Measuring labor-force participation and the incidence and duration of unemployment

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Opinions expressed herein are those of the authors alone and do not necessarily reflect the views of the Federal Reserve System.

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Purpose of this paper

Current Population Survey (CPS)

- Primary source for U.S. statistics on unemployment and labor force
- Contains many internal inconsistencies

Our paper

- Documents these problems
- Proposes a reconciliation

Current Population Survey

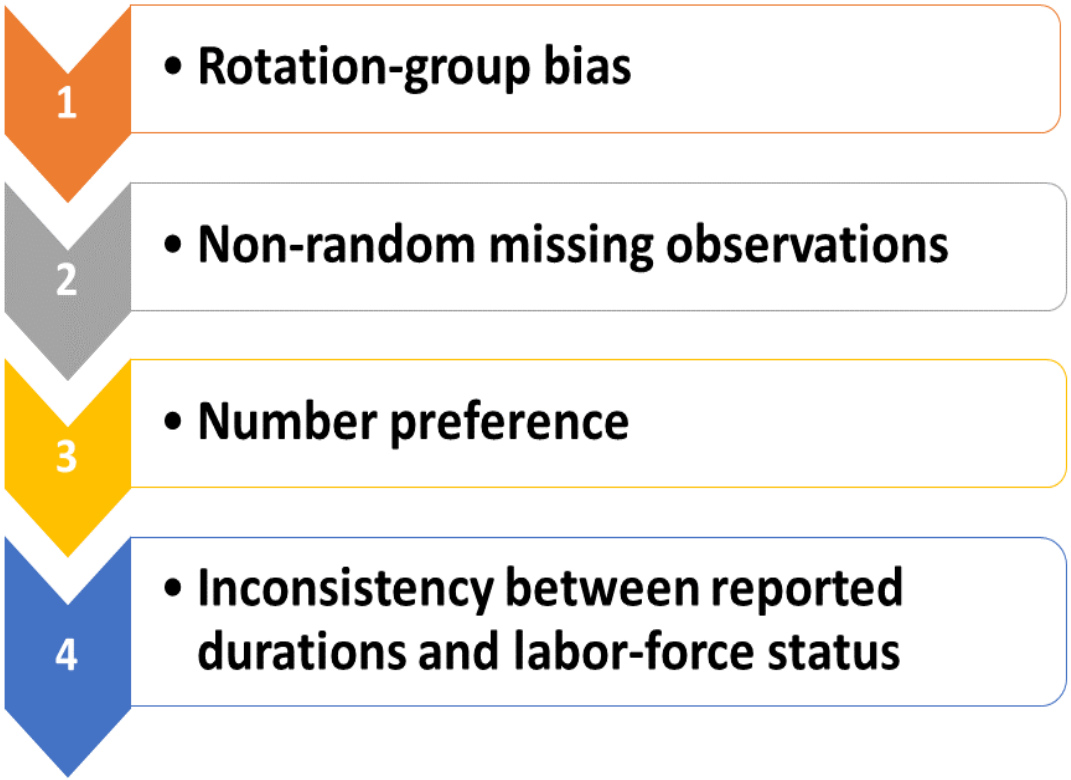
CPS randomly selects address and seeks to classify each noninstitutionalized individual aged 16 and over:

- Employed (E)
  - Worked during reference week for own business or for pay or absent due to vacation, illness, weather
- Unemployed (U)
  - Not employed but made specific efforts to find work any time during last 4 weeks
- Not in labor force (N)

Rotation group structure (4-8-4)

- 1/8 of households enter the survey for the first time, are surveyed four times, leave the survey for 8 months, return to the survey and are surveyed for 4 months.

Key measurement problems



Problem 1: Rotation-group bias

- The UR and LFPR should be the same across rotations.
- Average UR and LFPR (July 2001-April 2018)
  - 6.8 percent in rotation 1, 5.9 percent in rotation 8
  - 66.0 percent in rotation 1, 64.3 percent in rotation 8

Implication if track fixed group of individuals over time, in typical month find net flows out of U and out of LF.

Solution

- Model statistically the way answers change the more times people have been asked → Rotation-specific interview technology
- Propose a method to calculate measures using any of the 8 interview technologies: first interview technology.

Problem 2: Non-random missing observations

- If someone was sampled last month but missing this month, more likely than general population to have been U last month
- If someone was missing last month but sampled this month, more likely than general population to be U this month

Solutions

- Add a fourth observed category (M = missing)
- Construct data set in which accounting identities relating stocks and flows hold by construction
- Sum of EE, NE, ME, UE transitions between rotation 1 and 2 exactly equals number of E for rotation 2
- Will use observations when individuals are E, N, U to infer something about status when M

Problem 3: Number (digit) preference

When reporting the duration of unemployment, more likely to

- round to months or years
- report in even numbers (2,4,6,8,10 weeks $>$ 1,3,5,7,9 weeks) or rounded numbers (3 months, 6 months, 1 year)

Our solution: represent individuals' perceived duration of unemployment using a parametric monotonic function; model digit-reporting preferences as layer on top of this

Our contribution: our parametric specification allows direct linkage of data on stocks, flows, and durations and includes both digit and interval preference.

Problem 4: Reported durations of unemployment inconsistent with reported labor-force histories

NU^{5+} **transitions**: Consider N in RG1 (t) , U in RG2 $(t+1)$.

- 2/3 say actively looking for work for longer than 4 weeks
- 8% say searching for 1 year and another 8% say 2 years

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Probability of leaving U. VS U. duration: Consider 2011.

- Long-term unemployed had probability 0.25 of exiting U.
- Implied mean duration: no larger than 4 (1/0.25) months.

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Solutions to the inconsistency

- Classify those who make $N_{t-1}U_t^{5.+}$ transitions as U in $t-1$
- Classify some of those who make $U_{t-1}^{15.+}N_t$ transitions as U in t

Adjusting for the measurement errors (2001 -2018)

1. **Unemployment rate** : $\Uparrow$ 1.9%p UR UR Error
   - RGB (+0.5pp), Missing (+0.3pp), NU adjustment (+1.1pp)
   - Counter-cyclical errors ($\leftarrow$ NU misclassification)

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2. **Labor-force participation rate** : ⇑ 2.2%p LFPR LFPR Error
   - RGB (+1.2pp), Missing (+0.2pp), NU adjustment (+0.8pp)
   - Slowly rising trend in errors (← RGB, missing observations)
   - Counter-cyclical errors (← NU misclassification)

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   - Counter-cyclical errors (← NU misclassification)
3. **Mean duration of U.** : ⇓ 9 weeks Duration
   - More inflows $>$ Fewer exits ← RGB, missing, NU adjustment
   - Adjusted LTU. $\approx$ Size of recipients of extended UI benefits

1	• Rotation-group bias	• Model statistically
2	• Non-random missing observations	• Allocate *MX* transitions based on observed *XX*
3	• Number preference	• Model statistically
4	• Inconsistency between reported durations and labor-force status	• Reclassify some *N* as *U*

Notation

- $\pi_t^{[j]} = (4 \times 1)$ vector of observed fractions of each status $X \in \{E, N, M, U\}$ in rotation j in month t
- $\Pi_t^{[j]} = (4 \times 4)$ matrix of probabilities that someone who reports status X_1 in rotation $j-1$ in month $t-1$ will report status X_2 in month t for rotation $j \in J = \{2, 3, 4\} \cup \{6, 7, 8\}$
- Our constructed data exactly satisfy $\pi_t^{[j]} = \Pi_t^{[j]} \pi_{t-1}^{[j-1]}$ for $j \in J$

$$\begin{bmatrix} \pi_{E,t}^{[j]} \\ \pi_{N,t}^{[j]} \\ \pi_{M,t}^{[j]} \\ \pi_{U,t}^{[j]} \end{bmatrix} = \begin{bmatrix} \pi_{EE,t}^{[j]} & \pi_{NE,t}^{[j]} & \pi_{ME,t}^{[j]} & \pi_{UE,t}^{[j]} \\ \pi_{EN,t}^{[j]} & \pi_{NN,t}^{[j]} & \pi_{MN,t}^{[j]} & \pi_{UN,t}^{[j]} \\ \pi_{EM,t}^{[j]} & \pi_{NM,t}^{[j]} & \pi_{MM,t}^{[j]} & \pi_{UM,t}^{[j]} \\ \pi_{EU,t}^{[j]} & \pi_{NU,t}^{[j]} & \pi_{MU,t}^{[j]} & \pi_{UU,t}^{[j]} \end{bmatrix} \begin{bmatrix} \pi_{E,t-1}^{[j-1]} \\ \pi_{N,t-1}^{[j-1]} \\ \pi_{M,t-1}^{[j-1]} \\ \pi_{U,t-1}^{[j-1]} \end{bmatrix}$$

Details 1: Fix based on Rotation 1 technology

Halpern-Manners and Warren (2012)

- Saying that you looked for a job hard but failed carries stigma
- Individuals may believe that follow-up questions for U are onerous
  - "What have you done to look for work in the last 4 weeks?"
  - "How long have you been looking for a job?"
- The unemployment rates in rotations 2-8 are likely to understate the truth. $\rightarrow$ fixed based on RG1 technology

Can correct for the RGB using any of the 8 interview technologies or some combinations of them.

Statistical description of the Rotation Group Bias

$R_t^{[j]}$: a matrix that contains the probabilities that an individual would have answered LFS X^1 using technology 1 given answered LFS X^j using technology j ($r^{[j]}_{X^1 X^j, t}$)

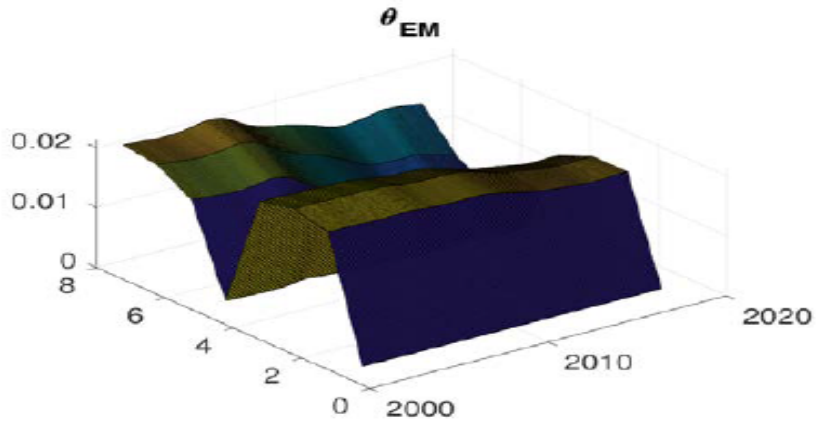
$$R_t^{[j]} \pi_t^{[j]} = \pi_t^{[1]} = \underbrace{\pi_t^*}_{\text{RGB fixed share}}$$

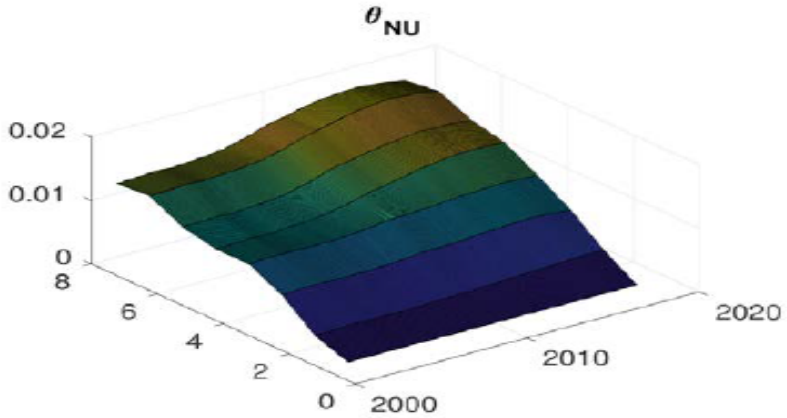
By picking 3 elements of $R_t^{[j]}$ could satisfy this exactly.

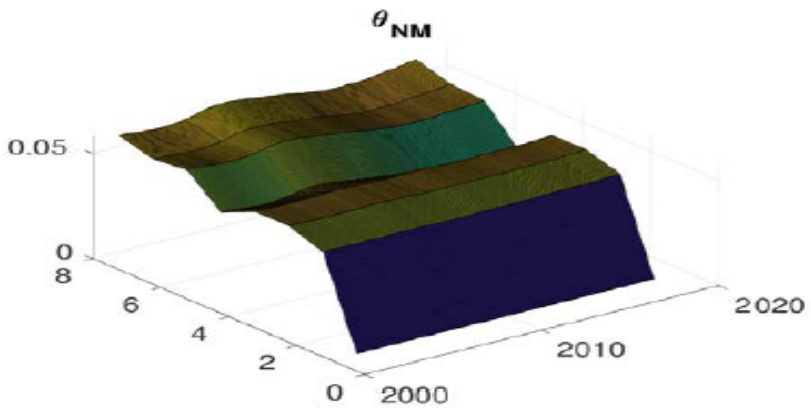
- More missing in RG.1 and 5
- Fewer E/N in in RG.1 and 5 ($\theta^{[j]}_{EM}$, $\theta^{[j]}_{NM}$)
- Rising N, falling U the more time surveyed ($\theta^{[j]}_{NU}$)

Changes in rotation-group bias over time

$\theta^{[j]}_{NU,t}$ = fraction of N in rotation j in month t who would have answered U if asked for first time







Reconciled stocks and flows for fixed interview technology

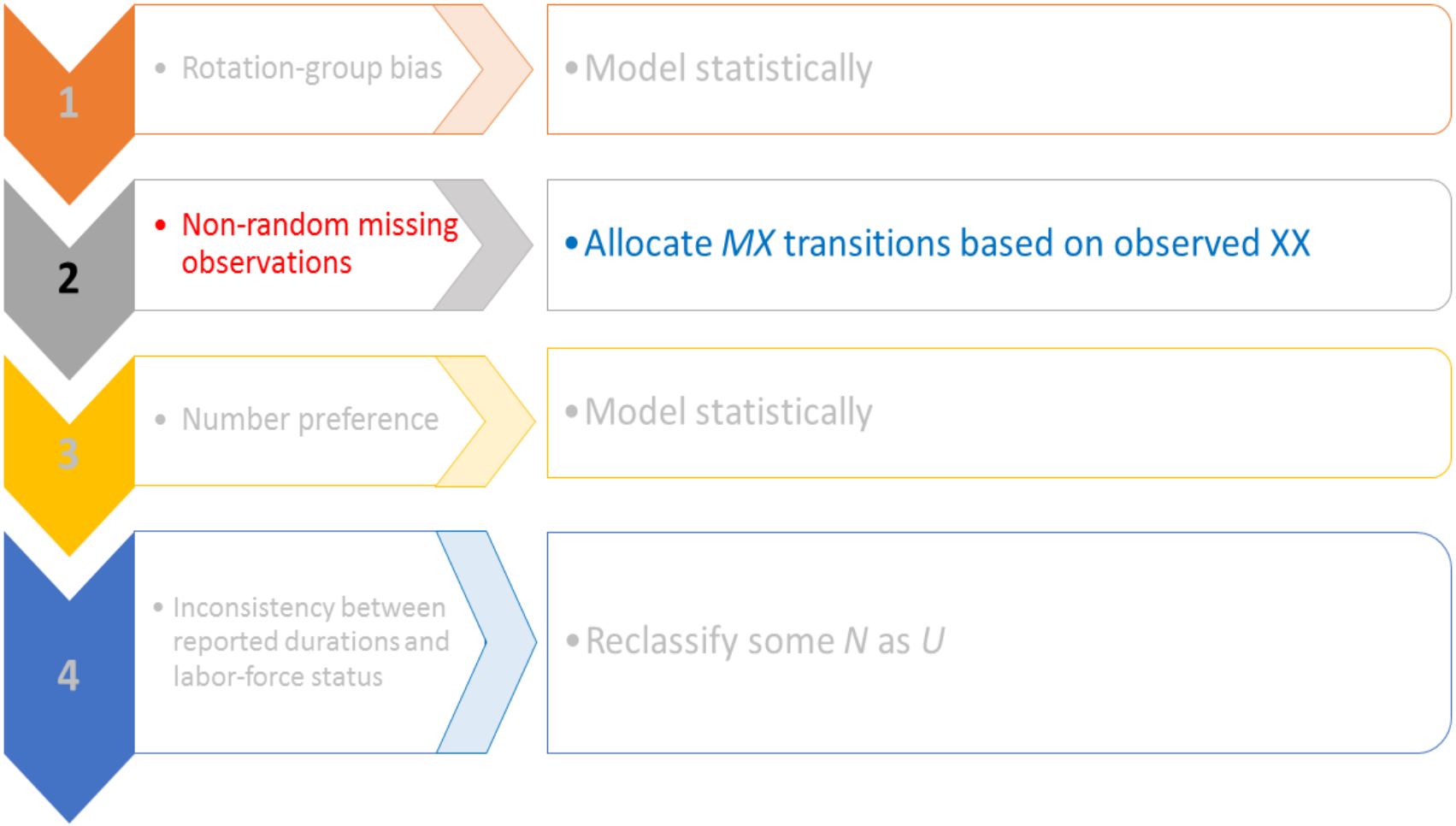
Π_t^*: LFS transition probabilities if interviewed with RG1 technology

$$R_t^{[j]} \Pi_t^{[j]} (R_{t-1}^{[j-1]})^{-1} = \Pi_t^*$$

Given π_{t-1}^*, choose Π_t^* to minimize sum of squares of

$$\Pi_t^{[j]} - (R_t^{[j]})^{-1} \Pi_t^* R_{t-1}^{[j-1]} \text{ for } j \in \{2,3,4\} \cup \{6,7,8\}$$
$$\pi_t^{[1]} - \Pi_t^* \pi_{t-1}^*$$
$$\pi_t^{[5]} - (R_t^{[5]})^{-1} \Pi_t^* \pi_{t-1}^*$$

Then set $\pi_t^* = \Pi_t^* \pi_{t-1}^*$ and iterate.


1
• Rotation-group bias
• Model statistically
2
• Non-random missing observations
• Allocate *MX* transitions based on observed XX
3
• Number preference
• Model statistically
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Details 2: Nonrandom missing observations

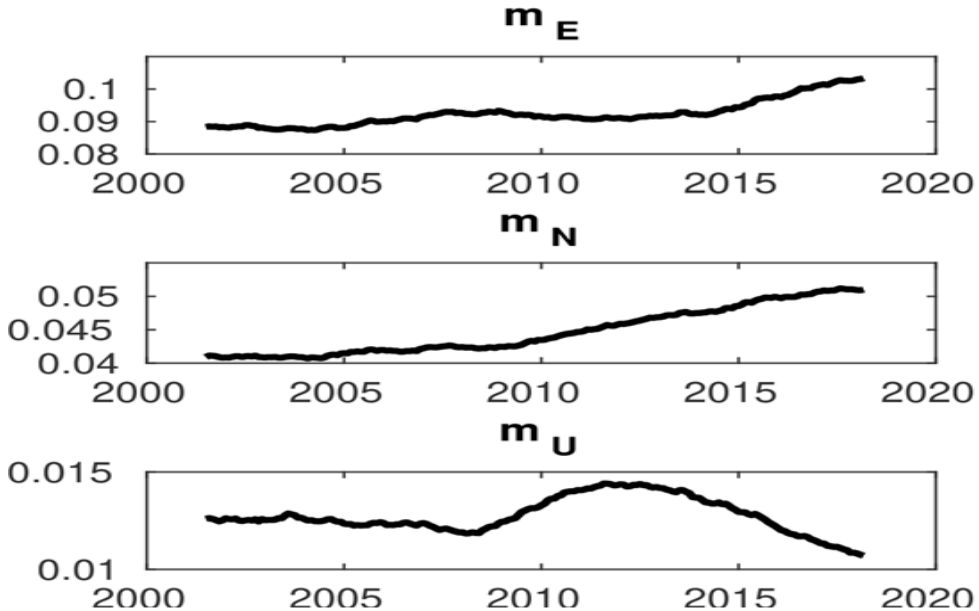
After correcting for the rotation group bias

Goal: recover the fraction of E,U, and N from missing individuals

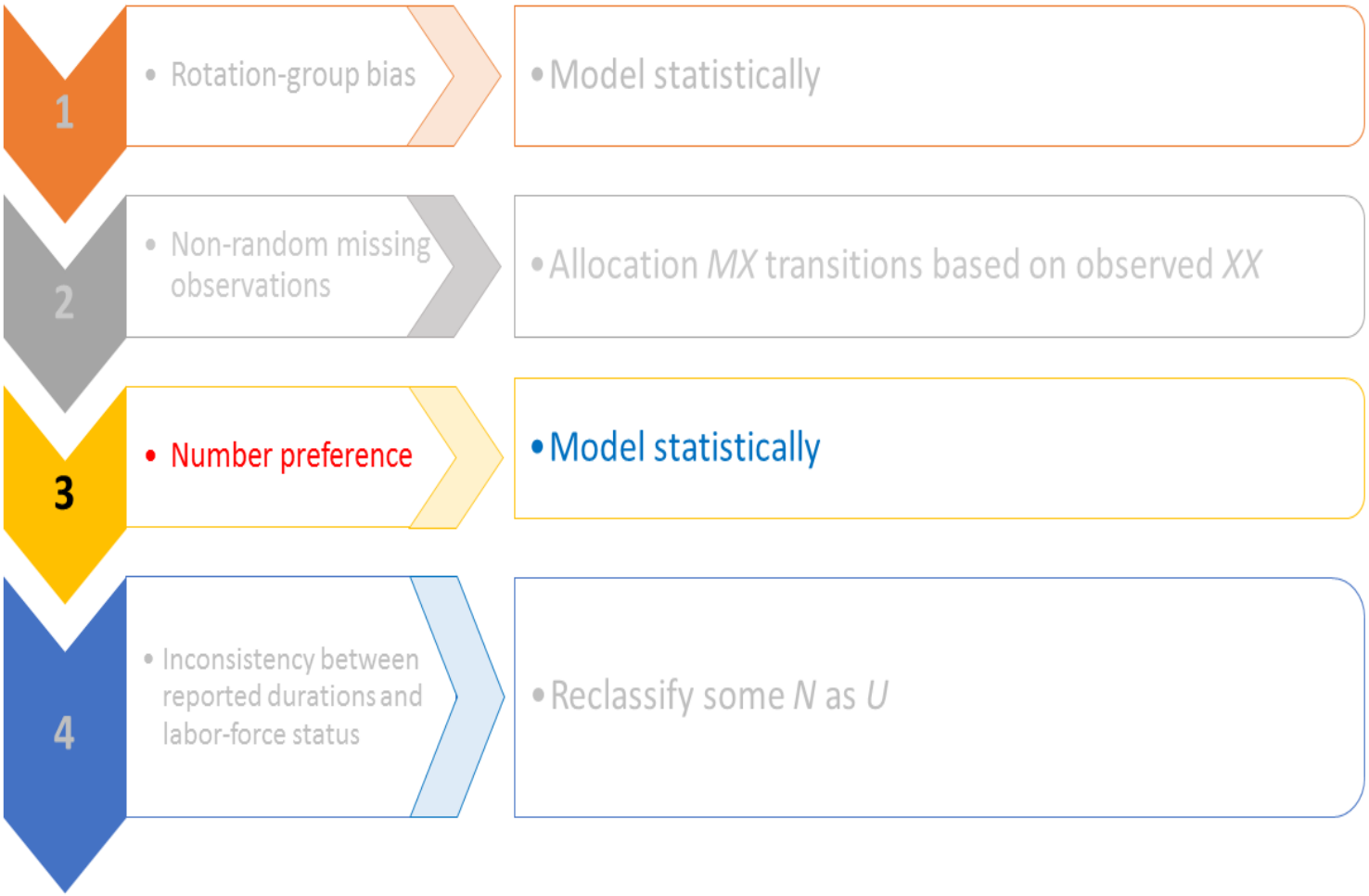
- True LFS of missing individuals might have been E, U, or N $\rightarrow$ ME transitions as mixtures of EE, NE, UE transitions
- Same for MN and MU

$$\begin{bmatrix} \pi^*_{ME,t} \\ \pi^*_{MN,t} \\ \pi^*_{MU,t} \end{bmatrix} = \begin{bmatrix} \pi^*_{EE,t} & \pi^*_{NE,t} & \pi^*_{UE,t} \\ \pi^*_{EN,t} & \pi^*_{NN,t} & \pi^*_{UN,t} \\ \pi^*_{EU,t} & \pi^*_{NU,t} & \pi^*_{UU,t} \end{bmatrix} \begin{bmatrix} m_{E,t-1} \\ m_{N,t-1} \\ m_{U,t-1} \end{bmatrix}$$

Fractions of M interpreted as E, N, or U each month

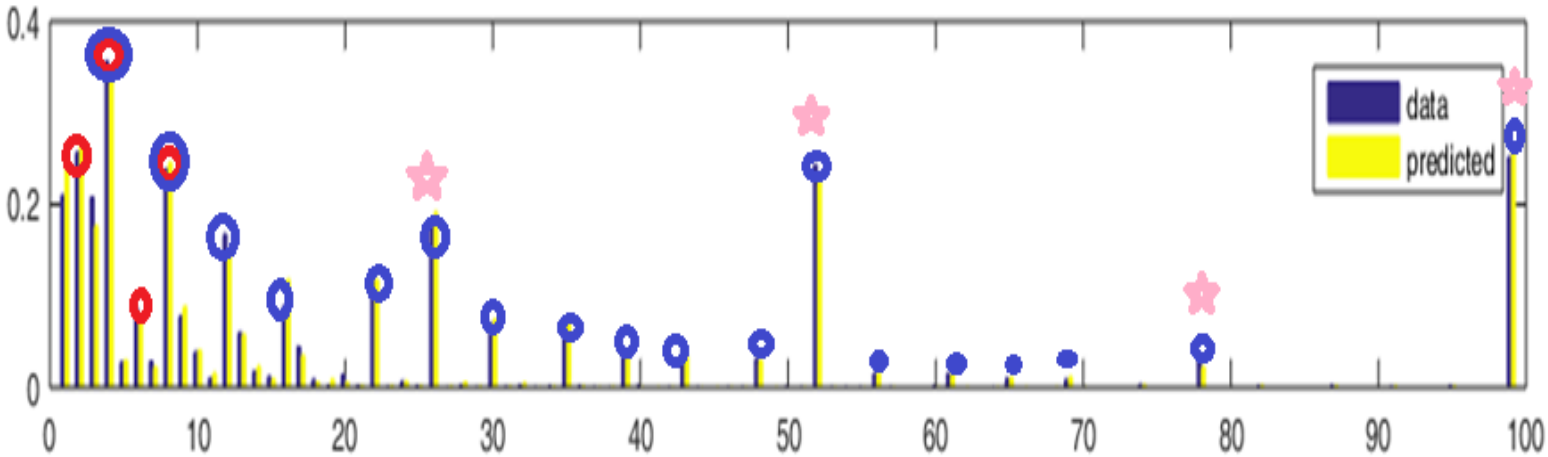


- Rising trend in missing individuals who might have been E/N.
- Countercyclical behavior of m_U: unemployed individuals are more likely to be missed during a weak labor market.


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Details 3: Number (Digit) preference

Distribution of unemployment duration: percent of rotation-group 1 population reporting duration τ weeks



- Preference for even numbers (red circle)
- Preference of rounded numbers (rounding to month: blue; half year: pink)

Distribution of U. duration free from number preference

Step 1: Model underlying latent distribution of perceived durations using a parametric monotonic distribution

- Baseline specification: mixture of exponentials

$$\pi_U^{\dagger}(\tau) = w_1(1-p_1)p_1^{\tau} + w_2(1-p_2)p_2^{\tau}$$

- w_i = fraction of unemployed of type i $(w_1 + w_2 = 1)$
- A fraction of the population $\pi_U w_i(1-p_i)$ lose their job each week and have unemployment-continuation prob p_i $(i = 1, 2)$

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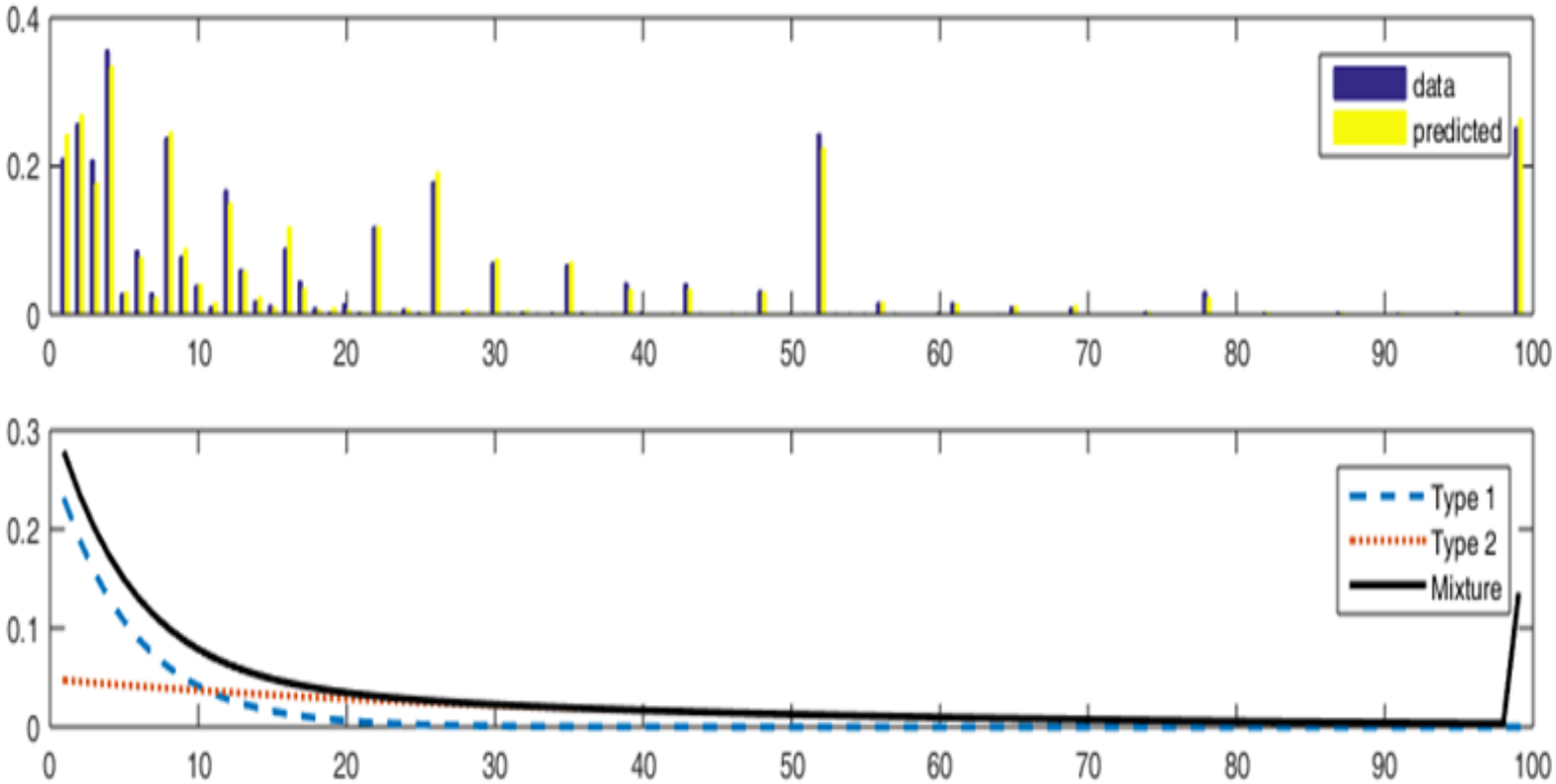
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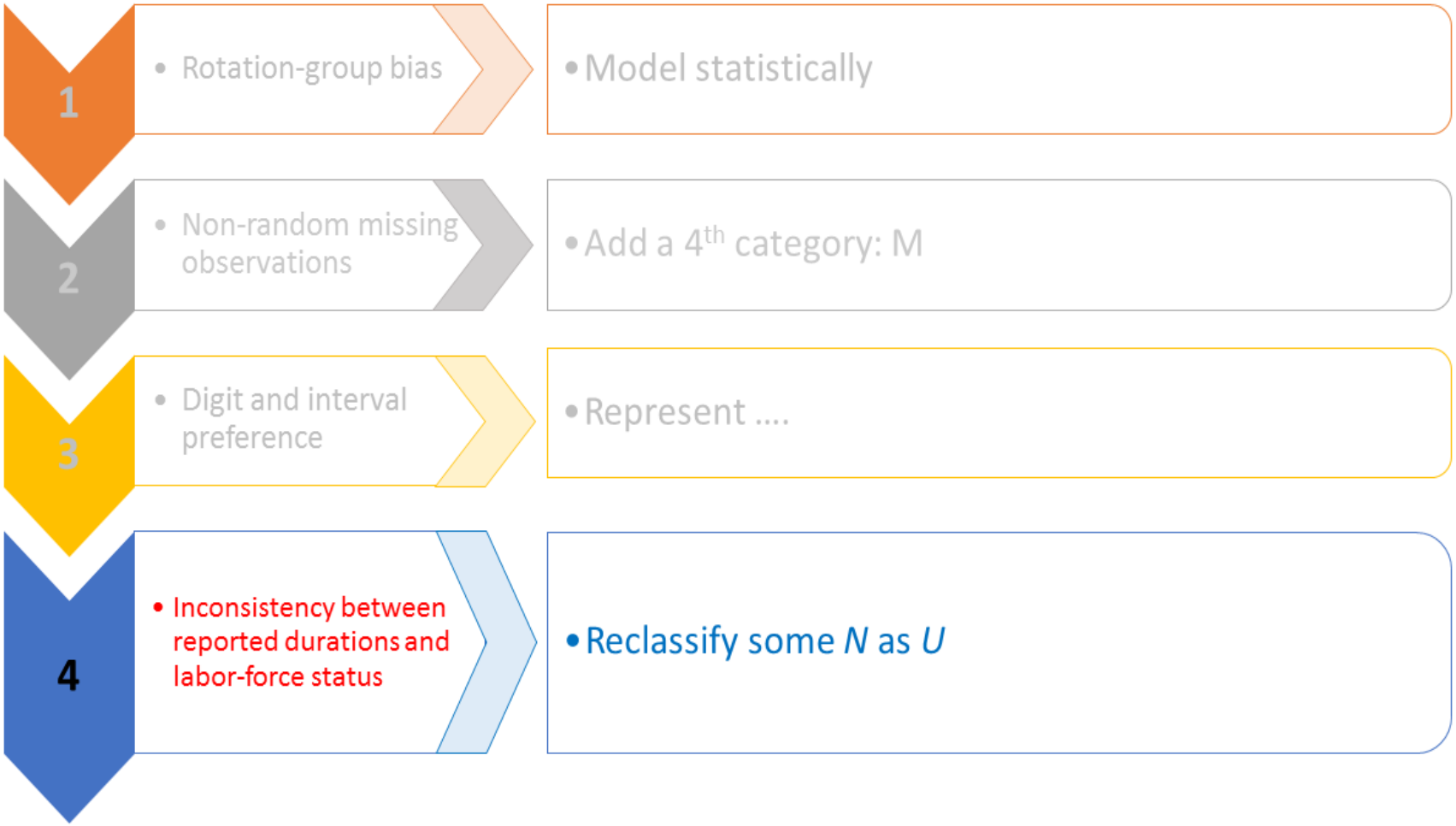
Step 2: Model reported durations as probabilistic transformation of perceived durations

- Preference for even numbers, digits and rounded numbers

Distribution of U. duration free from number preference

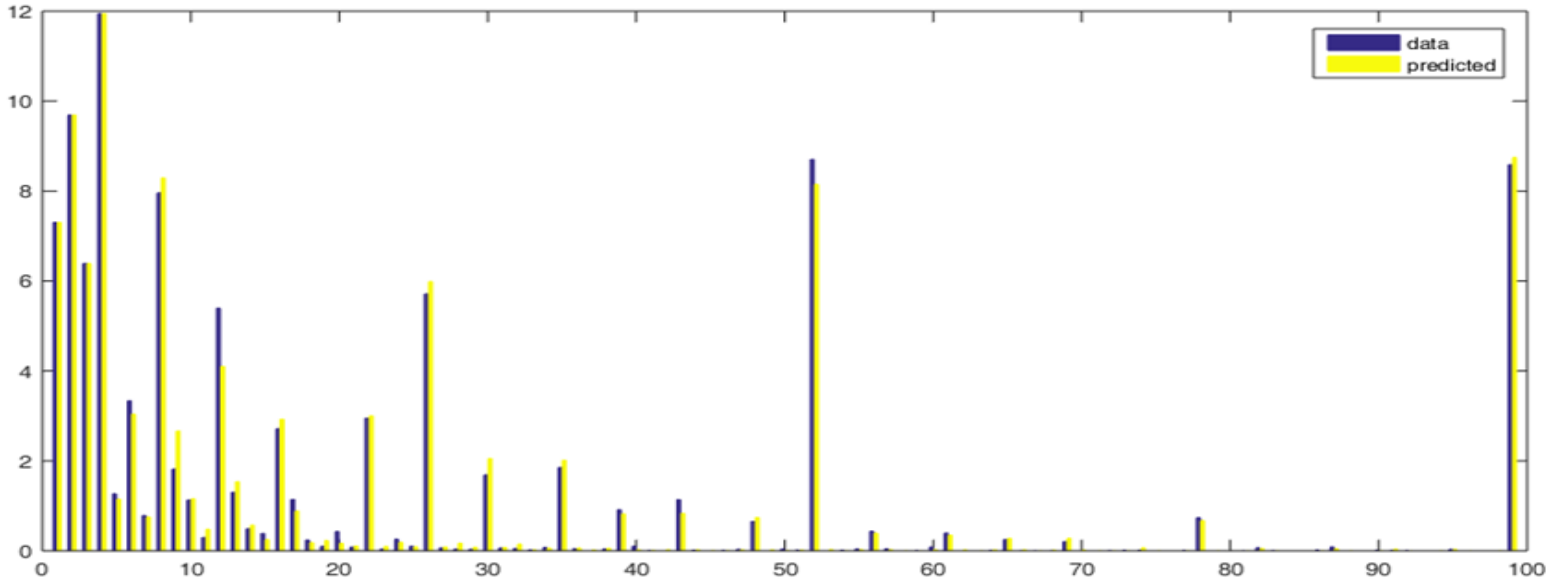


$$\hat{p}_1 = 0.8271,\ \hat{p}_2 = 0.9738,\ \hat{w}_1 = 0.4243,\ \hat{w}_2 = 0.5757$$


1
• Rotation-group bias
• Model statistically
2
• Non-random missing observations
• Add a 4th category: M
3
• Digit and interval preference
• Represent ....
4
• Inconsistency between reported durations and labor-force status
• Reclassify some N as U

Details 4: Transitions into unemployment

Distribution of unemployment duration reported for people who were N in rotation 1 and U in rotation 2



- Those with records $N_{t-1}U_t^{5.+}$ perceive their status at $t-1$ to have been looking for a job (U_t), though they reported N_{t-1}
- We propose to reclassify these individuals as U at $t-1$

Corroboration based on LFS history

- Preceding N carries information similar to U in predicting future employment
- The pattern of duration dependence is similar between UUU and UNU.

Re-employment probability in month t by LFS history

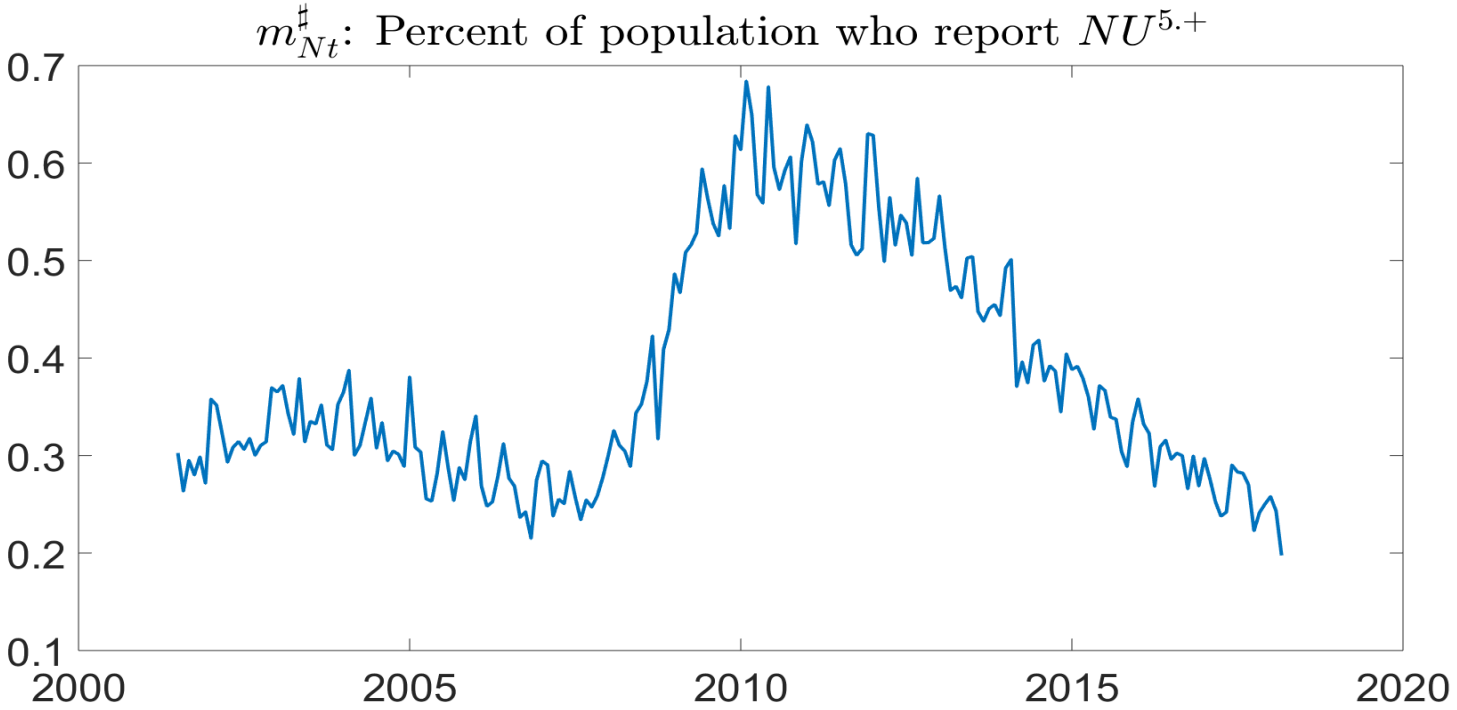
UUU	Probability	UNU	Probability
$U_{t-2}, U_{t-1}^{5.+}$	0.15	$N_{t-2}, U_{t-1}^{5.+}$	0.13
$U_{t-3}^{5.14}, U_{t-2}^{5.14}, U_{t-1}^{15.26}$	0.16	$U_{t-3}^{5.14}, N_{t-2}, U_{t-1}^{15.26}$	0.14
$U_{t-3}^{15.26}, U_{t-2}^{15.26}, U_{t-1}^{15.26}$	0.14	$U_{t-3}^{15.26}, N_{t-2}, U_{t-1}^{15.26}$	0.15
$U_{t-3}^{15.26}, U_{t-2}^{27.+}, U_{t-1}^{27.+}$	0.11	$U_{t-3}^{15.26}, N_{t-2}, U_{t-1}^{27.+}$	0.10
$U_{t-3}^{27.+}, U_{t-2}^{27.+}, U_{t-1}^{27.+}$	0.08	$U_{t-3}^{27.+}, N_{t-2}, U_{t-1}^{27.+}$	0.07

Importance of LFS history: Kudlyak and Lange (2018)

Corroboration from marginally attached workers and American Time Use Survey (ATUS)

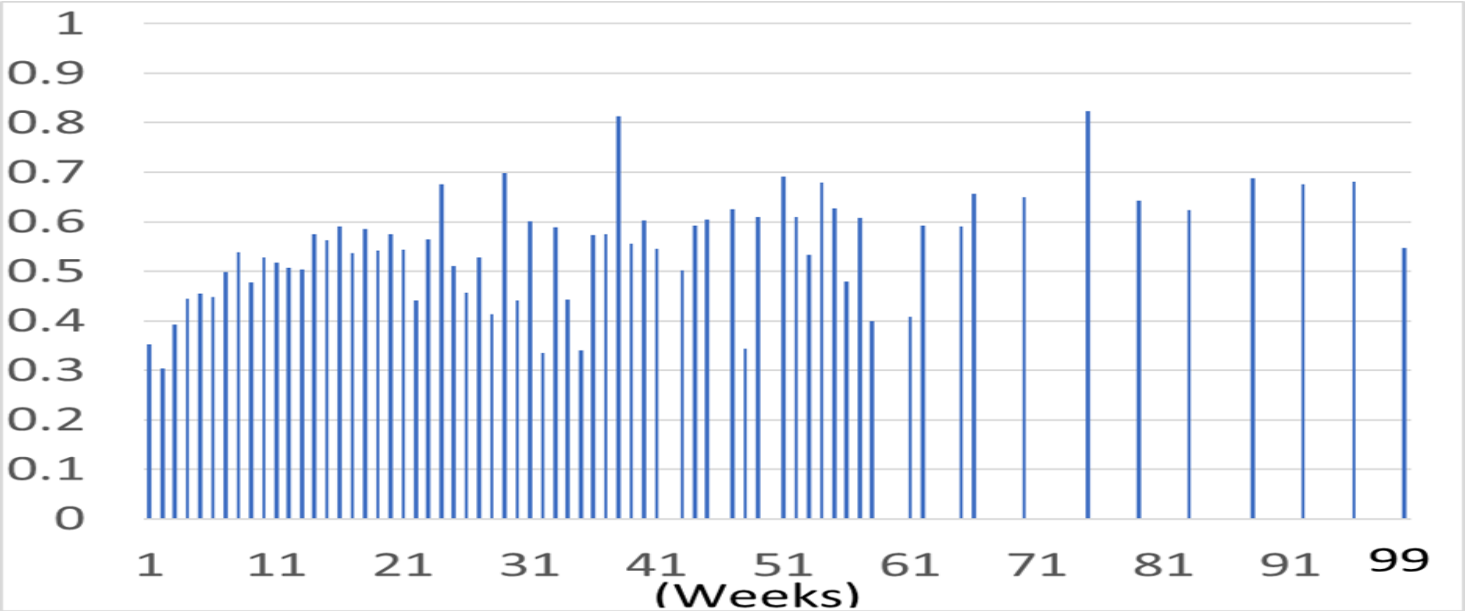
- **Marginally attached workers** reported N, but said they did job search some time in the last 12 months, but not the previous four weeks, and available for work.
- Marginally attached workers spend as much time for job search as unemployed workers according to ATUS. (154 mins vs 143 mins conditional on positive job search)
- 40% of $NU^{5.+}$ transitions were marginally attached workers, though they account for only 2.2 % of N.
- Only 10% of N who spend positive time searching in ATUS are counted as marginally attached. N category includes many job seekers who behave like the unemployed.

Size of $NU^{5.+}$: Countercyclical



Details 5: Transitions out of unemployment

Probability that someone who is U. in RG 1 with duration τ weeks will still be U in RG 2. $\rightarrow$ Duration dependence in UU continuation



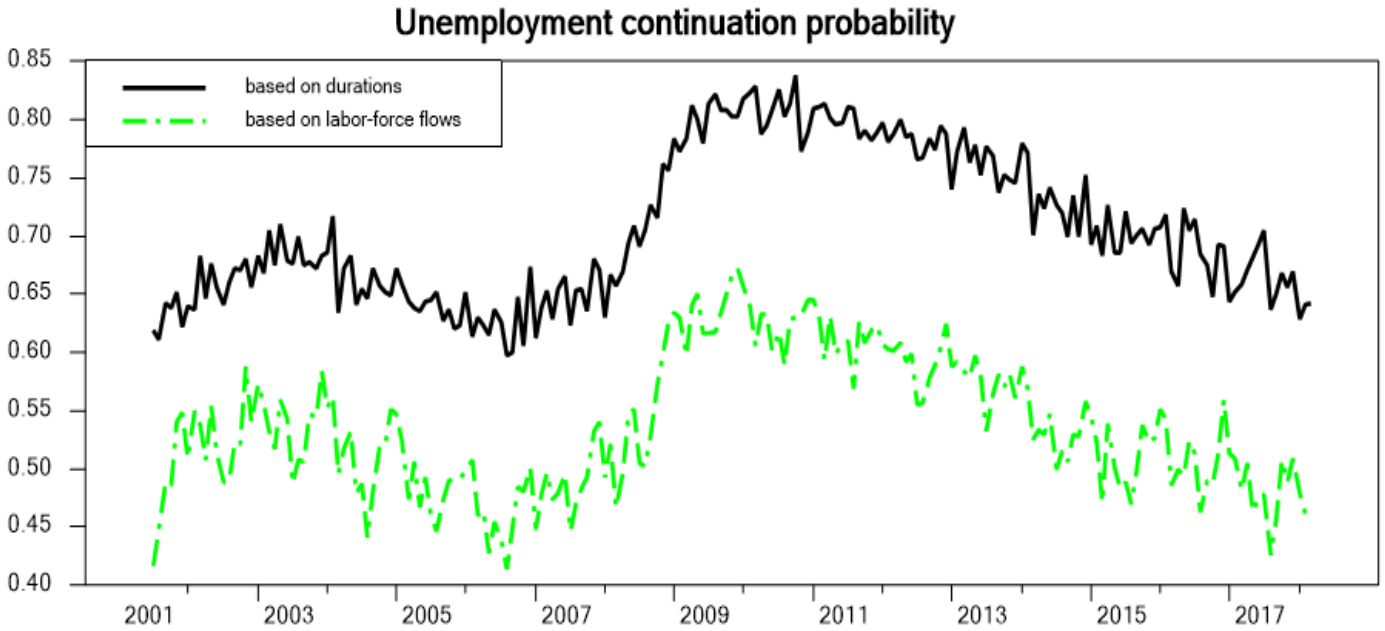
Can postulate, $\dot{\pi}_{UU}(\tau) = \eta_1(\tau)\gamma_{1,UU} + \eta_2(\tau)\gamma_{2,UU}$

$\gamma_{1,UU} = 0.37$, $\gamma_{2,UU} = 0.58$, $\eta_1(1) = 0.82$, $\eta_2(1) = 0.18$

Gamma estimates

$\gamma\hat{U}U^1$, $\gamma\hat{U}U^2$, $\hat{p}^1$, $\hat{p}^2 \rightarrow$ U. continuation probability?

1. Duration: the ratio of number unemployed for 5 weeks and over in t to number unemployed in $t-1$
2. Flows: the fraction of those who continue to be U in $t+1$ out of those who are U in $t \rightarrow$ What's the source of discrepancy?



Type 1: Perceived durations consistent with matched flows

Unemployment continuation probabilities estimated from the distribution of U. duration VS UU flows by duration

p_1: weekly U. continuation prob. from the U. distribution in RG.1

If this perception was consistent with objective probabilities,

$$\frac{\gamma_{1,UU}}{1-\gamma_{1,UM}} \approx p_1^{4.33}$$

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$$\begin{aligned} \frac{\gamma_{1,UU}}{1-\gamma_{1,UM}} &= 0.41 \\ p_1^{4.33} &= 0.40 \end{aligned}$$

Exactly what we should have expected!

Type 2: Perceived durations inconsistent with matched flows

We would also expect

$$\frac{\gamma_{2,UU}}{1-\gamma_{2,UM}} \approx p_2^{4.33}$$

However,

$$\frac{\gamma_{2,UU}}{1-\gamma_{2,UM}} = 0.63, \qquad p_2^{4.33} = 0.89.$$

Perceived durations of the long-term unemployed very different from observed continuation probabilities!

- To reconcile unemployment hazards from the distribution of U. duration and those from the matched flows data, type 2 transitions should be adjusted.

Adjust some *UN* transitions to *UU* continuations

Facts

- Similarity in the duration dependence of those with *UUU* and *UNU* $\rightarrow$ Some of *UN* also should be *UU*
- Discrepancy b/w flows and stock duration data in Type 2 unemployed's UU $\rightarrow$ Adjust type 2's UU $\rightarrow$ majority of $U_t^{15.+}$

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Reconciliation: Find hidden $U_{t-1}^{15.+}U_t$ from $U_{t-1}^{15.+}N_t$

Among those who reported LFS $U_{t-2}^{15.+}$ and N_{t-1}

- Fraction ξ_{UN}: $U_{t-1}^{15.+}U_{t-1}^{19.+}$
- Fraction $1-\xi_{UN}$: $U_{t-1}^{15.+}N_{t-1}^{*} \approx N_{t-1}, N_{t-2}$

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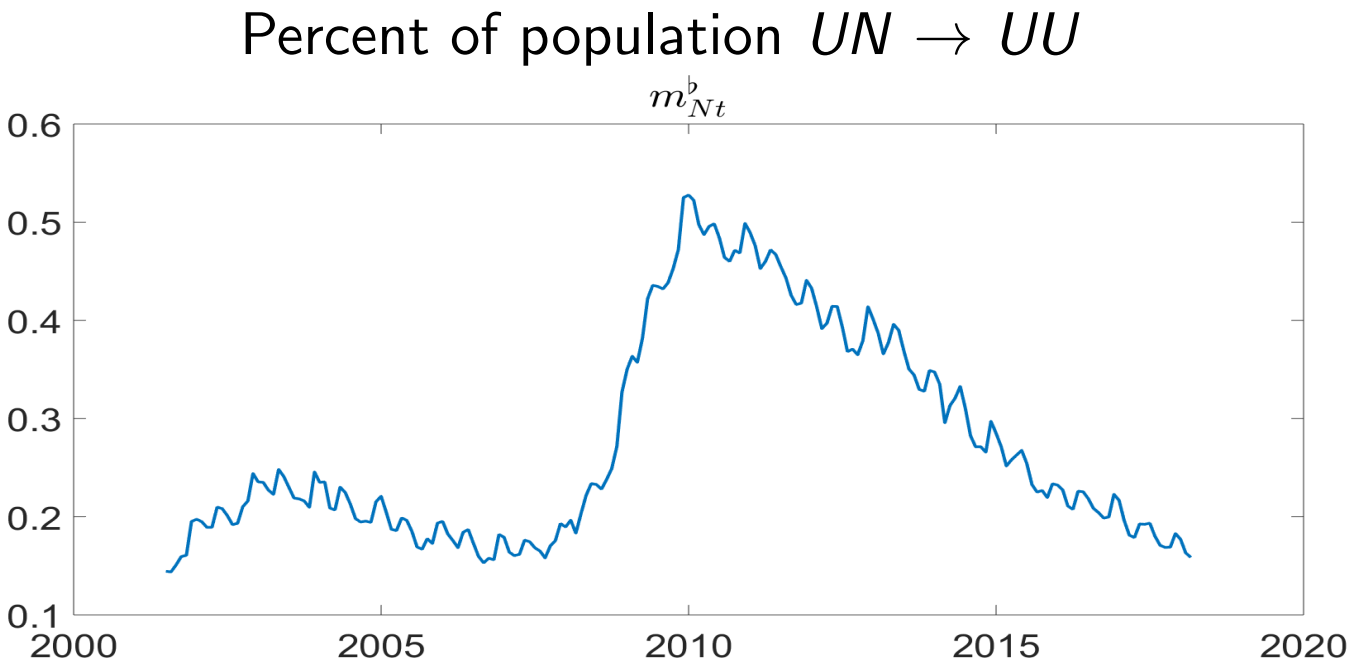
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- Fraction ξ_{UN}: $U_{t-1}^{15.+}U_{t-1}^{19.+}$
- Fraction $1-\xi_{UN}$: $U_{t-1}^{15.+}N_{t-1}^{*} \approx N_{t-1}, N_{t-2}$

$$P(E_t|N_{t-1}, U_{t-2}^{15.+}) = \underbrace{\xi_{UN}}_{=0.633} P(E_t|U_{t-1}^{15.+}, U_{t-2}^{15.+}) + (1-\xi_{UN}) \underbrace{P(E_t|N_{t-1}, N_{t-2})}_{\approx P(E_t|N_{t-1}^{*}, U_{t-2}^{15.+})}$$

Classify 63% of those reported $U_{t-1}^{15.+}N_t$ transitions as U_t. SS flows

Size of *UN* whom we interpret as *UU*: Countercyclical



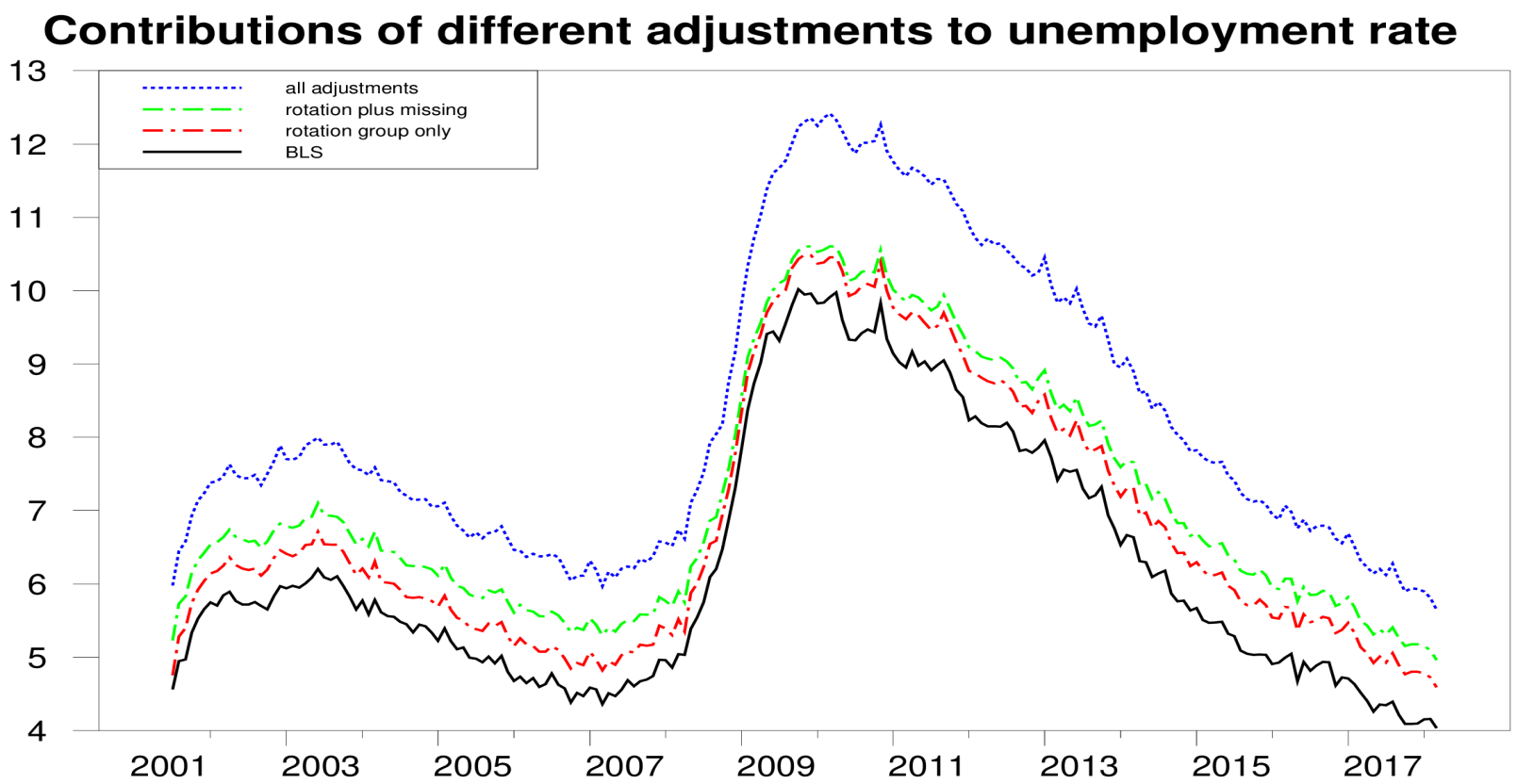
Adjusted unemployment and labor-force participation rates

1. Rotation-group bias $\rightarrow$ $LFPR(+)$, $UR(+)$
2. Missing observations $\rightarrow$ $LFPR(+)$, $UR(+)$
3. Number preference $\rightarrow$ Distribution of perceived duration
4. NU, UN adjustment $\rightarrow$ $LFPR(+)$, $UR(+)$, UU continuation probability $(+)$, Inflows $(+)$
5. Recover the distribution of U. duration

Estimation of time-varying parameters based on filtering with exponential smoothing. Monthly

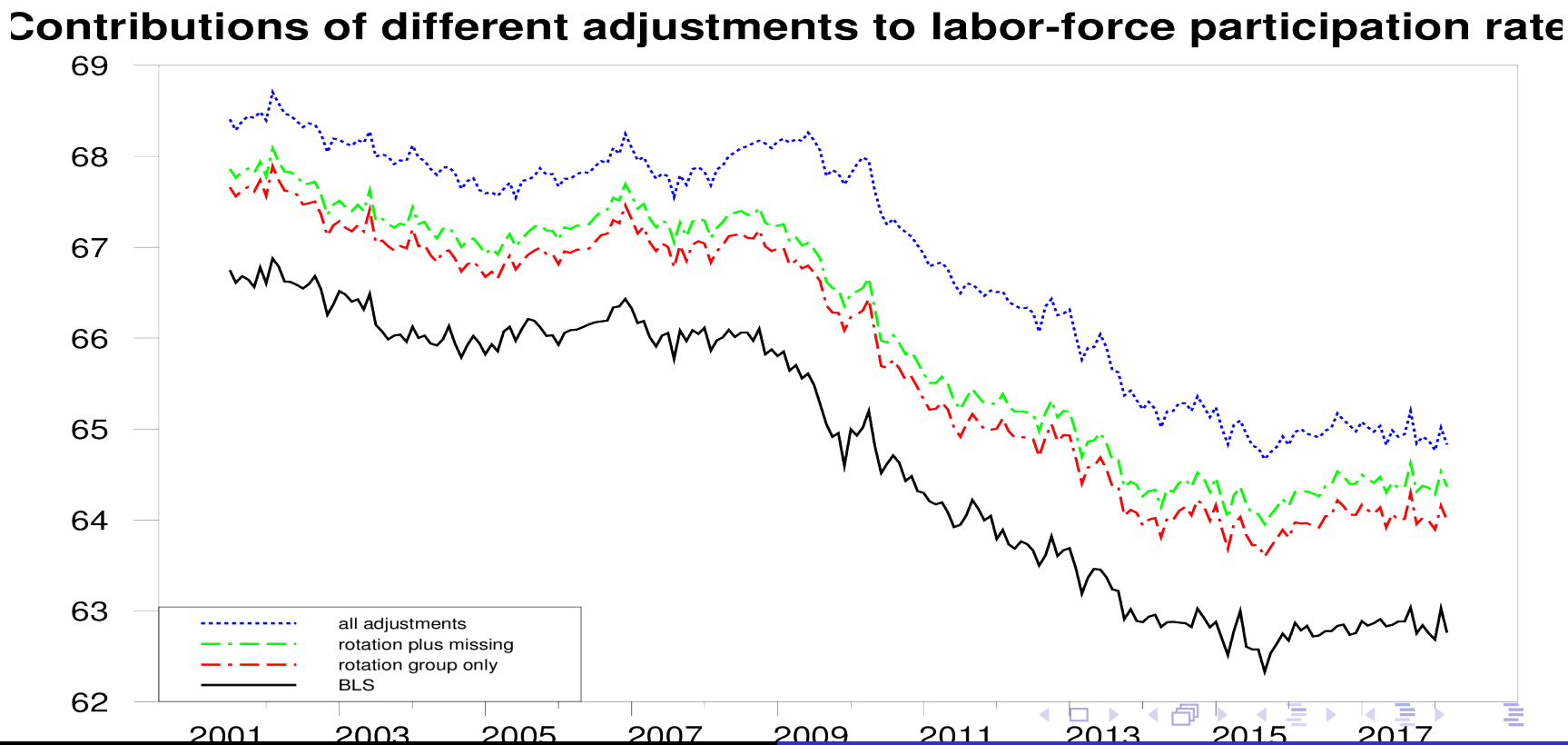
Gap between reconciled and published: weakly countercylical (← NU adjustment) Summary Plot

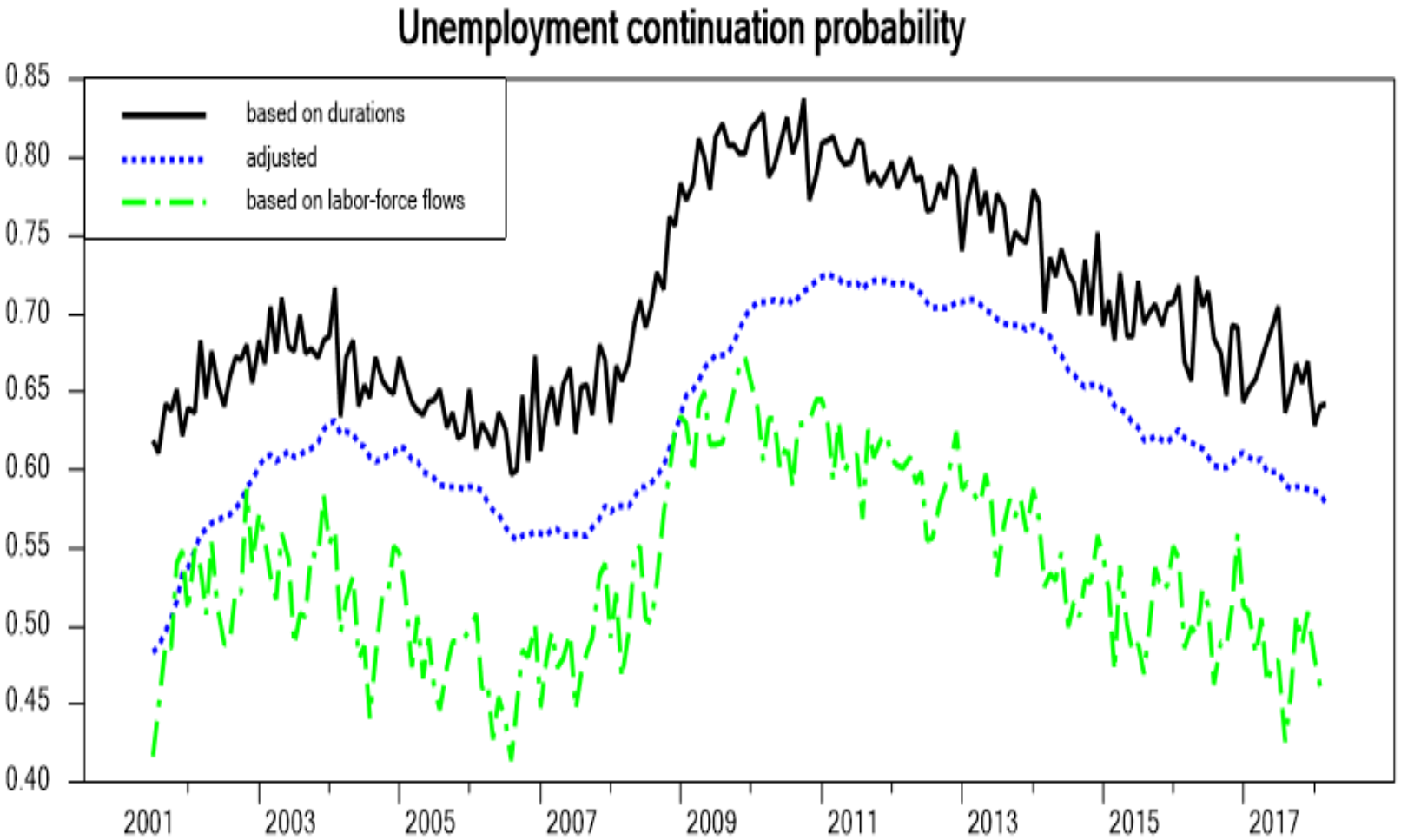
- RGB(+0.5%p), Missing (+0.3%p), NU adjustment (1.1%p)

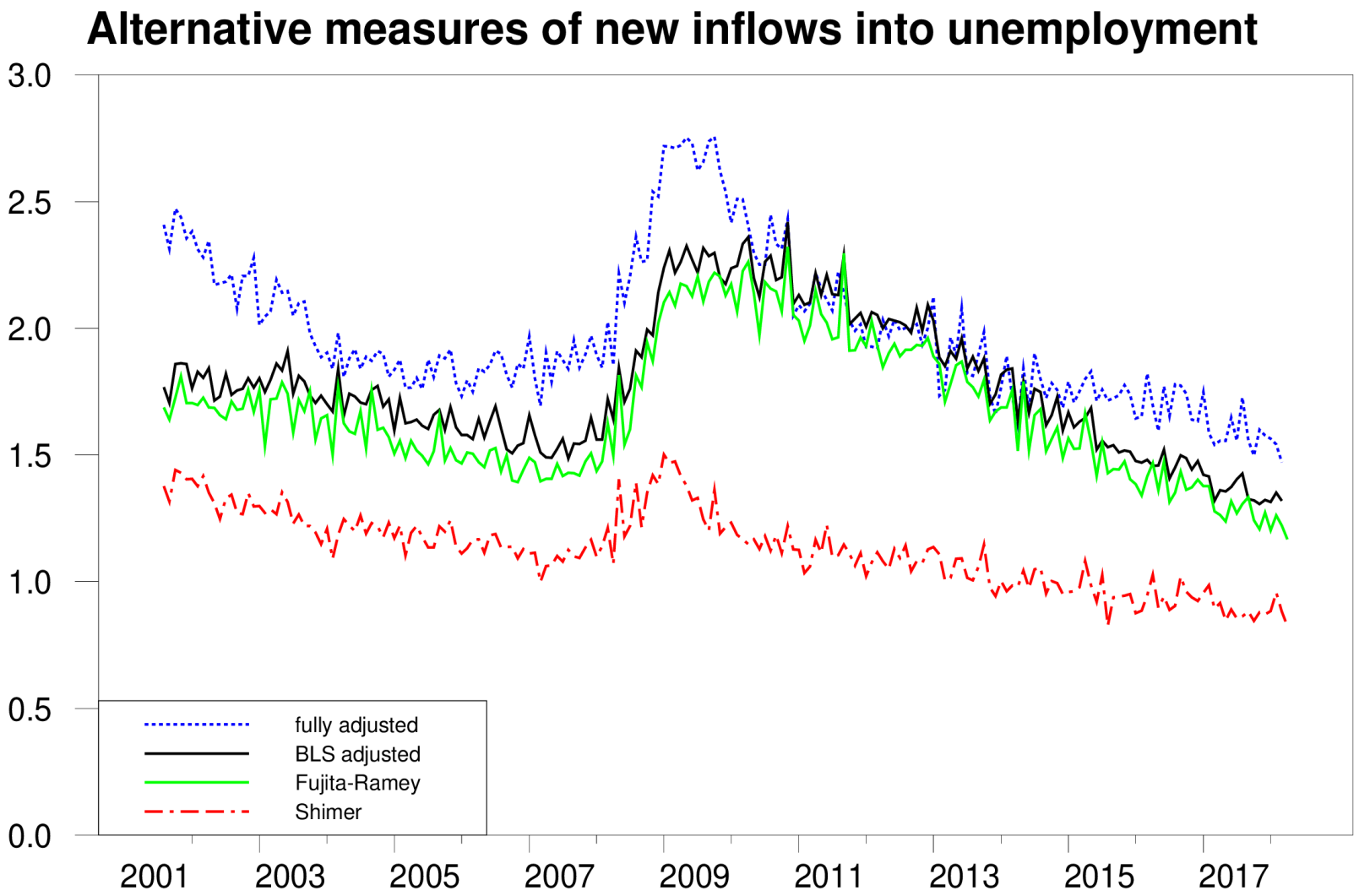


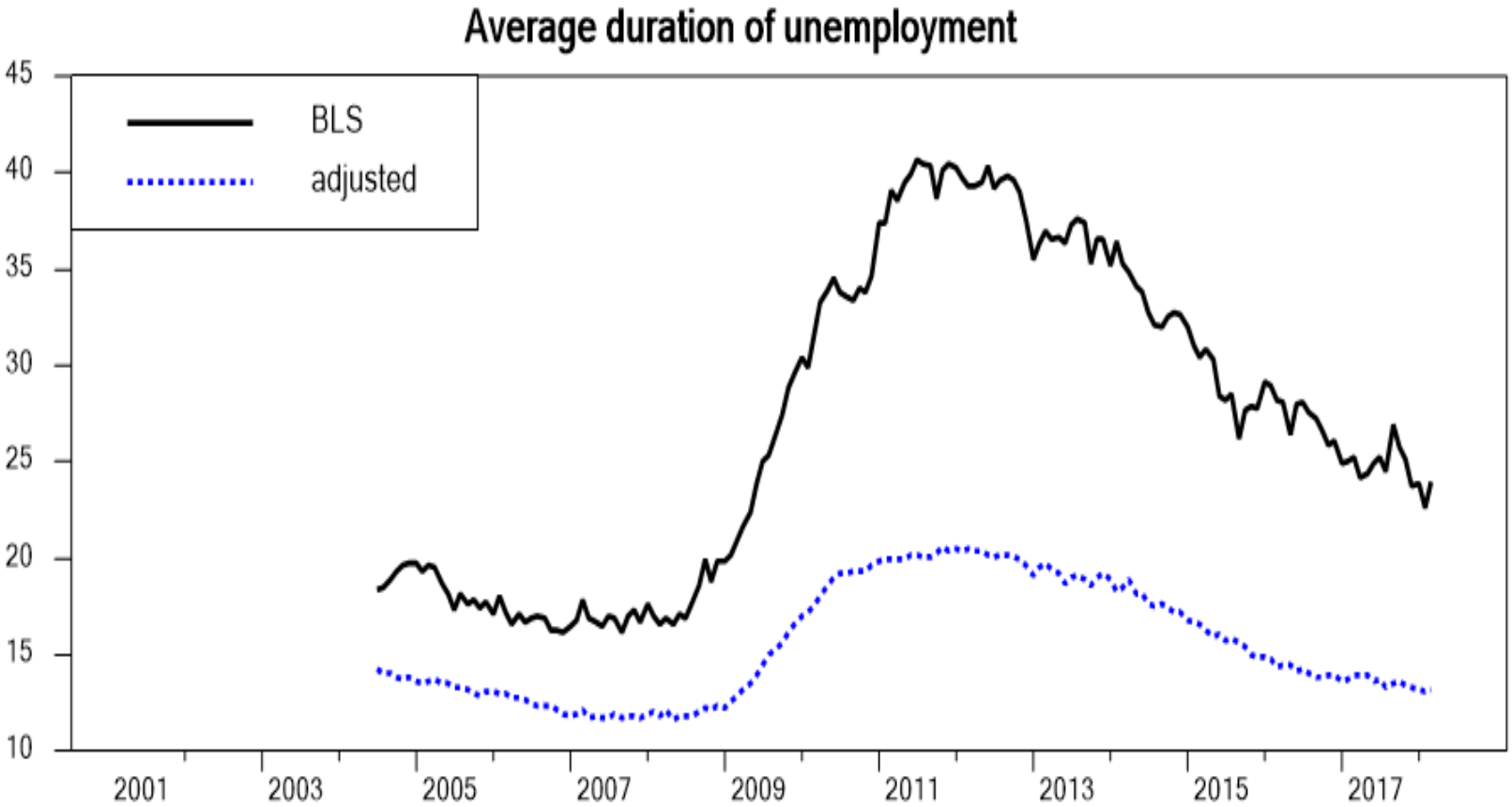
Gap between reconciled and published: weakly counter-cyclical (← NU adjustment) with slowly rising trend (← RGB, missing) Summary Plot

- RGB(+1.2%p), Missing (+0.2%p), NU adjustment (0.8%p)




Unemployment continuation probability
based on durations
adjusted
based on labor-force flows
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
2001
2003
2005
2007
2009
2011
2013
2015
2017


Alternative measures of new inflows into unemployment
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2001
2003
2005
2007
2009
2011
2013
2015
2017
fully adjusted
BLS adjusted
Fujita-Ramey
Shimer



Published: 25 weeks VS Adjusted: 16 weeks

Conclusion

CPS contains multiple internal inconsistencies.

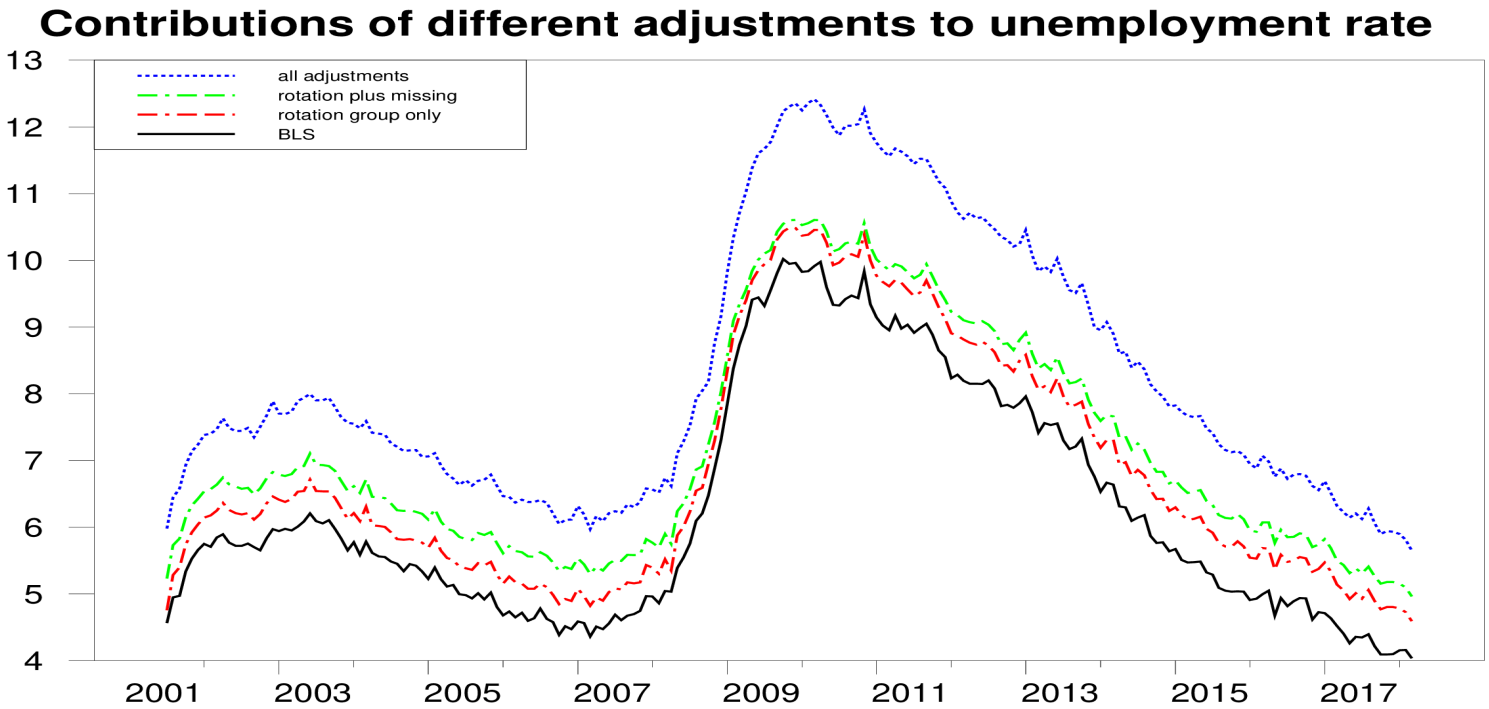
- Rotation group bias
- Non-random missing observations
- Number preference
- Inconsistency between reported durations and LFS histories.

Our paper is the first unified reconciliation, and concludes

- The published unemployment rate and labor-force participation rate are underestimated.
- The new inflows into unemployment are underestimated.
- The mean duration of unemployment is overestimated.

Adjustments to the unemployment rate

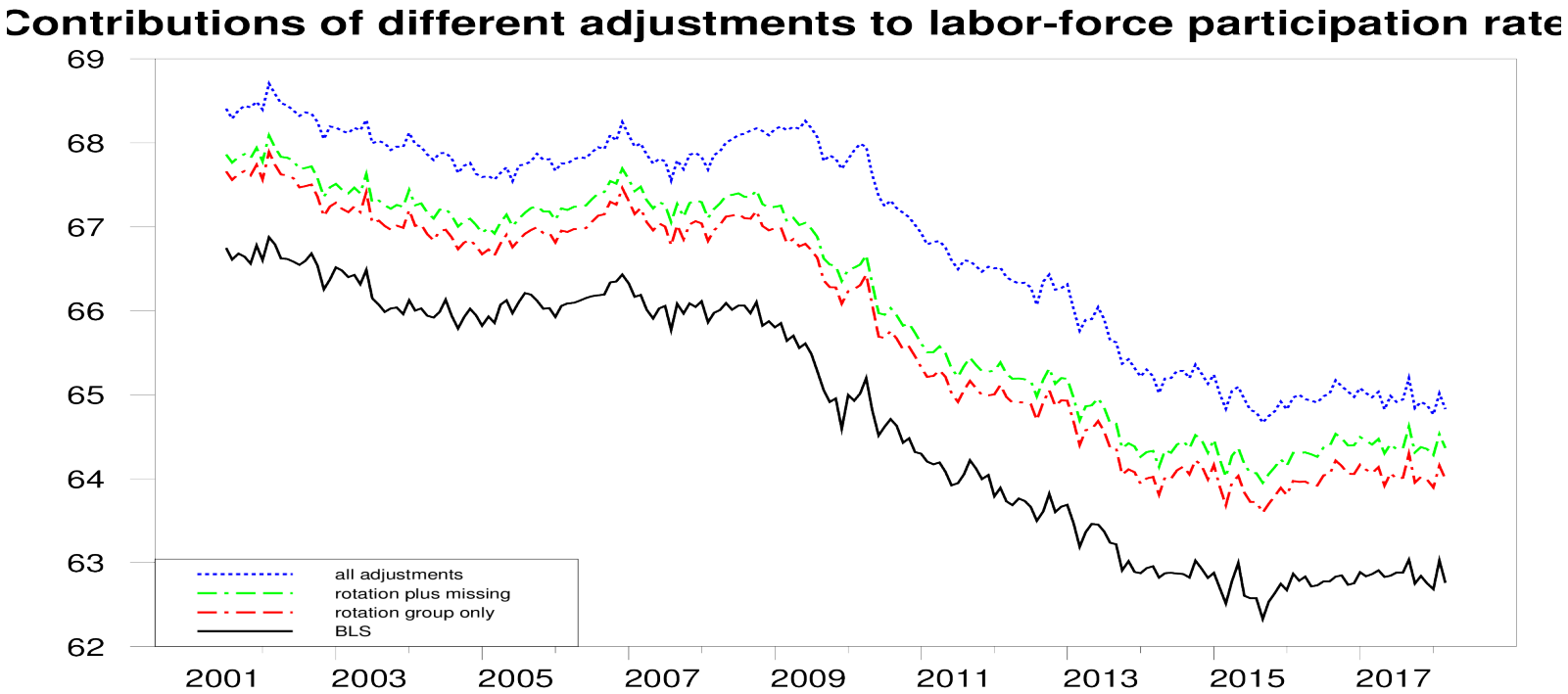
On average, correcting for rotation bias adds 0.5%, missing observations 0.3%, and *NU* adjustment adds 1.1% to UR



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Adjustments to the labor-force participation rate

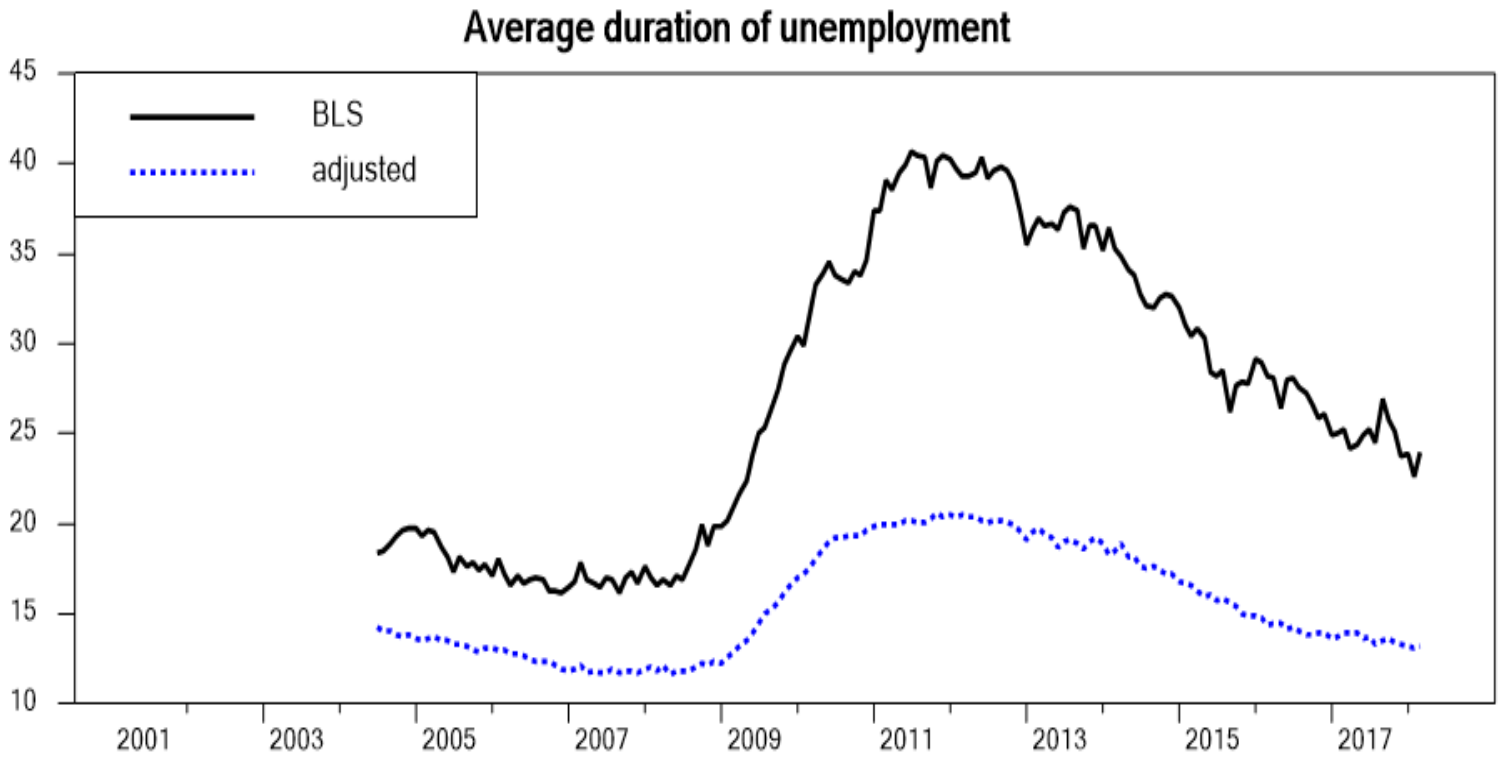
Correcting for rotation bias adds 1.2%p, missing observations 0.2%p, and NU 0.8%p to LFPR.



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Adjustment to the mean duration of unemployment

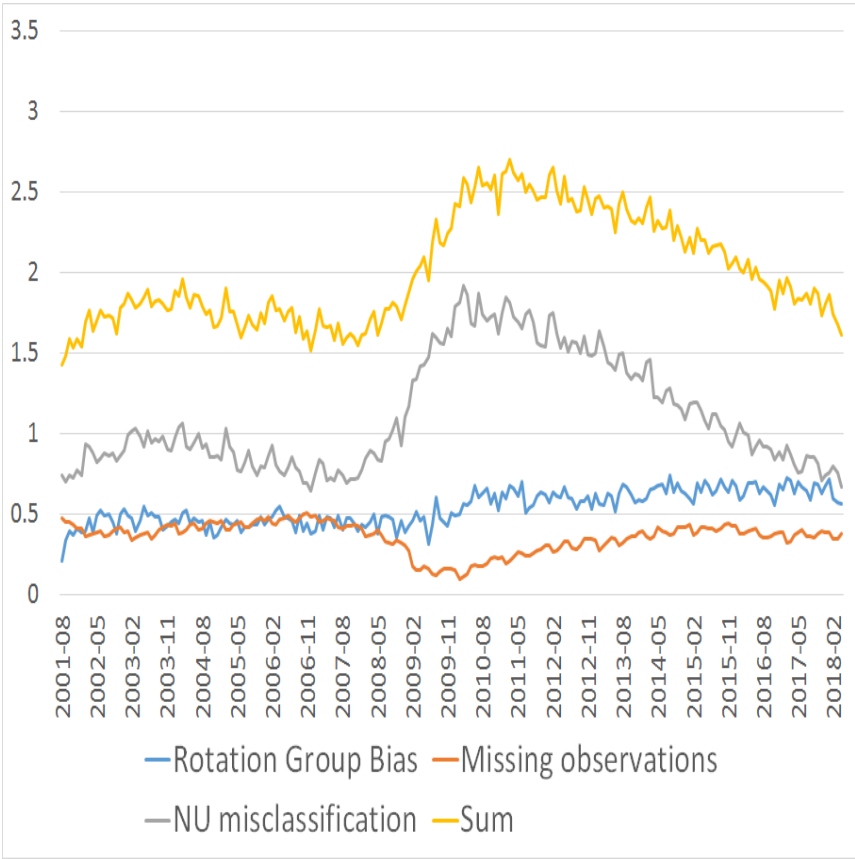
Published: 25 weeks VS Adjusted: 16 weeks



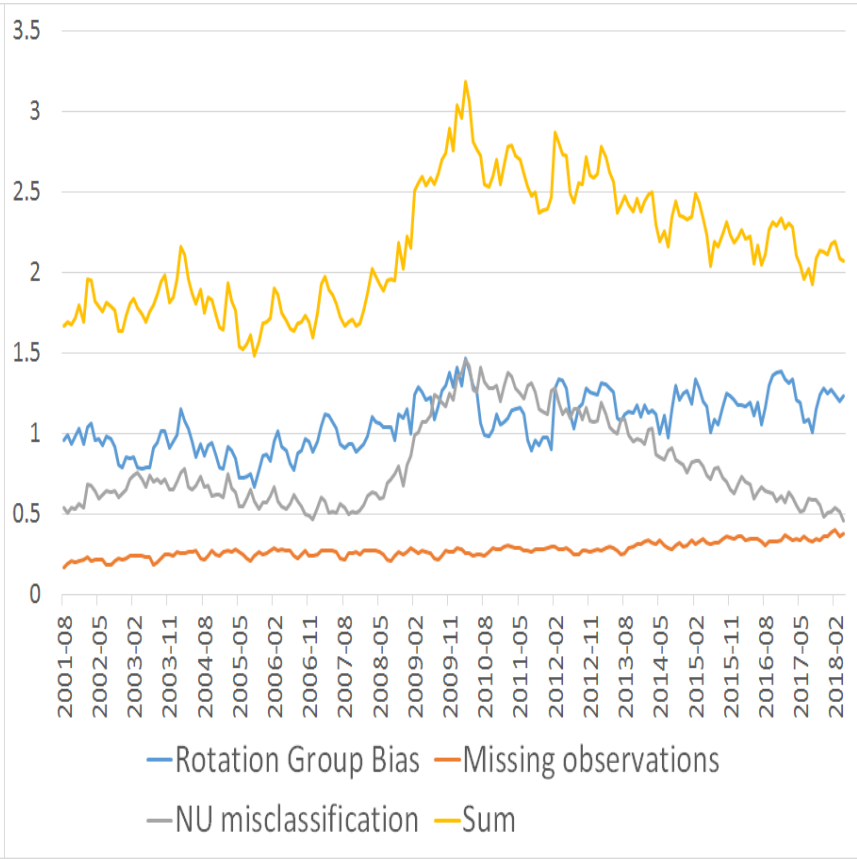
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Evolution of measurement errors in UR and LFPR

Unemployment rate



Labor-force participation rate



Back

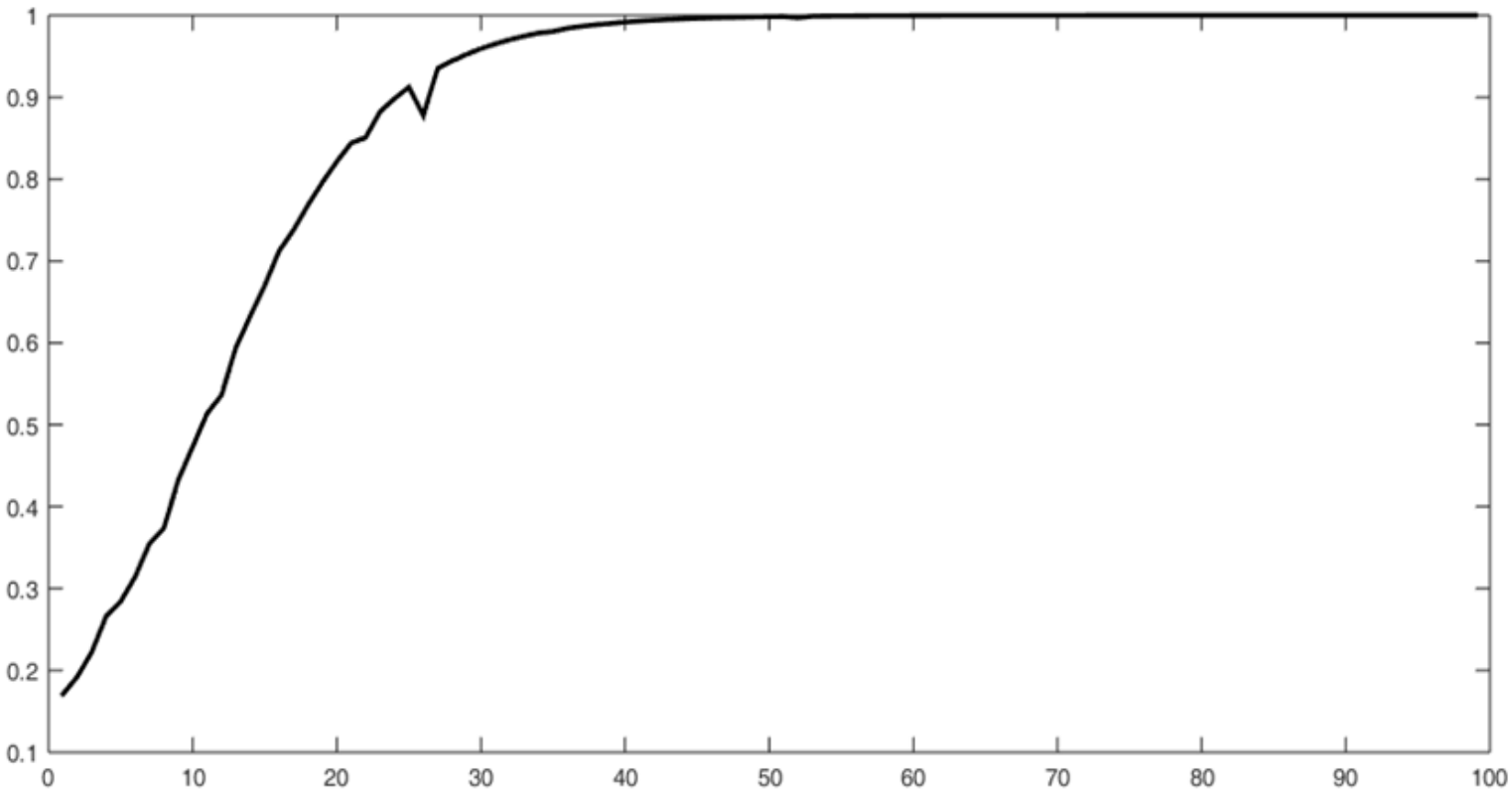
Maximum likelihood estimates

Postulate that probability that someone who is unemployed with duration τ in RG 1 will be $X \in \{E, N, M, U\}$ in RG 2 is $\dot{\pi}_{UX}(\tau) = \eta_1(\tau)\gamma_{1,UX} + \eta_2(\tau)\gamma_{2,UX}$ for $\gamma_{i,UX}$ unrestricted parameters

	[1]	[2]
parameter	Rotation 1 estimate	Standard error
$\gamma_{1,UE}$	0.3183	0.0053
$\gamma_{1,UN}$	0.2179	0.0032
$\gamma_{1,UM}$	0.0909	0.0025
$\gamma_{1,UU}$	0.3729	...
$\gamma_{2,UE}$	0.1153	0.0092
$\gamma_{2,UN}$	0.2353	0.0087
$\gamma_{2,UM}$	0.0735	0.0028
$\gamma_{2,UU}$	0.5759	...

A simple summary of how to use reported duration

$\eta_2(\tau) =$ probability someone who reports duration τ is of type 2



Is this a reasonable estimate? Additional corroboration

- Average fraction of population with reported *NU* that are really type 2 *UU* continuations: 0.0028
- Average fraction of population with reported *UN* that are interpreted as type 2 *UU* continuations: 0.0026

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Adjusting monthly estimates

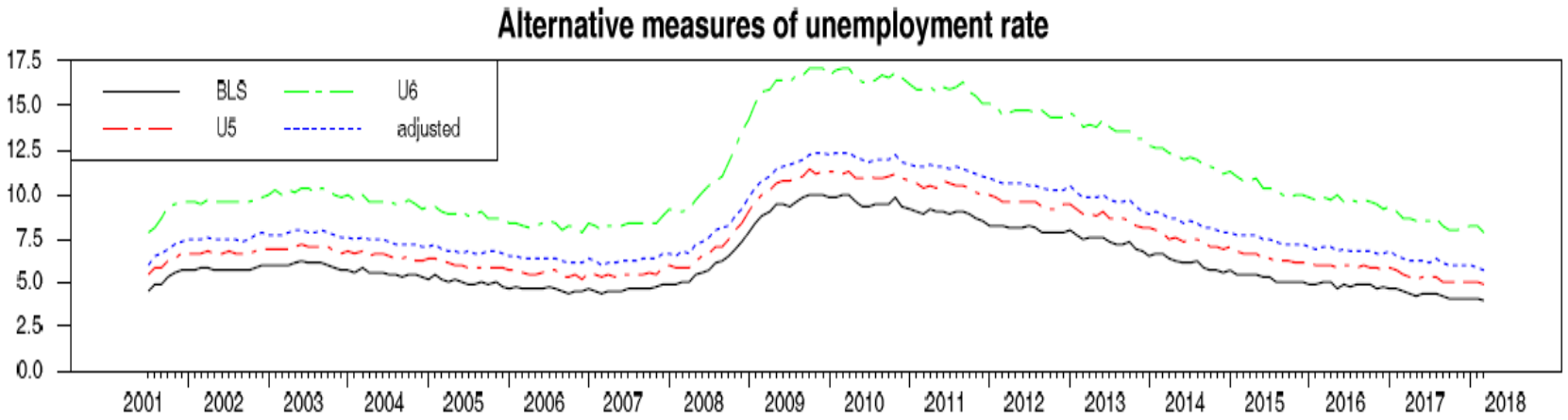
Estimation of time-varying parameters Filtering idea similar to Kalman filter

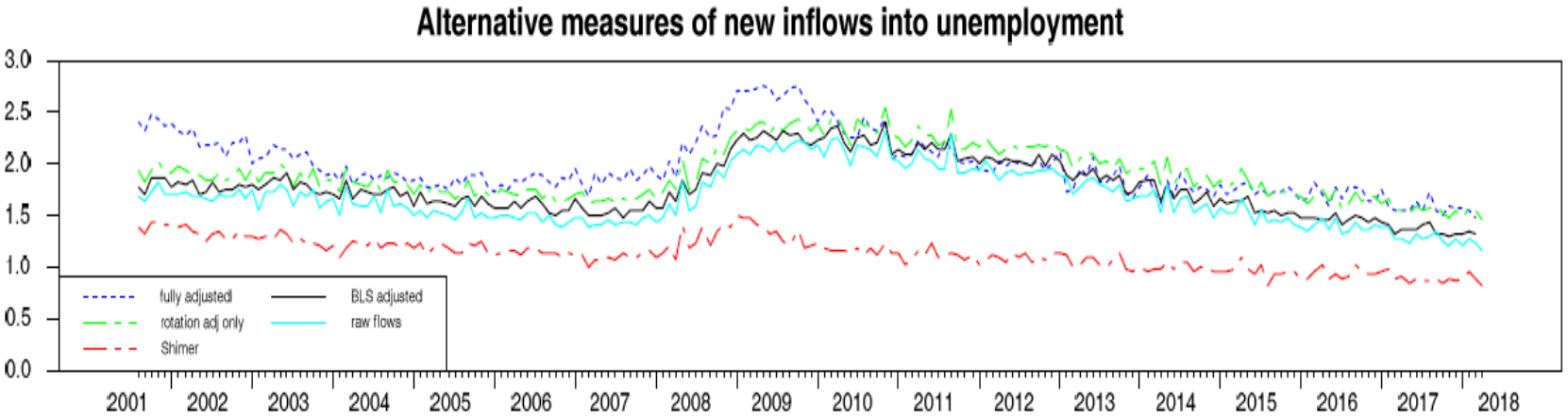
We use exponential smoothing to calculate a weighted average of recent observations through date t to infer how the adjustment parameters θ_t are changing over time. If θ_t denotes an estimate using observations from month t alone, we calculate

$$\overline{\theta}_t = (1 - \lambda)\theta_t + \lambda\overline{\theta}_{t-1}.$$

$$\lambda = 0.98$$

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Alternative measures of unemployment rate
BLS
U6
U5
adjusted
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018


Alternative measures of new inflows into unemployment
fully adjusted
rotation adj only
Shimer
BLS adjusted
raw flows
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

Back

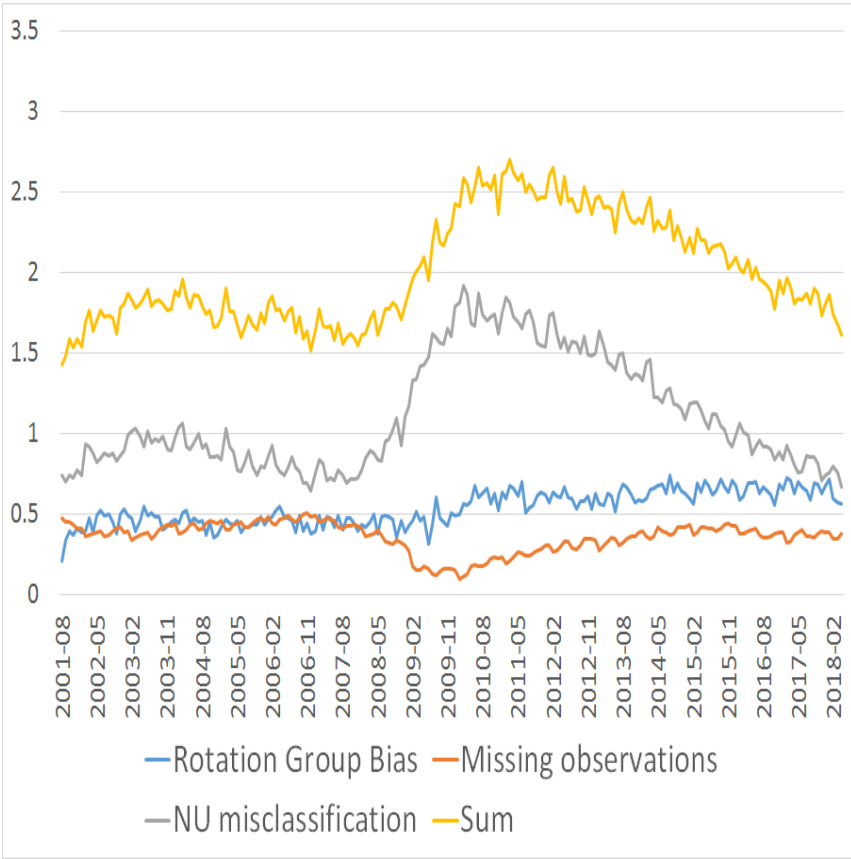
Features of measurement errors in UR and LFPR

	Unemployment rate			Labor force participation rate		
	Mean	Trend	Cycle	Mean	Trend	Cycle
Total	1.9	No	Counter	2.2	Rising	Counter
Rotation group bias	0.5	Slowly rising	No	1.2	Rising	No
Missing observations	0.3	No	Pro	0.2	Rising	No
N/U misclassification	1.1	No	Counter	0.8	No	Counter

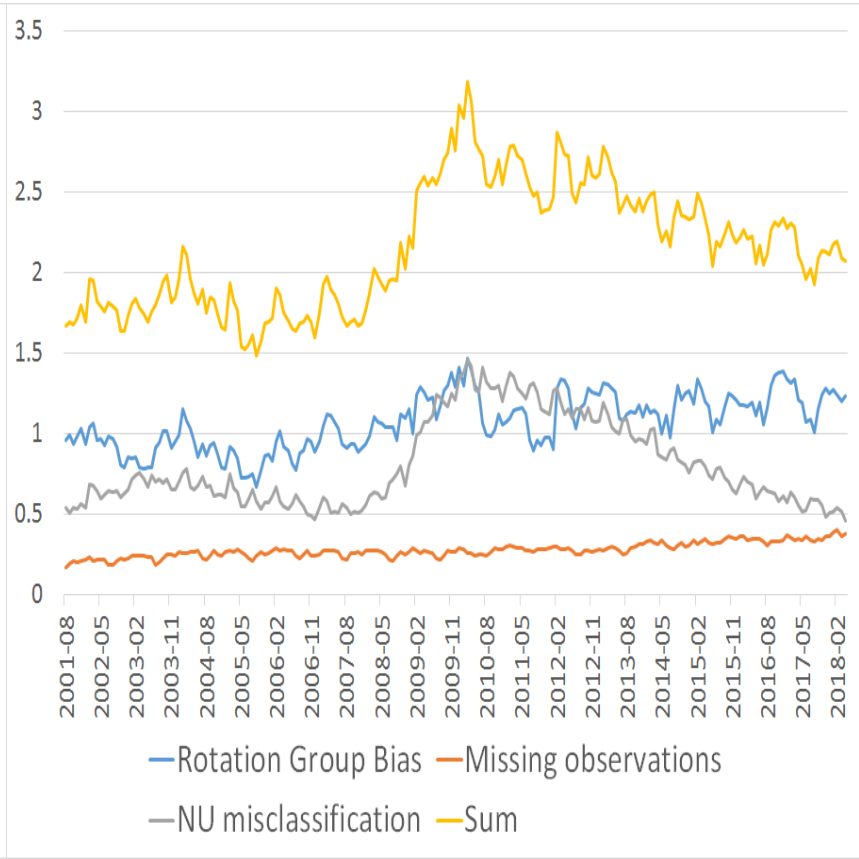
Back to UR Back to LFPR

Features of measurement errors in UR and LFPR

Unemployment rate



Labor-force participation rate



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Back to LFPR