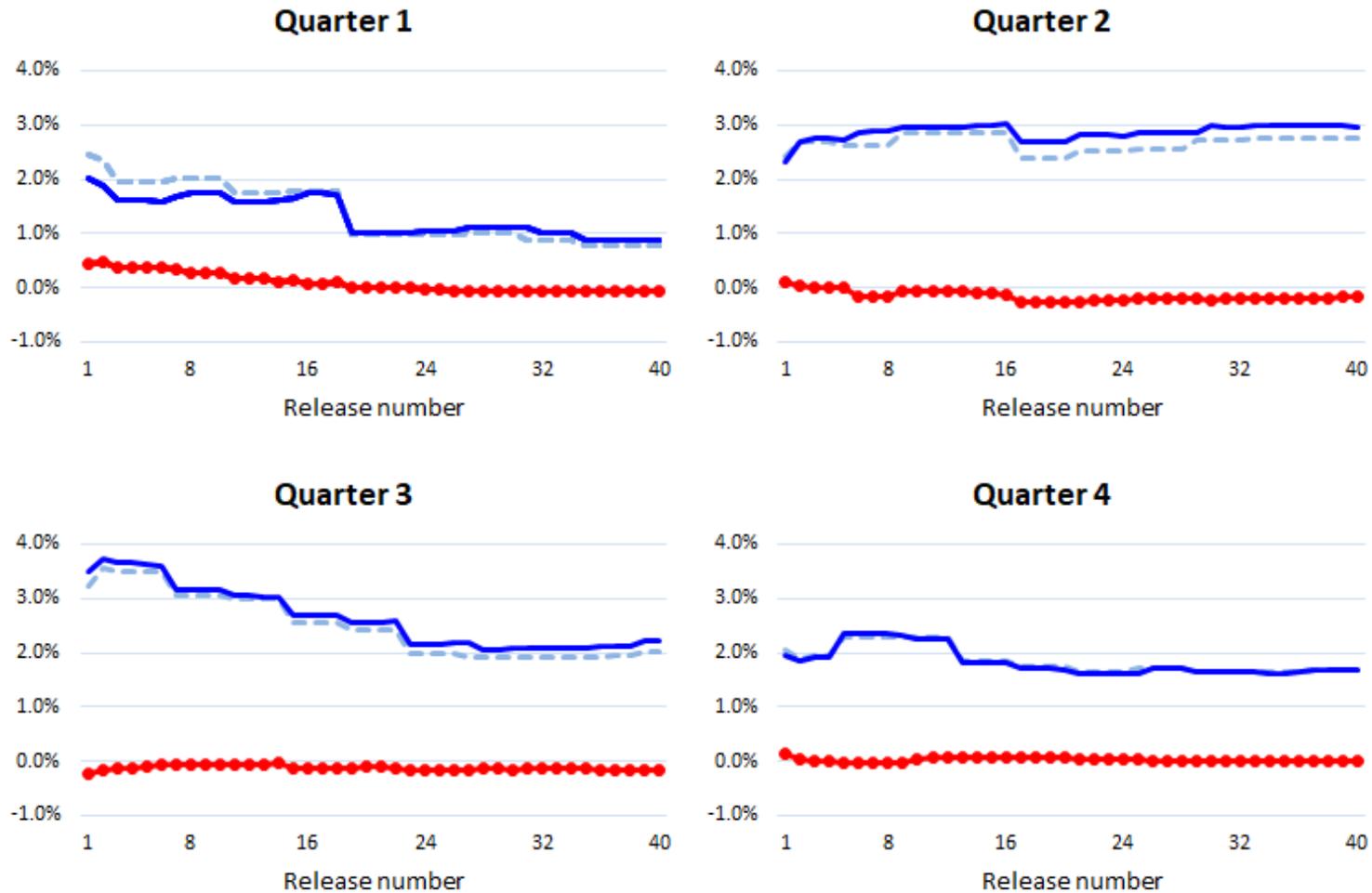
Revisions from 3 months to 5 years out are normal, with small negative mean



# Revisions vary by reference quarter

## Average Growth Rate Across Releases

--- Output    ● Hours    — Productivity





# Decomposition of Revisions

Revisions to labor productivity growth can be accounted for by changes to output or hours, and to the current *or prior quarter*.

For R0-to-R2, we find that changes to the previous year's Q4, e.g. from annual benchmarking, cause large effects on revisions to Q1 growth estimates.

# Are productivity revisions predictable ?

We tested how well  $LP_{40}$  is predicted by early estimates and other variables.

Several compressed OLS regression results below.

N=90 for reference quarters 1994Q1-2016Q2. Regressions include a constant.

- Regress  $LP_{40}$  on  $LP_0$  :  $R^2 = .39$
- Regress  $LP_{40}$  on  $LP_2$  :  $R^2 = .51$
- Regress  $LP_{40}$  on component hours and output growth rates from R0 & R2:  $R^2 = .54$
- Add quarter-of-year and recession indicators:  $R^2 = .57$  (not feasible in practice)

➔ The later LP estimate is better predicted by later data, and slightly better with components of earlier estimates and other controls

# Are Hours and Output revisions predictable?

Predictions of the components of  $LP_{40}$ :

- Regress  $Hours_{40}$  on  $Hours_0$  :  $R^2 = .89$
  - Regress  $Hours_{40}$  on  $Hours_2$  :  $R^2 = .92$
  - Regress  $Hours_{40}$  on  $Hours_2$  and quarter and recession indicators:  $R^2 = .94$
  
  - Regress  $Output_{40}$  on  $Output_0$ :  $R^2 = .61$
  - Regress  $Output_{40}$  on  $Output_2$ :  $R^2 = .68$
  - Regress  $Output_{40}$  on  $Output_2$  and quarter and recession indicators:  $R^2 = .74$
- ➔  $R_{40}$  estimates are predicted better by  $R_2$  than by  $R_0$  data



# Can we predict *magnitudes* of revisions?

- Are big revisions followed by big revisions? Only slightly.
- Regress  $\text{abs}(LP_{40} - LP_2)$  on  $\text{abs}(LP_2 - LP_0)$ :  $R^2 = .01$ 
  - Coefficients on previous magnitudes are positive for magnitude
- Add regressors for  $LP_0$ ,  $LP_2$ ,  $\text{abs}(LP_0)$ ,  $\text{abs}(LP_2)$ , quarter of year
  - $R^2$  is less than .2



# Predictability in special periods

- Do properties of reference quarter predict revisions of LP?
- In preliminary regressions, these predictors are not statistically significant for R2-to-R40 revisions or abs(R2-to-R40 revisions)
  - Recessions
    - 1990s vs 2000s vs 2010s
    - 9/11
- 2008 Q4 is an outlier, associated with financial crisis
  - Output, hours, and productivity were revised down a lot

# Comprehensive revisions to GDP

- BEA adopts conceptual and methodology changes in Comprehensive Revisions to GDP every 5 years
- Major changes adopted in 2013 recognized expenditures on R&D and original works of entertainment, art, and literature as capital, not just short-term expenses.
- This raised measured GDP *levels* by an average of 3.1% for the 1993-2012 period (Fixler, 2012)
- We find measured productivity *growth* for previous quarters increased on average by .15% per year.
  - The new elements were growing faster than the rest of GDP.
  - The effect varies greatly across quarters.
- The 2018 Comprehensive Revision raised measured labor productivity by .06% per year.

| Release month | Reference periods     | Average and range of revisions to output growth rate | Average and range of revisions to hours-worked growth rate | Average and range of revisions to labor productivity growth rate |
|---------------|-----------------------|------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------|
| Aug. 2013     | 1994-2011 (N=72 qtrs) | 0.174 (-2.43, 2.54)                                  | .023 (-0.056, 0.159)                                       | <b>0.150</b> (-2.74, 2.55)                                       |
| Aug. 2018     | 1994-2016 (N=92 qtrs) | 0.057 (-1.30, 1.431)                                 | -.003 (-.071, 0.066)                                       | <b>0.062</b> (-1.26, 1.45)                                       |



# 2020, the start of the covid period

- 2020's output and hours quarterly growth rates were extreme
  - Downturn starting in March and in Q2, then up in Q3, at 30% annual pace
- Agencies adopted special methods to capture this rapid change
  - BEA used high frequency data (e.g. credit cards transactions) and will continue
  - BLS used initial Unemployment Insurance claims to adjust hours (one time only)
- Revisions from  $LP_0$  to  $LP_2$  were of the size of the 2008Q4 revisions
- Possibly using high frequency data will reduce revision sizes permanently



# Updated news releases

**SIZE OF REVISIONS:** Productivity and cost measures are revised on a regular schedule as more complete data become available. . . .

**Based on past revisions, the third estimate of nonfarm business sector quarterly labor productivity growth has differed from the first estimate by -1.0 to +1.4 percentage point about 80 percent of the time. This interval is based on estimates for reference quarters from the first quarter of 2001 to the first quarter of 2021.**

For more about revisions to labor productivity growth see “How large are revisions to estimates of quarterly labor productivity growth?” at

<https://www.bls.gov/osmr/research-papers/2021/ec210040.htm>.



# Conclusions

- We measure revisions to output, hours, and labor productivity
- Revisions to output after R2 tend to be negative, especially for Q1
  - Methodology changes may have reduced size and quarterly variation
- Fan chart shows revisions distribution are not symmetric
  - Early revisions are not normally distributed, especially for output
  - Underlying distribution of hours-worked growth is peaked, not normal
  - We offer prediction intervals based on history, with no distribution assumptions
- Later revisions are not highly predicted by early ones
- We can evaluate effects of methodology changes
  - 2013 Comprehensive Revision raised measured labor productivity growth, .15%/yr

# Contact Information

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# Decomposition of R0-to-R2 Revisions

|              | Average Revision to: |                  |                 |                  | Total |
|--------------|----------------------|------------------|-----------------|------------------|-------|
|              | Output               |                  | Hours           |                  |       |
|              | Current Quarter      | Previous Quarter | Current Quarter | Previous Quarter |       |
| All Quarters | -0.16                | -0.27            | -0.06           | -0.05            | 0.13  |
| Q1           | -1.29                | -1.01            | -0.15           | -0.12            | -0.25 |
| Q2           | 0.25                 | -0.13            | -0.11           | 0.00             | 0.49  |
| Q3           | 0.38                 | 0.02             | 0.32            | 0.18             | 0.22  |
| Q4           | 0.04                 | 0.04             | -0.32           | -0.25            | 0.07  |

Revisions to Q1 output growth incorporate large revisions to the previous Q4

Sample: 2000-2019, excluding 2018Q4 due to government shutdown (For more see Asher et al., 2021)

# Decomposition of Revisions

Revisions to growth can be accounted for in terms of changes to output or hours, **and to current or prior quarter.**

We find that changes to the previous year's Q4 cause substantial effects on revisions to Q1 growth estimates.

Labor productivity growth can be approximated as:

$$LP\ Growth_{t-1,t} \approx [\ln(Q_t) - \ln(Q_{t-1})] - [\ln(H_t) - \ln(H_{t-1})]$$

where Q and H are indexes of output and hours

This gives us an additive framework to analyze revisions

$$LP\ Revision_{0,2} = LP\ Growth_{t-1,t}^{R2} - LP\ Growth_{t-1,t}^{R0}$$