Technical Appendix for "Trends in Labor Force Participation and Unemployment, 1976-2024"*

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1 Data

The data in the analysis are constructed from the monthly basic files of the Current Population Survey (CPS) from January 1976 to **April 2025**, downloaded from IPUMS-CPS, Flood, King, Rodgers, Ruggles, Warren and Westberry (2022). We use the CPS labor status variable to classify each member of the civilian non-institutionalized population of age 16 or older as employed, unemployed, or out of the labor force (OLF). We aggregate the individual microdata into age-gender-education cells using the composite weights such that group aggregates by age, gender, and education are comparable with the published BLS data.[1] We calculate annual averages of the raw monthly data, and for each cell, we construct the unemployment rate, the LFP rate, and population shares.

The age groups are 16-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 years and older. The educational categories for those aged 25 and older are less than high school, high school, some college, and college or higher. Note that we do not differentiate the young, those aged 24 or less, by education. Consequently, we have 44 age-gender-education cells.

Education categories The definition of education categories changed in 1992. We use the IPUMS EDUC variable to classify by education. EDUC is related to HIGRADES before 1992 and EDUC99 from 1992 on. The description of education variables is available at https://www.bls.gov/cps/definitions.htm#education.

Population projections We build on the baseline projection from the most recent U.S. Census Bureau (2025) population projections by age and gender to generate forecasts of aggregate unemployment and LFP rates. The Census covers the resident population, whereas the CPS covers the civilian noninstitutional population. We adjust the Census projections by age and gender by splicing them to the CPS population data in the last year of the CPS sample. This assumes that the adjustment factors from Census to CPS population remain unchanged.

1.1 Data adjustments

The CPS regularly adjusts the population controls based on information from the Census, especially after a new decennial census has been processed. These population controls are not adjusted backwards in time which can lead to noticeable discrete jumps in published population numbers for the demographic groups we consider. In the past, the BLS did publish research series which smoothed the population series between these decennial adjustments, e.g. Di Natale (2003). These research series linearly spread out the discrete adjustment of the month when the new population controls are introduced over the months since the last time population controls were adjusted. We use the same procedure to adjust our monthly population series for decennial adjustments and some large annual adjustments.[2]

[1] Composite weights are constructed using a raking procedure such that individual observations add to group totals at the state and national level, Census (2019), page 77, and are available starting 1998, Census (2019), p.35. For years before 1998, we use final weights.

[2] For various age-gender categories, especially males and females less than 25 years old, the CPS increased population controls noticeably in January 2023 and then reduced them again in January 2024. We remove

Education classification is by grade before 1990 as described in Kominski and Siegel (1993). The 1992 redefinition increases measured educational attainment. For men and women of all age groups, it mainly reduces the share of those with a high school education and increases the share of those with some college. We re-scale the pre-1992 monthly shares to match the education shares by degree in 1992.

1.2 Consistency with BLS aggregates

The MATLAB script `MargAGE_ImportData_CompareAggregates` produces aggregates for employment (EMP), unemployment (U), out-of-labor-force (OLF), and population (POP) from the demographic groups in the micro CPS sample. It compares them with the published BLS aggregates. We list the figures produced by the script, referenced as M.x, but unless otherwise noted, we do not display these figures here.

- After 1998 when composite weights become available the CPS aggregates and the published BLS aggregates are essentially the same.[3] Before 1998 there are noticeable differences between the CPS aggregates and the published BLS aggregates in the monthly raw data. See figures M.1-5 for levels and M.10-14 for ratios.
  - For the years 1976-1979 the level of CPS EMP is 1-2%, OLF is 1.5-3%, POP is 1.5-2% less than the corresponding level of the BLS aggregate, and CPS-U is between 2% more or 3% less than BLS-U. These differences in levels are mostly attributable to CPS POP levels being 1.5 to 2 % lower than BLS POP.
  - For the years 1980-1998 the differences in levels are smaller. CPS-EMP tends to exceed BLS-EMP by 0.25%, and CPS-OLF tends to be less than BLS-OLF by 0.25%. CPS-U deviates from BLS-U by up to 2%, but it is small relative to total EMP and OLF. So the EMP and OLF deviations cancel each other, and POP is essentially the same.
  - This means that for the years 1976-1998 the CPS EMP rate, LFP rate, and U rate tend to be larger than the corresponding BLS rates. Before 1985 that can be up to 0.3 ppts for the EMP rate and LFP rate, and 0.15 ppts for the U rate. After 1985, these differences are cut in half.
- The differences between annual averages of CPS aggregates and published BLS aggregates are a bit smaller, but of similar magnitude. See Figures M.31-35 for levels.
  - For annual aggregate ratios, EMP/POP, U/(EMP+U), (U+EMP)/POP, it does not make a difference if we calculate them as ratios of annual averages or as annual averages of monthly ratios. Since our counterfactual trends for annual data build up aggregates from group rates and population shares, we define aggregate ratios as ratios of annual aggregates. The MATLAB script produces figures M.51-54 for ratios.

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these population 'humps' by smoothing the population series from December 2023 to January 2024. After this pre-filter, we adjust population controls in the following years: 1980, 1990, 2000, 2003, 2012, 2022, and 2025.

[3] Except for April and June 2001. Not sure what is going on in these two months.

- Adjusting the population controls of the CPS data backward in between the BLS's decennial adjustments leads to further deviations of the CPS aggregates from the BLS aggregates for the complete sample. See Figures M.41-45 for levels.
  - From 1976-1979 the population adjustments eliminate the large level differences for EMP, OLF, and POP. However, after 1980, the population adjustments introduced small level differences because the BLS does not retroactively adjust POP after a decennial census.
  - Population control adjustments mainly affect 16-24 year old males and females, Figure 1.
- Adjusting the education shares of the CPS data before 1992 has a minimal impact on aggregates. See Figures M.41-45 for levels.
- Adjusting population controls and education shares of the CPS data has a similar impact on ratios as it has on levels, see Figure 2 for the LFP rate, Figure 3 for the unemployment rate, and Figure 4 for the employment rate. The maximal difference to the BLS ratios is about 0.2 ppts for E/POP, 0.15 ppts for U/L, and 0.3 ppts for L/POP, Figure 5.

1.3 Long run averages

Before we discuss the model used to estimate long-run trends in the unemployment and LFP rate, we briefly discuss the sample averages of the unemployment and LFP rates by gender, education, and age groups. We consider three sample periods 1976-1990, 1991-2005, and 2006-2019, each covering 15 years, except for the last one. We exclude the COVID year 2020 and the years following because of the unusual behavior of unemployment and LFP in these years.

Tables 1 through 3 display the sample averages of unemployment and LFP rates for the younger population, those 16 to 24 years old. Young men tend to have a higher unemployment rate and LFP rate than young women. For both, the unemployment (LFP) rate for the 20-24 year old group is substantially lower (higher) than for the 16-19 year old group. Finally, over time, the unemployment sample averages are U-shaped, they decline from the first third (1976-1990) to the second third (1991-2005) and then increase again in the final third (2006-2019). For men, the sample averages for the LFP rate decline steadily, whereas for women this applies only to the very young, those aged 16-19. For women aged 20-24, the sample averages for the LFP rate remain mostly constant.

Tables 4 through 6 display the sample averages of unemployment and LFP rates for those 25 and older. The unemployment rate declines with age and education for both men and women. The LFP rate declines with age and increases with education for both men and women, with one exception: for all education groups, women aged 35-44 have a higher LFP rate than women aged 25-34. Relative to women, men tend to have a lower unemployment rate and a higher LFP rate for all age groups and education levels.

Comparing unemployment rates across samples, there is little evidence of a trend in the sample averages: for men U-shaped for those with less than a college degree, and increasing for those with a college degree; for women U-shaped for all education levels and age groups. This pattern may well reflect the sample composition, with the Great Recession dominating the third sample.

Comparing the LFP rates across samples, we see a downward trend for men's LFP rates, except for the oldest age group and the most educated group: their LFP rates increase in the third sample. For women, LFP rates are increasing over time for all age groups and education levels, with the exception of LFP rates of women older than 65, which do not increase from the first to the second sample; this is suggestive of cohort effects.

2 Dynamic factor model of group LFP and unemployment rates

- A demographic group is defined by gender and education. We have 10 demographic groups: those aged 16 to 24 years, not differentiated by education, and those aged 25 years and older, differentiated by education (less than high school, high school, some college, college or above), for men and women. We split those aged 16 to 24 years into two age groups 16 to 19 years old, and 20 to 24 years old. We split those aged 25 years and older into the age groups 25 to 34 years, 35 to 44 years, 45 to 54 years, 55 to 64 years, and 65 years and older.

- For a demographic group at time t, we have observations on the outcome q (labor force participation rate, ℓ, and unemployment rate, u) and the population share p for the age groups A_g, e.g., those aged 35 to 44 years,

$$\begin{aligned} Q &= \{q_{g,t} : t = 1, \ldots, T \text{ and } g = 1, \ldots n_G\} \\ P &= \{p_{g,t} : t = 1, \ldots, T \text{ and } g = 1, \ldots n_G\}. \end{aligned}$$

- The measurement equations for the unemployment rate and LFP rate of age group g of a demographic group are

$$q_{g,t} = \tilde{x}_{qg,t} + y_{qg,t} + \gamma_{qg} z_{q,t} + e_{qg,t} \text{ with } e_{qg,t} \sim N\left(0, \sigma^2_{qg}\right)$$
$$\tilde{x}_{qg,t} = \frac{1}{\#A_g} \sum_{a \in A_g} x_{qa,t}$$

where $x_{qa,t}$ is the fixed effect for cohorts entering at time $t - a + 1$, $\tilde{x}_{qg,t}$ is the average cohort effect in age group g, $y_{qg,t}$ is a possibly time-varying age-group effect, $z_{q,t}$ is a common cyclical factor for all age groups of the demographic group, and γ_{qg} is the loading of the age group g on the cyclical factor. There is a total of $n_A = \sum_{g=1,\ldots,n_G} \#A_g$ cohorts in all age groups of a demographic group. We define the trend of a demographic group's labor force status as

$$\bar{q}_{g,t} = \tilde{x}_{qg,t} + y_{qg,t} \tag{1}$$

- The state equations for the cohort and age effects of the unemployment rate and LFP rate are

$$\begin{aligned} x_{q1,t} &= x_{q1,t-1} + \varepsilon_{q1x,t} \text{ with } \varepsilon_{q1x,t} \sim N\left(0, \sigma^2_{qx}\right) \\ x_{q,a,t} &= x_{q,a-1,t-1} \text{ for } a > 1 \\ y_{q1,t} &= y_{q1,t-1} \\ y_{qg,t} &= y_{qg,t-1} + \varepsilon_{qgy,t} \text{ with } \varepsilon_{qgy,t} \sim N\left(0, \sigma^2_{qgy}\right) \text{ for } g > 1. \end{aligned}$$

An entering cohort's fixed effect is a random variation of the cohort that entered in the previous period. The age effect for the first age group is fixed, whereas the age effects for the remaining age groups are time-varying. With the latter assumption on age effects, the Kalman-filter estimate for the posterior variance of the state vector converges to a finite value.

- The cyclical states of unemployment and LFP are

$$\begin{aligned} z_{u,t} &= \rho z_{u,t-1} + \varepsilon_{uz,t} \text{ with } \varepsilon_{uz,t} \sim N\left(0, \sigma_{uz}^2\right) \\ z_{\ell,t} &= \sum_{s=0}^{n_Z} \phi_s z_{u,t-s} + \varepsilon_{\ell z,t} \text{ with } \varepsilon_{\ell z,t} \sim N\left(0, \sigma_{\ell z}^2\right) \end{aligned}$$

  The cycle being transitory, we assume that $|\rho| < 1$. We define the overall cyclical state through the cyclical state of unemployment, and the cyclical state of LFP is a moving average of the current and past cyclical states of unemployment. The cyclical effects are common factors for the unemployment and LFP rates of the age groups of a demographic group. Note that

$$\begin{aligned} z_{\ell,t} &= \phi_0 z_{u,t} + \sum_{s=1}^{n_Z} \phi_s z_{u,t-s} + \varepsilon_{\ell z,t} \\ &= \phi_0 \left(\rho z_{u,t-1} + \varepsilon_{uz,t}\right) + \sum_{s=1}^{n_Z} \phi_s z_{u,t-s} + \varepsilon_{\ell z,t} \\ &= \left(\rho\phi_0 + \phi_1\right) z_{u,t-1} + \sum_{s=2}^{n_Z} \phi_s z_{u,t-s} + \left(\phi_0 \varepsilon_{uz,t} + \varepsilon_{\ell z,t}\right) \end{aligned}$$

  We will use this relation in the state-space formulation of the model.

- We normalize the cyclical effects by normalizing the factor loading for the first age group

$$\gamma_{u1} \equiv 1 \text{ and } \gamma_{\ell 1} \equiv 1.$$

  The first normalization leaves σ_{uz}^2 unrestricted, and the second normalization leaves $\sum_{s=0}^{n_Z} \phi_s$ and $\sigma_{\ell z}^2$ unrestricted.

- We normalize the values for the initial entering cohorts at zero

$$x_{u1,1} \equiv 0 \text{ and } x_{\ell 1,1} \equiv 0.$$

  In subsection 2.2 we show that with this normalization age and cohort effects are separately identified.

2.1 Matrix representation

- For the matrix representation of the state space model define

$$\begin{aligned} q_t &= \left(q_{1,t}, \ldots, q_{n_G,t}\right)^T \text{ for } q = u, \ell \\ x_{q,t} &= \left(x_{q1,t}, \ldots, x_{qn_A,t}\right)^T \\ y_{q,t} &= \left(y_{q1,t}, \ldots, y_{qn_G,t}\right)^T \\ z_t &= \left(z_{u,t}, \ldots, z_{u,t-n_Z+1}, z_{\ell,t}\right)^T \end{aligned}$$

The observation and state vectors are

$$\begin{aligned} Y_t &= \left[u_t^T, \ell_t^T\right]^T \\ X_t &= \left[x_{u,t}^T, y_{u,t}^T, x_{\ell,t}^T, y_{\ell,t}^T, z_t^T\right]^T, \end{aligned}$$

The measurement equation is

$$Y_t = HX_t + W_t \tag{2}$$

with

$$H = \left[\begin{array}{cccc} S & I_{n_G} & 0 & 0 \\ 0 & 0 & S & I_{n_G} \end{array}, \Gamma \right]$$
$$\Gamma = \left[\begin{array}{ccc} \gamma_u & 0_{n_G \times (n_Z - 1)} & 0_{n_G \times 1} \\ 0_{n_G \times 1} & 0_{n_G \times (n_Z - 1)} & \gamma_\ell \end{array} \right]$$

where S is the $n_G \times n_A$ aggregation matrix that maps cohorts to age groups. In our application we assume that each age group has the same number of cohorts and that each cohort receives the same weight, that is,

$$S = \left[I_{n_G} \otimes \iota'_{n_A/n_G}\right] / n_A.$$

Finally, the measurement errors are assumed to be iid normal,

$$\begin{aligned} W_t &\sim N(0, R) \\ R &= \left[\begin{array}{cc} diag\left(\sigma_{u\cdot}^2\right) & 0 \\ 0 & diag\left(\sigma_{\ell\cdot}^2\right) \end{array} \right]. \end{aligned}$$

The law of motion for the state is

$$X_t = FX_{t-1} + V_t \tag{3}$$

with

$$\begin{aligned} F &= \left[\begin{array}{ccccc} M_x & 0 & 0 & 0 & 0 \\ 0 & M_y & 0 & 0 & 0 \\ 0 & 0 & M_x & 0 & 0 \\ 0 & 0 & 0 & M_y & 0 \\ 0 & 0 & 0 & 0 & \Omega \end{array} \right] \\ M_x &= \left[\begin{array}{c} \left[1, 0'_{n_A - 1}\right] \\ \left[I_{n_A - 1}, 0_{n_A - 1}\right] \end{array} \right] \text{ and } M_y = I_{n_G} \\ \Omega &= \left[\begin{array}{cccccc} \rho & 0 & \dots & 0 & 0 & 0 \\ 1 & 0 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & 1 & 0 & 0 \\ \rho\phi_0 + \phi_1 & \phi_2 & & \phi_{n_Z - 1} & \phi_{n_Z} & 0 \end{array} \right] \end{aligned}$$

where Ω is $(n_Z+1)\times(n_Z+1)$, and the innovations to the state are

$$V_t = \left[\varepsilon_{ux,t}^T, \varepsilon_{uy,t}^T, \varepsilon_{\ell x,t}^T, \varepsilon_{\ell y,t}^T, \varepsilon_{z,t}^T\right]^T \sim N(0, Q).$$

The cohort and age components of V are

$$\begin{aligned}
\varepsilon_{qx,t} &\sim N(0, Q_{qx}) \text{ with } Q_{qx} = \begin{bmatrix} \sigma_{qx}^2 & 0_{1\times(n_A-1)} \\ 0_{(n_A-1)\times 1} & 0_{(n_A-1)\times(n_A-1)} \end{bmatrix} \\
\varepsilon_{qy,t} &\sim N(0, R_{qy}) \text{ with } Q_{qy} = diag\left(\sigma_{qy\cdot}^2\right) \text{ and } \sigma_{qy\cdot}^2 = \left[0, \sigma_{qy,2}^2, \ldots, \sigma_{qy,n_G}^2\right]^T.
\end{aligned}$$

The cyclical components of V are

$$\begin{aligned}
\varepsilon_{z,t} &= \left[\varepsilon_{uz,t}, \quad 0_{1\times(n_Z-1)}, \quad \phi_0\varepsilon_{uz,t} + \varepsilon_{\ell z,t}\right]^T = D_z\left[\varepsilon_{uz,t}, \varepsilon_{\ell z,t}\right]^T \\
\text{with } D_z &= \begin{bmatrix} [1 \quad 0] \\ 0_{(n_Z-1)\times 2} \\ [\phi_0 \quad 1] \end{bmatrix}
\end{aligned}$$

such that

$$\varepsilon_{z,t} \sim N(0, Q_z) \text{ with } Q_z = D_z \begin{bmatrix} \sigma_{uz}^2 & 0 \\ 0 & \sigma_{\ell z}^2 \end{bmatrix} D_z^T.$$

Finally,

$$Q = \begin{bmatrix} Q_{ux} & 0 & 0 & 0 & 0 \\ 0 & Q_{uy} & 0 & 0 & 0 \\ 0 & 0 & Q_{\ell x} & 0 & 0 \\ 0 & 0 & 0 & Q_{\ell y} & 0 \\ 0 & 0 & 0 & 0 & Q_z \end{bmatrix}$$

2.2 Identification of age and cohort effects

Consider a simplified version of the state-space model that ignores the time aggregation of cohorts and separates unemployment from LFP.

$$\begin{aligned}
q_{g,t} &= \tilde{x}_{g,t} + y_{g,t} + \gamma_g z_t + e_{g,t} \text{ with } e_{g,t} \sim N\left(0, \sigma_g^2\right), \\
\tilde{x}_{1,t} &= \tilde{x}_{1,t-1} + \varepsilon_{1x,t} \text{ with } \varepsilon_{1x,t} \sim N\left(0, \sigma_x^2\right), \\
\tilde{x}_{g,t} &= \tilde{x}_{g-1,t-1} \text{ for } g > 1, \\
y_{g,t} &= y_{g,t-1} + \varepsilon_{gy,t} \text{ with } \varepsilon_{gy,t} \sim N\left(0, \sigma_{gy}^2\right) \text{ for } g \geq 1, \\
z_t &= \rho z_{t-1} + \varepsilon_{z,t} \text{ with } \varepsilon_{z,t} \sim N\left(0, \sigma_z^2\right).
\end{aligned}$$

We have dropped the subindex q. Note also that we allow the first age effect to follow a random walk.

Cohort, age, and cycle effects are not identified if there exists a non-zero perturbation $(\delta\tilde{x}, \delta y, \delta z)$ of the state that is consistent with the dynamics of the model and that does not affect outcomes. We will show that such a perturbation does not exist for the normalization

$$\tilde{x}_{1,1} = 0.$$

The perturbations have to satisfy the following constraints. From the observation equation

$$0 = \delta\tilde{x}_{g,t} + \delta y_{g,t} + \gamma_g \delta z_t.$$

From the law of motion for cohorts

$$\delta\tilde{x}_{1,t} = \delta\tilde{x}_{1,t-1} \text{ and } \delta\tilde{x}_{g,t} = \delta\tilde{x}_{g-1,t-1}.$$

From the law of motion for age effects

$$\delta y_{g,t} = \delta y_{g,t-1}.$$

From the law of motion for cycle effects

$$\delta z_t = \rho \delta z_{t-1}.$$

Using these laws of motion, we get the following restrictions on perturbations

$$\begin{aligned} \delta\tilde{x}_{g,t} &= \delta\tilde{x}_{1,1} \text{ for } g \leq t, \\ \delta y_{g,t} &= \delta y_{g,1}, \\ \delta z_t &= \rho^{t-1}\delta z_1. \end{aligned}$$

And the restrictions on the observation equation become

$$0 = \delta\tilde{x}_{1,1} + \delta y_{g,1} + \gamma_g \rho^{t-1}\delta z_1 = \delta y_{g,1} + \gamma_g \rho^{t-1}\delta z_1 \text{ for } g \leq t,$$

using the normalization of cohort effects. Since by assumption $\gamma_1 \equiv 1$ and $0 < |\rho| < 1$, $\delta z_1 = 0$. And therefore $\delta y_{g,1} = 0$. Therefore, $\delta\tilde{x}_{g,t} = 0$ for all t, g. Thus, there is no non-zero perturbation of the state that does not affect outcomes.

We can generalize this argument for our model with time aggregation of cohorts,

$$\begin{aligned} \tilde{x}_{g,t} &= \frac{1}{\#A_g} \sum_{a \in A_g} x_{a,t}, \\ x_{1,t} &= x_{1,t-1} + \varepsilon_{1x,t} \text{ with } \varepsilon_{1x,t} \sim N\left(0, \sigma_x^2\right), \\ x_{a,t} &= x_{a-1,t-1} \text{ for } a > 1. \end{aligned}$$

For simplicity, assume that $\#A_g = \tilde{n}_A$. Choose the normalization

$$x_{1,1} = 0.$$

For this model, the cohort law of motion implies again that

$$\delta x_{a,t} = \delta x_{1,1} \text{ for } a \leq t.$$

Thus, with the normalization, we get that

$$\delta \tilde{x}_{g,t} = 0 \text{ for } \forall g \text{ and } t \geq n_A.$$

Thus, for $t \geq n_A$ we can again argue that $\delta y_g = \delta z = 0$. From this we can iterate backwards, showing that $\delta x_{a,t} = 0$ for $t < n_A$.

For this purpose, consider the matrix $A_1 = [\delta x_{t,a}]_{t=1,\dots,\tilde{n}_A,\ a=1,\dots,\tilde{n}_A}$ associated with the first age group, $g = 1$.[4] With the normalization and the laws of motion for cohort effects, the lower triangular part of the matrix is zero. Furthermore, all columns of the matrix sum to zero since $\delta \tilde{x}_{t,1} = 0$ for $t = 1, \dots, \tilde{n}_A$. Thus, working backwards, starting with $t = \tilde{n}_A - 1$ we get that $0 = \delta x_{\tilde{n}_A-1,\ \tilde{n}_A-1}$. From the cohort law of motion, it follows that the first upper off-diagonal is zero. But this implies $\delta x_{\tilde{n}_A-2,\ \tilde{n}_A-2} = 0$, etc. Repeating these steps, we find that the upper triangular part of the matrix is also zero, that is, $\delta \tilde{x}_{t,a} = 0$ for $\tilde{n}_A \geq a \geq t$.

The next step is to consider the matrix $A_2 = [\delta x_{t,a}]_{\{t=1,\dots,\tilde{n}_A,\ a=\tilde{n}_A+1,\dots,2\tilde{n}_A\}}$ associated with the second age group, $g = 2$. From the law of motion for cohorts and $A_1 = 0$, it follows that the lower triangular part of A_2 is zero. Furthermore, the columns sum to zero, $\delta \tilde{x}_{t,2} = 0$. By the same argument as above, then the upper triangular part of A_2 is also zero.

The same argument applies sequentially to the matrices associated with the remaining age groups. And we have shown that $\delta x_{a,t} = 0$ for all t and a.

The above argument applies to the unemployment part of our general model. From this, it follows that for a perturbation $\delta z_{u,t} = 0$. From the law of motion for the cyclical LFP effect, it follows that $\delta z_{\ell,t} = 0$. And then we can use the same argument to show that age and cohort effects in the LFP part of our model are identified.

[4] Note that we switched the time and cohort indices such that time denotes rows.

3 Estimation with Gibbs sampler

- The data are $Y_{1:T} = (Y_1, ..., Y_T)$
- The parameters are $\theta = (\gamma_q, \rho, \phi, \sigma_{qg}, \sigma_{qx}, \sigma_{qy}, \sigma_{qz}$ for $q = u, \ell$ and $g = 1, \dots, n_G)$
- The state-space model is

$$Y_t = H'Y_t + W_t \text{ with } W_t \sim \mathcal{N}(0, R) \tag{4}$$
$$X_t = FX_{t-1} + V_t \text{ with } V_t \sim \mathcal{N}(0, Q) \tag{5}$$

  where (H, F, Q, R) are functions of the parameter vector θ.

- The unobserved state is $\zeta_{1:T} = (\zeta_1, \dots, \zeta_T)$ with

$$\zeta_t = \{X_t, V_t, W_t\} \text{ with } \zeta_t \overset{iid}{\sim} N(0, \Sigma_\zeta)$$

- Let $\Theta = [\zeta_{1:T}, \theta]$
- Fix the parameters, (α, β), for the prior inverse gamma distributions for the variances $\{\sigma_{qg}, \sigma_{qx}, \sigma_{qy}, \sigma_{qz} : q = u, z \text{ and } g = 1, \dots, n_G\}$
- Normalize $\gamma_{u1} = \gamma_{\ell 1} = 1$
- Normalize $x_{u1,1} = x_{\ell 1,1} = 0$.

Bayes' rule implies that

$$\Pr(\Theta|Y_{1:T}) = \Pr(Y_{1:T}|\Theta) \Pr(\Theta) / \Pr(Y_{1:T}),$$

where $\Pr(\Theta)$ is the prior distribution, $\Pr(Y_{1:T}|\Theta)$ is the likelihood, $\Pr(Y_{1:T})$ is the marginal likelihood, and $\Pr(\Theta|Y_{1:T})$ is the posterior distribution we are interested in estimating.

We estimate the posterior distribution

$$\Pr(\zeta_{1:T}, \theta|Y_{1:T}),$$

by way of Gibbs sampling in two steps. The first Gibbs step draws $\zeta_{1:T}|\theta, Y_{1:T}$ and is described in section 3.2. The second Gibbs step draws $\theta|\zeta_{1:T}, Y_{1:T}$ and is described in sections 3.3 and 3.4. The Gibbs sampler iteration follows Mark Watson's code. The initialization of the parameters is model-specific and described in section 3.1.

3.1 Step 1. Initialize the parameters

3.1.1 Priors for unemployment rate process parameters

- Take the demeaned unweighted average unemployment rate of a gender-education group as a stand-in for the group's CE,

$$\hat{\hat{z}}_{u,t} = u_t - \bar{u} \text{ with } u_t = \frac{1}{n_G} \sum_{g=1}^{n_G} u_{gt}$$

- Prior for (γ_{ug}): Regress the first age group's unemployment rate on $\hat{\hat{z}}_u$,

$$u_{1,t} = a + \tilde{\gamma}_{u1}\hat{\hat{z}}_{u,t} + e_t$$

and rescale $\hat{\hat{z}}_u$ such that the regression coefficient is one, $\hat{z}_u = \tilde{\gamma}_{u1}\hat{\hat{z}}_u$. For the remaining age groups estimate the regressions

$$u_{g,t} = a + \tilde{\gamma}_{ug}\hat{z}_{u,t} + e_t$$

for which we obtain heterogeneity and autocorrelation consistent estimates of the standard deviations of $\tilde{\gamma}_{ug}^{HAC}$, $\sigma_{\gamma_{ug}}^{HAC}$. Define the prior means and standard deviations for γ_{ug}

$$\bar{\gamma}_{u1} = 1, \bar{\sigma}_{\gamma_{u1}} = 0 \text{ and } \bar{\gamma}_{ug} = \tilde{\gamma}_{ug}^{HAC}, \bar{\sigma}_{\gamma_{ug}} = 2\sigma_{\gamma_{ug}}^{HAC} \text{ for } g = 2, \ldots, n_G \tag{6}$$

- Prior for (ρ, σ_{uz}): Estimate an AR(1) for the scaled stand-in cyclical indicator

$$\hat{z}_{u,t} = \tilde{\rho}\hat{z}_{u,t-1} + e_{uz,t}$$
$$\hat{\sigma}_{uz}^2 = \frac{1}{T}\sum_{t=1}^{T} e_{uz,t}^2$$

with heterogeneity and autocorrelation consistent estimates of the standard deviations of $\tilde{\rho}^{HAC}$, σ_ρ^{HAC}. Define the prior means and standard deviations

$$\bar{\rho} = \tilde{\rho}^{HAC}, \ \bar{\sigma}_\rho = 2\sigma_\rho^{HAC} \text{ and } \bar{\sigma}_{uz} = \hat{\sigma}_{uz} \tag{7}$$

- Prior for $(\sigma_{ug}, \sigma_{ux}, \sigma_{uy})$: Define the age and cyclically adjusted unemployment rates, $\tilde{u}_{g,t} = u_{g,t} - \tilde{\gamma}_{ug}\hat{z}_{u,t}$, and calculate and calculate the average variance of their first differences for the age groups

$$s_u^2 = \frac{1}{n_G}\sum_{g=1}^{n_G} \text{Var}\left(\Delta\tilde{u}_{ug,t}\right)$$

Define the priors for $(\sigma_{ug}, \sigma_{ux}, \sigma_{uy})$

$$\bar{\sigma}_{ux} = \bar{\sigma}_{uy} = \bar{\sigma}_{ug} = s_u/\sqrt{3} \tag{8}$$

3.1.2 Priors for LFP process parameters

- Prior for (ϕ): Visual inspection of the LFP rates suggests that, unlike the unemployment rates, LFP rates are not very cyclical. Given the assumed random walk nature of the trend components, the first differences in LFP rates are

$$\begin{aligned}\Delta\ell_{g,t} &= \gamma_{\ell g}\Delta z_{\ell,t} + \left[\frac{1}{\#A_g}\sum_{a\in A_g}\varepsilon_{\ell ax,t} + \Delta y_{\ell g,t} + \Delta e_{\ell g,t}\right] \\ &= \gamma_{\ell g}\sum_{s=0}^{n_z}\phi_s\Delta\hat{z}_{u,t-s} + .\end{aligned}$$

and we have replaced the cyclical indicator with the scaled average unweighted unemployment rate as before. We use the normalization $\gamma_{\ell 1} = 1$ and estimate ϕ by OLS for the first age group

$$\Delta l_{1,t} = \sum_{s=0}^{n_z} \tilde{\phi}_s \Delta \hat{z}_{u,t-s} + e_t$$

with heteroscedastic and autocorrelation consistent estimates of the standard deviations of $\tilde{\phi}^{HAC}$, σ_ϕ^{HAC}. Define the prior means and standard deviations of ϕ

$$\bar{\phi} = \tilde{\phi}^{HAC} \text{ and } \bar{\sigma}_\phi = 2\sigma_\phi^{HAC} \tag{9}$$

- Prior for (γ_ℓ): Conditional on $\bar{\phi}$, define the stand-in of the cyclical effect for the LFP rate

$$\hat{z}_{\ell,t} = \sum_{s=0}^{n_z} \bar{\phi}_s \hat{z}_{u,t-s}.$$

For the remaining age groups perform least squares

$$\ell_{g,t} = \tilde{\gamma}_{\ell g} \hat{z}_{\ell,t} + e_t, \text{ for } g = 2, ..., n_G$$

and obtain heteroscedastic and autocorrelation consistent estimates of the standard deviations of $\tilde{\gamma}_{\ell g}^{HAC}$, $\sigma_{\gamma_{\ell g}}^{HAC}$. Define the prior means and standard deviations of $\gamma_{\ell g}$

$$\bar{\gamma}_{\ell,1} = 1, \bar{\sigma}_{\gamma_{\ell,1}} = 0, \text{ and } \bar{\gamma}_{\ell g} = \tilde{\gamma}_{\ell g}^{HAC}, \, \bar{\sigma}_{\gamma_{\ell g}} = 2\sigma_{\gamma_{\ell g}}^{HAC}, \text{ for } g = 2, \ldots, n_G \tag{10}$$

- Prior for $(\sigma_{\ell x}, \sigma_{\ell y}, \sigma_{\ell z}, \sigma_{\ell g})$: Remove the estimated cyclical effects from the LFP rates, $\tilde{\ell}_{g,t} = \ell_{g,t} - \tilde{\gamma}_{\ell g} \hat{z}_{\ell,t}$, and calculate the average variance for the first differences of the age groups

$$s_\ell^2 = \frac{1}{n_G} \sum_g \text{Var}\left(\Delta \tilde{\ell}_{\ell,g,t}\right)$$

Define the prior means for $(\sigma_{\ell x}, \sigma_{\ell y}, \sigma_{\ell z}, \sigma_{\ell g})$

$$\bar{\sigma}_{\ell x} = \bar{\sigma}_{\ell y} = \bar{\sigma}_{\ell z} = \bar{\sigma}_{\ell g} = s_\ell/\sqrt{6} \tag{11}$$

3.1.3 Priors for states

- Prior for $\left(x_{qa,0|0}\right)$: Note that adding and subtracting a common and constant factor to the fixed age and cohort effects does not affect the observed unemployment/LFP rates

$$q_{g,t} = \frac{1}{\#A_g} \sum_{a \in A_g} (x_{qa,t} + \Delta) + (y_{qg,t} - \Delta) + \gamma_{qg} z_{q,t} + e_{qg,t}$$

This means we can normalize $x_{q1,0|0} = 0$. For the initial prior of the state covariance matrix, we take into account the cross-cohort correlations. We approximate the random walk for incoming cohorts with a highly persistent auto-regressive process, $\tilde{M}_x$, by replacing the first element in M_x with 0.99, and we calculate the invariant covariance matrix, $\Sigma_{qx,0|0}$, implied by $\tilde{M}_x$ and the estimated prior for $\sigma_{q,x}$. Since we normalize the first element of $x_{qx,0|0}$ we set the first row and column of $\Sigma_{qx,0|0}$ to zero,

$$\left[x_{q,0|0}\right](a) = 0 \text{ and } \left[\Sigma_{qx,0|0}\right](a, a') = 0 \text{ for } a = a' = 1. \tag{12}$$

- Prior for $\left(y_{qg,0|0}\right)$: We use the mean of the cyclically adjusted unemployment and LFP rates for the first 5 years and a large variance for the age effects

$$y_{qg,0|0} = \frac{1}{5} \sum_{t=1,\ldots,5} \left(\tilde{q}_{gt}\right) \text{ and } \Sigma_{qy,0|0} = 4 I_{n_G} \tag{13}$$

3.2 Step 2: Obtain an estimate of the unobserved state, $X^{(i)}$ using the Kalman filter

- For given $\left(Y_{1:T}, H^{(i-1)}, F^{(i-1)}, Q^{(i-1)}, R^{(i-1)}\right)$ solve the Kalman-filter and obtain draws for $\left\{X_t^{(i)}\right\}$.
- Use the prior for $X_{0|0}$ defined in 3.1.3.
- We use the method of Carter and Kohn (1994) to obtain draws for $\left\{X_t^{(i)}\right\}$

With known (H, F, R, Q), equations (4) and (5) are interpreted as the observation equation and state equation, respectively, in a Kalman filtering context,

$$Y_t = H' X_t + W_t, \qquad W_t \sim N\left(0, R\right),$$

$$X_t = F X_{t-1} + V_t, \qquad V_t \sim N\left(0, Q\right).$$

The linear-Gaussian structure implies that $X_{1:T}|Y_{1:T}$ is normally distributed, and the goal is to obtain draws from this distribution. As shown in Carter and Kohn (1994), this can be achieved as follows:

- Use the Kalman filter to obtain $X_{T|T} = E\left[X_T|Y_{1:T}\right]$ and $P_{T|T} = \text{Var}(X_T|Y_{1:T})$.
- Draw X_T from $\mathcal{N}(X_{T|T}, P_{T|T})$.
- Note that the distribution of $X_t|\left(Y_{1:T}, X_{t+1}, ..., X_T\right)$ depends only on $(Y_{1:t}, X_{t+1})$ and $X_t|(Y_{1:t}, X_{t+1}) \sim \mathcal{N}(\mu_t, \Sigma_t)$ where $\mu_t = X_{t|t} - P_{t|t} F' P_{t+1|t}^{-1} (X_{t+1} - X_{t+1|t})$ and $\Sigma_t = P_{t|t} - P_{t|t} F' P_{t+1|t}^{-1} F P_{t|t}$. Recursively draw $X_{T-1}, X_{T-2}, ..., X_1$.

3.3 Step 3. Obtain parameters in (H, F)

- Loading on CE, $\gamma_q^{(i)}$. Define for $q = u, \ell$

$$\begin{aligned} X_{q,t}^{(i)} &= \begin{bmatrix} x_{q,t}^{(i)} \\ y_{q,t}^{(i)} \end{bmatrix} \\ A &= \begin{bmatrix} S & I_{n_G} \end{bmatrix} \\ \hat{Y}_{q,t}^{(i)} &= q_t - A X_{q,t}^{(i)} = \gamma_{q,t} z_{q,t}^{(i)} + e_{q,t} \end{aligned}$$

Define the Kalman filter for

$$
\begin{aligned}
\hat{Y}_{q,t}^{(i)} &= z_{q,t}^{(i)} \hat{\gamma}_{q,t} + \hat{e}_{q,t} \text{ with } \hat{e}_{q,t} \sim N\left(0, \hat{Q}_q^{(i-1)}\right) \\
\hat{\gamma}_{q,t} &= \hat{\gamma}_{q,t-1} + 0
\end{aligned}
$$

Derive the posterior $\gamma_{q,T|T}$ and its variance, and make a draw for $\gamma_q^{(i)}$.

  - Prior for $\gamma_{qg,1|0} \sim N\left(\bar{\gamma}_{qg}, \bar{\sigma}_{\gamma_{qg}}^2\right)$ from (6) for $q = u$, and (10) for $q = \ell$.

- AR(1) coefficient for unemployment CE, $\rho^{(i)}$. Taking $z_{u,t}^{(i)}$ as given, define the Kalman filter for

$$
\begin{aligned}
z_{u,t}^{(i)} &= z_{u,t}^{(i)} \hat{\rho}_t + \varepsilon_{uz,t} \text{ with } \varepsilon_{uz,t} \sim N\left(0, \left(\sigma_{uz}^{(i-1)}\right)^2\right) \\
\hat{\rho}_t &= \hat{\rho}_{t-1} + 0
\end{aligned}
$$

  Derive the posterior $\rho_{T|T}$ and its variance, and make draws for $\rho^{(i)}$ until you have a draw whose absolute value is less than a predefined upper bound, ρ^{ub}. If that does not happen for a finite number of draws use the upper bound on exit.

  - Prior for $\rho_{uz,1|0} \sim N\left(\bar{\rho}_{uz}, \bar{\sigma}_\rho^2\right)$ from (7)

- Cyclical Indicator for LFP. Taking $\left\{z_{u,t}^{(i)}, z_{\ell,t}^{(i)}\right\}$ as given, define the Kalman filter for

$$
\begin{aligned}
z_{\ell,t}^{(i)} &= \sum_{s=0}^{n_Z} z_{u,t-s}^{(i)} \phi_{s,t} + \varepsilon_{\ell z,t} \text{ with } \varepsilon_{\ell z,t} \sim N\left(0, \left(\sigma_{\ell z}^{(i-1)}\right)^2\right) \\
\phi_t &= \phi_{t-1} + 0
\end{aligned}
$$

  Derive the posterior $\phi_{T|T}$ and its variance, and make a draw for $\phi^{(i)}$.

  - Prior for $\phi_{1|0} \sim N\left(\bar{\phi}, \bar{\sigma}_\phi^2\right)$ from (9)

3.4 Step 4. Obtain variance parameters (Q, R)

- For the measurement equations, $q \in \{u, \ell\}$, define the 'sample' variances

$$
\hat{\sigma}_{qg}^2 = \frac{1}{T} \sum_{t=1}^{T} \left(\hat{Y}_{qg,t}^{(i)} - z_{q,t}^{(i)} \gamma_g^{(i)}\right)^2
$$

  and make draws for $\sigma_{qg}^{(i)}$ assuming an inverse gamma distribution for the prior

$$
\tilde{\sigma}_{qg}^2 \sim IG\left(\frac{\bar{T}_{qg}}{2}, \frac{\bar{T}_{qg}\bar{\sigma}_{qg}^2}{2}\right).
$$

  This implies sampling from an inverse gamma distribution posterior

$$
\left(\sigma_{qg}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{qg} + T}{2}, \frac{\bar{T}_{qg}\bar{\sigma}_{qg}^2 + T\hat{\sigma}_{qg}^2}{2}\right).
$$

– We use a diffuse prior with $\bar{T}_{qg} = 2$, $\bar{\sigma}_{ug}$ from (8), and $\bar{\sigma}_{\ell g}$ from (11).

- For the cyclical unemployment indicator define the 'sample' variance

$$\hat{\sigma}_{uz}^2 = \frac{1}{T}\sum_{t=1}^{T}\left(z_{u,t}^{(i)} - \rho^{(i)} z_{u,t}^{(i)}\right)^2$$

  and make a draw for $\sigma_{uz}^{(i)}$ from the posterior inverse gamma distribution,

$$\left(\sigma_{uz}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{uz} + T}{2}, \frac{\bar{T}_{uz}\bar{\sigma}_{uz}^2 + T\hat{\sigma}_{uz}^2}{2}\right).$$

  – We use a diffuse prior with $\bar{T}_{uz} = 2$ and $\bar{\sigma}_{uz}$ from (7).

- For the cyclical LFP indicator define the 'sample' variance

$$\hat{\sigma}_{\ell z}^2 = \frac{1}{T}\sum_{t=1}^{T}\left(z_{\ell,t}^{(i)} - \sum_{s=0}^{n_Z} \phi_s^{(i)} z_{u,t-s}^{(i)}\right)^2$$

  and make a draw for $\sigma_{\ell z}^{(i)}$ from the inverse gamma distribution,

$$\left(\sigma_{\ell z}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{\ell z} + T}{2}, \frac{\bar{T}_{\ell z}\bar{\sigma}_{\ell z}^2 + T\hat{\sigma}_{\ell z}^2}{2}\right).$$

  – We use a diffuse prior with $\bar{T}_{\ell z} = 2$ and $\bar{\sigma}_{\ell z}$ from (11).

- For the law of motion for cohort effects, $q \in (u, \ell)$, define the 'sample' variance

$$\hat{\sigma}_{qx}^2 = \frac{1}{T}\sum_{t=1}^{T}\left(x_{q1,t}^{(i)} - x_{q1,t-1}^{(i)}\right)^2,$$

  and make a draw for $\sigma_{qx}^{(i)}$ from the inverse gamma distribution,

$$\left(\sigma_{qx}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{qx} + T}{2}, \frac{\bar{T}_{qx}\bar{\sigma}_{qx}^2 + T\hat{\sigma}_{qx}^2}{2}\right).$$

  – We use a diffuse prior with $\bar{T}_{qx} = 2$, $\bar{\sigma}_{ux}^2$ from (8), and $\bar{\sigma}_{\ell x}^2$ from (11).

- For the laws of motion for age effects, $q \in (u, \ell)$, and $g = 2, \ldots, n_G$, define the 'sample' variance

$$\hat{\sigma}_{qgy}^2 = \frac{1}{T}\sum_{t=1}^{T}\left(y_{qg,t}^{(i)} - y_{qg,t-1}^{(i)}\right)^2$$

  and make a draw for $\sigma_{qgy}^{(i)}$ from the inverse gamma distribution,

$$\left(\sigma_{qgy}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{qgy} + T}{2}, \frac{\bar{T}_{qgy}\bar{\sigma}_{qgy}^2 + T\hat{\sigma}_{qgy}^2}{2}\right),$$

  – We use a diffuse prior with $\bar{T}_{qgy} = 2$, $\bar{\sigma}_{ugy}^2$ from (8), and $\bar{\sigma}_{\ell gy}^2$ from (11).

4 A factor model of education shares

- Consider a group defined by gender, s, and education, e, for those 25 years and older. At time t, we have observations on the fraction of age group A_g with education level e, $m^{se}_{g,t} \equiv p^{se}_{g,t}/p^{s}_{g,t}$

$$m^{se} = \left\{m^{se}_{g,t} : t = 1, \ldots, T \text{ and } g = 1, \ldots n_G\right\}.$$

  In the following, we will drop the gender-education superscript when no confusion can arise.

- We assume that the observed education shares for age groups reflect the averages of the group's cohorts

$$m_{g,t} = \frac{1}{\#A_g} \sum_{a \in A_g} x_{a,t} + \varepsilon_{g,t} \text{ with } \varepsilon_{g,t} \sim N\left(0, \sigma^2_{mg}\right), \tag{14}$$

  We also assume a random walk in the cohort shares, similar to the trend in the models for group unemployment and LFP rates.

$$x_{1,t} = x_{1,t-1} + \varepsilon_{x1,t}, \text{ with } \varepsilon_{\delta 1,t} \sim N\left(0, \sigma^2_{x1}\right), \tag{15}$$

$$x_{a,t} = x_{a-1,t-1} + \varepsilon_{xg,t}, \text{ with } \varepsilon_{xg,t} \sim N\left(0, \sigma^2_{xg}\right) \text{ for } a \in A_g \text{ and } g = 2, \ldots, n_G. \tag{16}$$

  For this model, the best forecast of future education shares are current education shares.

- In this model, we do not distinguish between cohort and age effects, unlike we do for the labor force status model, Section 2. At the same time, we no longer treat cohort effects as fixed effects. Changes in the educational composition of the sample over time occur through two channels. First, there is an entry 'vintage' channel reflected in the shock to the education shares of entering cohorts, which reflects changes in educational attainment. Second, we no longer assume that the cohort effect is fixed over time, but can change may be due to further educational improvements over time or differential death rates across education groups, for example, Aaronson and Sullivan (2001). Finally, the time series for education shares are quite smooth and there is no apparent cyclical variation. We therefore do not include a cyclical component in the model, unlike the labor force status model.

- The models are estimated independently for each education level; that is, we do not impose the restriction that the education shares sum to 1. When we forecast future education shares, one draw of the joint forecast path for the four education shares is based on four independent draws of the education share forecasts, which are then normalized to add to one. The results are not sensitive to whether this normalization is imposed, see Section 7.9.4.

4.1 Matrix representations of the model

- For the matrix representation of the state space model define

$$m_t = (m_{1,t}, \ldots, m_{n_G,t})^T$$
$$x_t = (x_{1,t}, \ldots, x_{n_A,t})^T$$

The observation and state vectors are

$$Y_t = m_t$$
$$X_t = x_t.$$

The measurement equation is

$$Y_t = HX_t + h_t + v_t$$

with

$$H = S$$
$$h_t = 0$$
$$\text{and } v_t \sim N(0, Q)$$
$$Q = \text{diag}\left(\sigma^2_{m\cdot}\right)$$

where S is the $n_G \times n_A$ aggregation matrix that maps cohorts to age groups. The law of motion for the state is

$$X_t = FX_{t-1} + f_t + w_t$$

with

$$F = M_{xx}$$
$$M_{xx} = \left[\begin{bmatrix} 1, & 0_{1\times(n_A-1)} \\ I_{n_A-1}, & 0_{(n_A-1)\times 1} \end{bmatrix} \right]$$
$$f_t = 0$$

where the innovations to the state are

$$w_t = \hat{R}\varepsilon_{x,t}$$

with

$$\hat{R} = \begin{bmatrix} \iota_1 & 0_{n_A\times(n_G-1)} \\ 0_{n_A(n_G-1)\times 1} & I_{n_G-1} \otimes 1_{n_A\times 1} \end{bmatrix} \text{ with } \iota_i = \left[0'_{i-1}, 1, 0'_{n-i-1}\right]'$$
$$\varepsilon_{x,t} \sim N(0, \text{diag}(\sigma_{x\cdot}))$$
$$E\left[w_t w'_t\right] = R = \hat{R}\text{diag}(\sigma^2_{x\cdot})\hat{R}'$$

4.2 Estimation of the model with Gibbs sampler

- The parameters are $\theta = (\sigma_m, \sigma_x)$.
- Fix the parameters, (α, β), for the prior inverse gamma distributions for the variances $\{\sigma_{mg}, \sigma_{xg}\}$ for $g = 1, \ldots, n_G$.

The way we initialize the parameters, Step 1, is model-specific. The iteration on the Gibbs sampler, Steps 2 through 4, follows the code of Mark Watson. The procedure is the same as the one for the estimation of unemployment rate and LFP rate trends in section 3.

4.2.1 Step 1. Initialize the parameters

Priors for variances Set the variances $\bar{\sigma}_{mg} = \bar{\sigma}_{xg} = 1$.

Priors for states

- Prior for $x_{g,1|0}$: Define $x_{g,1|0} = \sum_{t=1}^{5} m_{g,t}$ as the mean of the group's education shares for the first 5 years.
- Prior for Σ_x. For the initial prior of the state covariance matrix we calculate the invariant covariance matrix of X from equations (15) and (16), where we replace the random walk in the initial cohort and the drift term with a persistent AR(1) process with coefficient 0.9.

4.2.2 Step 2: Obtain an estimate of the unobserved state, $X^{(i)}$, using the Kalman filter

- For given $\left(Y, H^{(i-1)}, F^{(i-1)}, Q^{(i-1)}, R^{(i-1)}\right)$ solve the Kalman-filter and obtain draws for $\left\{X_t^{(i)}\right\}$.
- Use the prior for $X_{1|0}$ defined in 4.2.1.
- We use the method of Carter and Kohn (1994) to obtain draws for $\left\{X_t^{(i)}\right\}$

4.2.3 Step 3. Obtain variance parameters (Q, R)

- Measurement equation, σ_m. Taking $x_{a,t}^{(i)}$ as given, define

$$\begin{aligned} \hat{Y}_t^{(i)} &= HX_t^{(i)} \\ Y_{gt}^{(i)} &= \left(m_{g,t} - \hat{Y}_{g,t}^{(i)}\right)^2 \end{aligned}$$

and the 'sample' variance

$$\hat{\sigma}_{mg}^2 = \frac{1}{T} \sum_{t=1}^{T} Y_{gt}^{(i)}$$

and make draws for $\sigma_{mg}^{(i)}$ assuming an inverse gamma distribution for the prior

$$\tilde{\sigma}_{mg}^2 \sim IG\left(\frac{\bar{T}_{mg}}{2}, \frac{\bar{T}_{mg}\bar{\sigma}_{mg}^2}{2}\right).$$

This implies sampling from an inverse gamma distribution posterior

$$\left(\sigma_{mg}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{mg}+T}{2}, \frac{\bar{T}_{mg}\bar{\sigma}_{mg}^2 + T\hat{\sigma}_{mg}^2}{2}\right).$$

  - We use a diffuse prior with $\bar{T}_{mg} = 2$, and $\bar{\sigma}_{mg}$.

- Cohort equations, σ_x. Taking $x_{a,t}^{(i)}$ as given, define

$$\begin{aligned} Y_{1t}^{(i)} &= \left(\hat{x}_{1,t}^{(i)} - \hat{x}_{1,t-1}^{(i)}\right)^2 \\ Y_{ga,t}^{(i)} &= \left(\hat{x}_{a,t}^{(i)} - \hat{x}_{a-1,t-1}^{(i)}\right)^2 \text{ for } a \in A_g, \text{ and } g = 2, \ldots, n_G, \end{aligned}$$

and define the 'sample' variance

$$\begin{aligned} \hat{\sigma}_{x1}^2 &= \frac{1}{T}\sum_{t=1}^{T} Y_{1t}^{(i)} \\ \hat{\sigma}_{xg}^2 &= \frac{1}{T\#A_g}\sum_{t=1}^{T}\sum_{a\in A_g} Y_{ga,t}^{(i)} \text{ for } g = 2, \ldots, n_G \end{aligned}$$

and make draws for $\sigma_{xg}^{(i)}$ assuming an inverse gamma distribution for the prior

$$\tilde{\sigma}_{mg}^2 \sim IG\left(\frac{\bar{T}_{xg}}{2}, \frac{\bar{T}_{xg}\bar{\sigma}_{xg}^2}{2}\right).$$

This implies sampling from an inverse gamma distribution posterior

$$\left(\sigma_{xg}^{(i)}\right)^2 \sim IG\left(\frac{\bar{T}_{xg}+T}{2}, \frac{\bar{T}_{xg}\bar{\sigma}_{xg}^2 + T\hat{\sigma}_{xg}^2}{2}\right).$$

  - We use a diffuse prior with $\bar{T}_{xg} = 2$, and $\bar{\sigma}_{xg}$.

5 Aggregate LFP and unemployment rate

Given the LFP and unemployment rates, $\ell^i_{g,t}$ and $u^i_{g,t}$, for the age groups g of a demographic group, i, with population shares $p^i_{g,t}$, the aggregate LFP rate is

$$\ell_t = \sum_{i,g} p^i_{g,t} \ell^i_{g,t}, \tag{17}$$

and the aggregate unemployment rate is

$$u_t = \frac{\sum_{i,g} p^i_{g,t} \ell^i_{g,t} u^i_{g,t}}{\sum_{i,g} p^i_{g,t} \ell^i_{g,t}} \tag{18}$$

The trend of the aggregate LFP rate and unemployment rate is calculated by replacing the actual rates, $\ell^i_{g,t}$ and $u^i_{g,t}$, with their trend estimates, $\bar{\ell}^i_{g,t}$ and $\bar{u}^i_{g,t}$, see equation (1).

Equations (17) and (18) define mappings from $\left(p^i_{g,t}, \ell^i_{g,t}, u^i_{g,t}\right)$ to the aggregate LFP rate and unemployment rate. To account for changes in the aggregate LFP and unemployment rate in terms of changes in population shares, education shares, and group LFP and unemployment rates, we first decompose population shares of groups into the parts coming from gender and age, and then education conditional on gender and age.[5] For individuals aged 25 and older let $p^i_{g,t}$ denote the population share of the age group g for the cell with gender s and education e, $i = (s, e)$. Then define the marginals for the gender-age group (s, g)

$$p^s_{g,t} = \sum_e p^{(s,e)}_{g,t} \tag{19}$$

and the education shares of that gender-age group

$$p^s_{e|g,t} = p^{(s,e)}_{g,t} / p^s_{g,t} \tag{20}$$

We can write the aggregate LFP rate and unemployment rate as functions of the age-gender shares, p^s_g, the conditional education shares, $p_{e|s,g}$, and the group LFP and unemployment rates, $\ell^{(s,e)}_g$ and $u^{(s,e)}_g$,

$$\ell = L\left(\left\{p^s_g\right\}, \left\{p^s_{e|g}\right\}, \left\{\ell^{(s,g)}_g\right\}\right) \tag{21}$$

$$u = U\left(\left\{p^s_g\right\}, \left\{p^s_{e|g}\right\}, \left\{\ell^{(s,e)}_g\right\}, \left\{u^{(s,e)}_g\right\}\right) \tag{22}$$

We can calculate first-order approximations for changes in aggregate rates

$$\Delta\ell_t = \sum_{s,g} \frac{\partial L_t}{\partial p^s_{g,t}} \Delta p^s_{g,t} + \sum_{s,g,e} \frac{\partial L_t}{\partial p^s_{e|g,t}} \Delta p^s_{e|g,t} + \sum_{s,g,e} \frac{\partial L_t}{\partial \ell^{(s,e)}_{g,t}} \Delta \ell^{(s,e)}_{g,t} \tag{23}$$

$$\Delta u_t = \sum_{s,g} \frac{\partial U_t}{\partial p^s_g} \Delta p^s_g + \sum_{s,g,e} \frac{\partial U_t}{\partial p^s_{e|g,t}} \Delta p^s_{e|g,t} + \sum_{s,g,e} \frac{\partial U_t}{\partial \ell^{(s,e)}_{g,t}} \Delta \ell^{(s,e)}_{g,t} + \sum_{s,g,e} \frac{\partial U_t}{\partial u^{(s,e)}_{g,t}} \Delta u^{(s,e)}_{g,t} \tag{24}$$

[5]Since individuals younger than 25 are not differentiated by education this procedure is not applied to them.

The first sum represents the contributions of changes in the age-gender distribution, the second sum represents contributions of changes in the education distribution, the third sum represents contributions of changes in group LFP rates, and the fourth sum in the unemployment rate equation represents contributions of changes coming from group unemployment rates.

Cumulative changes in the LFP and unemployment rate are simply

$$\ell_t - \ell_{t_0} = \sum_{\tau=t_0+1}^{t} \Delta\ell_\tau \text{ and } u_t - u_{t_0} = \sum_{\tau=t_0+1}^{t} \Delta u_\tau \tag{25}$$

with a similar decomposition of the sources of change. We can use this method to decompose changes in the actual or trend aggregates of LFP and unemployment rates. Either way, this first-order approximation is highly accurate.

6 Results

6.1 Cyclical factors

- Cyclical factor
  - Table 7. Among 16-24-year-old men and women, the cyclical factor for unemployment is persistent, with AR coefficients of about 0.8. The cyclical factor for LFP is a moving average of the unemployment cyclical factor with predominantly negative coefficients, but for the second and third lags, zero tends to be included in the 90% percentile range. The sum of median coefficients is about -0.3 for men and -0.2 for women, that is, there is a weak negative correlation between the cyclical factors for LFP and U. The cyclical unemployment and LFP factors are roughly coincident with median correlation coefficients of about -0.8, Table 20.
  - Table 8. Among men and women 25 and older, the unemployment-cyclical factors are persistent with AR coefficients around 0.75 for men and 0.7 for women, and volatility declines with education, especially for the college-educated. The sum of median coefficients of the MA for the LFP cyclical factor ranges from -0.15 to -0.5, but only the contemporaneous coefficients tend to be inside the 90% percentile range.[6] The correlation between the cyclical unemployment and LFP factors is weaker than for those 16 to 24 years old; the largest correlation coefficients range from -0.6 to -0.8 for men and from -0.3 to -0.8 for women, see Table 20. The strongest correlation tends to be for the LFP cyclical factor lagging the unemployment factor by one year.
  - Figure 6. The cyclical factors for unemployment are highly correlated across all demographic groups and with the aggregate unemployment rate. The volatility of the cyclical factor tends to decline with education, and it tends to be lower for women relative to men.
  - Figure 7. The cyclical factors for the LFP rates are correlated across all demographic groups and negatively correlated with the aggregate unemployment, either contemporaneously or with a lag of one year. The volatility of the cyclical factor tends to decline with education.

- Unemployment rate loadings on the cyclical factor
  - By construction, the youngest age group in each demographic group responds 1-1 to a change in the unemployment cyclical factor, that is, their unemployment rate increases as the unemployment cyclical factor increases.
  - Table 9. Among 16-24-year-old men and women, 20-24-year-old men and women respond significantly less to the cyclical factor.
  - Table 10. Among men and women 25 and older, the response to the unemployment cyclical factor tends to decline with age for all education groups, except for those

[6] For men, the sum of median MA coefficients is [-0.3 (LTHS), -0.1 (HS), -0.3 (SoCO), -0.2 (CO+)], and for women, the sum of median MA coefficients is [-0.4 (LTHS), -0.5 (HS), -0.4 (SoCO), -0.1 (CO+)].

with a college degree. The difference between prime age (25-55) and 55+ is not very pronounced, and for those 65 and older, the unemployment rate is only noticeably less sensitive to the cyclical factor for men with an HS education or less.

- LFP rate loadings on the cyclical factor
  - By construction, the LFP response of the youngest age group of each demographic group to the LFP cyclical factor is 1-1, and since the LFP cyclical factor is negatively correlated with the unemployment cyclical factor, the LFP rate tends to decline with the unemployment rate.
  - Table 11. Among 16-24-year-old men and women, 20-24-year-old men and women respond half as much to the cyclical factor as does the younger group.
  - Table 12. Among those 25 and older, older age groups tend to respond less to the LFP cyclical factor for all education groups. For men 65 and older and for women 55 and older, the factor loading on the cyclical factor tends to be not significant, zero is included in the 90% coverage intervals. The same is true more generally for women with a college education.

6.2 Trends: cohort and age effects for demographic groups

A demographic group's trend is the sum of age and cohort effects.

- Unemployment rate trends and cohort and age effects
  - We plot the age effects and trend, for men in columns A of Figures 8 through 12, and for women in columns A of Figures 13 through 17.
  - Across demographic groups, (trend) unemployment rates tend to decrease with age and education for both men and women. The decline with age is less pronounced for women, especially for those with more than a high-school education, Figures 16 and 17. This pattern is already apparent in sample averages discussed in section 1.3.
  - Over time, trend unemployment rates have declined somewhat, but not much. For men, the decline is apparent in the early 1990s, and for women, the decline is apparent somewhat later, around 2000. Women with a college degree are the exception: the decline in their trend unemployment rate is already apparent in the mid-1980s, Figure (17).
  - Age effects are relatively stable over time, and the decline in trends is mostly due to cohort effects: the difference between the trends (red lines) and age effects (blue lines). This is apparent in the gap between the (red) trend lines and the (blue) age lines opening up over time; panels A of Figures 8 through 17. Overall, age and cohort effects for unemployment rates are estimated with relatively wide coverage areas.

    * For men and women, with few exceptions, the estimated variance of shocks to age effects is not significantly different across age groups or education levels, see Tables 13 and 14. Notable differences are apparent for individuals older than 65, with higher than average volatility, and men with a college education, with lower than average volatility. Note also that the age effect of the first age group is assumed to be fixed throughout the sample.
    * Shocks to entering cohorts are about as volatile as shocks to age effects, the last row of Tables 13 and 14.
    * Estimated age effects and unemployment cyclical effects are only weakly correlated, Tables 21, 22, and 23, consistent with age effects capturing trends. Most correlations are less than 0.3 in absolute value, and with a few exceptions, even the 66% coverage areas include zero.
  - The changes in average cohort effects for different age groups reflect the estimated fixed effects of entering cohorts, Figure 18. For almost all demographic groups, cohort effects decline over time, though the declines are limited, and they start later for women than for men. Men and women with less than a high-school education are the exception, displaying a marked decline of fixed effects, though also considerable uncertainty surrounding that decline.
  - Our procedure to separate cyclical effects from trends fails for young men and women aged 20 to 24 following the 2020-COVID pandemic. The procedure places some of the 2020 unemployment rate spike into the age effect and thus the trend. That being said, the uncertainty surrounding the trend estimates for these age groups is large.

- LFP rate trends and age and cohort effects

  - We plot the age effects and trend, for men in columns B of Figures 8 through 12, and for women in columns B of Figures 13 through 17.
  - For men and women 16-24 trend LFP rates increase with age. For those 25 and older, trend LFP rates tend to increase until age 35-44 after which they decrease. For all age groups and both genders the trend LFP rates tend to increase with education. This pattern is already apparent in sample averages discussed in section 1.3.
  - Over time trends for men's LFP rates have mostly declined, more so than the trends for unemployment rates. Women's LFP rate trends first increased, starting to peak for the younger age groups in the mid-1990s, and have since declined gradually, except for women with a college degree.
    * For men aged 25-34, the LFP rate trends declined steadily across all education groups, Figures 9 through 12.
    * For men aged 35-54 with less than a high-school degree, LFP rates declined until the mid-1990s, and have recently increased again. For all other education levels, the LFP rate trends of men in this age group steadily declined.

* For men older than 55, LFP rate trends declined noticeably until the 1990s and then stabilized for those aged 55-64, and started to increase for those 65 and older for all education groups, with one exception. For men older than 65 with a college degree, the trend LFP rate peaked around 2010 and has been declining since.
* For women with a high school education or less, LFP rates increase over time until they peak in the late 1990s, and then decline for prime age women, 25-54, and flatten out for those older than 55, Figures 14 and 15.
* For women with at least some college education, the LFP rates increase over time until they peak, after which the LFP rates remain flat, Figures 16 and 17. Unlike for men, there is no noticeable qualitative difference between women with some college and women with a college education or higher.
* The persistent differences emerging between the trend and age effects, the red and blue lines respectively, reflect the cohort effects. Given our identification, that the age effect of the youngest group is constant, we can see the cohort effects in the divergence between the trend and age effects for the youngest groups. These cohort effects then work their way from the younger age groups early in the sample to the older age groups later in the sample, see, e.g. Figure 15. The counterpart of the notable cohort effects is quite a bit of variation in the age effects over time.
* For men and women 16-19 years old, trend LFP rates declined over the sample period by about 25 pp for men, Figures 8, and 15 pp for women 13. For those 20-24 years old, men's LFP rates declined by about 12 pp, whereas women's LFP rates remained stable. Since our model imposes constant age effects for the first age group, the divergence in trend LFP rates between the first and second age groups is reflected in increasing age effects for the second age group.
    * Note that the substantial negative trend declines among 20-24 year old men are not reflected in the cohort effects of the different education groups of those 25 years and older. For 25-34 year old men, estimated average cohort effects decline between 3 pp (CO+) and 10 pp (LTHS), relative to a 14 ppt trend decline for 20-24 year old men, see Figure 20. In other words, the decline in the average trend rates for men aged 20-24 is much larger than the decline in the cohort effects of men aged 25-34 in all education groups.
    * This issue does not arise for young women. For all education groups of women aged 25-34 years, changes in cohort LFP rates are more in line with changes in trend LFP rates of women aged 20-24 years, see Figure 21.
* Age effects are somewhat correlated with LFP cyclical effects, Tables 24, 25, and 26. Correlations are usually less than 0.4 in absolute value, but more frequently than for the cyclical and age effects of the unemployment rate the coverage areas do not exclude zero.

- The trend estimates for LFP rates are tightly estimated, at least relative to trend estimates for unemployment rates. The only exception is for women older than 25 with less than a high school education, Figure 14, whose LFP rates tend to be more volatile than those of other education groups. The estimation procedure attributes this difference to a noticeably larger measurement error for women with less than a high school education, Table 19, and not to a larger volatility of shocks to either the age or cohort effects, Table 16.
- The changes in average cohort effects for different age groups reflect the estimated fixed effects of entering cohorts, Figure 19. For men and women younger than 25 years and all men 25 and older, cohort effects decline over time; the cohort effects for young women decline less than for young men, and they decline less for more educated men. For women older than 25, cohort effects increased until the 1990s, but have remained flat or declined afterward. Cohort effects have remained consistently high only for women with at least some college. The changes in median LFP cohort effects tend to be significant, i.e., the coverage areas do not include zero, unlike the estimated unemployment cohort effects, Figure 18.

6.3 Fixed age effects for the first age group

We have specified the unemployment rate and LFP rate of a demographic group defined by education and gender as the sum of cohort effects, age effects, and cyclical effects. In section 2.2, we have shown that if we normalize the initial entering cohorts, $x_{u1,1} = x_{\ell 1,1} = 0$, we attain identification, independent of the assumption on age effects of the first age group. We have assumed that the first age effect is fixed for the posterior state-covariance matrices of the Kalman filter to remain bounded. In this section, we show that a model with a random walk for the first age effect not only has an unbounded state-covariance matrix but is also likely to produce biased estimates of age and cohort effects.

First, we describe a simulation exercise. For this exercise, the baseline model assumes that the first age effect remains fixed, and the cyclical effect follows a stationary AR(1) process. For the alternative model, we assume that the first age effect follows a random walk.

The baseline model is similar to our model from Section 2 for the unemployment rate only. For our simulation model, we use 5 age groups, each with 10 cohorts, and assume unit standard deviation shocks for age and cohort effects, and measurement error. The cyclical effect is a persistent AR(1) with age-group loadings that decline with age.

- $n_G = 5$, $\#A_g = 10$ for $g = 1, \ldots, n_g$
- $\sigma_x = 1$, $\sigma_{gy} = 1$ for $g = 2, \ldots, n_g$, and $\sigma_{gm} = 1$ for $g = 1, \ldots, n_g$
- $\sigma_z = 1$, $\rho = 0.8$, $\gamma = [1, 0.8, 0.6, 0.4, 0.2]'$

We generate a realization of this model with 100 observations, adding a constant drift term to the expression for entering cohorts, $x_{1,t}$. We take the generated observations from that realization, y_t, and using the Gibbs sampler, see Section 3.2, generate a distribution for the estimated unobserved state variables, using the known parameters of the model. Note that at this stage, we do not include the drift term for the entering cohort. This is our baseline model.

For the alternative model, we assume that the first age group also follows a random walk, with the same standard deviation shock as all other age groups. Nothing changes otherwise. We again simulate the model with the same constant drift term and use the Gibbs sampler to generate a distribution for the unobserved state variables. The state-space model of the Gibbs-sampler includes the random walk nature of the first age group, but again, not the drift term.

We plot the distribution of the estimated entering cohorts in Figure 22. For the baseline model, Figure 22a, there is a slight downward bias in the median estimated cohort effect, but the true cohort effect is within the 90% coverage area of the simulations. For the alternative model, Figure 22b, the median estimate of the cohort effect is noticeably below the true cohort effect after 25 observations, and this bias increases over time. The counterpart of the biased estimated cohort effect is an estimated upward trend in the age effect of the first age group (not shown here). We conclude that the model with time-varying effects for the first age group is likely to yield biased estimates of age and cohort effects.

In a second step, we estimate the alternative model with time-varying age effects in the first age group for the U.S. data. The results confirm the simulation example: the baseline model with identified cohort effects tends to deliver cohort effects that are larger in absolute value than the alternative model with time-varying first group age effects. These differences tend to be small for the unemployment rate, but large for the LFP rate.

- For the unemployment rate, we plot the estimates for the fixed effects of entering cohorts for our baseline and alternative models in Figure 23. As we can see, relative to the baseline model, the estimated median cohort effects tend to be smaller in absolute value for the alternative model. At the same time, the uncertainty surrounding the estimates is sufficiently large that the differences are not significant.

- For the LFP rates we plot the estimates for the fixed effects of entering cohorts for our baseline and alternative models in Figure 24. As we can see, relative to the baseline model, the estimated median cohort effects for the alternative model tend to be smaller in absolute value, and the differences are significant.

End of revision so far

6.4 Trends for aggregate unemployment and LFP rates

We now describe the trends in the aggregate and gender specific labor market ratios and how changes in the age and education composition, and group LFP and unemployment rate trends affect the aggregates. The construction of the trend for the aggregate LFP rate, unemployment rate, and employment rate, and the contributions of demographic and group trend changes are described in section 5.

We plot the estimated trends of the aggregate LFP rate, unemployment rate, and employment rate in the first column of Figure 25. In the second column of Figure 25, we plot the cumulative contributions of changes in the age distribution, education shares, and estimated trends in gender-education contingent group trends for the LFP, unemployment, and employment rate. The final column decomposes the changes of group trends into cohort and age effects.

The trend LFP rate is a smoothed version of the LFP rate, characterized by its well-known hump shape, which peaks in the late 1990s, Figure 25a. Whereas deviations from trend are relatively small before the 1990s, we estimate noticeable and persistent deviations of the LFP rate from its trend after the 1990s: above trend from the mid-1990s until the 2008 recession, but mostly below trend in the recovery from the 2008 recession. The increase in the trend LFP rate from 1976 to the mid-1990s (+4.1 pp) is mostly accounted for by the shift towards more educated groups (+2.2 pp), and the increasing trend group LFP rates (+1.2 pp), Figure 25b. Conversely, the decline of the LFP rate from the mid-1990s to the present (-4.4 pp) is mostly accounted for by the well-known ageing of the baby boom generation (-4.3 pp) and the decline of trend group LFP rates (-2.3 pp). Finally, the hump-shaped contribution from trend group LFP rates is mostly accounted for by a corresponding hump-shape in cohort effects, reinforced by declining age effects starting in the mid-1990s, Figure 25c.

The trend unemployment rate declines smoothly from about 8 percent in 1976 to 5 percent in 2024, Figure 25d. Deviations of the unemployment rate from trend are large, especially in the 1990s boom (below trend) and the recovery from the 2008 recession (above trend). Furthermore, the unemployment rate tends to be above (below) trend when the LFP rate is below (above) trend. Changes in group unemployment and LFP trend rates, and education and age distributions contribute about equally to the declining unemployment rate trend, Figure 25e. Finally, cohort effects dominate the decline in group unemployment and LFP trend rates, 25f.

The trend employment rate is dominated by the trend LFP rate, whereas the trend deviations are dominated by the unemployment rate deviations, Figure 25g. The contributions of age and education distributions and group trend LFP rates to changes in the trend employment rate mirror their contributions to the aggregate trend LFP rate, with a minor impact from changes in group trend unemployment rates, Figure 25h. Finally, the hump-shaped path of the cohort effects from group LFP trend rates dominates the path of group LFP trend rates, 25i.

Overall, our decomposition of the trends in aggregate LFP, unemployment, and employment rates points to the important role of composition effects arising from changes in the age and education distribution: they account for one-half to three-fourths of trend changes. However, this might overstate the importance of compositional changes since the aggregates reflect diverging trends among men and women, Figure 26. From 1976 to 2024 men's trend LFP rate declined by about 10 pp, whereas women's trend LFP rate first increased by about 10 pp until 2000 and subsequently declined by 2 pp, Figure 26a and 26b. Compositional changes from age and education affect men's and women's LFP rates about equally. Still, men's group trend LFP rates decline uniformly by about 9 pp, whereas they increase by about 7 pp for women, Figure 26c and 26d. Since age and education effects cancel each other, the changes in group trend LFP rates account for almost all of the net change in men's and women's trend LFP rates. Finally, we again see the important role of cohort effects in determining group trend LFP rates, as shown by the blue lines in Figures 26e and 26f. Note that the declining LFP rates of young males less than 25 years old account for roughly one-third of the declining contribution coming from men's trend LFP rates, whereas young women have much less of an impact on women's trend LFP rates, the green lines in Figures 26e and 26f.

We see much less disparity in the trend unemployment rates for men and women, Figure 27. For both genders trend unemployment rates decline, with qualitatively similar contributions from changes in age and education distribution, and group trend LFP and unemployment rates. The only difference is the relatively larger decline in group trend unemployment rates for men. Again, cohort effects tend to dominate changes in group trend LFP and unemployment rates.

6.5 Trends and forecasts for education shares

In the previous section 6.4, we have shown that increasing educational attainment in the population is an important source of trend increases in the aggregate LFP rate and trend declines in the unemployment rate. We now provide a more detailed picture of changes in the population's educational attainment. In particular, we point out the importance of vintage effects for the path of educational attainment. This also provides a prelude for section 6.6 where we use our models to forecast the aggregate LFP rate and unemployment rate. Even without any further changes in the educational attainment for entering cohorts, the cohort structure of current vintages will have an impact on aggregates going forward.

In Figures 46 to 49, we plot how our four education shares for men and women evolve in our five age groups for the population aged 25 and older. Educational attainment has increased: among the entering cohorts aged 25-34, the share of those with a high-school education or less has decreased, and the share of those with some college or more has increased. With few exceptions, these changes were mostly monotonic across all four education groups. Education shares have also evolved smoothly; the actual values are pretty much the same as the trends, and the coverage areas are quite narrow.

Vintage effects are apparent in the behavior of education shares across age groups. For example, consider men with a high-school education, the left column of Figure 47. The share of 25-34-year-old men starts to decline in 1990. This pattern is echoed about 10 years later among 35-44-year-old men, and 20 years later among 45-54-year-old men. We can observe similar patterns for other education groups.

The trends in observed education shares reflect trends in the estimated education shares for entering cohorts, Figure 50. For men, the process of increasing educational attainment is mostly finished by the beginning of our sample in 1976. From this time on, the share of men with LTHS or HS in the entering cohorts remains roughly constant. Starting around 2000, more men finish their high school and college education, and there is a further increase in the share of men with a completed high school and college education. For women, educational attainment increases throughout the sample: the share of women in the entry cohorts with LTHS and HS education declines, and the shares of those with some college or completed college increase, except for the last few years.

Our model of education shares implies no predictable changes in cohort education shares. Nevertheless, past changes in educational attainment are embedded in the current cohort structure and imply predictable changes in observed education shares for gender-age groups. In Figures 51 to 54 we plot past trends and 20 year projections for the population aged 25 and older: the education shares of men and women for our five age groups and four education categories.[7]

Our forecasts suggest only limited changes to the share of those with LTHS since, as we have noted, those shares have been relatively unchanged at their lower bound for the past twenty years. But for those with a high-school education or higher, there are predicted share changes due to the cohort structure. For example, the share of men 35-44 years old is predicted to increase over the next 20 years, Figure 52. This prediction simply reflects that currently the share of men 25-34 years old with a high school education is larger than that share for the 35-44 year old men. Thus, as the men with a high-school education in the 25-34 year age group transition into the 35-44 year age group, the share of that group will increase. The forecast calls for some offsetting changes in the shares among those with at least some college education. Given the vintage structure, these forecasts reflect more recent patterns observed over the last twenty years.

In section 4, we have noted that our model of education treats each share as an independent process. Thus, a joint draw of projections of future education shares will not add up to one if they are based on independent Monte Carlo draws. We deal with this problem by constructing joint draws for all four shares that are then normalized to one. In Figures 55 to 58 we plot the medians and coverage areas for the normalized joint and independent projections of the education shares. The projections are essentially the same.

6.5.1 A digression on trends for aggregate LFP and unemployment rates

In section 6.4, we have constructed the trend of the aggregate LFS rates (LFP rate, unemployment rate, and employment rate) from population share weighted trends of the corresponding LFS rates for gender-age-education-based groups. Once we estimate the trend in education shares, one may ask why not incorporate these estimated trends in the calculation for the trend for the aggregate LFS rates. In Figure 59 we plot both trends for the aggregate LFS rates: the ones constructed using the actual education shares, Figure 25, and the ones constructed from the actual gender-age shares and the estimated trends for the education shares. As we have noted before, the deviations of estimated trends from actual education shares are small with narrow confidence intervals. Thus, the constructed trends are essentially the same, and in the following, we will continue to use the actual education shares for aggregate LFS rates.

6.6 Forecasts for aggregate LFP and unemployment rates

In Figure 60 we plot the historical series (black), the estimated median trend (red), and the median forecast (blue) with uncertainty bands (shaded) for the aggregate unemployment rate, LFP rate, and employment-to-population ratio. In Figures 61 and Figures 62, we plot the same objects separately for men and women for the LFP and unemployment rates. In Figure 63 we plot these objects for men and women 16-24 years old. And in Figures 64 through 67 we plot these objects for men and women 25 and older for the four education groups.

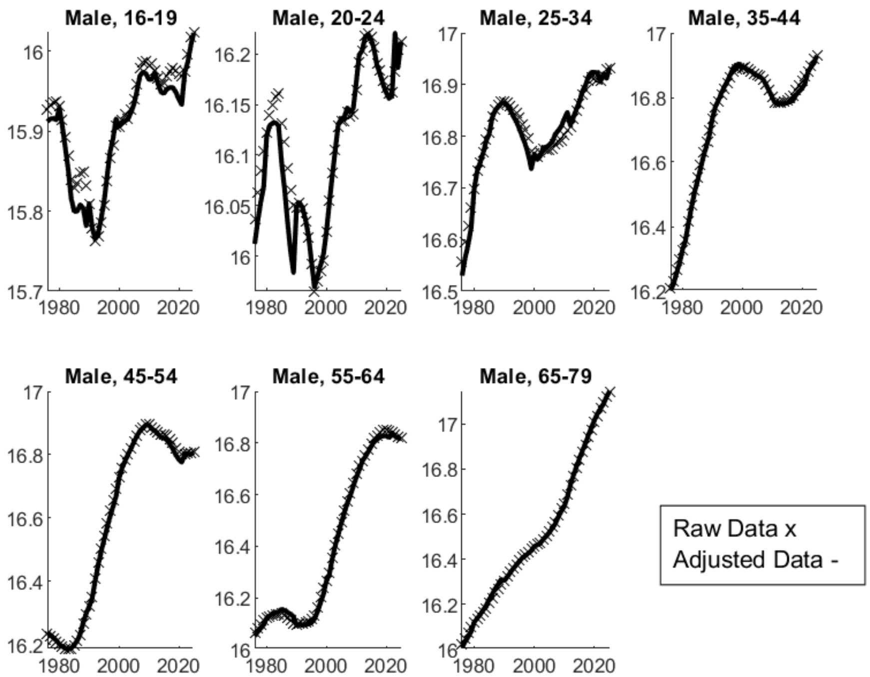
[7]Our projections are based on Monte Carlo simulations and involve random draws on estimated parameters and the state space model. See section 4.

7 Figures

List of Figures

Figure 1: Population Controls Adjustment

(a) Men



(b) Women

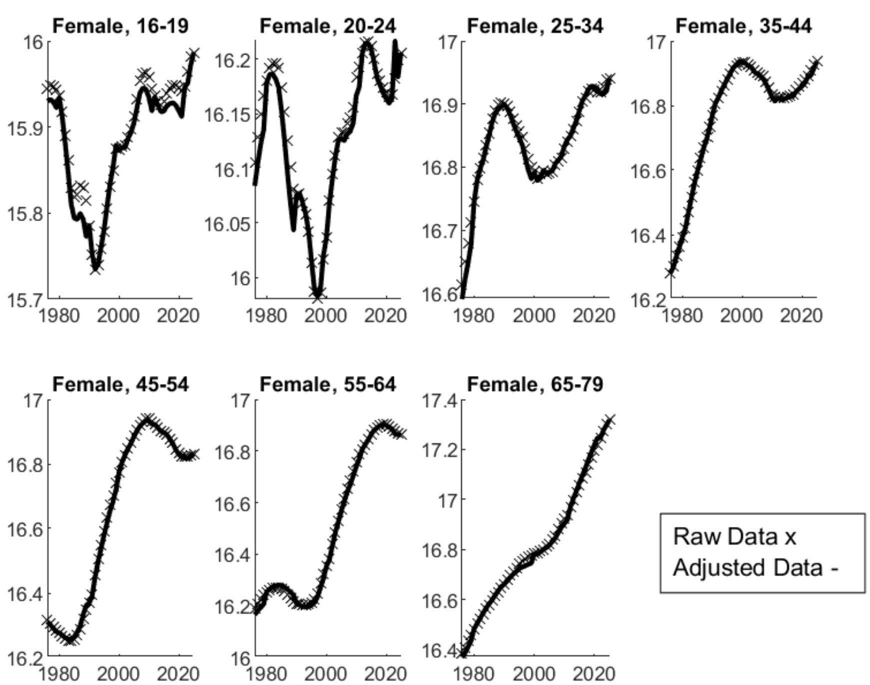
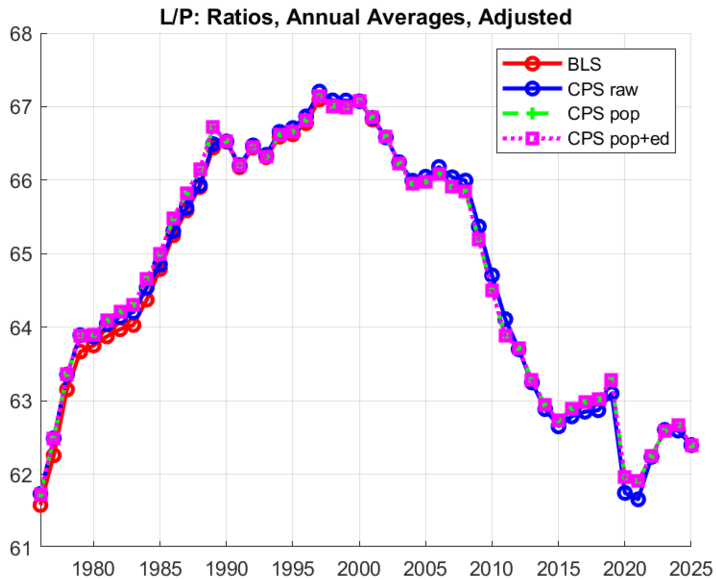
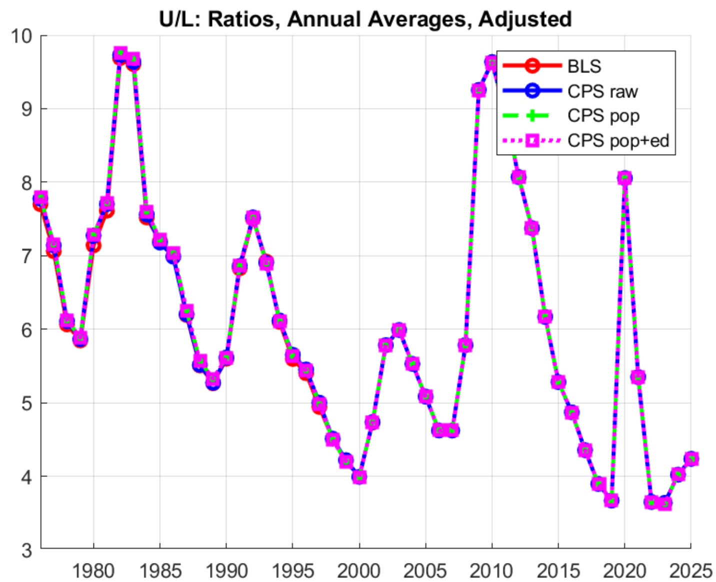


Figure 2: LFP Rate: CPS aggregate versus BLS published



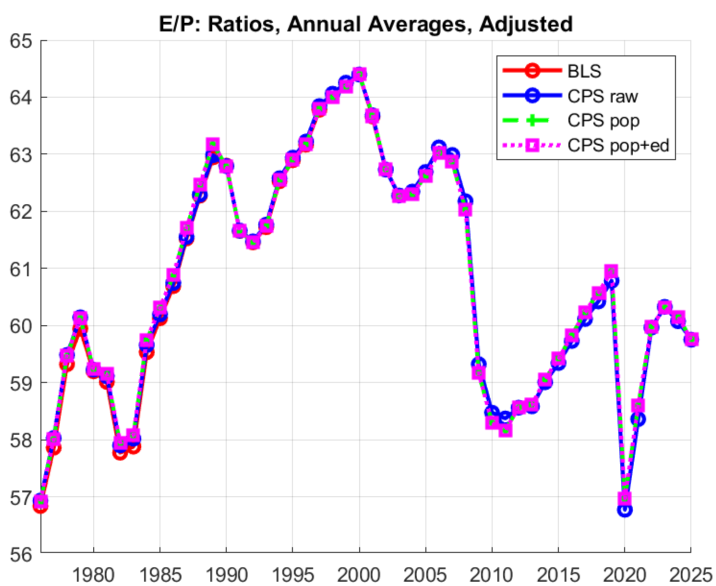
Note: This graph displays the aggregate LFP rate. The solid red line with circle markers labeled `BLS` represents published BLS data. The solid blue line with circle markers labeled `CPS raw` is based on the CPS micro-sample. The dashed green line with plus sign markers labeled `CPS pop` is based on the CPS micro-sample after smoothing through changes in the population controls. The dotted purple line with square markers labeled `CPS pop+ed` is based on the CPS micro-sample after smoothing through changes in the population controls and adjusting education shares in 1992 as described in the text.

Figure 3: Unemployment Rate: CPS aggregate versus BLS published



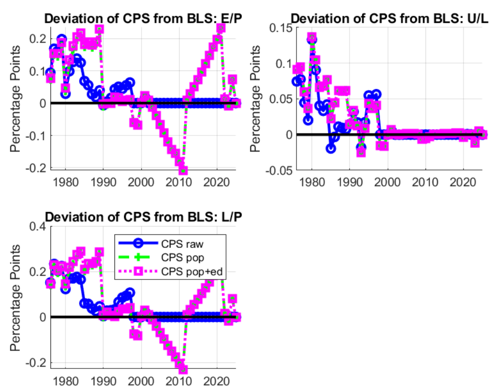
Note: This graph displays the unemployment rate. For the labels see the note to Figure 2.

Figure 4: Employment-Population Ratio: CPS aggregate versus BLS published



Note: This graph displays the employment rate. For the labels see the note to Figure 2.

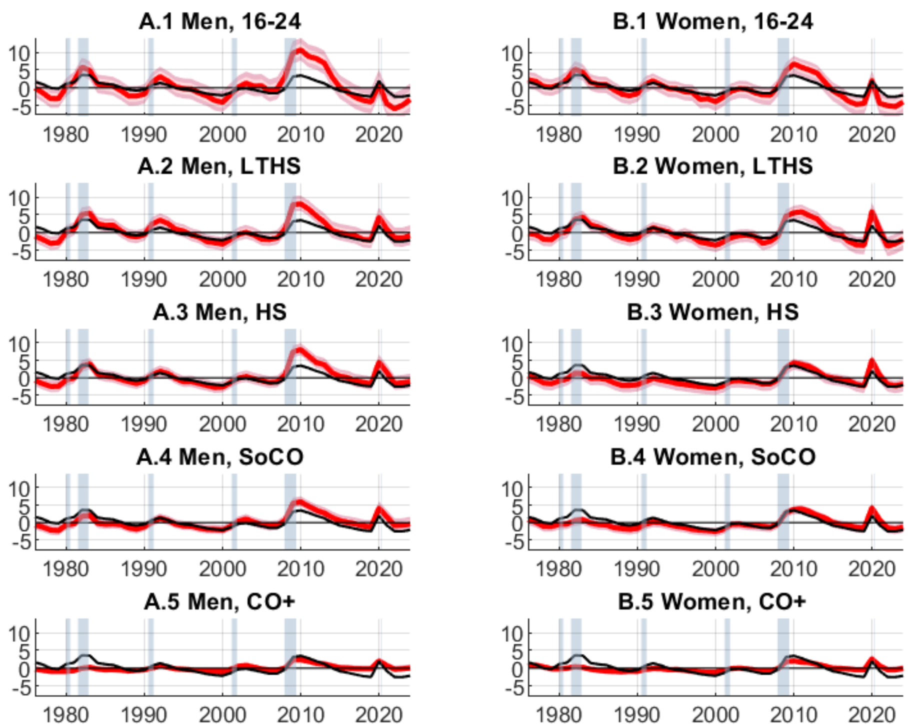
Figure 5: Deviations of CPS aggregates from published BLS aggregates



Note: This graph displays deviations of constructed LFS rates from BLS published. For the labels see the note to Figure 2.

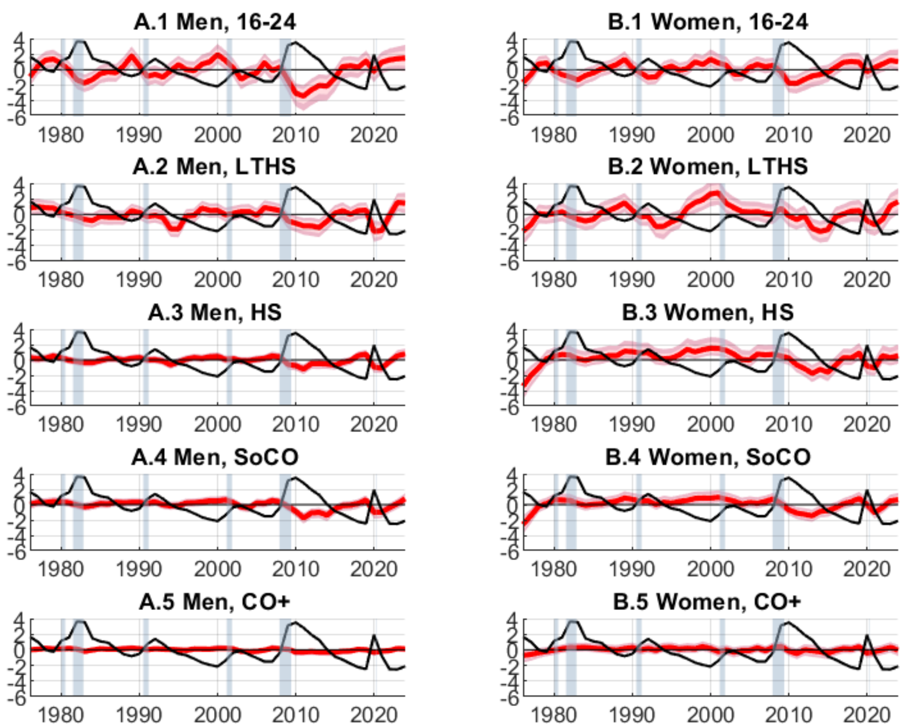
7.1 Cyclical effects for section

Figure 6: Cyclical effect for unemployment rates



Note: Estimated cyclical effect by gender for the age group 16-24 (not differentiated by education), and for those 25 or older by education groups less than high school (LHS), high school (HS), some college (SoCO), and college or above (CO+). The left column (A) is for men, and the right column (B) is for women. Solid red lines denote the estimated median cyclical effect, and the light (dark) shaded areas denote the 66% (90%) coverage area. The thin black line is the demeaned aggregate unemployment rate.

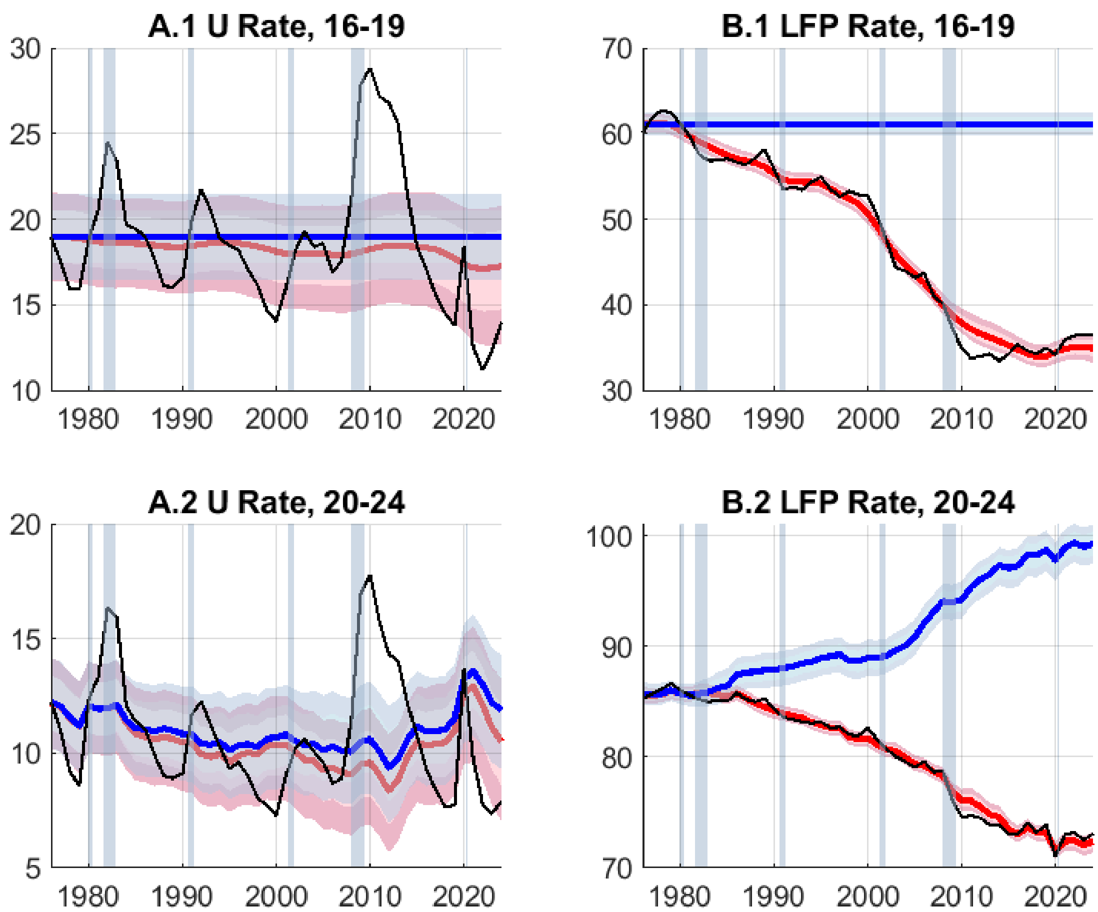
Figure 7: Cyclical effect for LFP rates



Note: See notes for Figure 6

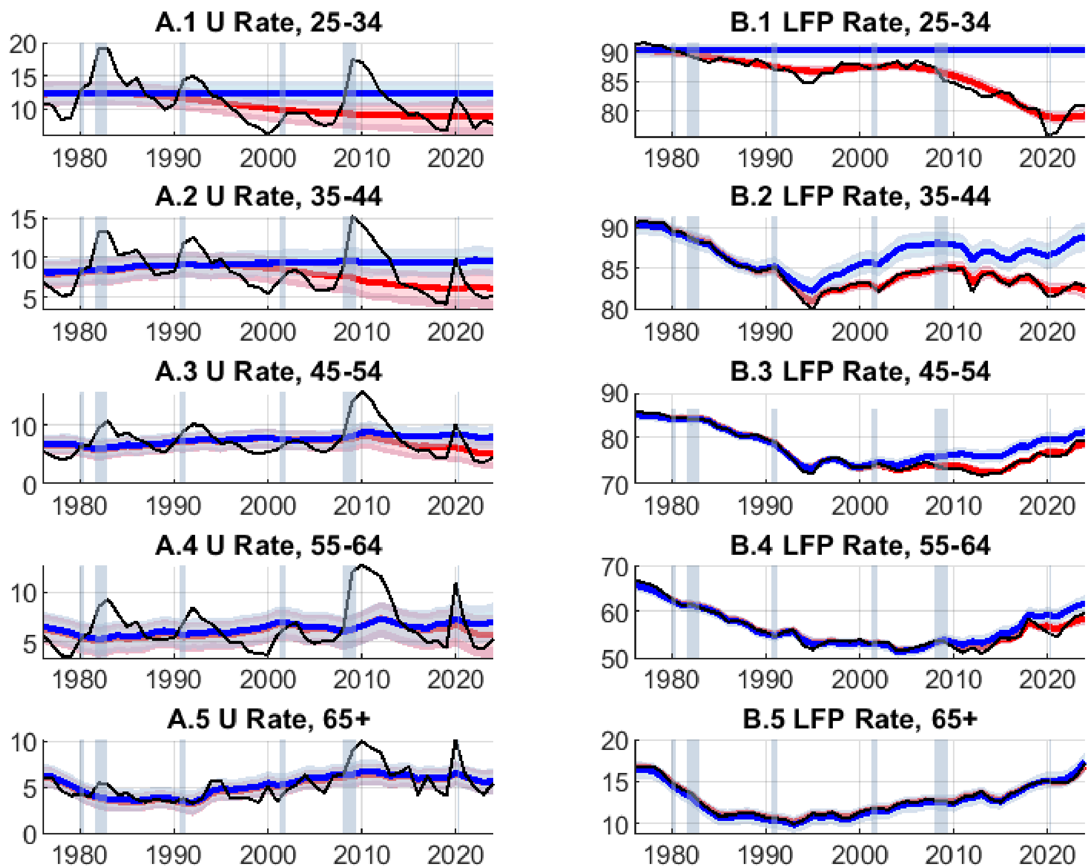
7.2 Age and trend estimates for men

Figure 8: Men, 16-24 years old: Age effect and trend



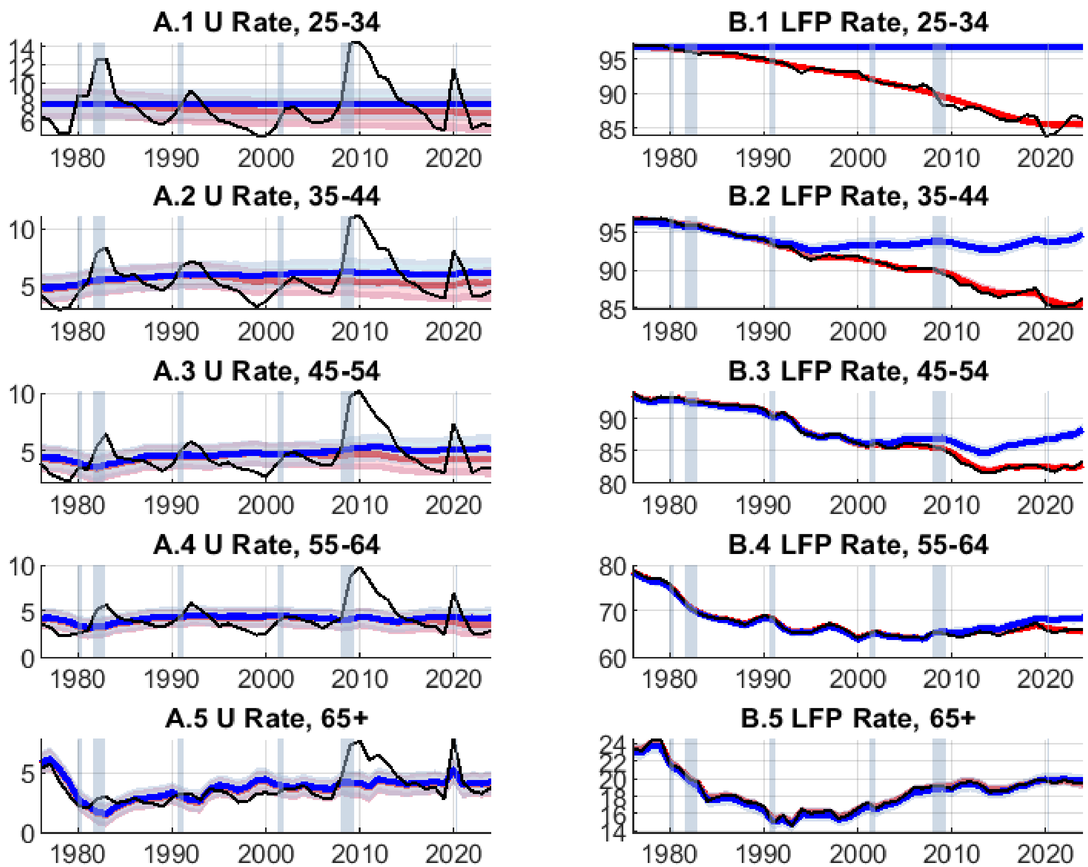
Note: Unemployment rate (A) and LFP rate (B). Solid blue lines denote the estimated median age effect, solid red lines denote the estimated median trend, the sum of age and cohort effect, and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area. The thin black lines are the actual unemployment rate and LFP rate, respectively.

Figure 9: Men, 25 years and older, with less than a high-school education: Age effect and trend



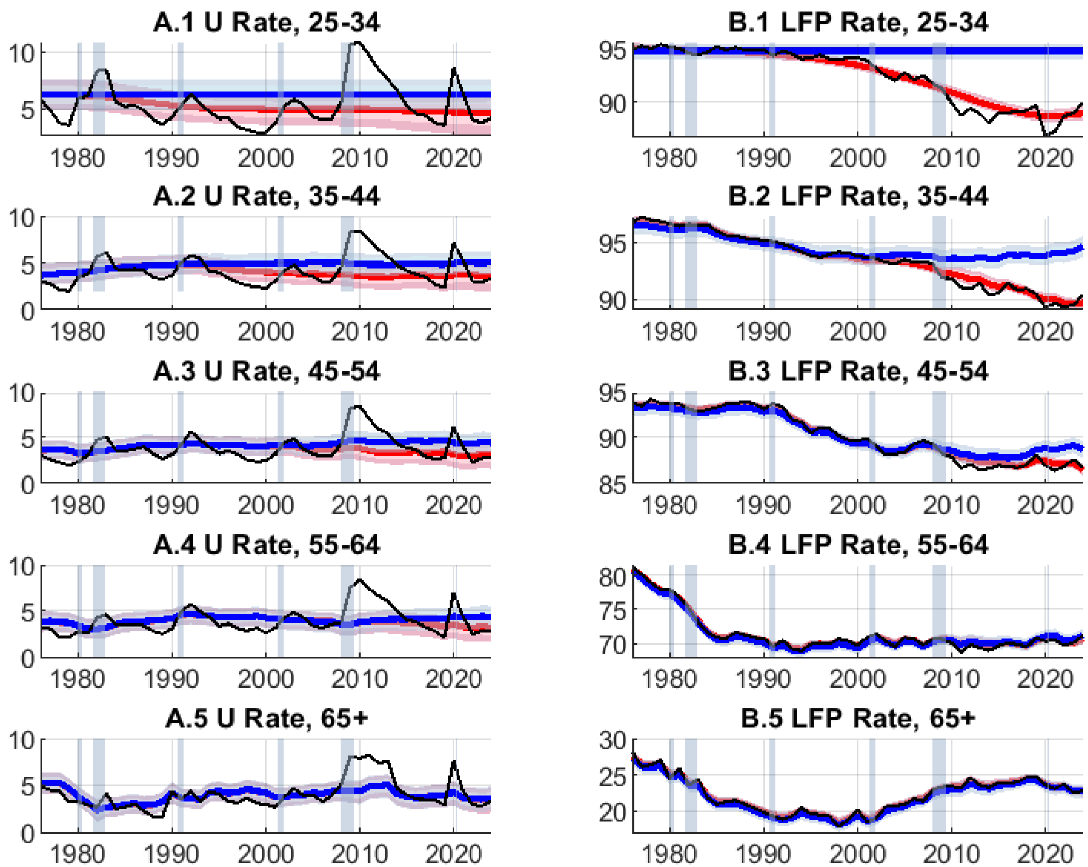
Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

Figure 10: Men, 25 years and older, with a high-school education: Age effect and trend



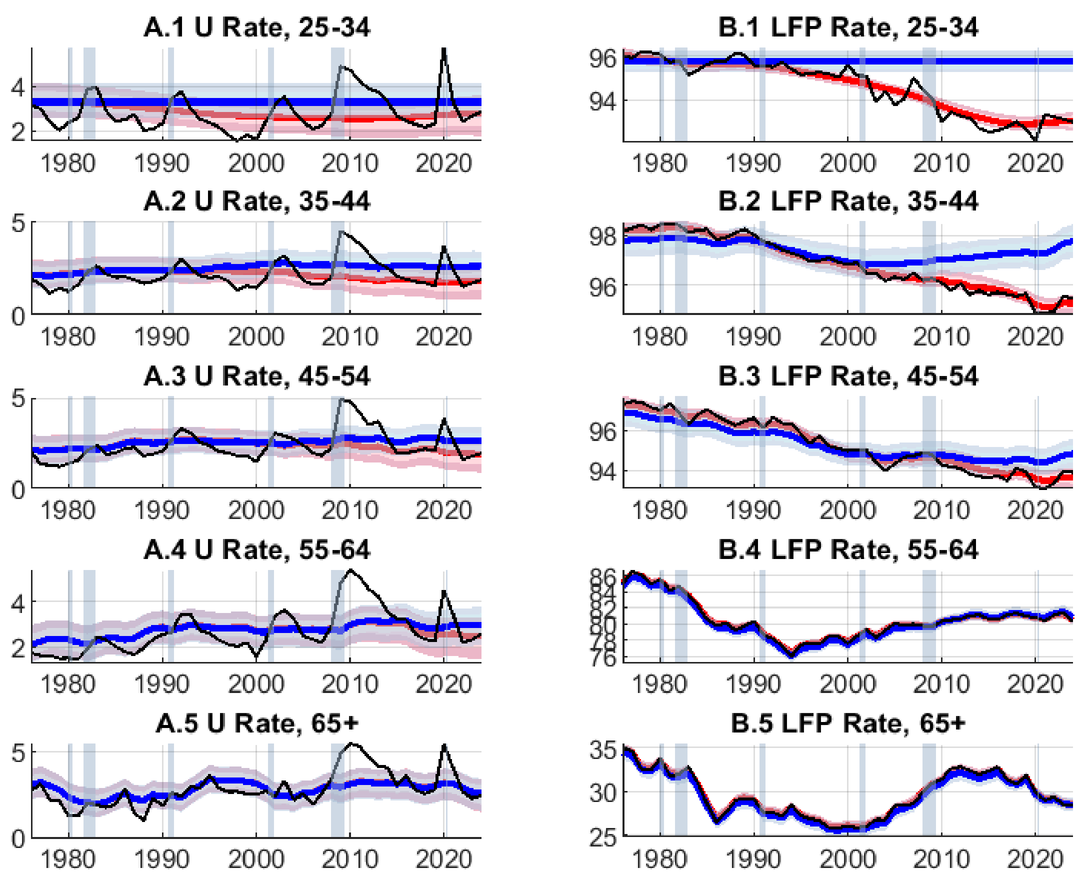
Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

Figure 11: Men, 25 years and older, with some college: Age effect and trend



Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

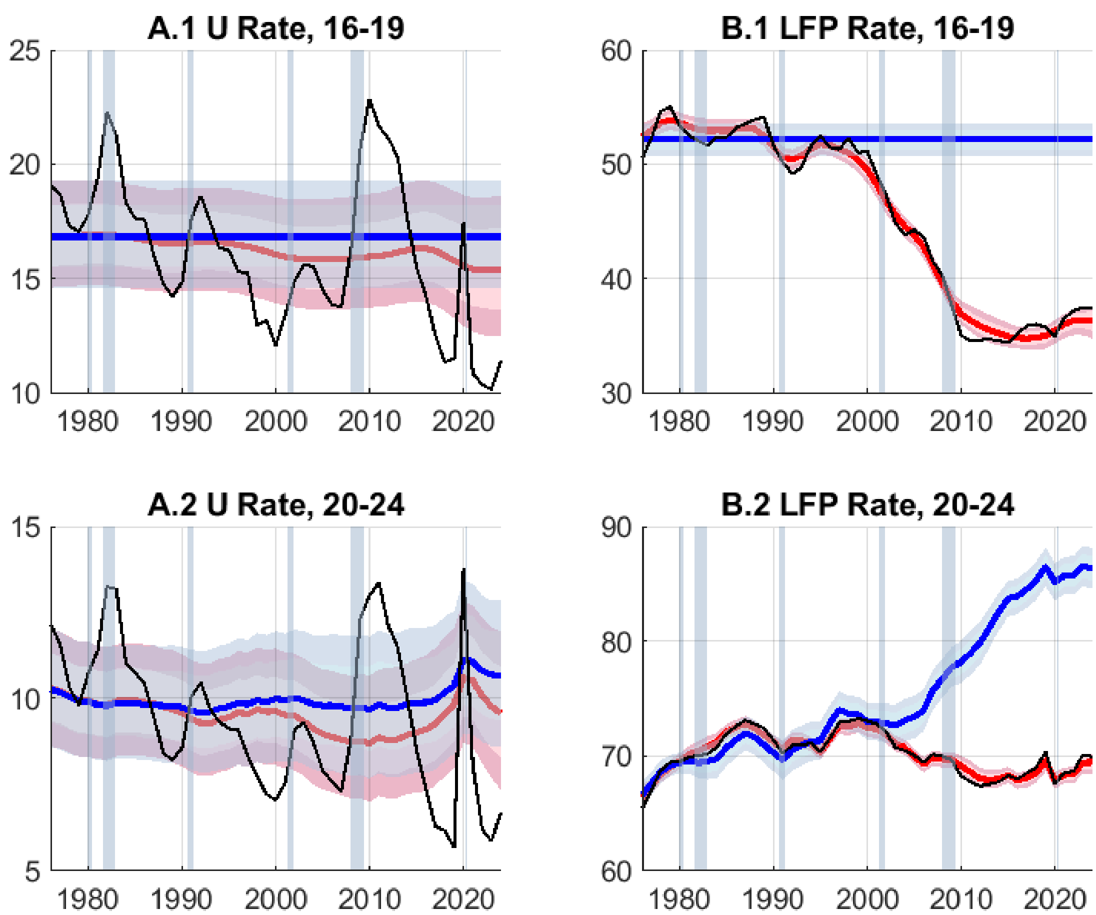
Figure 12: Men, 25 years and older, with a college degree or higher: Age effect and trend



Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

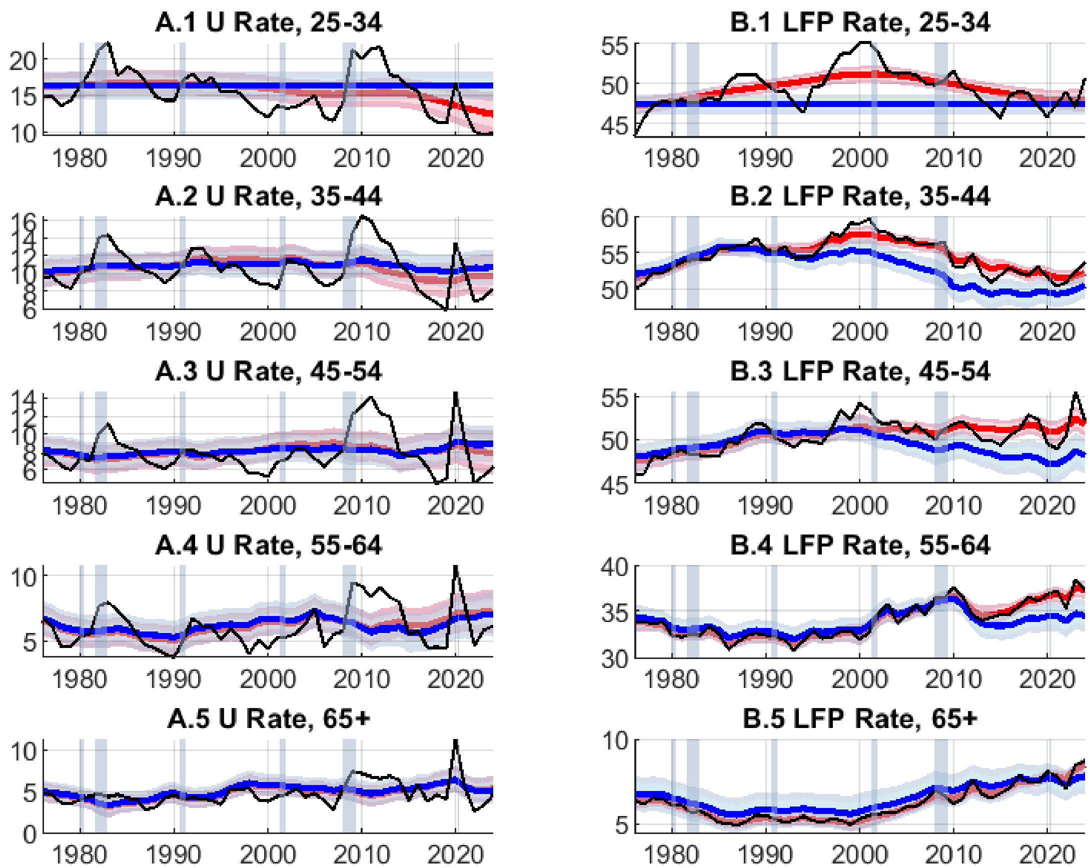
7.3 Age and trend estimates for women

Figure 13: Women, 16-24 years old: Age effect and trend



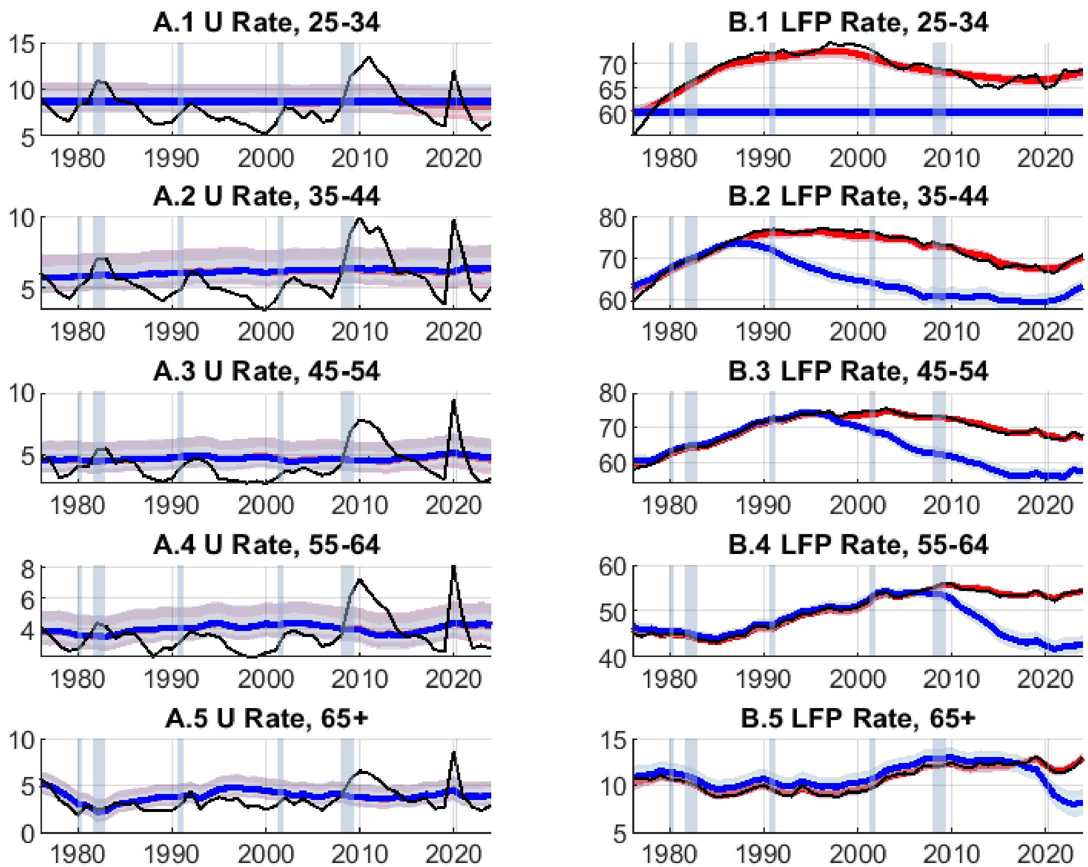
Note: See notes for Figure 8.

Figure 14: Women, 25 years and older, with less than a high-school education: Age effect and trend



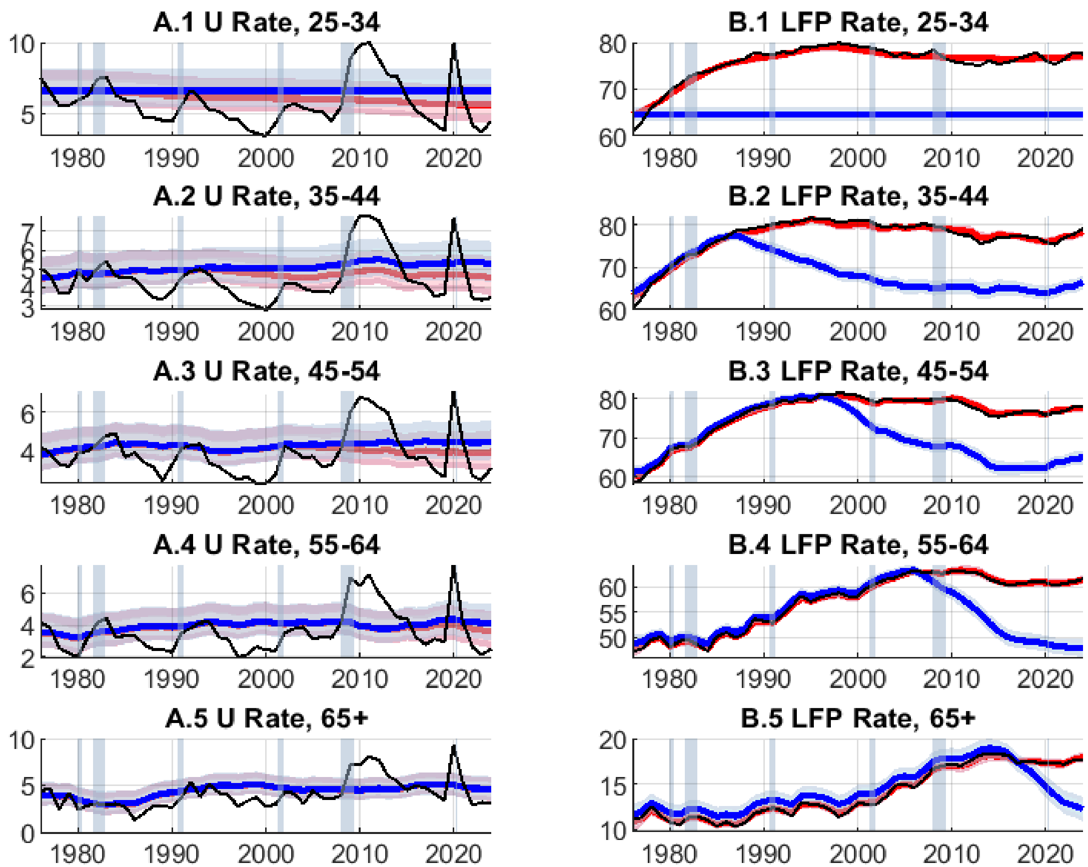
Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

Figure 15: Women, 25 years and older, with a high-school education: Age effect and trend



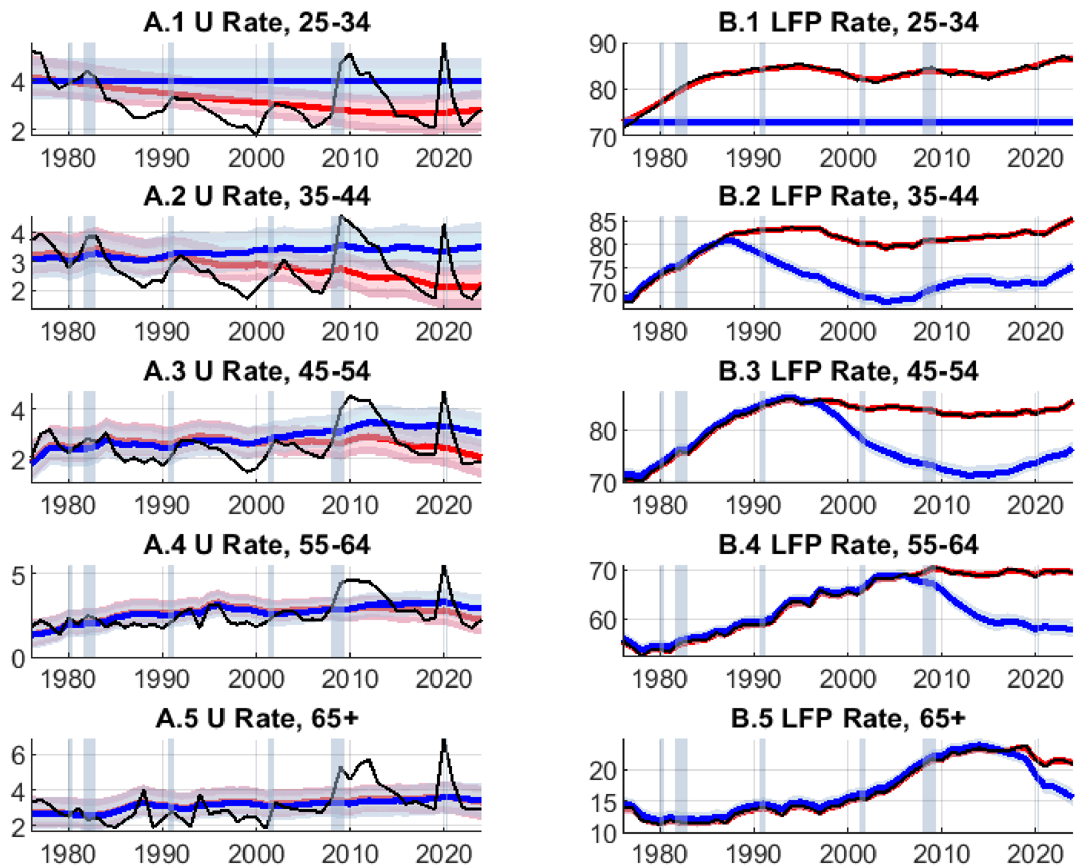
Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

Figure 16: Women, 25 years and older, with some college: Age effect and trend



Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

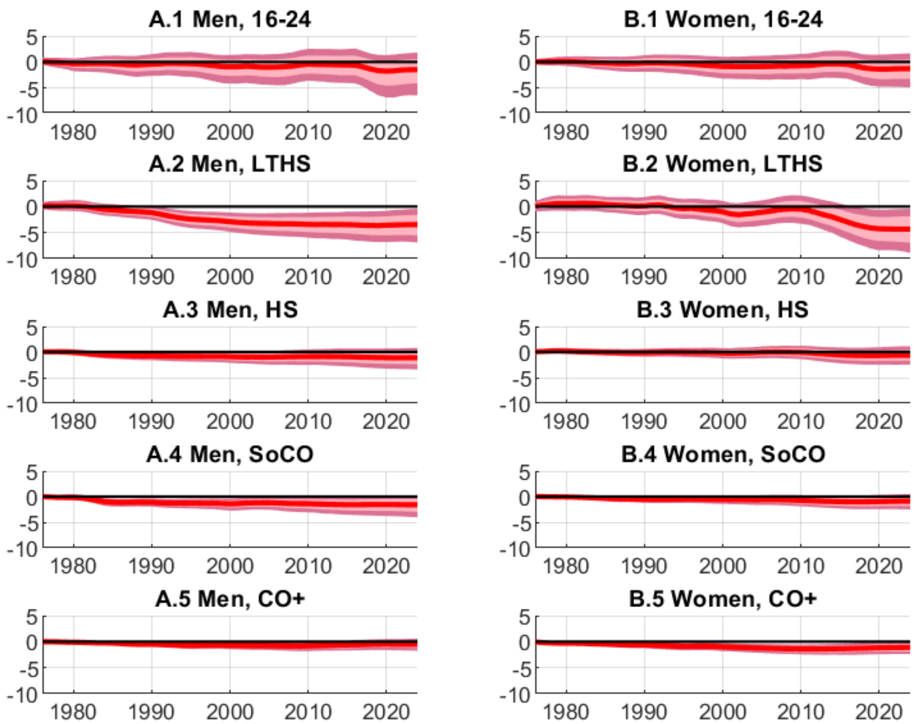
Figure 17: Women, 25 years and older, with a college degree or higher: Age effect and trend



Note: Unemployment rate (A) and LFP rate (B) for age groups 25-34, 35-44, 45-54, 55-64, and 65+. See notes for Figure 8.

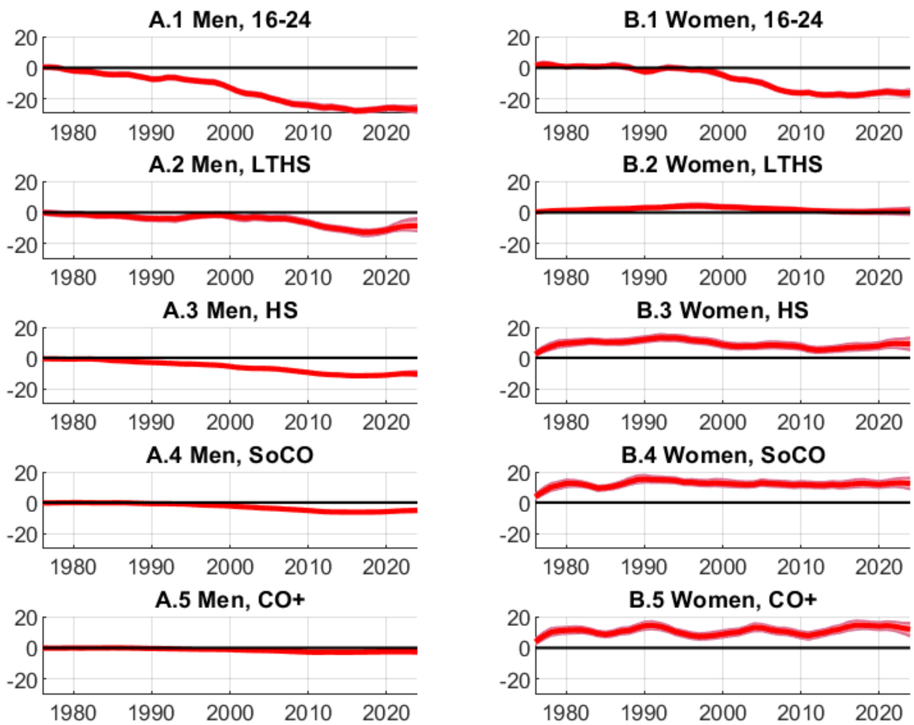
7.4 Cohort effects

Figure 18: Fixed effect of entering cohorts for unemployment rates



Note: Estimate of median fixed effect of entering cohorts for men (A) and women (B) for the age group 16-24 not differentiated by education and for education groups with less than a high-school degree (LTHS), a high-school degree (HS), some college (SoCO), The light (dark) shaded areas denote the 66% (90%) coverage area.

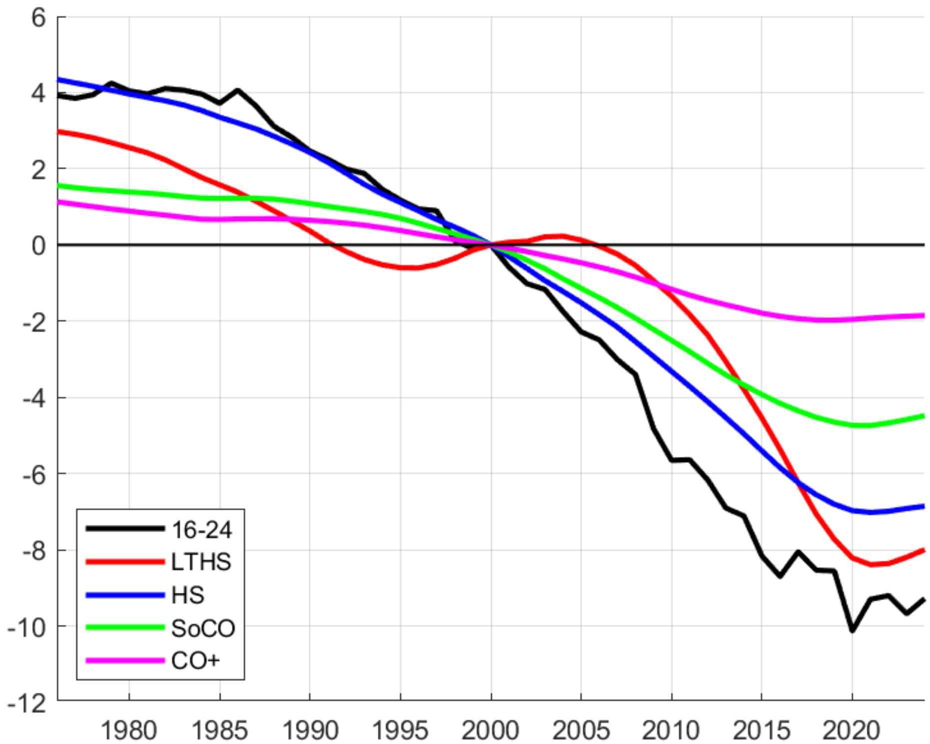
Figure 19: Fixed effect of entering cohorts for LFP rates



Note: See notes to Figure 18.

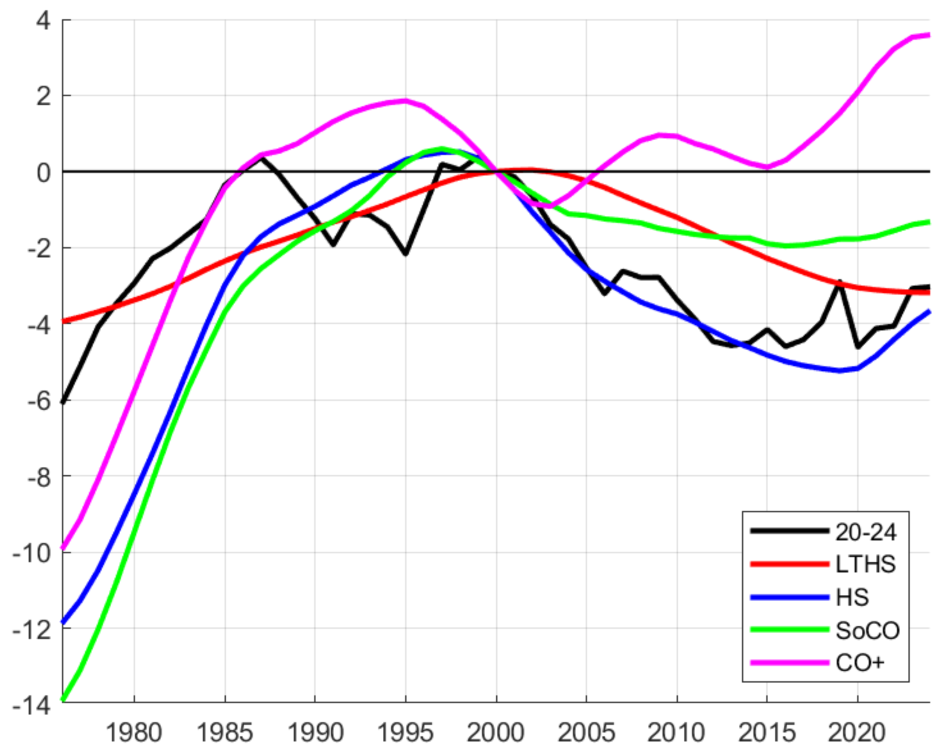
7.5 The labor supply of young workers

Figure 20: Relative LFP rates of Young Men



Note: Estimated average trend LFP rate of young men, 20-24 years, and estimated average LFP cohort effects for men aged 25-34 years, by education. LFP rates are in percentage points and normalized relative to 2000 values.

Figure 21: Relative LFP rates of Young Women

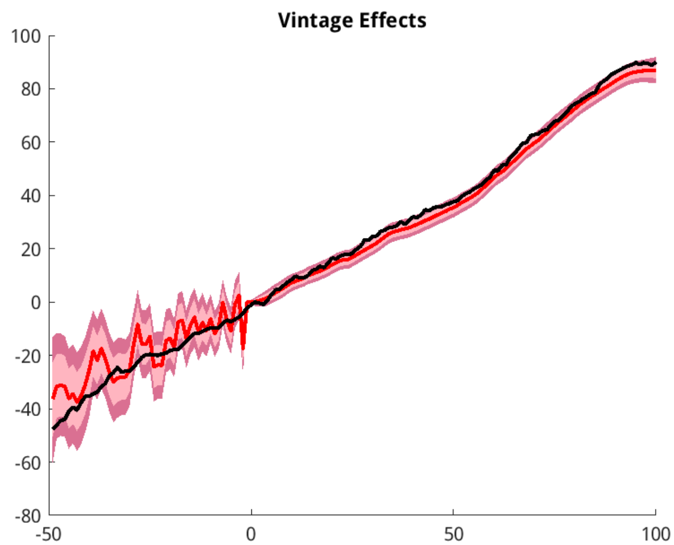


Note: Estimated average trend LFP rate of young women, 20-24 years, and estimated average LFP cohort effects for women aged 25-34 years, by education. LFP rates are in percentage points and normalized relative to 2000 values.

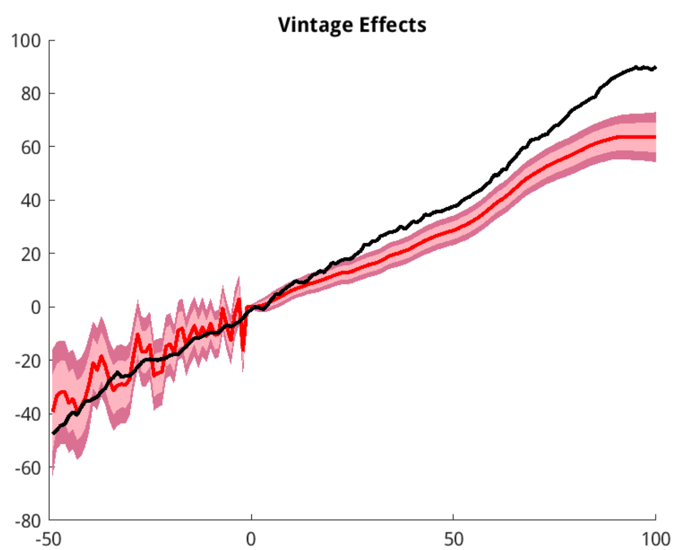
7.6 Fixed age effect for first age group

Figure 22: Simulated fixed effect from entering cohorts

(a) Baseline Model

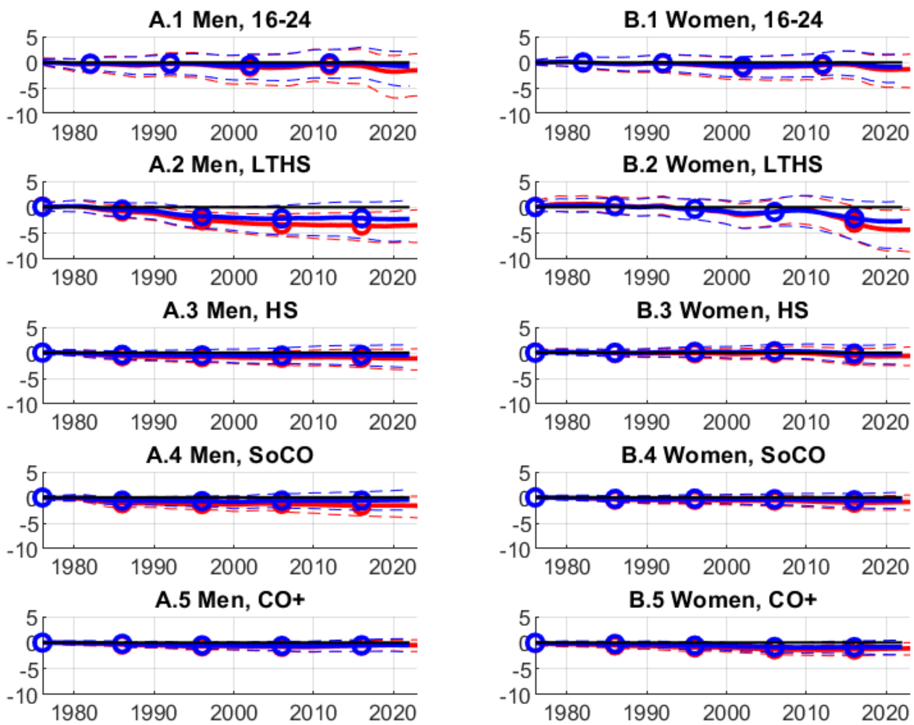


(b) Alternative Model



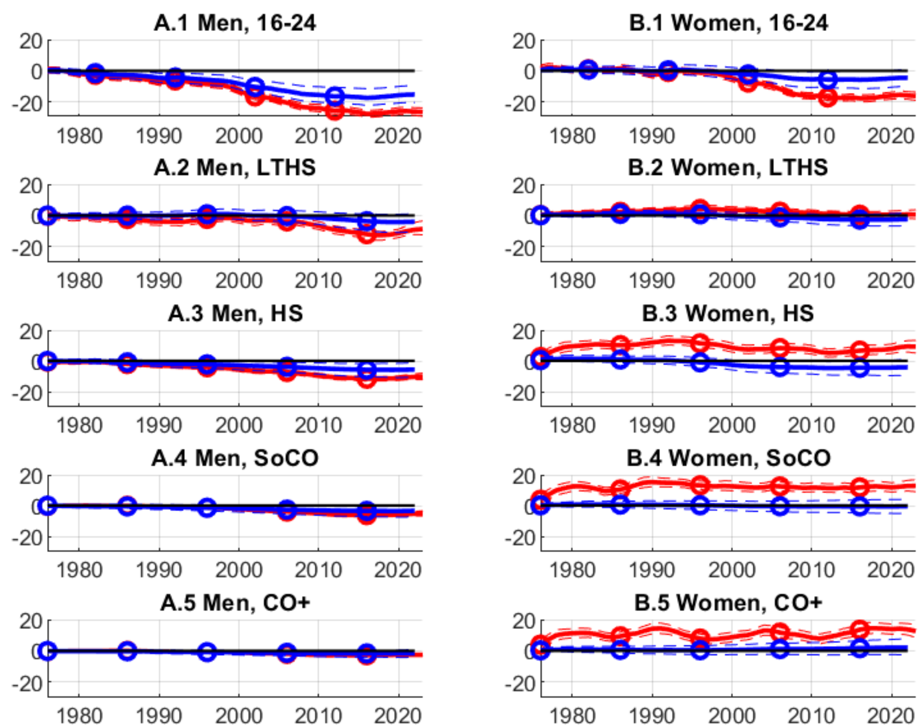
Note: Distribution of estimated fixed effect for entering cohorts for (a) the baseline model with fixed age effect of the first age group, and (b) the alternative model with random walk age effect of the first age group. In each panel, the black line plots the true fixed effects for entering cohorts, and the red line plots the median estimate of the cohort fixed effect with light (dark) shaded 66% (90%) coverage areas.

Figure 23: Estimated cohort fixed effects for unemployment rates.
The role of fixed age effects



Note: Estimates of median fixed effect of entering cohorts for the baseline model (red) with age effect of the first age group fixed versus an alternative model (blue) with a random walk for the age effect of the first age group. Solid lines are median estimates, thin dashed lines denote the 90% coverage area.

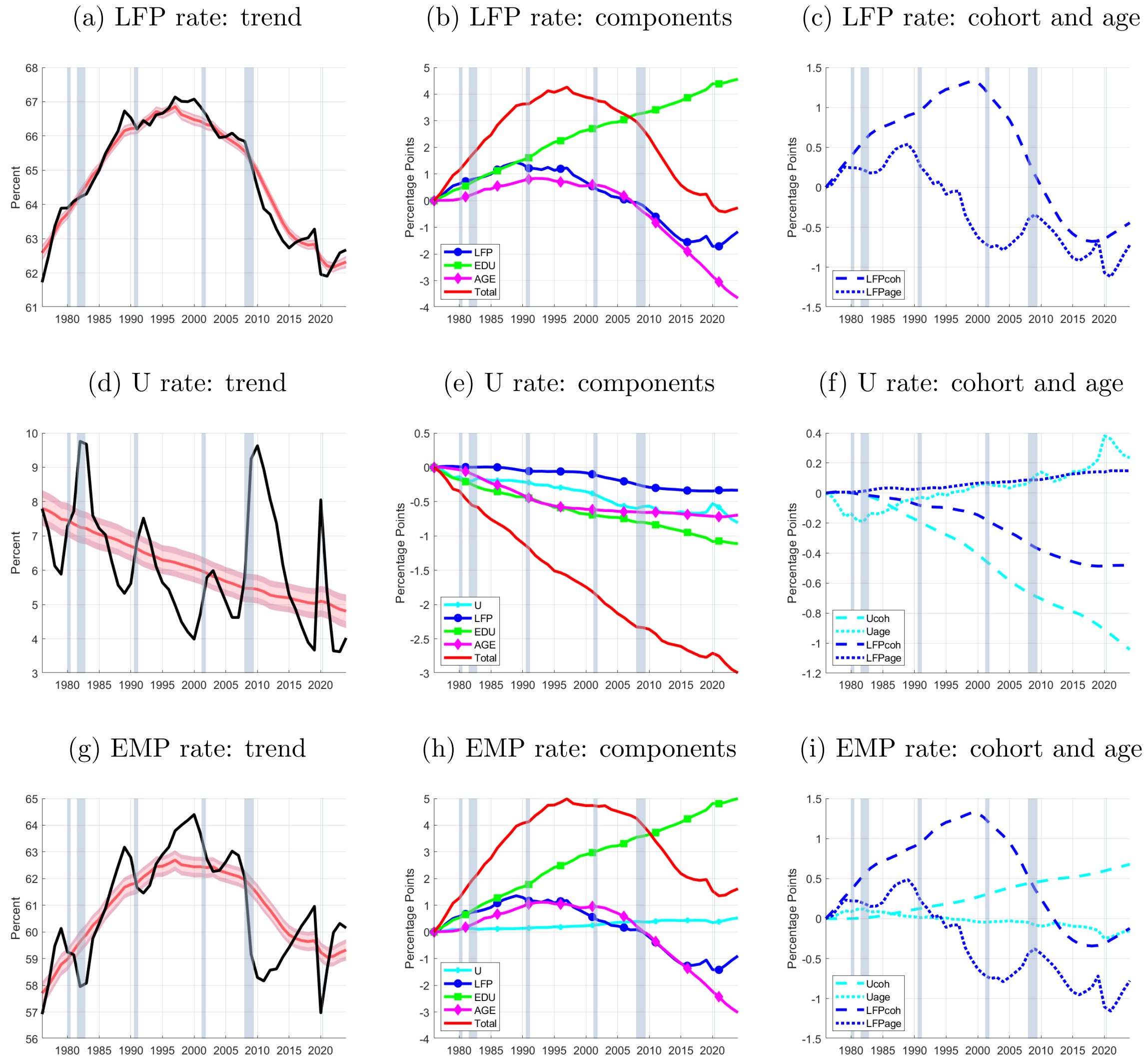
Figure 24: Estimated cohort fixed effect for LFP rates.
The role of fixed age effects



Note: See notes to Figure 23.

7.7 Aggregate trends

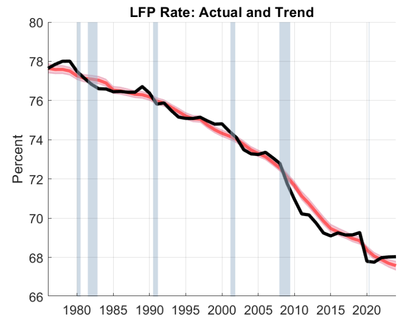
Figure 25: Aggregate trends



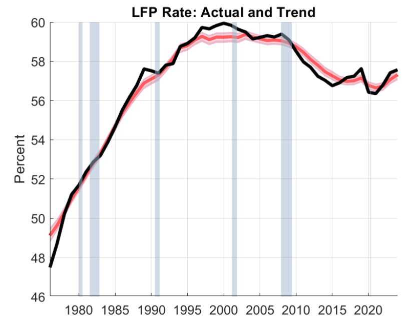
Note: The panels in the left column plot the aggregate LFS rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) shaded 66% (90%) coverage areas. The panels in the middle column plot the cumulative contributions to changes in the trend (Total) coming from changes in population shares by age (AGE), education shares (EDU), and trend LFS rates (LFP and U). The panels in the right column split the contributions of trend LFS rates into age (dotted) and cohort (dashed) effects.

Figure 26: Aggregate LFP trends for men and women

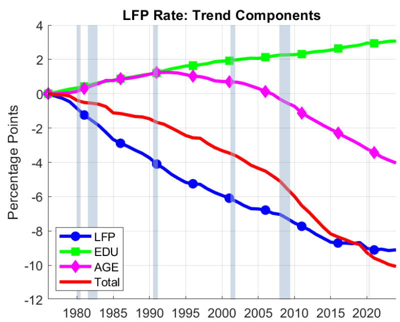
(a) Men: trend



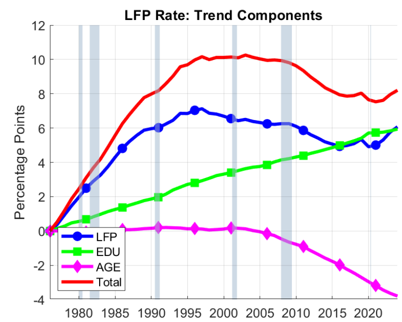
(b) Women: trend



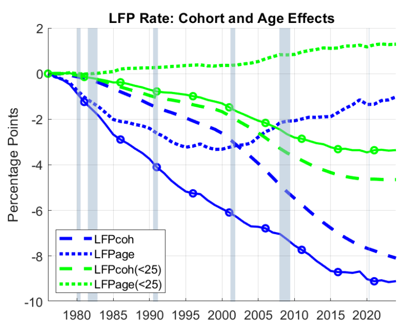
(c) Men: components



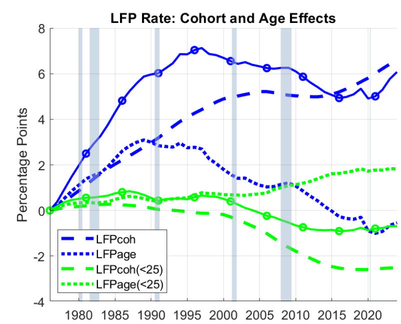
(d) Women: components



(e) Men: cohort and age



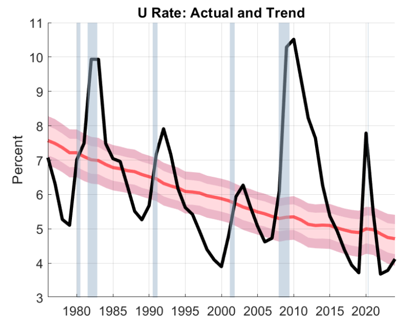
(f) Women: cohort and age



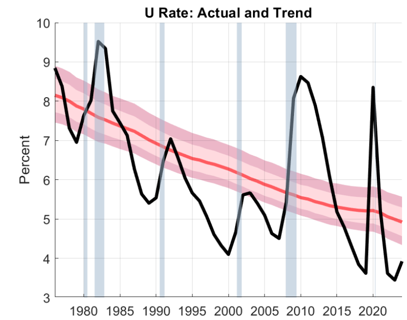
Note: The top panels plot the LFP rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) shaded 66% (90%) coverage areas. The middle panels plot the cumulative contributions to changes in the trend (Total) coming from changes in population shares by age (AGE), education shares (EDU), and trend LFP rates (LFP). The bottom panels split the contributions of trend LFP rates into age (dotted) and cohort (dashed) effects. The blue lines capture all age groups and the green lines capture those 16 to 24 years old.

Figure 27: Aggregate unemployment trends for men and women

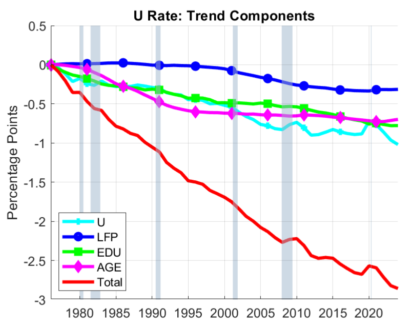
(a) Men: trend



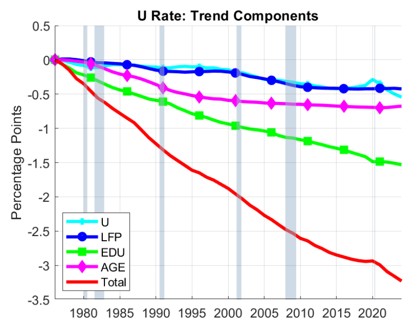
(b) Women: trend



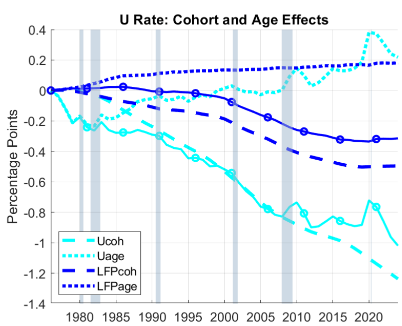
(c) Men: components



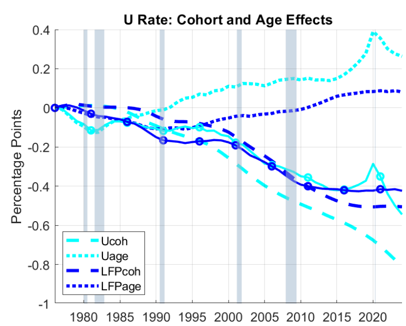
(d) Women: components



(e) Men: cohort and age



(f) Women: cohort and age

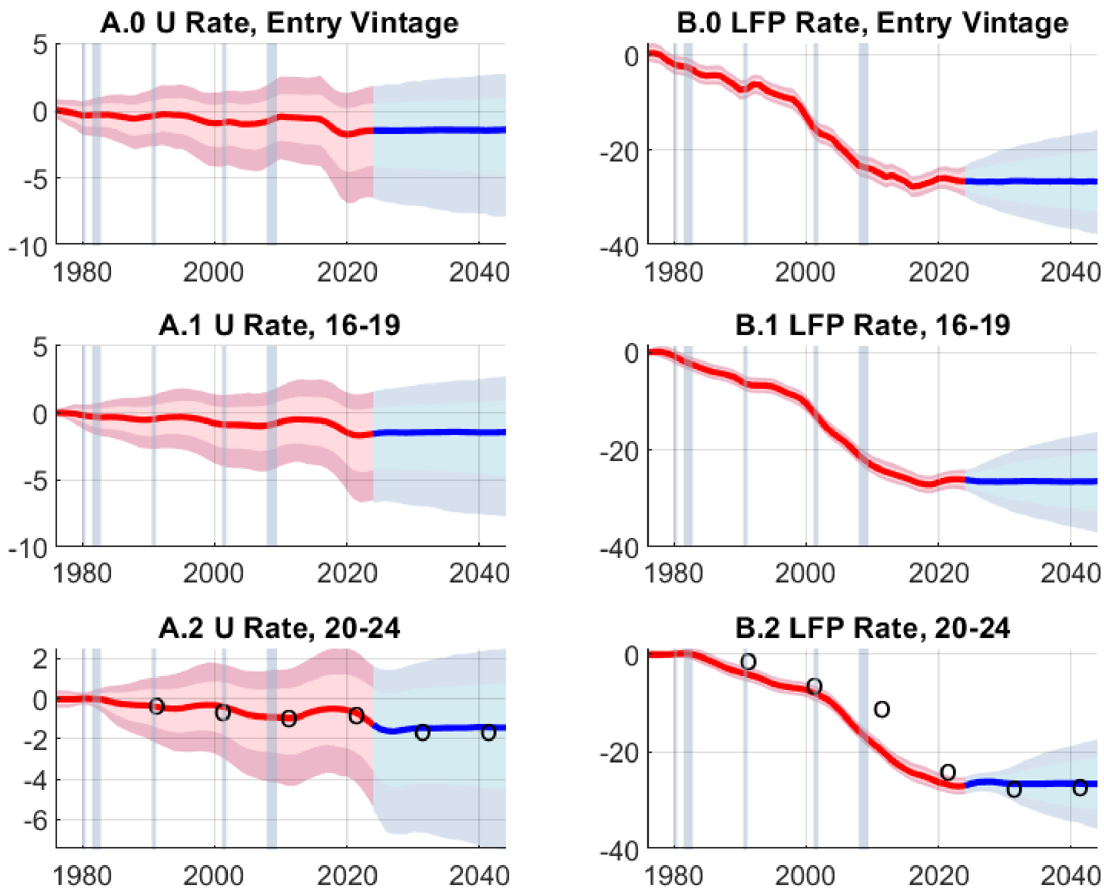


Note: The top panels plot the aggregate LFP rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) shaded 66% (90%) coverage areas. The middle panels plot the cumulative contributions to changes in the trend (Total) coming from changes in population shares by age (AGE), education shares (EDU), and trend LFP rates (LFP). The bottom panels split the contributions of trend LFP rates into age (dotted) and cohort (dashed) effects.

7.8 Projections for group unemployment and LFP rates

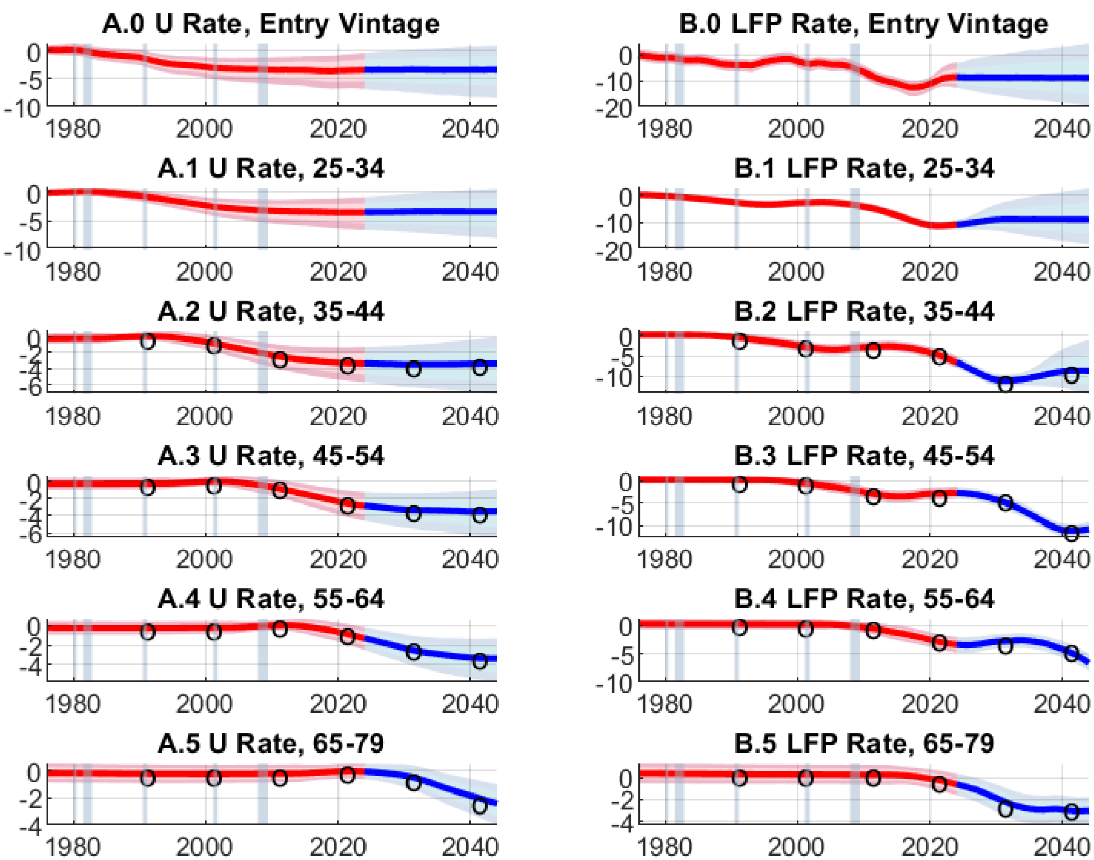
7.8.1 Projections of cohort effects for men

Figure 28: Men, 16-24 years old: cohort effect



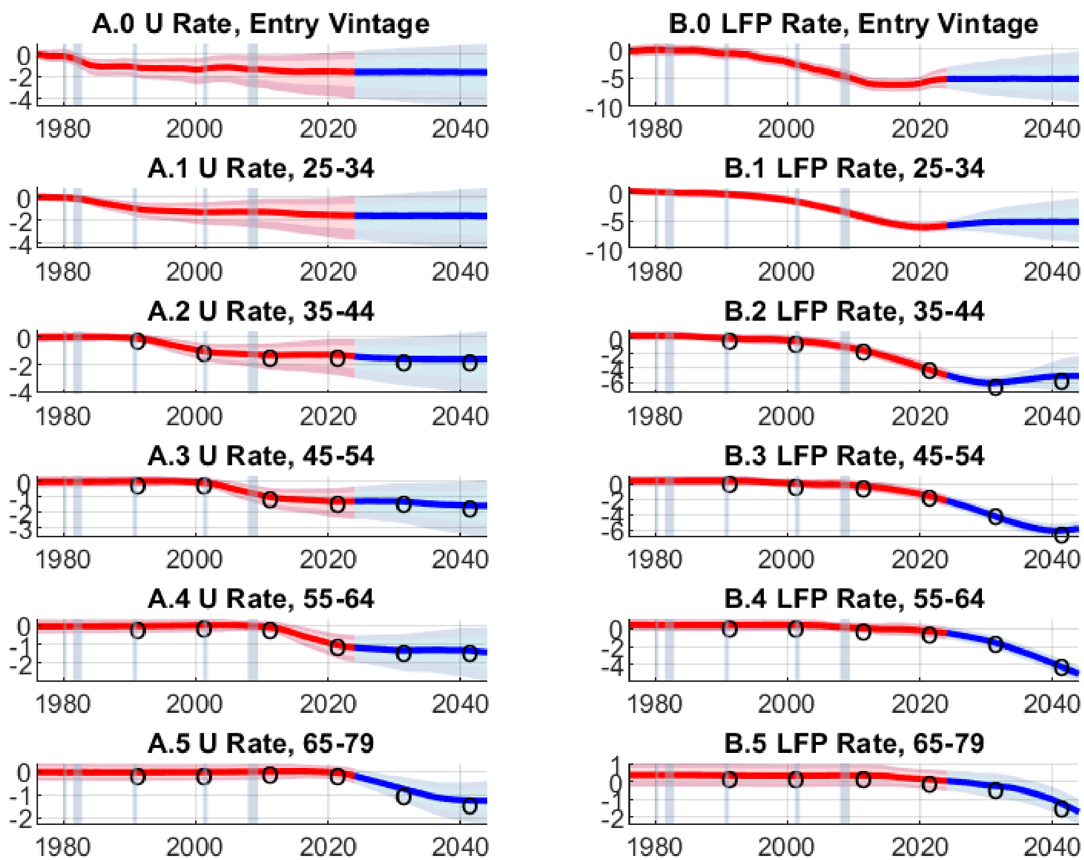
Note: Unemployment rate (A) and LFP rate (B). The top panels plot the fixed effects of entering cohorts in a year, the remaining panels plot the average cohort fixed effects for an age group. Solid lines denote the median cohort effect, and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area. The red (blue) lines and shaded areas denote the estimated (projected) cohort effects. The circles denote the average cohort effect of the preceding age group ten years prior.

Figure 29: Men, 25 years and older with LTH: cohort effect



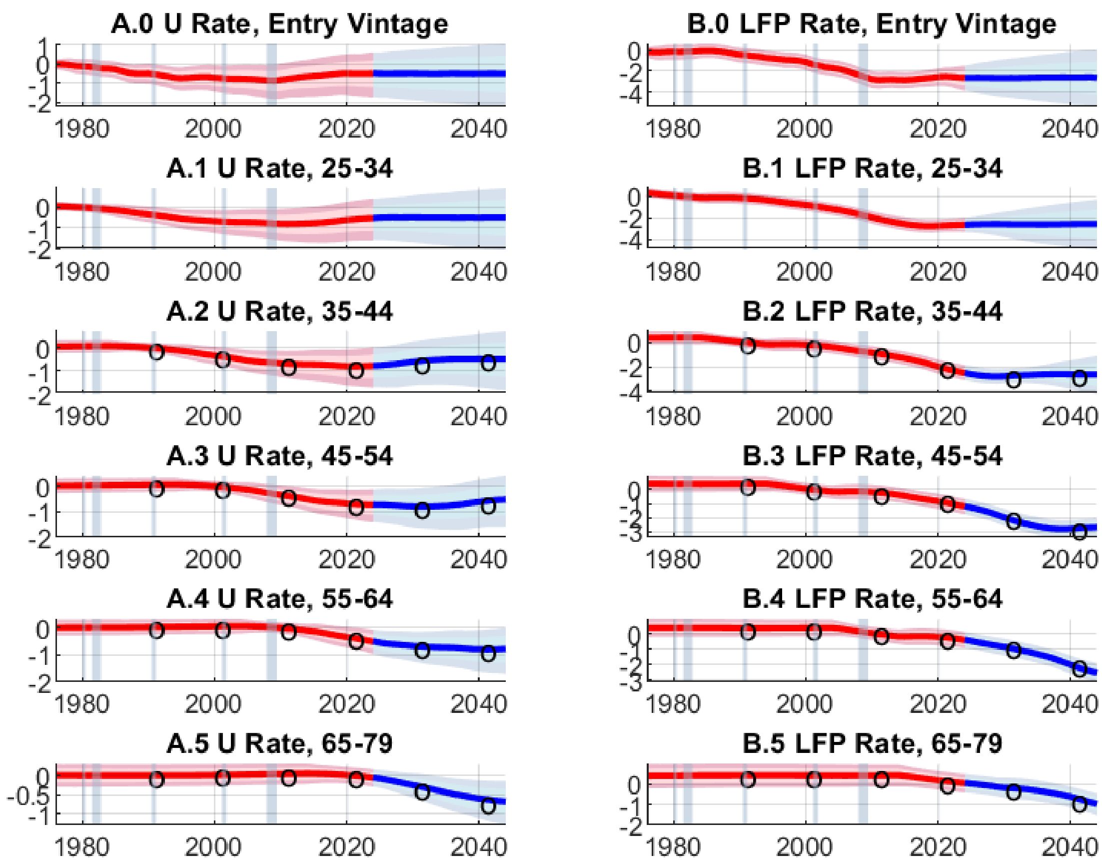
Note: See notes to Figure 28.

Figure 30: Men, 25 years and older with SoCo: cohort effect



Note: See notes to Figure 28.

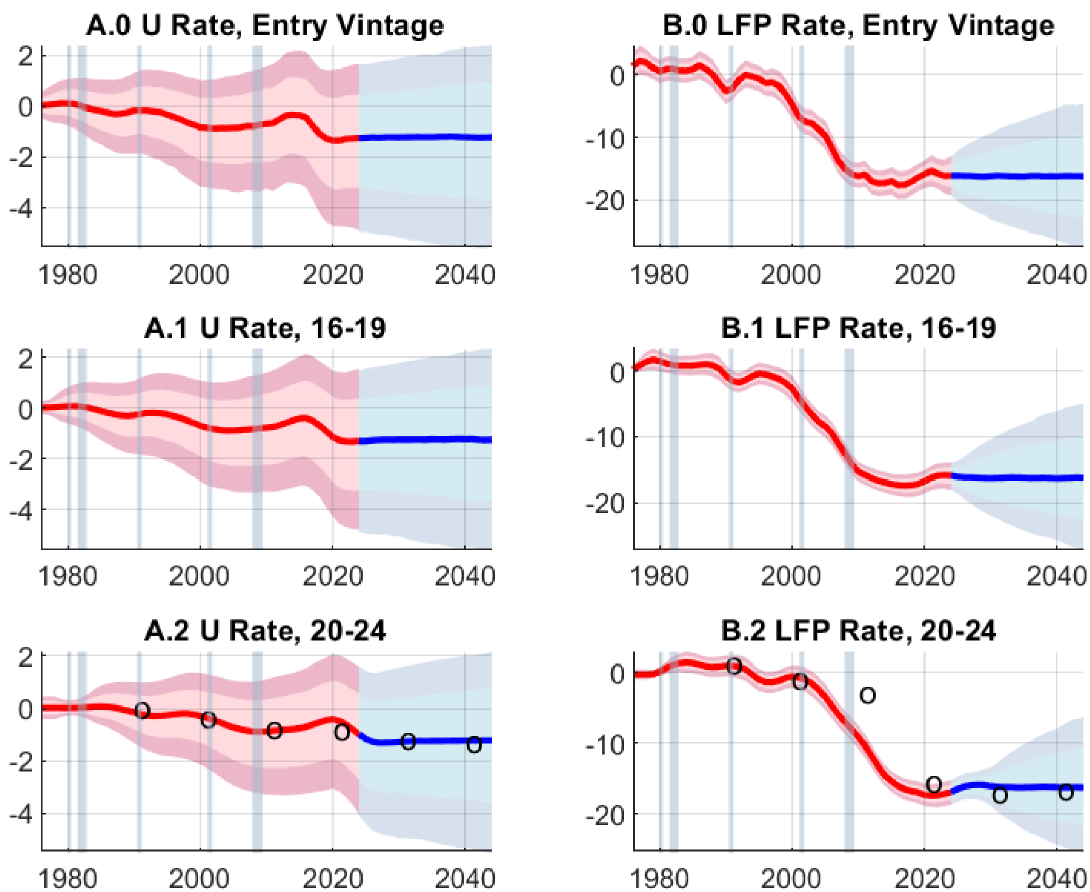
Figure 31: Men, 25 years and older with College: cohort effect



Note: See notes to Figure 28.

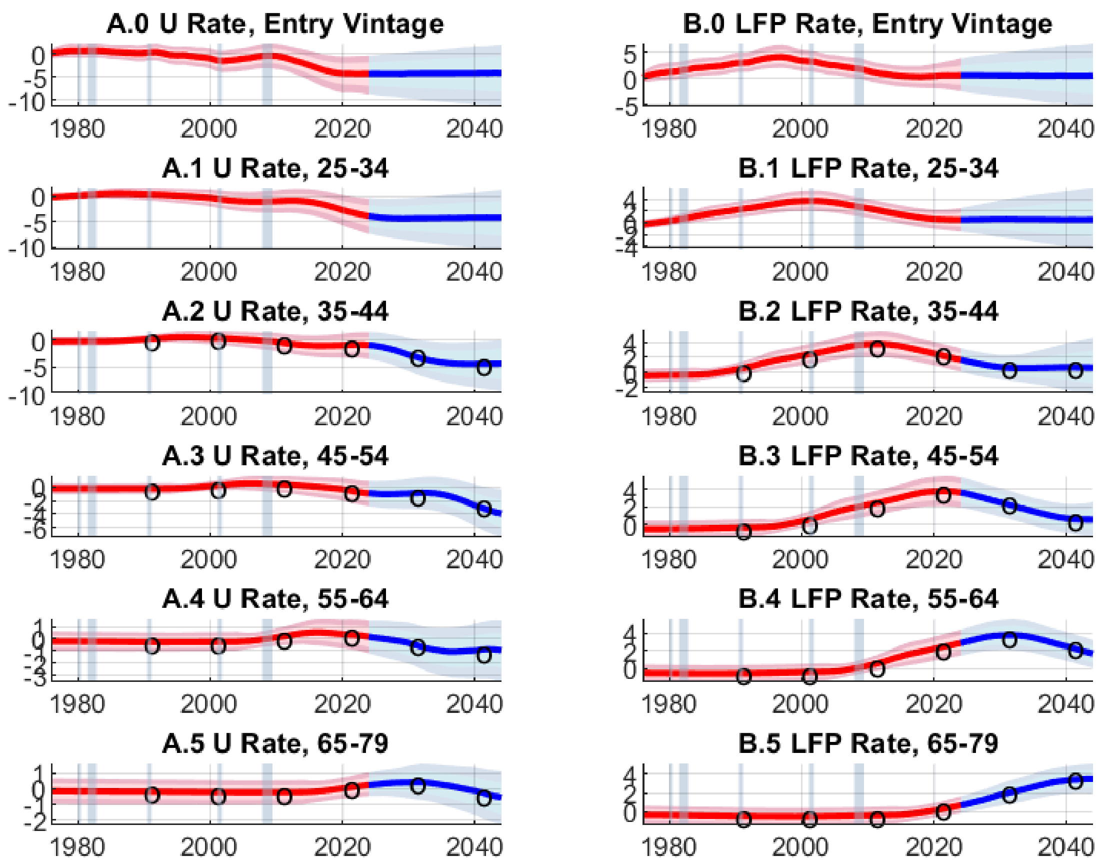
7.8.2 Projections of cohort effects for women

Figure 32: Women, 16-24 years old: cohort effect



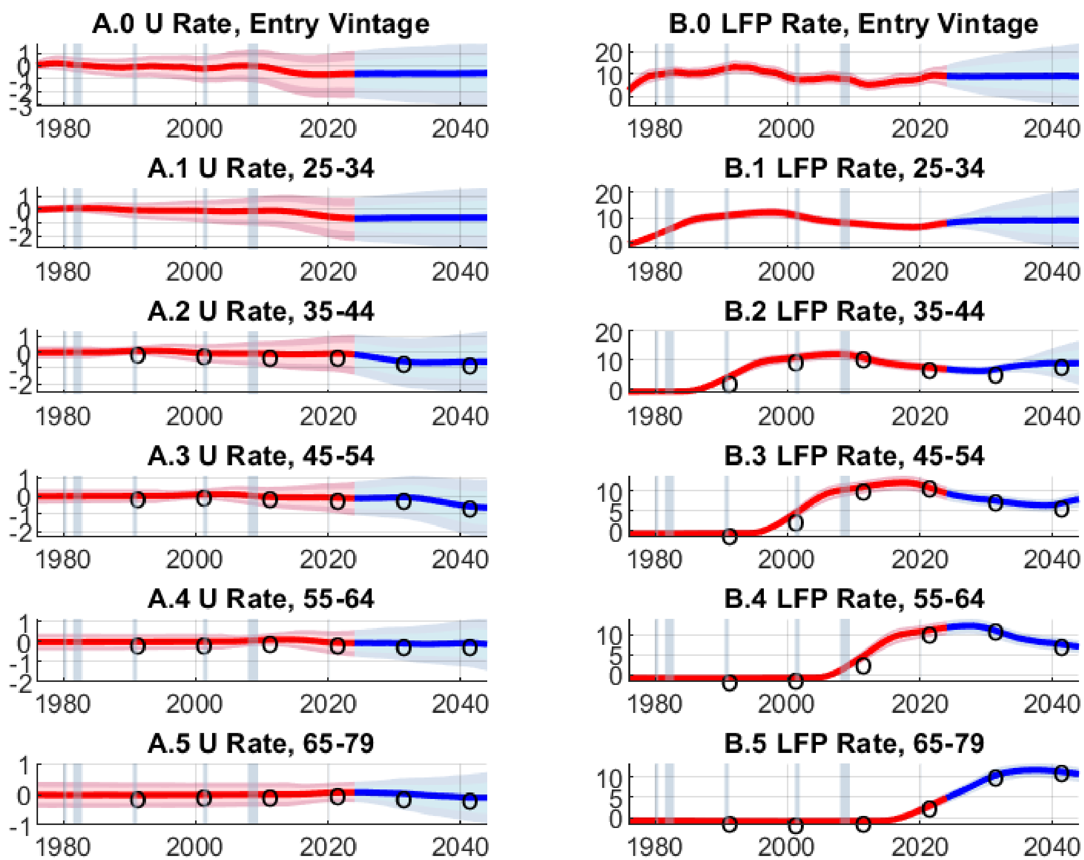
Note: See notes to Figure 28.

Figure 33: Women, 25 years and older with LTH: cohort effect



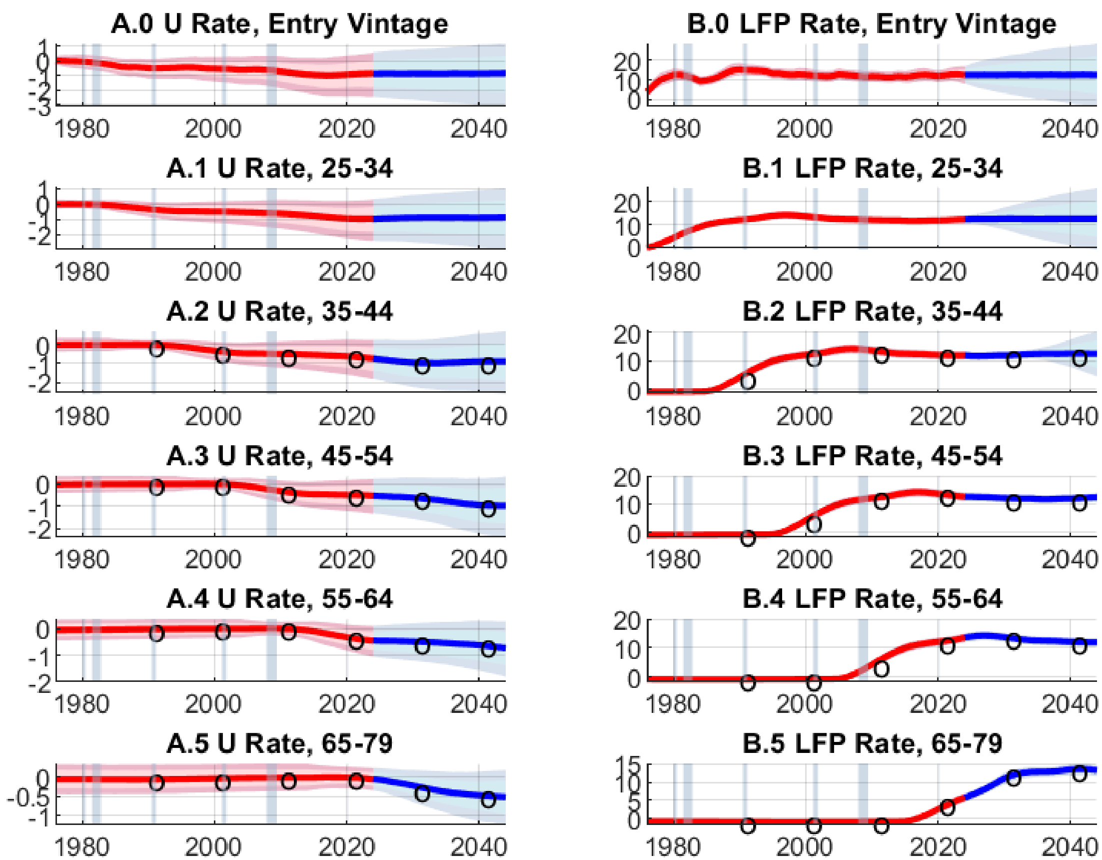
Note: See notes to Figure 28.

Figure 34: Women, 25 years and older with HS: cohort effect



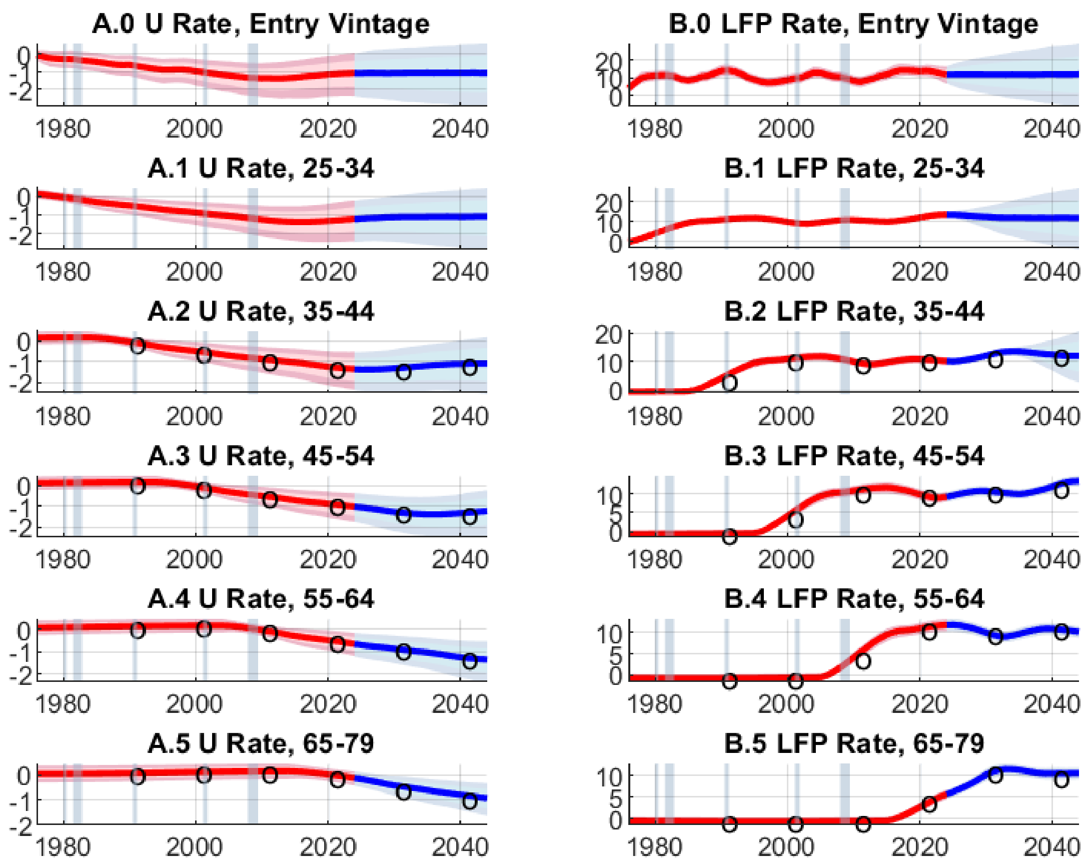
Note: See notes to Figure 28.

Figure 35: Women, 25 years and older with some College: cohort effect



Note: See notes to Figure 28.

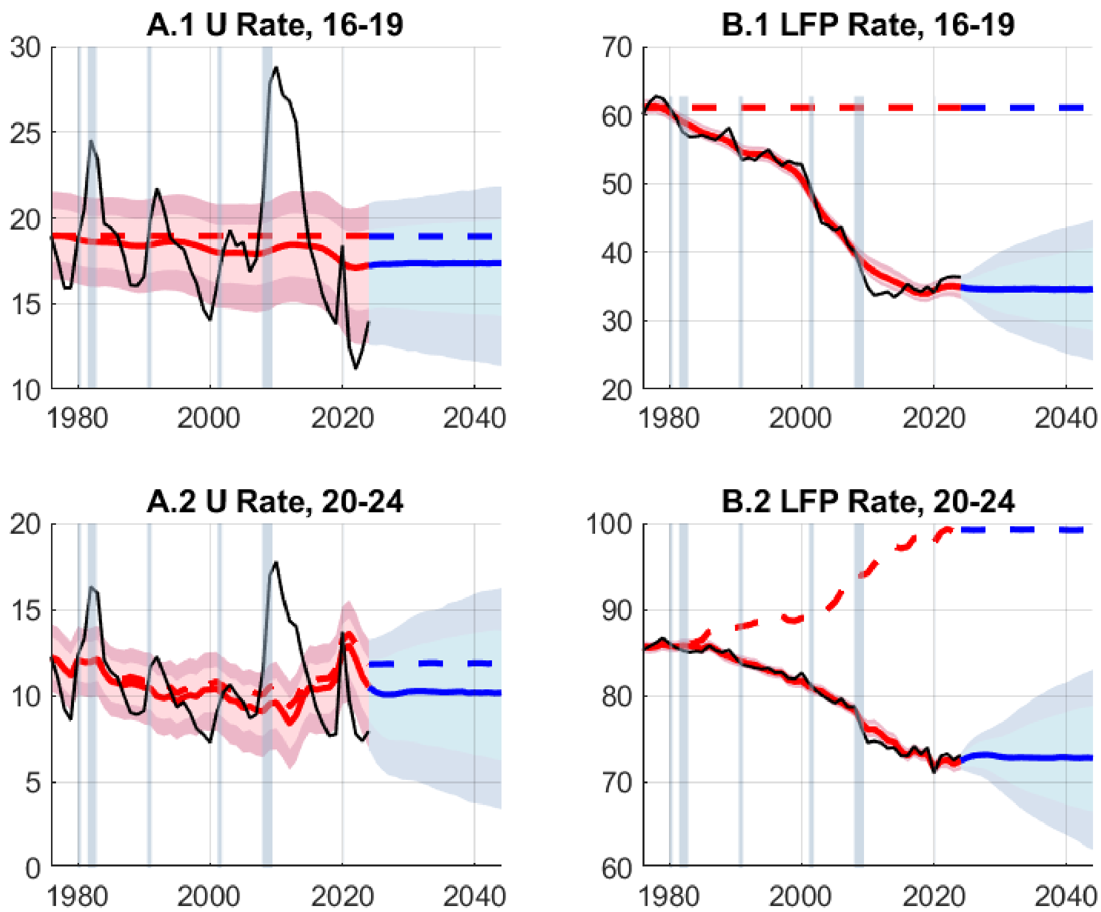
Figure 36: Women, 25 years and older with College: cohort effect



Note: See notes to Figure 28.

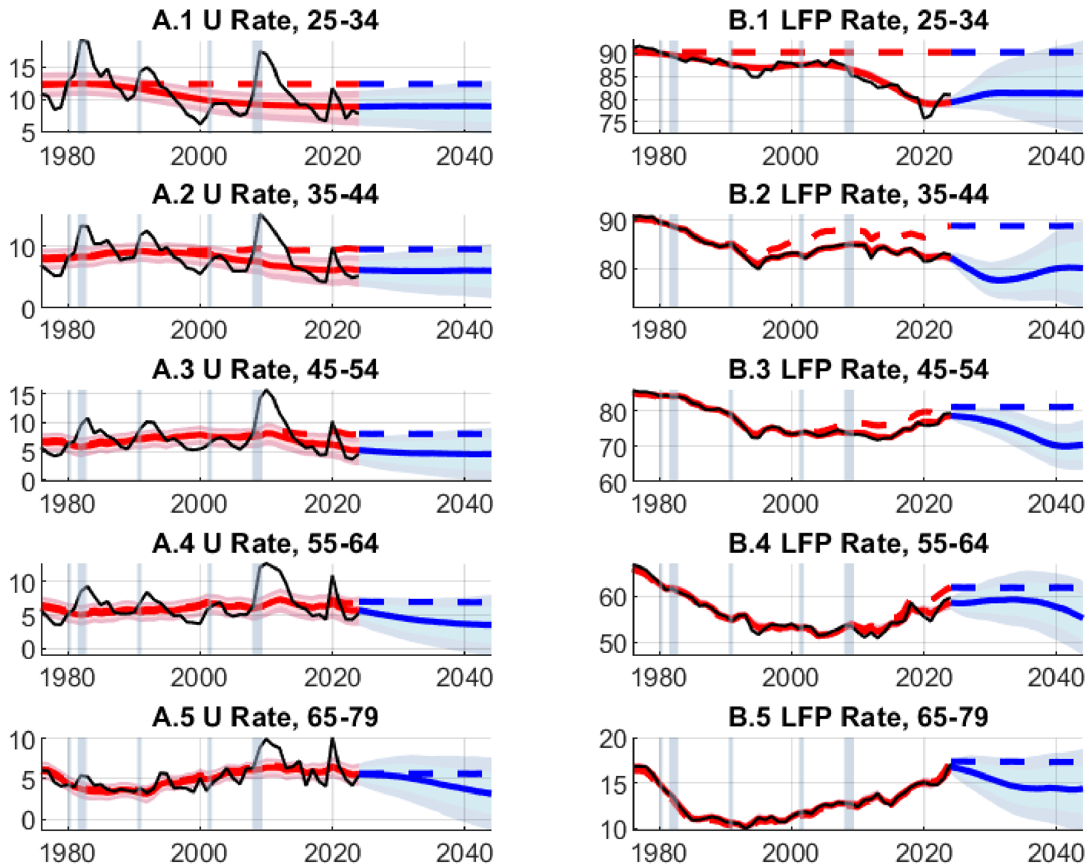
7.8.3 Projections of trend and age effects for men

Figure 37: Men, 16-24 years old: trend and age effects



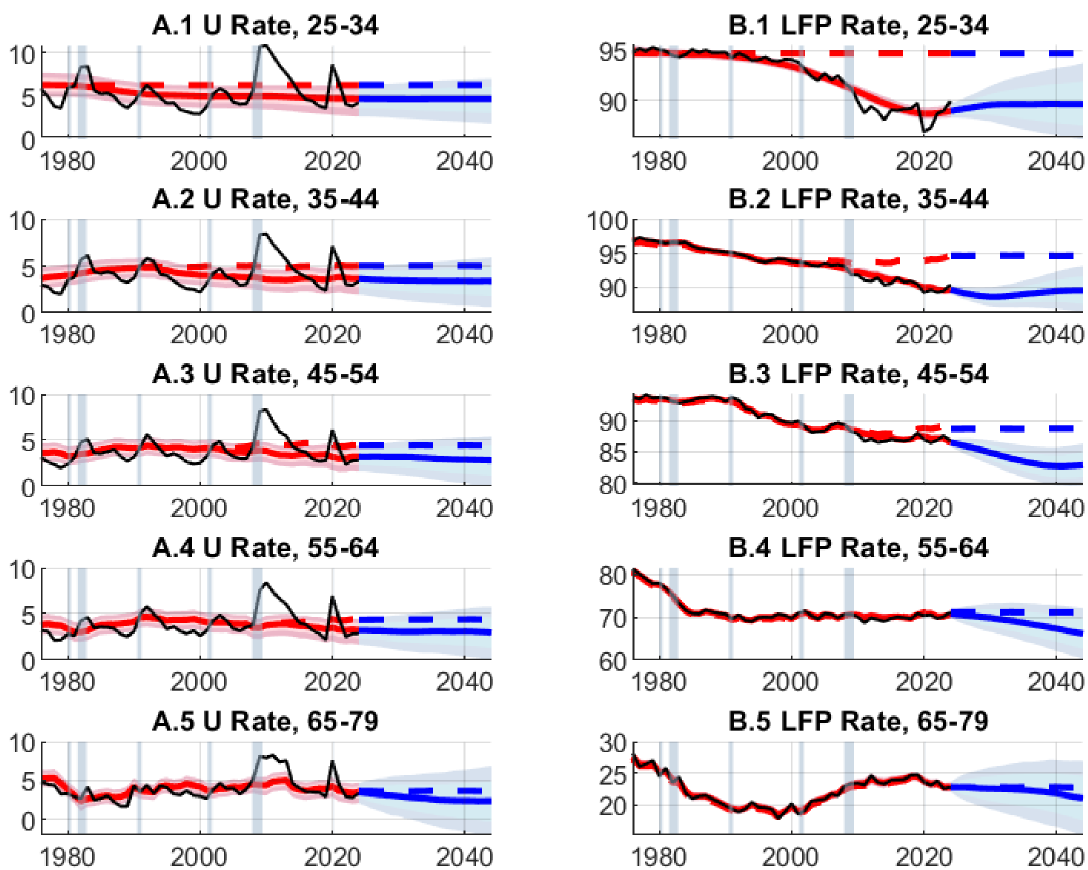
Note: Unemployment rate (A) and LFP rate (B). The thin black lines are actual values for the sample. The solid red (blue) lines denote the median trend estimate (projection), and the corresponding light (dark) shaded areas denote the 66% (90%) coverage areas. The red (blue) dashed lines denote the median estimated (projected) age effects.

Figure 38: Men, 25 years and older with LTH: trend and age effects



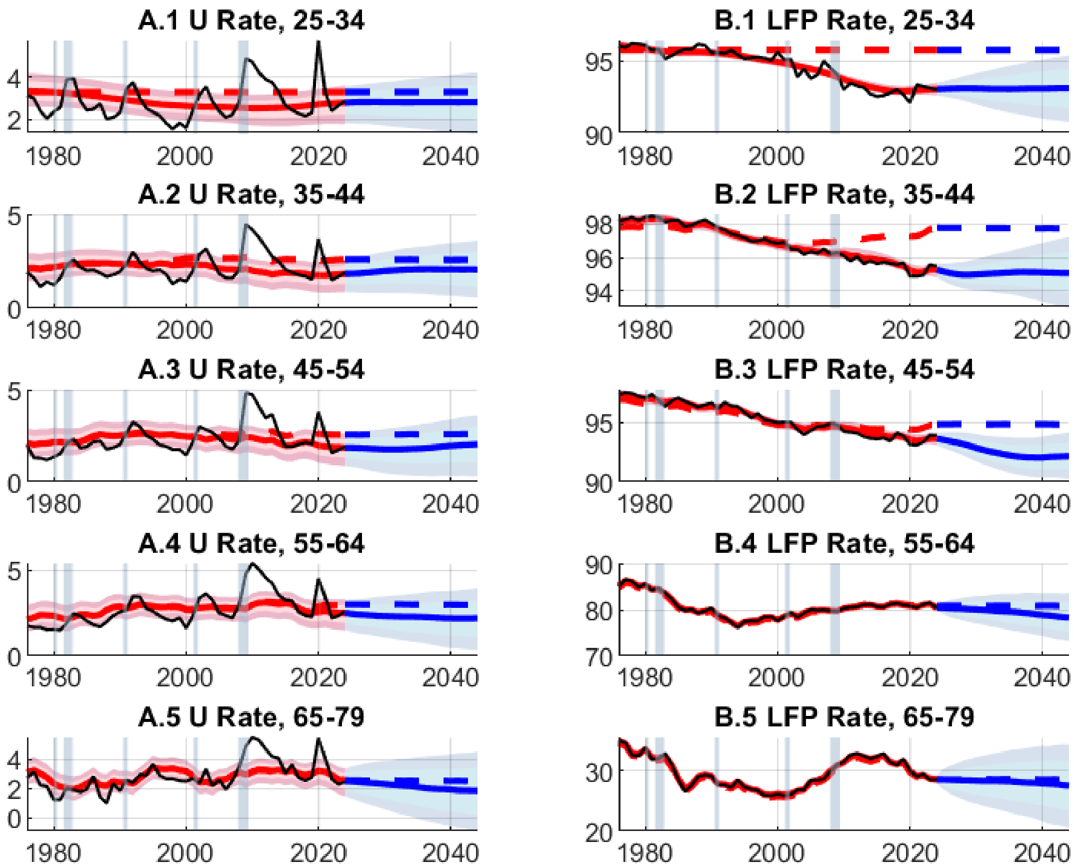
Note: See notes to Figure 37.

Figure 39: Men, 25 years and older with SoCo: trend and age effects



Note: See notes to Figure 37.

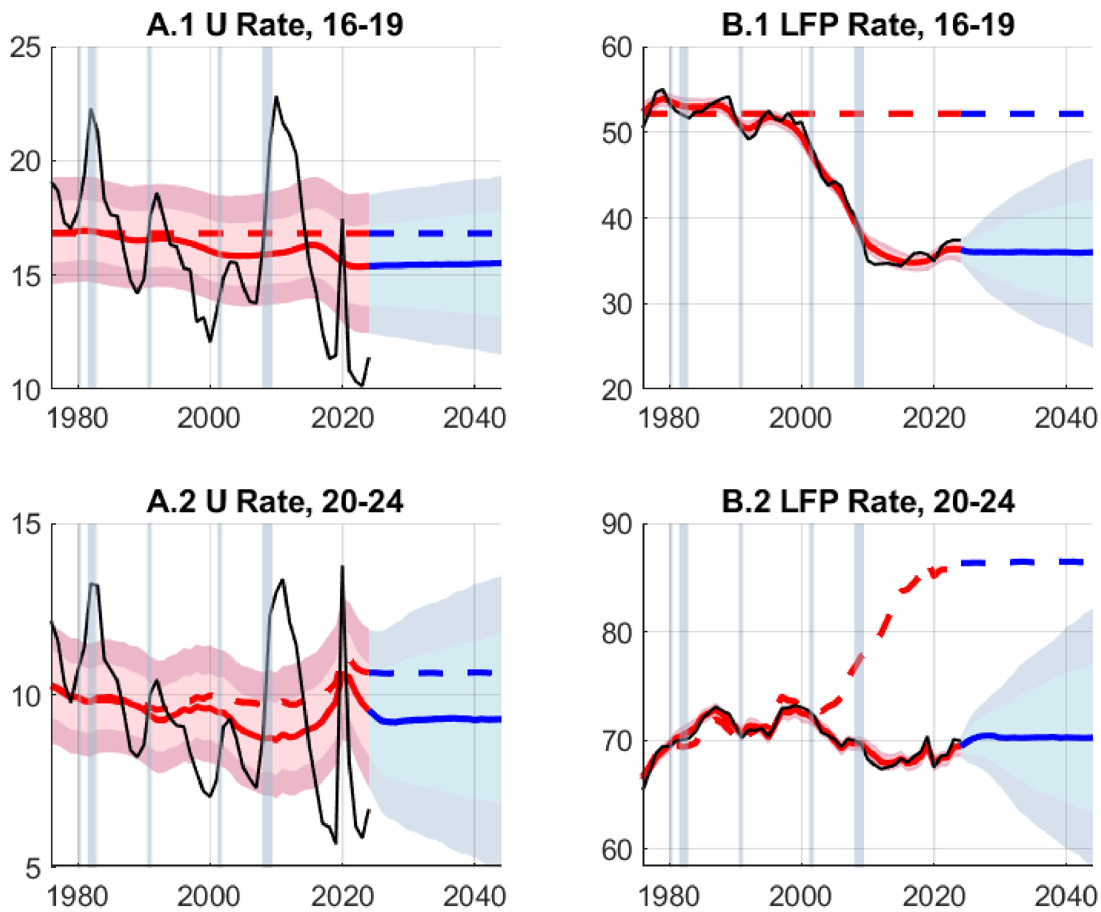
Figure 40: Men, 25 years and older with College: trend and age effects



Note: See notes to Figure 37.

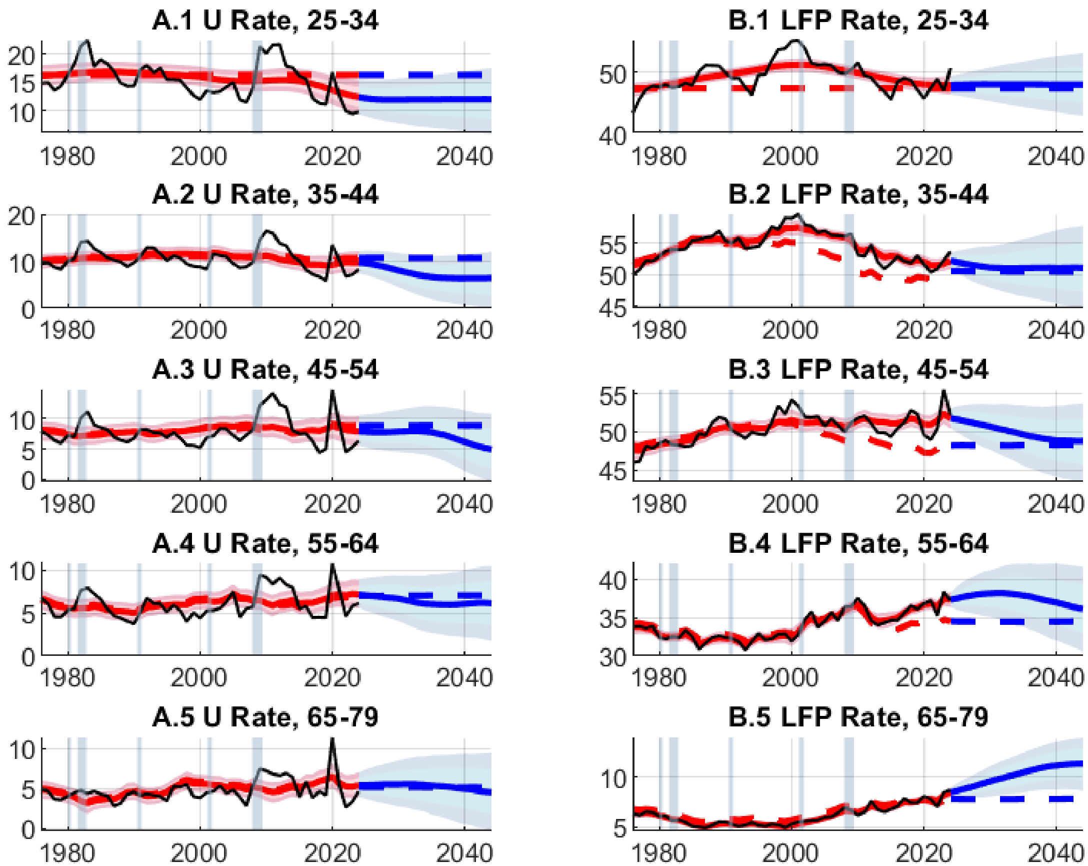
7.8.4 Projections of trend and age effects for women

Figure 41: Women, 16-24 years old: trend and age effects



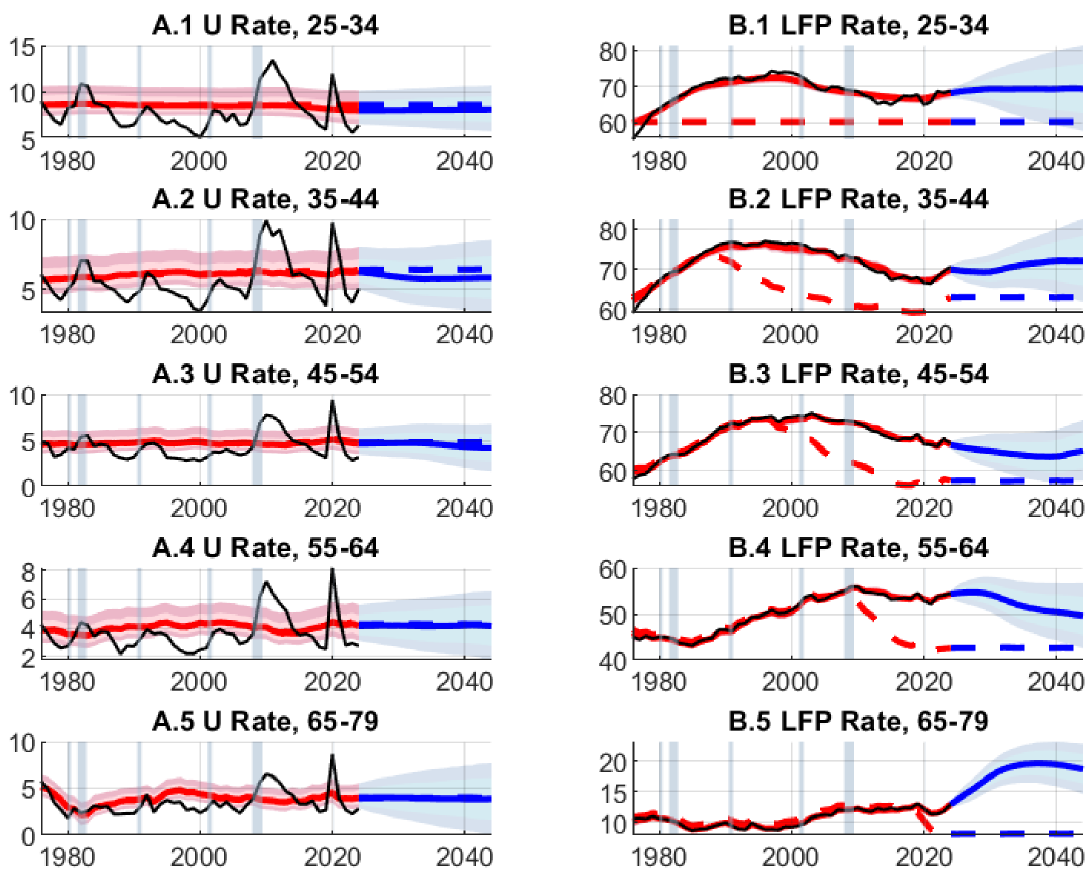
Note: See notes to Figure37.

Figure 42: Women, 25 years and older with LTH: trend and age effects



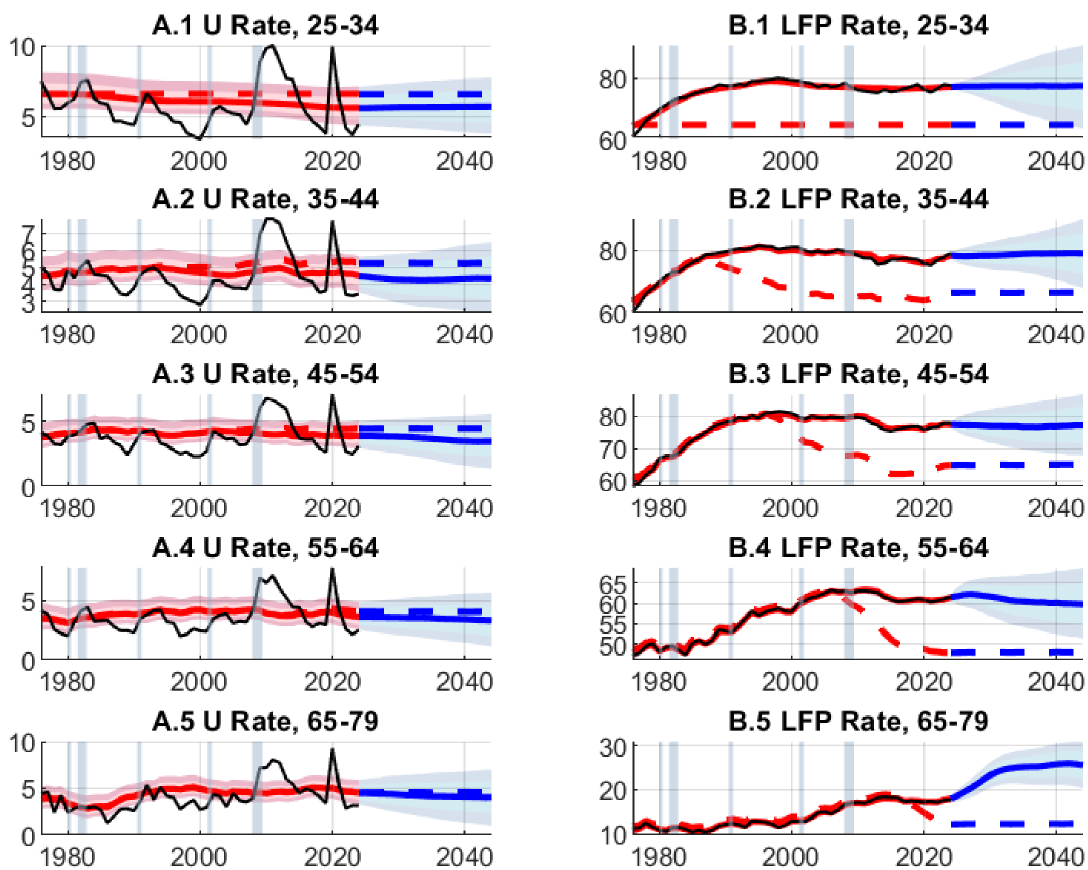
Note: See notes to Figure37.

Figure 43: Women, 25 years and older with HS: trend and age effects



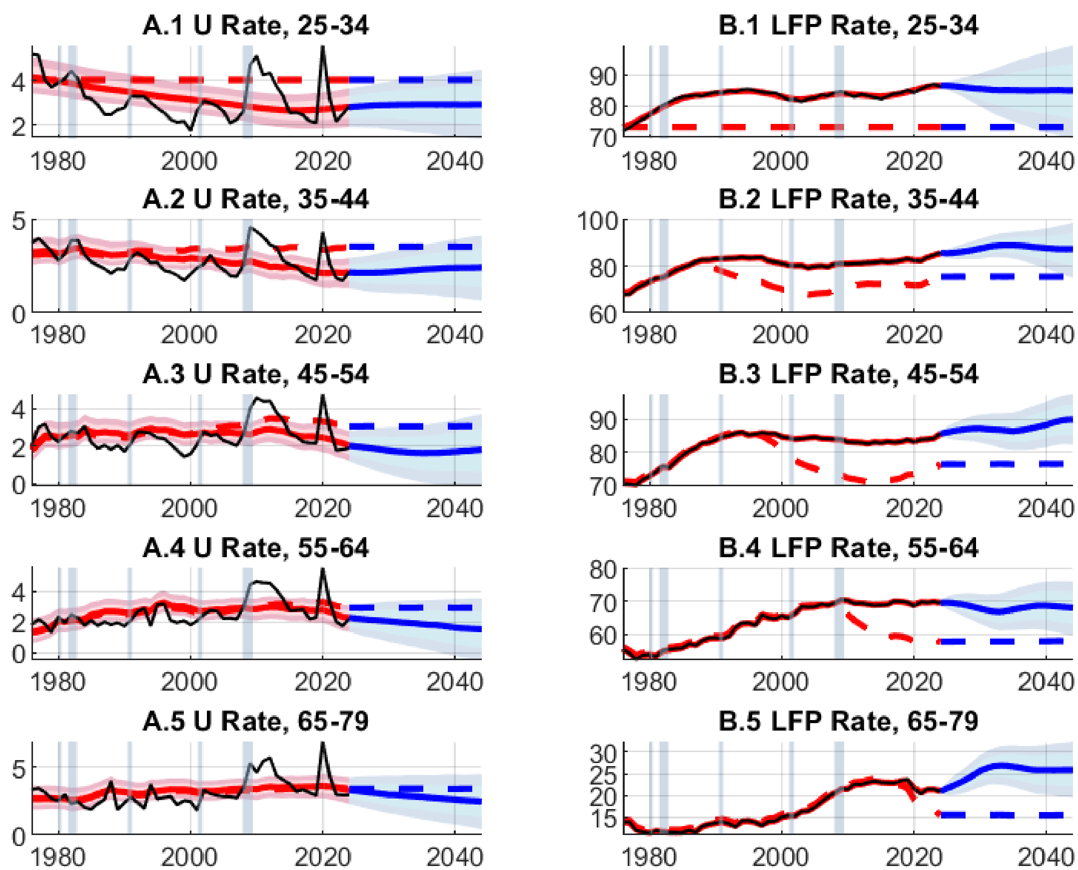
Note: See notes to Figure 37.

Figure 44: Women, 25 years and older with some College: trend and age effects



Note: See notes to Figure37.

Figure 45: Women, 25 years and older with College: trend and age effects

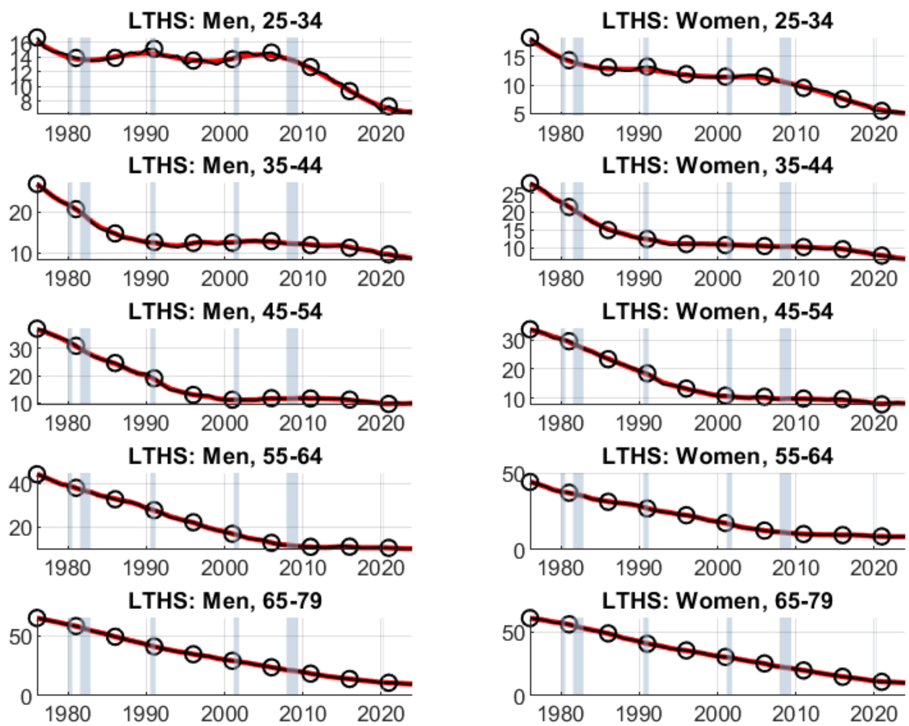


Note: See notes to Figure 37.

7.9 Education shares

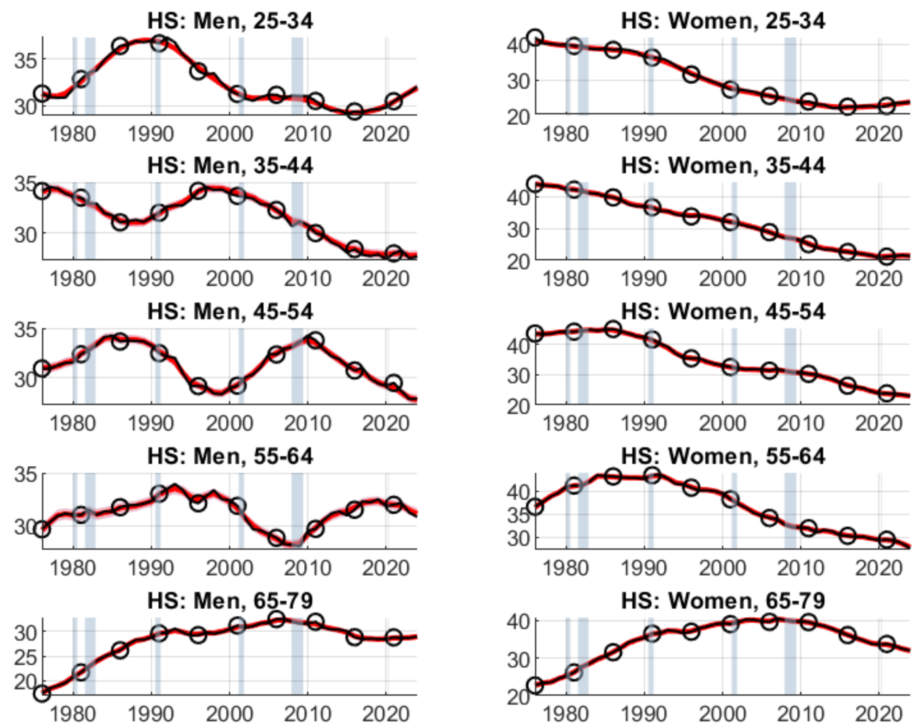
7.9.1 Actual and trend

Figure 46: Share with less than a high school education,
Actual and trend



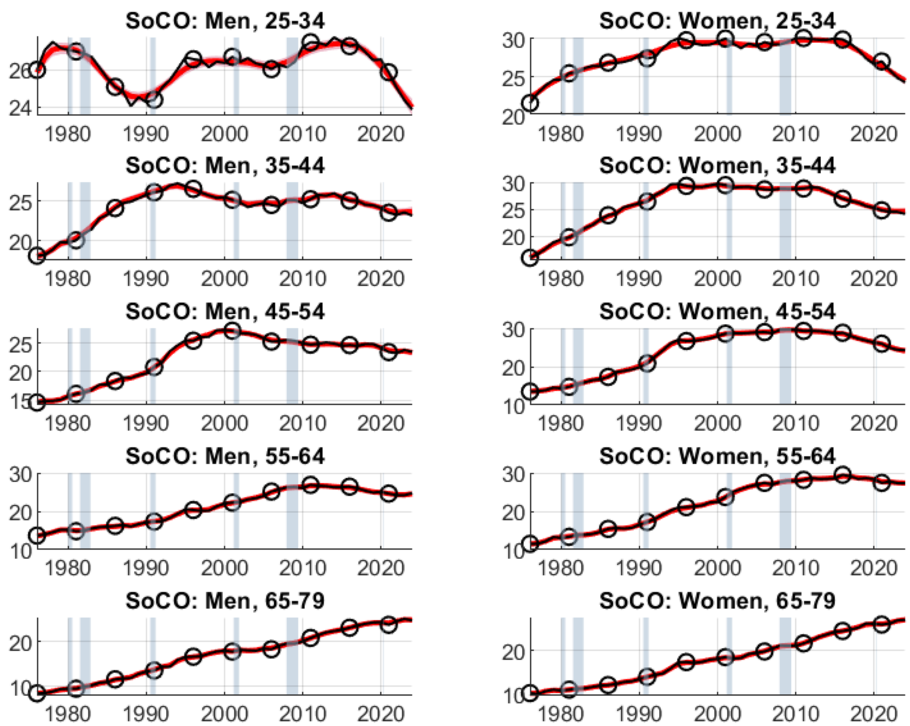
Note: Share of gender-age group with the indicated education. Solid red lines denote the estimated median trend and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area. The thin black lines with circle markers are the actual shares.

Figure 47: Share with a high school education,
Actual and trend



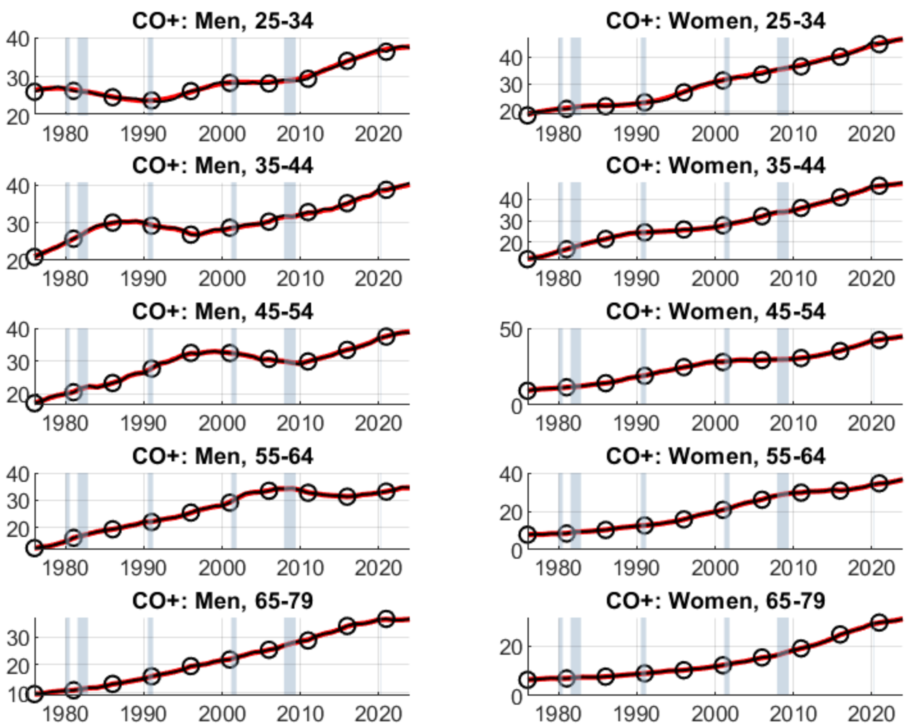
Note: See Figure 46.

Figure 48: Share with some college education,
Actual and trend



Note: See Figure 46.

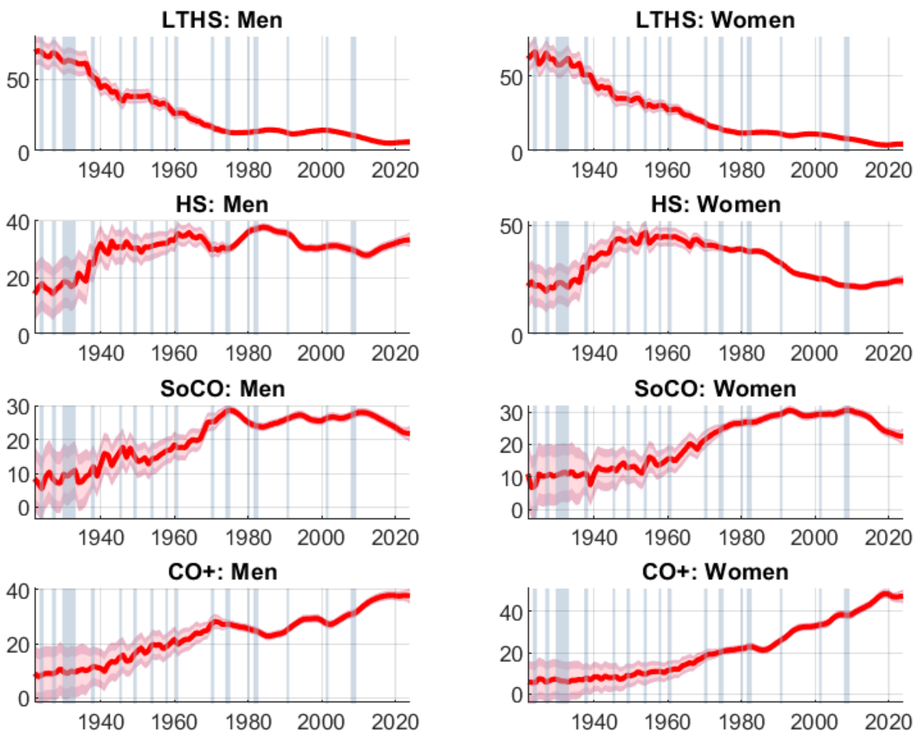
Figure 49: Share with a completed college education,
Actual and trend



Note: See Figure 46.

7.9.2 Cohort effects

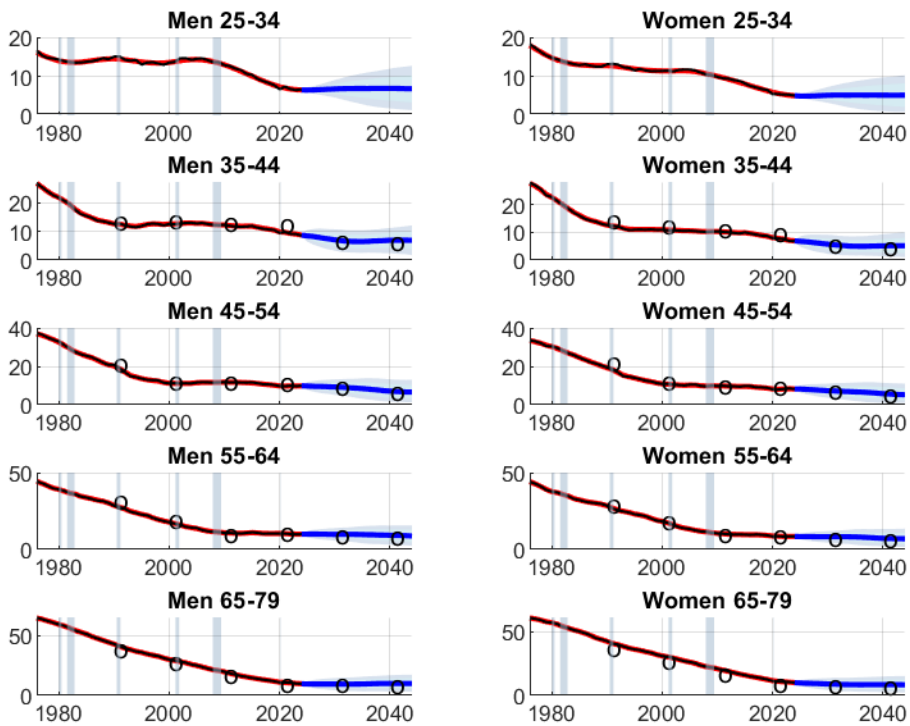
Figure 50: Education share of entry cohort



Note: Shares of the entering gender cohort with the indicated education. Solid red lines denote the estimated median trend, and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area. The thin black lines with circle markers are the actual shares.

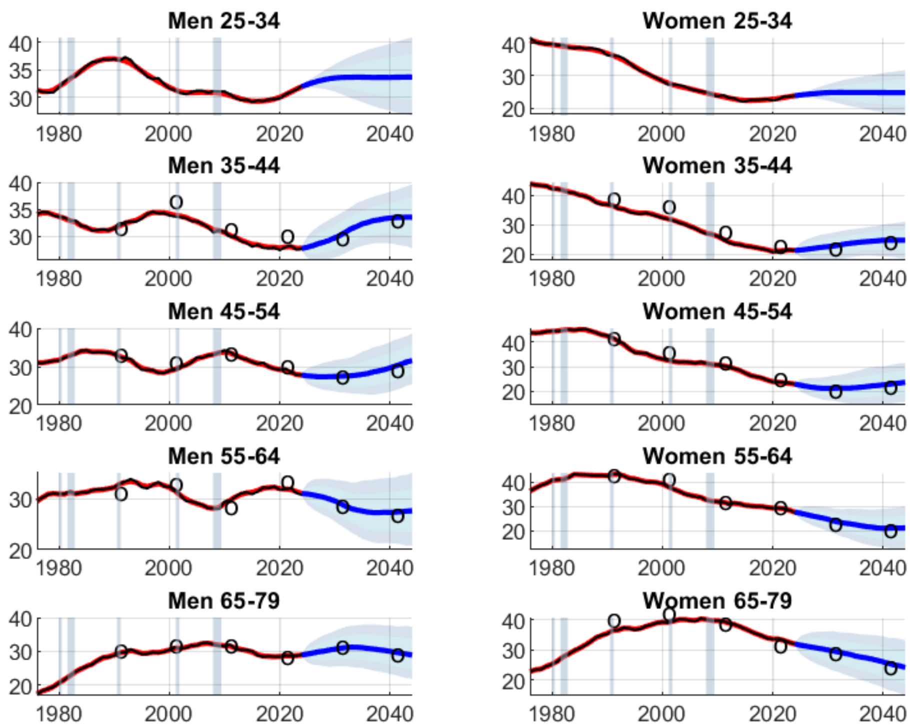
7.9.3 Actual, trend, and forecast

Figure 51: Share with less than a high school education,
Actual, trend, and forecast



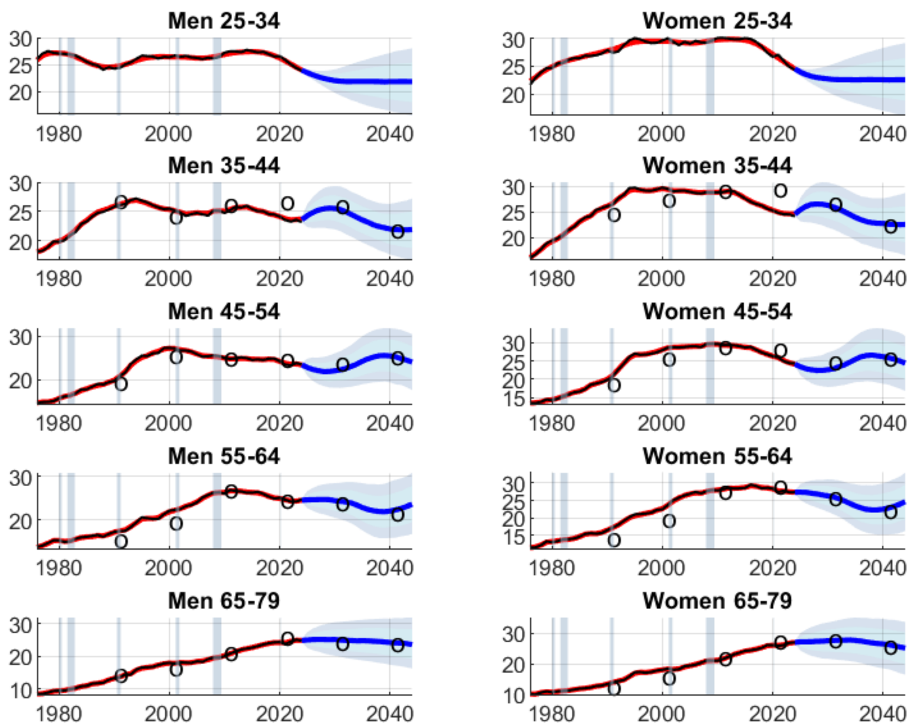
Note: Share of gender-age group with the indicated education. The thin black lines are the actual shares. The solid red lines denote the estimated median trend, and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area. The solid blue lines denote the median forecast, and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area of forecasts. The circles denote the average cohort effect of the preceding age group ten years prior.

Figure 52: Share with a completed high school education,
Actual, trend, and forecast



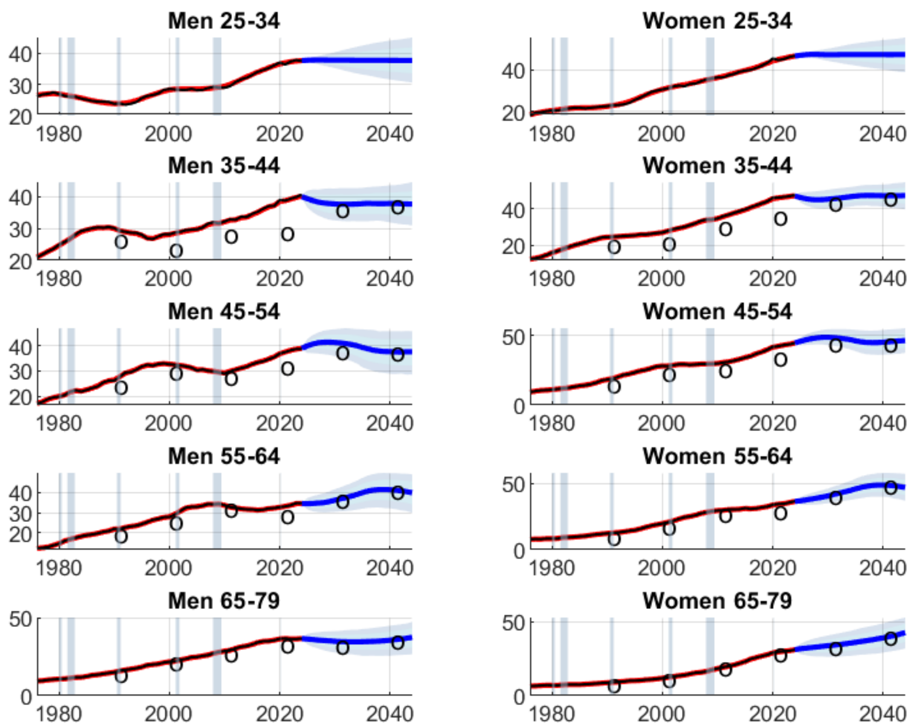
Note: See Figure 51.

Figure 53: Share with some college education,
Actual, trend, and forecast



Note: See Figure 51.

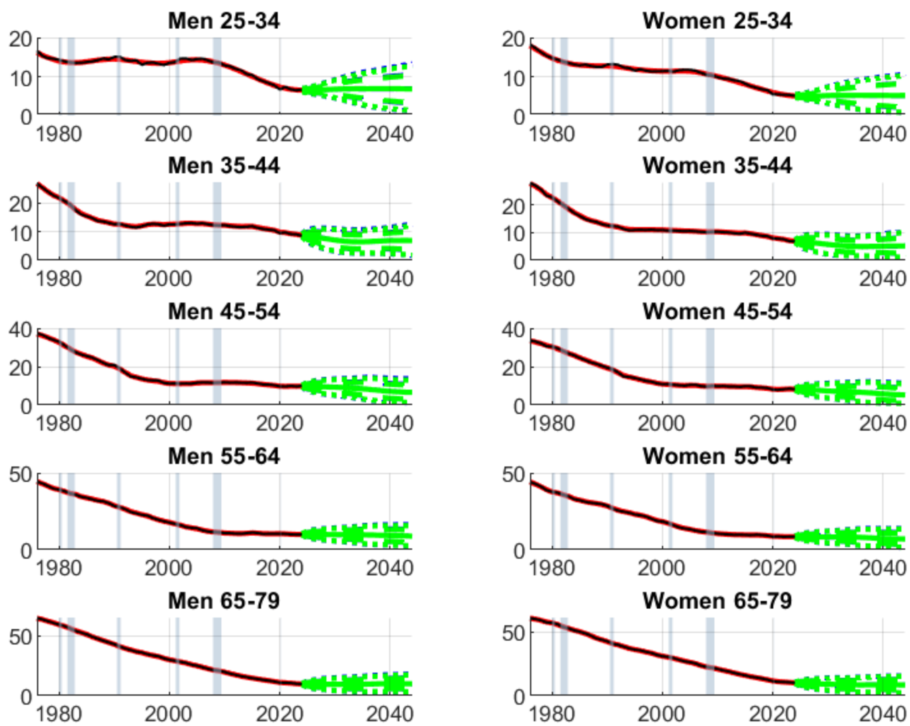
Figure 54: Share with a completed college education,
Actual, trend, and forecast



Note: See Figure 51.

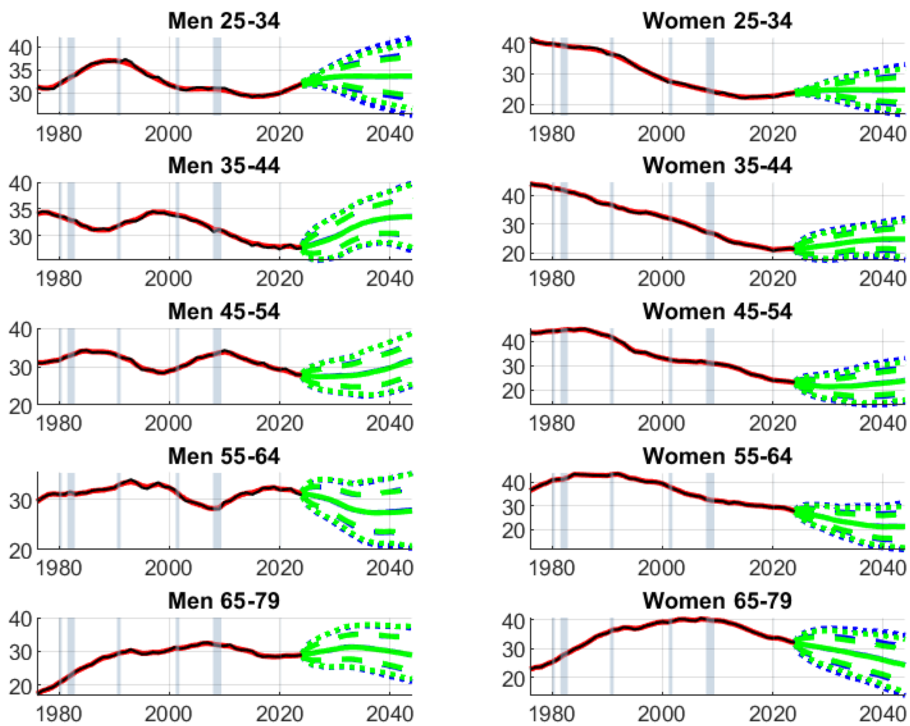
7.9.4 Actual, trend, and (normalized) forecast

Figure 55: Share with less than a high school education,
Actual, trend, and (normalized) forecast



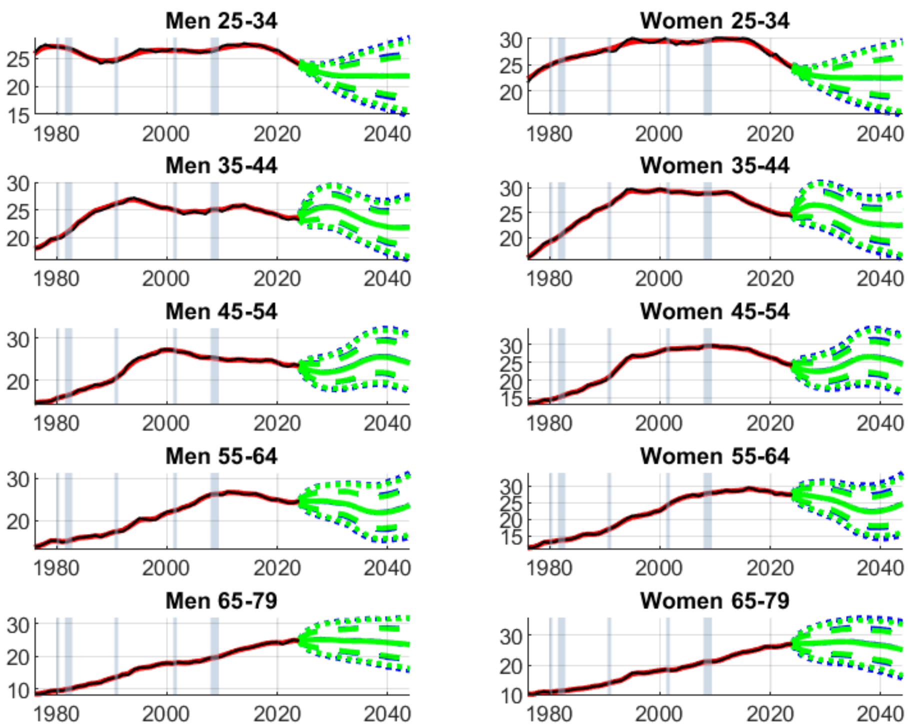
Note: Share of gender-age group with the indicated education. The thin black lines are the actual shares. The solid red lines denote the estimated median trend, and the corresponding light (dark) shaded areas denote the 66% (90%) coverage area. The solid blue lines denote the median forecast, and the corresponding dashed (dotted) lines denote the 66% (90%) coverage area of forecasts. The green lines denote corresponding median and coverage areas of the normalized forecasts.

Figure 56: Share with a completed high school education,
Actual, trend, and (normalized) forecast



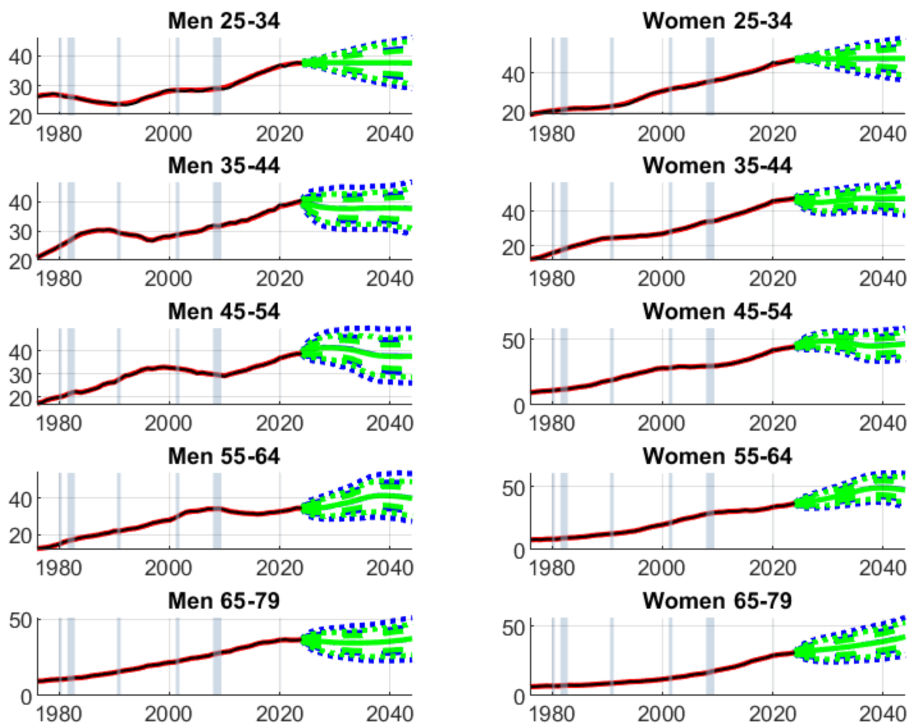
Note: See Figure 55.

Figure 57: Share with some college education,
Actual, trend, and (normalized) forecast



Note: See Figure 55.

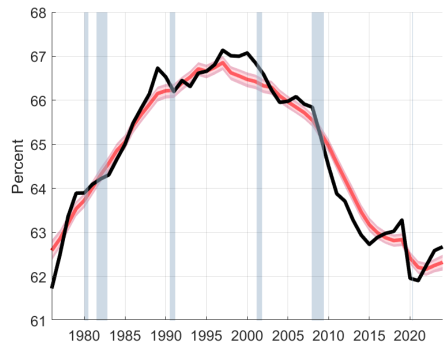
Figure 58: Share with a completed college education,
Actual, trend, and (normalized) forecast



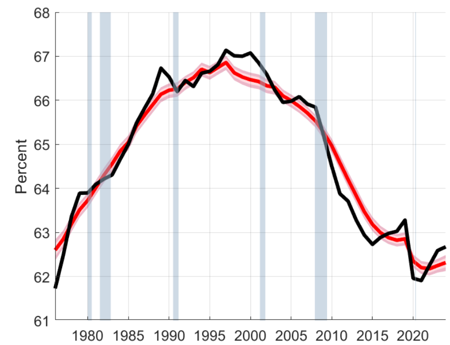
Note: See Figure 55.

Figure 59: Aggregate trends: actual versus trend education shares

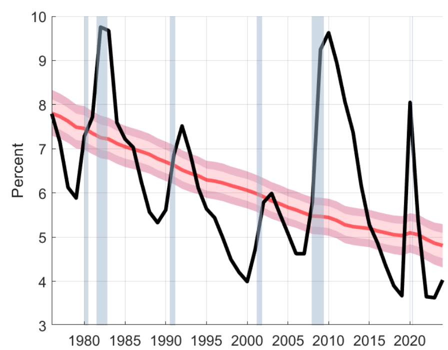
(a) LFP rate: actual edu shares



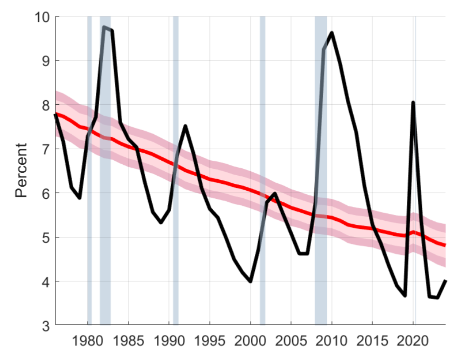
(b) LFP rate: trend edu shares



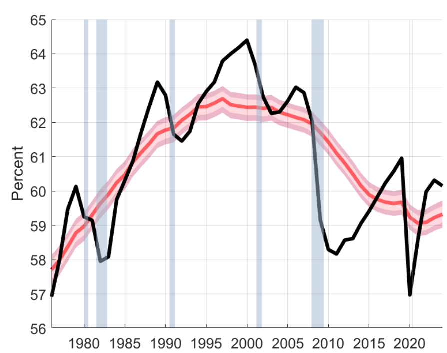
(c) U rate: actual edu



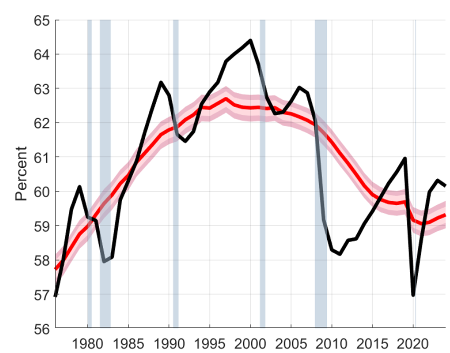
(d) U rate: trend edu



(e) EMP rate: actual edu



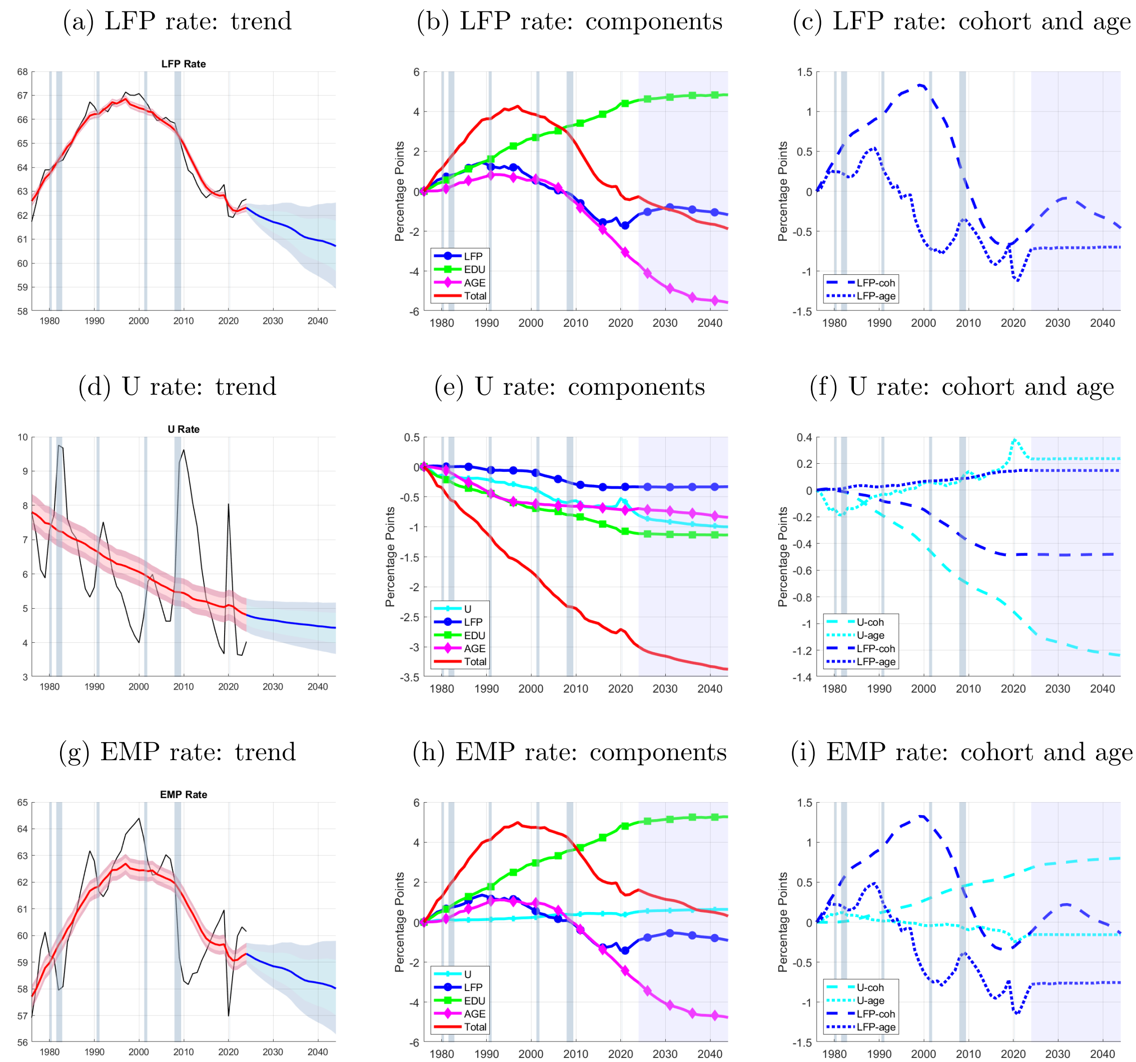
(f) EMP rate: trend edu



Note: The panels in the left column plot the aggregate LFS rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) shaded 66% (90%) coverage areas. Same as in Figure 25. The panels in the right column plot the same aggregate LFS rates when the population share weights are calculated based on estimated education share trends.

7.10 Aggregate projections

Figure 60: Aggregate trends and projections



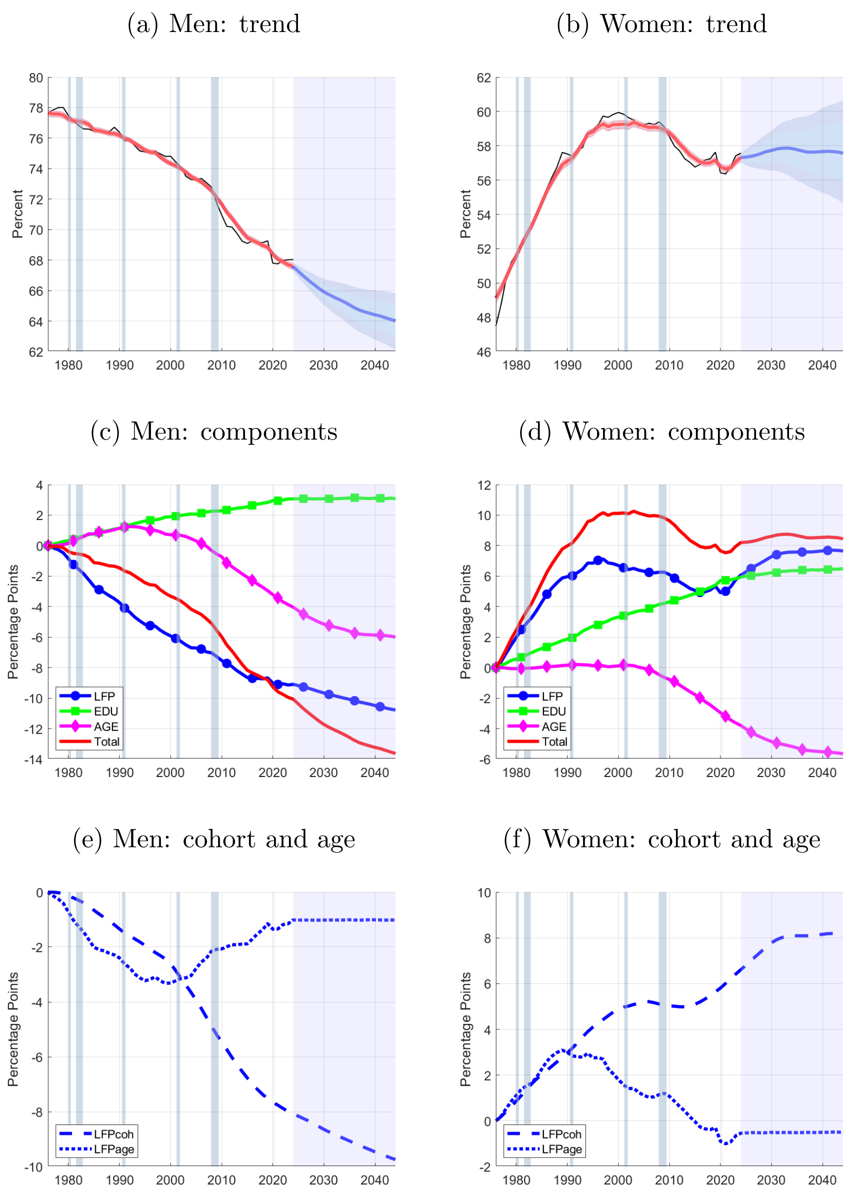
(a) LFP rate: trend (b) LFP rate: components (c) LFP rate: cohort and age

(d) U rate: trend (e) U rate: components (f) U rate: cohort and age

(g) EMP rate: trend (h) EMP rate: components (i) EMP rate: cohort and age

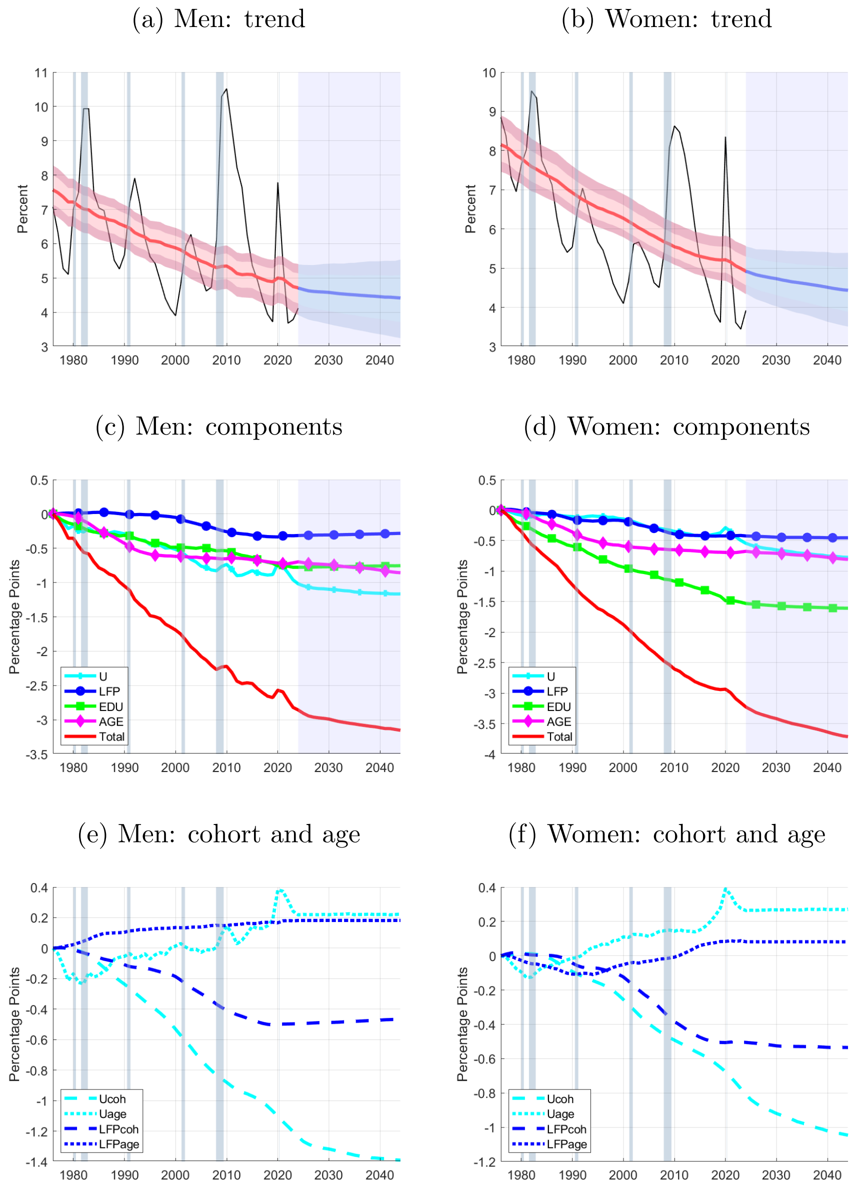
Note: The panels in the left column plot the aggregate LFS rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) red shaded 66% (90%) coverage areas for the sample 1976-2024. The dark blue lines and shaded areas represent the median forecasts and coverage areas for the period 2025-2044. The panels in the middle column plot the cumulative contributions to changes in the trend (Total) coming from changes in population shares by age (AGE), education shares (EDU), and trend LFS rates (LFP and U). The panels in the right column split the contributions of trend LFS rates into age (dotted) and cohort (dashed) effects. The lines in the right shaded areas represent the forecasted contributions.

Figure 61: Aggregate LFP rate trends and projections for men and women



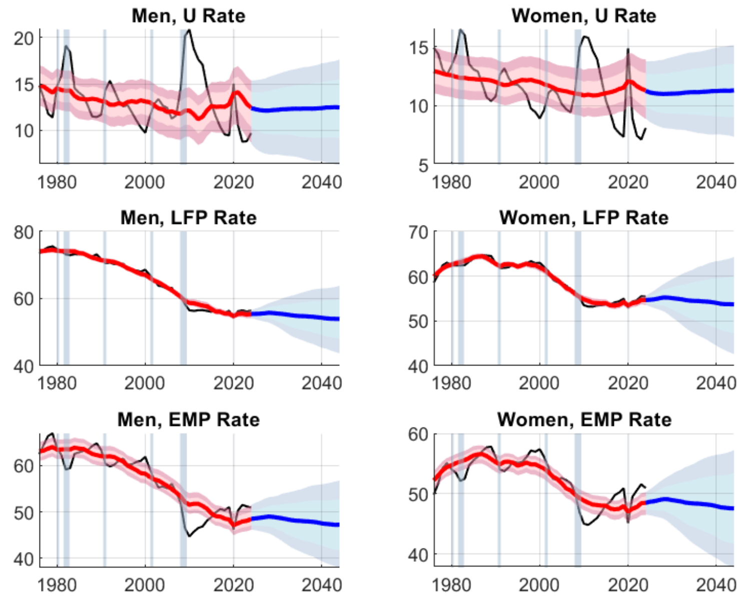
Note: The top panels plot the LFP rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) shaded 66% (90%) coverage areas for the sample 1976-2024. The dark blue lines and shaded areas represent the median forecasts and coverage areas for the period 2025-2044. The middle panels plot the cumulative contributions to changes in the trend (Total) coming from changes in population shares by age (AGE), education shares (EDU), and trend LFP rates (LFP). The bottom panels split the contributions of trend LFP rates into age (dotted) and cohort (dashed) effects.

Figure 62: Aggregate unemployment rate trends and projections for men and women



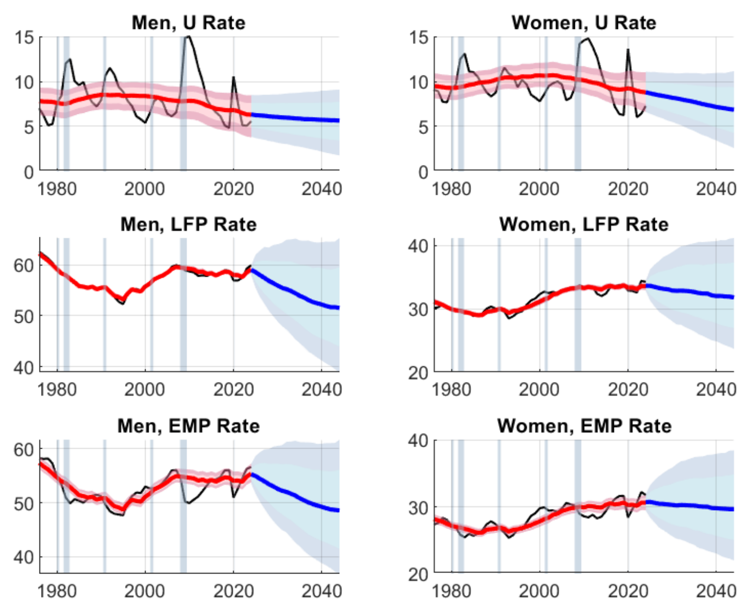
Note: The top panels plot the LFP rates (black lines) and their trends based on the population share-weighted median estimates of the group trends (red lines), with light (dark) shaded 66% (90%) coverage areas for the sample 1976-2024. The dark blue lines and shaded areas represent the median forecasts and coverage areas for the period 2025-2044. The middle panels plot the cumulative contributions to changes in the trend (Total) coming from changes in population shares by age (AGE), education shares (EDU), and trend LFP rates (LFP). The bottom panels split the contributions of trend LFP rates into age (dotted) and cohort (dashed) effects.

Figure 63: Trends and projections for men and women 16-24 years old



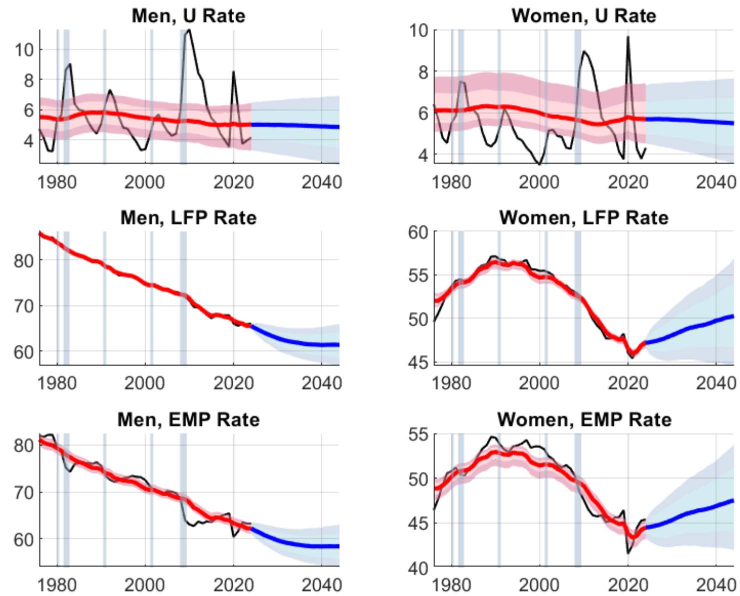
Note: See Note for top panels in Figure 61.

Figure 64: Trends and projections for men and women with less than high school



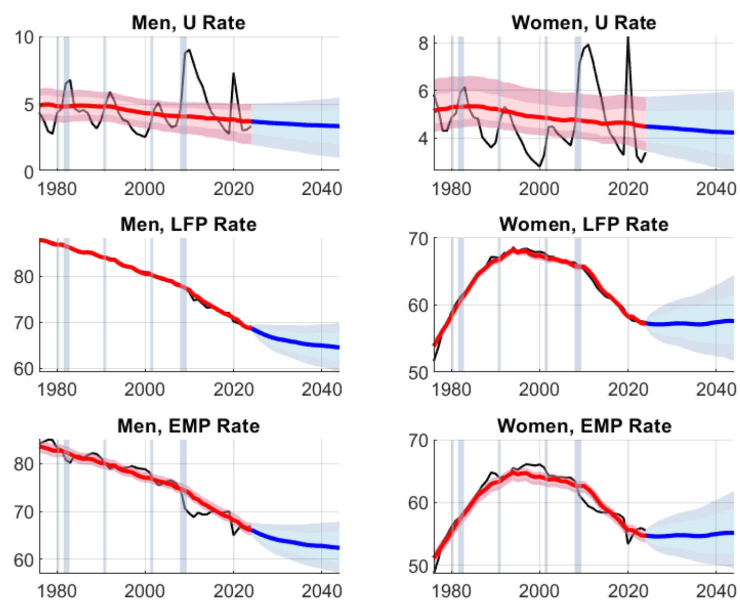
Note: See Note for top panels in Figure 61.

Figure 65: Trends and projections for men and women with completed high school



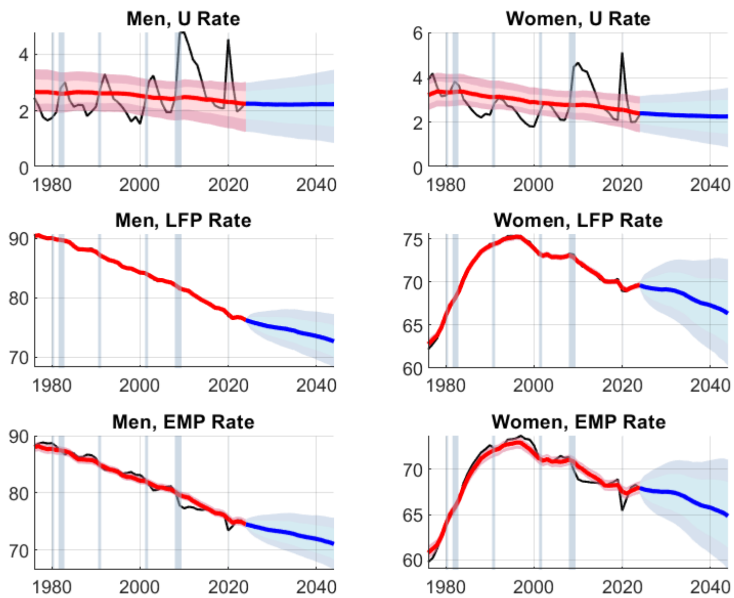
Note: See Note for top panels in Figure 61.

Figure 66: Trends and projections for men and women with some college



Note: See Note for top panels in Figure 61.

Figure 67: Trends and projections for men and women with college and higher



Note: See Note for top panels in Figure 61.

8 Tables

List of Tables

8.1 Sample averages

8.1.1 Population, 16-24 years old by gender and age

Table 1: Average Unemployment and LFP Rates, 16-24 years old, 1976-1990

	Men		Women	
Age Group	U rate	LFP rate	U rate	LFP rate
16-19	18.66	58.68	17.74	52.87
20-24	11.36	85.43	10.62	70.37

Table 2: Average Unemployment and LFP Rates, 16-24 years old, 1991-2005

	Men		Women	
Age Group	U rate	LFP rate	U rate	LFP rate
16-19	17.99	50.94	15.26	49.31
20-24	9.73	81.96	8.72	71.57

Table 3: Average Unemployment and LFP Rates, 16-24 years old, 2006-2019

	Men		Women	
Age Group	U rate	LFP rate	U rate	LFP rate
16-19	20.90	36.13	16.66	36.68
20-24	11.70	75.14	9.29	68.72

8.1.2 Population 25 and older by gender, education, and age

Table 4: Average Unemployment and LFP Rates, 25+ years, 1976-1990

	U rate				LFP rate			
Age Group	LTHS	HS	SoCO	CO+	LTHS	HS	SoCO	CO+
	Men							
25-34	12.74	7.49	5.35	2.68	89.34	96.13	94.86	95.82
35-44	8.86	5.05	3.76	1.82	87.94	95.57	96.27	98.21
45-54	6.82	3.87	3.26	1.79	83.17	92.56	93.48	96.90
55-64	5.97	3.62	3.14	1.92	60.94	71.80	74.57	82.84
65-79	4.38	3.10	3.20	1.96	13.26	20.06	23.53	31.04
	Women							
25-34	16.73	8.09	5.93	3.60	48.31	66.14	71.74	79.66
35-44	10.60	5.28	4.32	3.05	53.96	69.56	72.64	76.36
45-54	7.68	4.07	3.75	2.38	48.82	64.50	69.16	76.57
55-64	5.65	3.29	3.09	1.97	32.70	44.72	49.75	55.66
65-79	4.12	2.99	2.95	2.67	5.71	9.96	11.18	12.24

Table 5: Average Unemployment and LFP Rates, 25 and older, 1991-2005

	U rate				LFP rate			
Age Group	LTHS	HS	SoCO	CO+	LTHS	HS	SoCO	CO+
	Men							
25-34	10.08	6.31	4.50	2.55	86.93	92.92	93.72	95.06
35-44	8.42	5.02	3.83	2.15	82.79	91.65	93.98	96.97
45-54	7.13	4.14	3.68	2.37	74.50	87.36	90.41	95.36
55-64	5.76	3.86	3.91	2.68	53.42	65.68	70.14	78.18
65-79	4.45	3.27	3.66	2.71	11.18	16.34	19.58	26.89
	Women							
25-34	14.92	7.00	5.00	2.70	51.26	72.17	78.57	83.67
35-44	10.59	4.87	3.92	2.50	56.78	76.16	80.56	81.88
45-54	7.17	3.57	3.35	2.29	51.30	73.57	79.98	85.06
55-64	5.58	3.15	3.19	2.40	32.88	50.55	58.43	64.44
65-79	4.46	3.18	3.84	2.70	5.36	9.63	12.78	14.59

Table 6: Average Unemployment and LFP Rates, 25 and older, 2006-2019

	U rate				LFP rate			
Age Group	LTHS	HS	SoCO	CO+	LTHS	HS	SoCO	CO+
	Men							
25-34	10.77	8.81	6.40	3.12	83.86	87.97	89.86	93.36
35-44	8.38	6.55	4.86	2.51	84.09	88.17	91.52	95.92
45-54	8.54	5.71	4.65	2.81	73.74	83.50	87.62	94.12
55-64	7.75	5.17	4.82	3.47	53.52	65.28	69.91	80.53
65-79	6.63	4.77	5.24	3.64	13.25	19.12	23.50	31.30
	Women							
25-34	15.98	9.08	6.59	3.15	48.97	67.48	76.46	83.61
35-44	10.75	6.55	5.30	2.86	53.64	70.42	77.86	81.31
45-54	8.89	5.06	4.54	3.07	51.06	70.60	77.81	83.34
55-64	6.64	4.26	4.52	3.29	35.56	54.36	62.06	69.38
65-79	5.39	4.12	5.32	3.92	6.87	12.19	17.17	22.09

8.2 Cyclical effects

Table 7: Cyclical factor by gender, 16-24 year old

Param	Men	Women
CE U: rho	0.84 (0.81)	0.81 (0.77)
	(0.78, 0.91)	(0.73, 0.90)
	[0.73, 0.95]	[0.66, 0.94]
CE U: std	2.18 (1.54)	1.90 (1.44)
	(1.97, 2.43)	(1.72, 2.11)
	[1.86, 2.62]	[1.62, 2.28]
CE LFP: phi(0)	-0.18 (-0.28)	-0.16 (-0.29)
	(-0.23,-0.13)	(-0.23,-0.10)
	[-0.27,-0.10]	[-0.28,-0.06]
CE LFP: phi(1)	-0.08 (-0.09)	-0.10 (-0.12)
	(-0.13,-0.04)	(-0.16,-0.04)
	[-0.17,-0.00]	[-0.20,-0.01]
CE LFP: phi(2)	-0.11 (-0.11)	-0.03 (-0.03)
	(-0.16,-0.06)	(-0.08, 0.02)
	[-0.19,-0.03]	[-0.11, 0.05]
CE LFP: phi(3)	0.06 (0.06)	0.07 (0.03)
	(0.00, 0.12)	(0.01, 0.13)
	[-0.04, 0.15]	[-0.03, 0.17]
CE LFP: std	0.67 (0.97)	0.59 (0.96)
	(0.57, 0.80)	(0.49, 0.71)
	[0.51, 0.90]	[0.43, 0.81]

Notes: For each parameter the first row displays the median and (prior), the second row displays the (68.0 percentile range), and the third row displays the [90.0 percentile range]

Table 8: Cyclical factor by gender and education, 25 and older

Param	LTHS	HS	SoCO	CO+
	Men			
CE U: rho	0.77 (0.74)	0.76 (0.71)	0.75 (0.70)	0.75 (0.70)
	(0.69, 0.86)	(0.67, 0.85)	(0.66, 0.85)	(0.64, 0.86)
	[0.63, 0.91]	[0.61, 0.91]	[0.59, 0.91]	[0.57, 0.92]
CE U: std	1.93 (1.42)	1.73 (1.33)	1.37 (1.16)	0.61 (0.74)
	(1.73, 2.16)	(1.57, 1.93)	(1.24, 1.52)	(0.54, 0.69)
	[1.62, 2.32]	[1.47, 2.07]	[1.16, 1.63]	[0.51, 0.74]
CE LFP: phi(0)	-0.14 (-0.29)	-0.08 (-0.22)	-0.10 (-0.26)	-0.07 (-0.32)
	(-0.21,-0.07)	(-0.13,-0.04)	(-0.15,-0.05)	(-0.15,-0.01)
	[-0.26,-0.02]	[-0.17,-0.01]	[-0.18,-0.02]	[-0.22, 0.02]
CE LFP: phi(1)	-0.07 (-0.04)	-0.05 (-0.03)	-0.12 (-0.13)	-0.05 (0.02)
	(-0.14, 0.01)	(-0.10,-0.00)	(-0.16,-0.07)	(-0.14, 0.03)
	[-0.19, 0.06]	[-0.13, 0.03]	[-0.20,-0.04]	[-0.20, 0.09]
CE LFP: phi(2)	-0.04 (-0.02)	-0.05 (-0.03)	-0.05 (-0.04)	-0.05 (-0.07)
	(-0.11, 0.04)	(-0.10,-0.00)	(-0.10,-0.00)	(-0.13, 0.03)
	[-0.16, 0.09]	[-0.13, 0.03]	[-0.14, 0.03]	[-0.19, 0.08]
CE LFP: phi(3)	-0.01 (0.02)	0.04 (0.08)	-0.02 (-0.05)	-0.01 (-0.04)
	(-0.07, 0.06)	(-0.00, 0.08)	(-0.06, 0.03)	(-0.08, 0.05)
	[-0.12, 0.10]	[-0.03, 0.11]	[-0.10, 0.06]	[-0.14, 0.09]
CE LFP: std	0.82 (1.01)	0.42 (0.73)	0.39 (0.76)	0.22 (0.65)
	(0.68, 0.99)	(0.34, 0.51)	(0.32, 0.47)	(0.18, 0.29)
	[0.58, 1.12]	[0.29, 0.57]	[0.28, 0.52]	[0.16, 0.34]
	Women			
CE U: rho	0.68 (0.63)	0.68 (0.62)	0.68 (0.66)	0.71 (0.61)
	(0.58, 0.79)	(0.56, 0.82)	(0.57, 0.80)	(0.58, 0.83)
	[0.50, 0.87]	[0.48, 0.90]	[0.50, 0.88]	[0.51, 0.90]
CE U: std	2.09 (1.49)	1.49 (1.21)	1.24 (1.10)	0.67 (0.79)
	(1.88, 2.34)	(1.34, 1.67)	(1.12, 1.39)	(0.60, 0.75)
	[1.77, 2.52]	[1.25, 1.80]	[1.05, 1.50]	[0.56, 0.80]
CE LFP: phi(0)	-0.12 (-0.19)	-0.12 (-0.28)	-0.06 (-0.20)	-0.08 (-0.24)
	(-0.21,-0.05)	(-0.20,-0.05)	(-0.12,-0.00)	(-0.19, 0.03)
	[-0.27,-0.00]	[-0.26,-0.01]	[-0.15, 0.03]	[-0.27, 0.10]
CE LFP: phi(1)	-0.07 (0.05)	-0.16 (-0.15)	-0.23 (-0.26)	-0.06 (-0.03)
	(-0.15, 0.02)	(-0.23,-0.09)	(-0.30,-0.17)	(-0.18, 0.07)
	[-0.21, 0.08]	[-0.28,-0.05]	[-0.34,-0.13]	[-0.27, 0.16]
CE LFP: phi(2)	-0.10 (-0.09)	0.00 (0.03)	-0.09 (-0.10)	-0.05 (-0.04)
	(-0.18,-0.02)	(-0.07, 0.07)	(-0.15,-0.03)	(-0.19, 0.08)
	[-0.23, 0.03]	[-0.11, 0.12]	[-0.19, 0.01]	[-0.29, 0.18]
CE LFP: phi(3)	-0.06 (-0.22)	-0.22 (-0.20)	-0.03 (0.05)	0.05 (0.14)
	(-0.15, 0.01)	(-0.29,-0.14)	(-0.10, 0.04)	(-0.09, 0.18)
	[-0.21, 0.06]	[-0.35,-0.09]	[-0.14, 0.08]	[-0.18, 0.27]
CE LFP: std	1.07 (1.13)	0.59 (0.94)	0.39 (0.87)	0.41 (0.88)
	(0.80, 1.36)	(0.47, 0.74)	(0.32, 0.47)	(0.34, 0.51)
	[0.66, 1.55]	[0.40, 0.85]	[0.29, 0.52]	[0.31, 0.58]

Notes: See Table 7.

Table 9: Unemployment rate loading on cyclical factor by gender, 16-24 year old

Param	Men	Women
U: gamma (16-19)	1.00 (1.00)	1.00 (1.00)
	(1.00, 1.00)	(1.00, 1.00)
	[1.00, 1.00]	[1.00, 1.00]
U: gamma (20-24)	0.76 (0.66)	0.70 (0.66)
	(0.71, 0.80)	(0.67, 0.73)
	[0.69, 0.82]	[0.65, 0.76]

Notes: See Table 7.

Table 10: Unemployment rate loading on cyclical factor by gender and education groups, 25 and older

Param	LTHS	HS	SoCO	CO+
	Men			
U: gamma (25-34)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)
	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)
	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]
U: gamma (35-44)	0.92 (0.89)	0.75 (0.76)	0.82 (0.80)	0.95 (0.92)
	(0.87, 0.96)	(0.72, 0.77)	(0.80, 0.85)	(0.90, 1.01)
	[0.84, 0.99]	[0.70, 0.79]	[0.78, 0.87]	[0.87, 1.05]
U: gamma (45-54)	0.87 (0.90)	0.68 (0.70)	0.75 (0.76)	0.96 (1.03)
	(0.82, 0.92)	(0.66, 0.71)	(0.72, 0.78)	(0.90, 1.02)
	[0.78, 0.96]	[0.64, 0.72]	[0.70, 0.80]	[0.86, 1.07]
U: gamma (55-64)	0.77 (0.76)	0.64 (0.65)	0.76 (0.78)	0.99 (1.21)
	(0.72, 0.82)	(0.62, 0.66)	(0.73, 0.80)	(0.92, 1.06)
	[0.69, 0.85]	[0.60, 0.68]	[0.71, 0.82]	[0.88, 1.10]
U: gamma (65-79)	0.38 (0.37)	0.44 (0.42)	0.66 (0.76)	0.95 (1.19)
	(0.32, 0.45)	(0.38, 0.49)	(0.59, 0.73)	(0.85, 1.06)
	[0.28, 0.49]	[0.35, 0.53]	[0.55, 0.77]	[0.78, 1.14]
	Women			
U: gamma (25-34)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)
	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)
	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]
U: gamma (35-44)	0.81 (0.80)	0.82 (0.83)	0.75 (0.78)	0.86 (0.84)
	(0.77, 0.85)	(0.78, 0.85)	(0.72, 0.78)	(0.80, 0.92)
	[0.74, 0.88]	[0.76, 0.87]	[0.70, 0.80]	[0.76, 0.96]
U: gamma (45-54)	0.85 (0.80)	0.77 (0.76)	0.72 (0.72)	0.87 (0.95)
	(0.80, 0.90)	(0.74, 0.81)	(0.70, 0.75)	(0.81, 0.93)
	[0.77, 0.93]	[0.72, 0.83]	[0.68, 0.77]	[0.77, 0.97]
U: gamma (55-64)	0.56 (0.51)	0.70 (0.67)	0.80 (0.82)	0.94 (1.01)
	(0.52, 0.60)	(0.67, 0.73)	(0.77, 0.84)	(0.87, 1.02)
	[0.49, 0.63]	[0.65, 0.75]	[0.75, 0.86]	[0.82, 1.08]
U: gamma (65-79)	0.48 (0.38)	0.67 (0.63)	0.86 (0.91)	1.00 (1.14)
	(0.41, 0.54)	(0.61, 0.73)	(0.80, 0.92)	(0.91, 1.09)
	[0.37, 0.59]	[0.57, 0.77]	[0.76, 0.96]	[0.85, 1.16]

Notes: See Table 7.

Table 11: LFP rate loading on cyclical factor by gender, 16-24 year old

Param	Men	Women
LFP: gamma (16-19)	1.00 (1.00)	1.00 (1.00)
	(1.00, 1.00)	(1.00, 1.00)
	[1.00, 1.00]	[1.00, 1.00]
LFP: gamma (20-24)	0.44 (0.01)	0.49 (0.40)
	(0.29, 0.60)	(0.29, 0.73)
	[0.19, 0.72]	[0.15, 0.91]

Notes: See Table 7.

Table 12: LFP rate loading on cyclical factor by gender and education groups, 25 and older

Param	LTHS	HS	SoCO	CO+
	Men			
LFP: gamma (25-34)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)
	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)
	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]
LFP: gamma (35-44)	0.29 (-0.42)	0.58 (0.67)	0.59 (1.08)	0.76 (2.20)
	(0.01, 0.53)	(0.29, 0.96)	(0.37, 0.92)	(0.24, 1.78)
	[-0.21, 0.67]	[0.05, 1.33]	[0.25, 1.19]	[0.02, 2.71]
LFP: gamma (45-54)	0.49 (0.03)	0.45 (0.79)	0.62 (1.41)	1.18 (2.50)
	(0.35, 0.65)	(0.23, 0.75)	(0.44, 0.85)	(0.50, 2.41)
	[0.26, 0.76]	[0.08, 1.00]	[0.32, 1.05]	[0.18, 3.36]
LFP: gamma (55-64)	0.69 (0.40)	0.63 (0.83)	0.57 (0.85)	0.06 (0.94)
	(0.45, 0.96)	(0.28, 1.07)	(0.30, 0.92)	(-0.61, 0.84)
	[0.27, 1.20]	[0.07, 1.43]	[0.12, 1.19]	[-1.20, 1.70]
LFP: gamma (65-79)	0.03 (0.30)	0.17 (-0.27)	-0.04 (-0.81)	-0.61 (-2.68)
	(-0.11, 0.19)	(-0.07, 0.41)	(-0.30, 0.22)	(-1.48, 0.14)
	[-0.21, 0.29]	[-0.22, 0.58]	[-0.49, 0.38]	[-2.19, 0.75]
	Women			
LFP: gamma (25-34)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)	1.00 (1.00)
	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)	(1.00, 1.00)
	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]	[1.00, 1.00]
LFP: gamma (35-44)	0.65 (0.68)	0.83 (2.16)	0.98 (0.88)	0.38 (1.24)
	(0.49, 0.84)	(0.61, 1.11)	(0.65, 1.34)	(-0.10, 0.91)
	[0.37, 0.98]	[0.44, 1.37]	[0.43, 1.60]	[-0.47, 1.46]
LFP: gamma (45-54)	0.73 (0.40)	0.54 (0.95)	0.72 (0.10)	0.25 (0.45)
	(0.57, 0.94)	(0.35, 0.75)	(0.41, 1.05)	(-0.17, 0.69)
	[0.45, 1.10]	[0.23, 0.92]	[0.20, 1.29]	[-0.51, 1.06]
LFP: gamma (55-64)	0.05 (0.10)	0.29 (-1.49)	0.24 (-2.10)	0.29 (-5.08)
	(-0.18, 0.29)	(0.01, 0.54)	(-0.16, 0.61)	(-0.25, 0.82)
	[-0.35, 0.48]	[-0.26, 0.71]	[-0.49, 0.86]	[-0.65, 1.20]
LFP: gamma (65-79)	0.06 (-0.08)	-0.12 (-0.80)	-0.18 (-1.82)	0.11 (-4.98)
	(-0.04, 0.17)	(-0.28, 0.01)	(-0.42, 0.03)	(-0.29, 0.50)
	[-0.12, 0.25]	[-0.41, 0.09]	[-0.61, 0.18]	[-0.61, 0.78]

Notes: See Table 7.

8.3 Age and cohort effects

Table 13: Unemployment rate age and cohort effects by gender, 16-24 year old

Param	Men	Women
U: Age effect, std	0.56 (0.26)	0.28 (0.28)
	(0.43, 0.67)	(0.19, 0.41)
	[0.33, 0.75]	[0.16, 0.52]
U: Cohort Effect, std	0.36 (0.26)	0.29 (0.28)
	(0.22, 0.62)	(0.20, 0.42)
	[0.16, 0.82]	[0.16, 0.53]

Notes: See Table 7.

Table 14: Unemployment rate age and cohort effects by gender and education groups, 25 and older

Param	LTHS	HS	SoCO	CO+
	Men			
U: Age effect (35-44), std	0.28 (0.46)	0.18 (0.27)	0.16 (0.25)	0.11 (0.19)
	(0.22, 0.35)	(0.14, 0.22)	(0.13, 0.19)	(0.09, 0.13)
	[0.19, 0.41]	[0.13, 0.25]	[0.11, 0.22]	[0.08, 0.15]
U: Age effect (45-54), std	0.38 (0.46)	0.20 (0.27)	0.20 (0.25)	0.13 (0.19)
	(0.29, 0.49)	(0.16, 0.24)	(0.16, 0.26)	(0.10, 0.17)
	[0.24, 0.58]	[0.14, 0.27]	[0.13, 0.29]	[0.09, 0.20]
U: Age effect (55-64), std	0.39 (0.46)	0.24 (0.27)	0.24 (0.25)	0.16 (0.19)
	(0.29, 0.51)	(0.19, 0.30)	(0.19, 0.30)	(0.13, 0.21)
	[0.24, 0.60]	[0.16, 0.34]	[0.16, 0.35]	[0.11, 0.24]
U: Age effect (65-79), std	0.50 (0.46)	0.61 (0.27)	0.51 (0.25)	0.31 (0.19)
	(0.38, 0.68)	(0.50, 0.73)	(0.39, 0.67)	(0.23, 0.42)
	[0.32, 0.83]	[0.43, 0.81]	[0.31, 0.77]	[0.18, 0.50]
U: Cohort Effect, std	0.41 (0.46)	0.21 (0.27)	0.23 (0.25)	0.15 (0.19)
	(0.30, 0.56)	(0.16, 0.29)	(0.17, 0.33)	(0.11, 0.20)
	[0.26, 0.70]	[0.13, 0.36]	[0.14, 0.43]	[0.10, 0.25]
	Women			
U: Age effect (35-44), std	0.38 (0.54)	0.17 (0.27)	0.15 (0.26)	0.13 (0.22)
	(0.29, 0.50)	(0.13, 0.22)	(0.12, 0.18)	(0.11, 0.17)
	[0.25, 0.60]	[0.11, 0.26]	[0.11, 0.21]	[0.09, 0.20]
U: Age effect (45-54), std	0.39 (0.54)	0.18 (0.27)	0.16 (0.26)	0.18 (0.22)
	(0.30, 0.53)	(0.14, 0.23)	(0.13, 0.20)	(0.14, 0.23)
	[0.25, 0.62]	[0.12, 0.28]	[0.11, 0.24]	[0.12, 0.27]
U: Age effect (55-64), std	0.40 (0.54)	0.20 (0.27)	0.20 (0.26)	0.20 (0.22)
	(0.32, 0.51)	(0.16, 0.25)	(0.15, 0.27)	(0.16, 0.26)
	[0.27, 0.60]	[0.14, 0.29]	[0.13, 0.32]	[0.13, 0.30]
U: Age effect (65-79), std	0.50 (0.54)	0.44 (0.27)	0.31 (0.26)	0.18 (0.22)
	(0.37, 0.68)	(0.34, 0.55)	(0.24, 0.41)	(0.13, 0.26)
	[0.31, 0.82]	[0.28, 0.64]	[0.20, 0.49]	[0.11, 0.34]
U: Cohort Effect, std	0.62 (0.54)	0.21 (0.27)	0.18 (0.26)	0.17 (0.22)
	(0.43, 0.91)	(0.15, 0.30)	(0.14, 0.25)	(0.13, 0.23)
	[0.34, 1.16]	[0.13, 0.38]	[0.12, 0.30]	[0.11, 0.28]

Notes: See Table 7.

Table 15: LFP rate age and cohort effects by gender, 16-24 year old

Param	Men	Women
LFP: Age effect, std	0.70 (0.50)	0.91 (0.45)
	(0.60, 0.80)	(0.80, 1.04)
	[0.55, 0.88]	[0.74, 1.14]
LFP: Cohort Effect, std	1.40 (0.50)	1.45 (0.45)
	(1.18, 1.71)	(1.18, 1.81)
	[1.06, 1.94]	[1.05, 2.09]

Notes: See Table 7.

Table 16: LFP rate age and cohort effects by gender and education groups, 25 and older

Param	LTHS	HS	SoCO	CO+
	Men			
LFP: Age effect (35-44), std	0.78 (0.59)	0.36 (0.42)	0.29 (0.44)	0.19 (0.42)
	(0.65, 0.92)	(0.29, 0.43)	(0.24, 0.34)	(0.16, 0.22)
	[0.58, 1.03]	[0.26, 0.49]	[0.21, 0.39]	[0.15, 0.25]
LFP: Age effect (45-54), std	0.88 (0.59)	0.55 (0.42)	0.42 (0.44)	0.23 (0.42)
	(0.78, 1.00)	(0.48, 0.63)	(0.36, 0.50)	(0.19, 0.28)
	[0.71, 1.09]	[0.44, 0.69]	[0.32, 0.55]	[0.17, 0.31]
LFP: Age effect (55-64), std	1.05 (0.59)	0.90 (0.42)	0.77 (0.44)	0.71 (0.42)
	(0.91, 1.21)	(0.81, 1.02)	(0.68, 0.88)	(0.62, 0.81)
	[0.82, 1.32]	[0.75, 1.10]	[0.63, 0.95]	[0.56, 0.88]
LFP: Age effect (65-79), std	0.58 (0.59)	0.71 (0.42)	0.76 (0.44)	0.92 (0.42)
	(0.51, 0.66)	(0.62, 0.82)	(0.63, 0.90)	(0.81, 1.05)
	[0.48, 0.72]	[0.56, 0.89]	[0.57, 1.00]	[0.75, 1.14]
LFP: Cohort Effect, std	1.31 (0.59)	0.76 (0.42)	0.52 (0.44)	0.32 (0.42)
	(0.94, 1.88)	(0.60, 0.98)	(0.41, 0.67)	(0.25, 0.41)
	[0.80, 2.41]	[0.52, 1.17]	[0.35, 0.81]	[0.22, 0.50]
	Women			
LFP: Age effect (35-44), std	0.68 (0.67)	0.93 (0.62)	1.01 (0.57)	1.02 (0.61)
	(0.56, 0.85)	(0.82, 1.06)	(0.90, 1.15)	(0.91, 1.14)
	[0.48, 0.97]	[0.76, 1.15]	[0.84, 1.25]	[0.85, 1.24]
LFP: Age effect (45-54), std	0.58 (0.67)	1.04 (0.62)	1.23 (0.57)	1.03 (0.61)
	(0.43, 0.80)	(0.93, 1.17)	(1.10, 1.38)	(0.92, 1.15)
	[0.37, 1.00]	[0.86, 1.27]	[1.03, 1.49]	[0.86, 1.25]
LFP: Age effect (55-64), std	0.68 (0.67)	0.90 (0.62)	1.15 (0.57)	1.06 (0.61)
	(0.54, 0.85)	(0.80, 1.02)	(1.03, 1.29)	(0.94, 1.21)
	[0.46, 0.96]	[0.74, 1.11]	[0.96, 1.40]	[0.87, 1.31]
LFP: Age effect (65-79), std	0.31 (0.67)	0.53 (0.62)	0.67 (0.57)	0.86 (0.61)
	(0.27, 0.37)	(0.46, 0.61)	(0.59, 0.76)	(0.76, 0.97)
	[0.24, 0.42]	[0.43, 0.66]	[0.54, 0.83]	[0.71, 1.05]
LFP: Cohort Effect, std	0.65 (0.67)	1.71 (0.62)	1.99 (0.57)	2.28 (0.61)
	(0.49, 0.90)	(1.35, 2.17)	(1.58, 2.53)	(1.84, 2.80)
	[0.41, 1.13]	[1.16, 2.54]	[1.37, 2.93]	[1.57, 3.20]

Notes: See Table 7.

8.4 Measurement errors

Table 17: Measurement errors for U and LFP rate by gender, 16-24 year old

Param	Men	Women
U: Meas age (16-19), std	0.21 (0.26)	0.23 (0.28)
	(0.15, 0.28)	(0.17, 0.31)
	[0.13, 0.35]	[0.14, 0.39]
U: Meas age (20-24), std	0.23 (0.26)	0.47 (0.28)
	(0.17, 0.33)	(0.38, 0.56)
	[0.14, 0.42]	[0.31, 0.62]
LFP: Meas age (16-19), std	0.36 (0.50)	0.37 (0.45)
	(0.28, 0.48)	(0.28, 0.50)
	[0.23, 0.58]	[0.23, 0.60]
LFP: Meas age (20-24), std	0.33 (0.50)	0.30 (0.45)
	(0.26, 0.41)	(0.24, 0.39)
	[0.23, 0.47]	[0.20, 0.46]

Notes: See Table 7.

Table 18: Measurement errors for U rate by gender, 25 years and older

Param	LTHS	HS	SoCO	CO+
	Men			
U: Meas age (25-34), std	0.68 (0.46)	0.53 (0.27)	0.23 (0.25)	0.29 (0.19)
	(0.58, 0.79)	(0.46, 0.62)	(0.20, 0.28)	(0.25, 0.33)
	[0.52, 0.87]	[0.41, 0.69]	[0.17, 0.31]	[0.23, 0.36]
U: Meas age (35-44), std	0.33 (0.46)	0.18 (0.27)	0.15 (0.25)	0.11 (0.19)
	(0.27, 0.41)	(0.15, 0.22)	(0.12, 0.18)	(0.09, 0.13)
	[0.23, 0.47]	[0.13, 0.25]	[0.11, 0.20]	[0.08, 0.15]
U: Meas age (45-54), std	0.42 (0.46)	0.15 (0.27)	0.20 (0.25)	0.15 (0.19)
	(0.33, 0.51)	(0.13, 0.19)	(0.16, 0.24)	(0.12, 0.18)
	[0.28, 0.58]	[0.11, 0.21]	[0.13, 0.27]	[0.10, 0.20]
U: Meas age (55-64), std	0.43 (0.46)	0.22 (0.27)	0.21 (0.25)	0.16 (0.19)
	(0.34, 0.53)	(0.18, 0.27)	(0.16, 0.26)	(0.12, 0.19)
	[0.29, 0.59]	[0.15, 0.30]	[0.14, 0.30]	[0.10, 0.22]
U: Meas age (65-79), std	0.80 (0.46)	0.34 (0.27)	0.45 (0.25)	0.35 (0.19)
	(0.68, 0.93)	(0.24, 0.45)	(0.32, 0.57)	(0.27, 0.43)
	[0.57, 1.03]	[0.19, 0.52]	[0.23, 0.64]	[0.21, 0.49]
	Women			
U: Meas age (25-34), std	1.02 (0.54)	0.45 (0.27)	0.26 (0.26)	0.21 (0.22)
	(0.89, 1.18)	(0.38, 0.52)	(0.22, 0.30)	(0.17, 0.24)
	[0.81, 1.30]	[0.34, 0.57]	[0.19, 0.33]	[0.15, 0.27]
U: Meas age (35-44), std	0.50 (0.54)	0.30 (0.27)	0.17 (0.26)	0.16 (0.22)
	(0.40, 0.61)	(0.25, 0.35)	(0.14, 0.20)	(0.13, 0.19)
	[0.34, 0.69]	[0.22, 0.39]	[0.12, 0.23]	[0.11, 0.21]
U: Meas age (45-54), std	0.49 (0.54)	0.23 (0.27)	0.23 (0.26)	0.18 (0.22)
	(0.38, 0.61)	(0.18, 0.27)	(0.20, 0.27)	(0.14, 0.22)
	[0.32, 0.69]	[0.16, 0.31]	[0.17, 0.30]	[0.12, 0.25]
U: Meas age (55-64), std	0.46 (0.54)	0.20 (0.27)	0.32 (0.26)	0.25 (0.22)
	(0.38, 0.56)	(0.16, 0.24)	(0.27, 0.38)	(0.20, 0.29)
	[0.33, 0.62]	[0.14, 0.27]	[0.23, 0.42]	[0.17, 0.33]
U: Meas age (65-79), std	0.69 (0.54)	0.38 (0.27)	0.55 (0.26)	0.49 (0.22)
	(0.55, 0.83)	(0.29, 0.48)	(0.47, 0.63)	(0.43, 0.56)
	[0.45, 0.92]	[0.23, 0.55]	[0.42, 0.70]	[0.39, 0.61]

Notes: See Table 7.

Table 19: Measurement errors for LFP rate by gender, 25 years and older

Param	LTHS	HS	SoCO	CO+
	Men			
LFP: Meas age (25-34), std	0.49 (0.59)	0.37 (0.42)	0.33 (0.44)	0.31 (0.42)
	(0.37, 0.64)	(0.28, 0.46)	(0.26, 0.40)	(0.26, 0.35)
	[0.30, 0.75]	[0.23, 0.52]	[0.22, 0.45]	[0.23, 0.38]
LFP: Meas age (35-44), std	0.40 (0.59)	0.22 (0.42)	0.24 (0.44)	0.17 (0.42)
	(0.32, 0.51)	(0.18, 0.27)	(0.20, 0.29)	(0.15, 0.20)
	[0.27, 0.59]	[0.16, 0.31]	[0.18, 0.33]	[0.13, 0.23]
LFP: Meas age (45-54), std	0.35 (0.59)	0.25 (0.42)	0.28 (0.44)	0.20 (0.42)
	(0.28, 0.45)	(0.20, 0.32)	(0.23, 0.34)	(0.17, 0.24)
	[0.25, 0.52]	[0.18, 0.37]	[0.20, 0.38]	[0.15, 0.28]
LFP: Meas age (55-64), std	0.42 (0.59)	0.28 (0.42)	0.29 (0.44)	0.31 (0.42)
	(0.33, 0.55)	(0.22, 0.36)	(0.23, 0.37)	(0.24, 0.40)
	[0.28, 0.66]	[0.19, 0.42]	[0.19, 0.43]	[0.20, 0.46]
LFP: Meas age (65-79), std	0.28 (0.59)	0.33 (0.42)	0.48 (0.44)	0.33 (0.42)
	(0.24, 0.34)	(0.25, 0.42)	(0.36, 0.59)	(0.25, 0.45)
	[0.21, 0.39]	[0.21, 0.48]	[0.30, 0.67]	[0.21, 0.54]
	Women			
LFP: Meas age (25-34), std	1.13 (0.67)	0.51 (0.62)	0.45 (0.57)	0.38 (0.61)
	(0.90, 1.37)	(0.37, 0.70)	(0.35, 0.58)	(0.30, 0.48)
	[0.73, 1.53]	[0.31, 0.86]	[0.30, 0.69]	[0.26, 0.56]
LFP: Meas age (35-44), std	0.51 (0.67)	0.34 (0.62)	0.34 (0.57)	0.34 (0.61)
	(0.39, 0.64)	(0.27, 0.42)	(0.27, 0.43)	(0.27, 0.42)
	[0.33, 0.74]	[0.24, 0.49]	[0.24, 0.50]	[0.24, 0.48]
LFP: Meas age (45-54), std	0.78 (0.67)	0.36 (0.62)	0.34 (0.57)	0.33 (0.61)
	(0.61, 0.95)	(0.29, 0.46)	(0.27, 0.43)	(0.27, 0.41)
	[0.49, 1.07]	[0.25, 0.53]	[0.24, 0.51]	[0.24, 0.47]
LFP: Meas age (55-64), std	0.61 (0.67)	0.34 (0.62)	0.37 (0.57)	0.41 (0.61)
	(0.48, 0.74)	(0.28, 0.42)	(0.29, 0.48)	(0.33, 0.52)
	[0.40, 0.84]	[0.25, 0.49]	[0.25, 0.56]	[0.28, 0.61]
LFP: Meas age (65-79), std	0.30 (0.67)	0.29 (0.62)	0.31 (0.57)	0.35 (0.61)
	(0.26, 0.34)	(0.24, 0.34)	(0.25, 0.37)	(0.28, 0.43)
	[0.23, 0.38]	[0.22, 0.39]	[0.22, 0.43]	[0.25, 0.49]

Notes: See Table 7.

8.5 Cross-correlations with cyclical factors

Table 20: Cross-correlations of Cyclical Effects

Lag	16-24	LTHS	HS	SoCO	CO+
			Men		
U(t),LFP(t+2)	-0.69	-0.44	-0.45	-0.65	-0.51
	(-0.76,-0.58)	(-0.57,-0.31)	(-0.60,-0.28)	(-0.73,-0.56)	(-0.66,-0.33)
	[-0.80,-0.50]	[-0.64,-0.22]	[-0.68,-0.17]	[-0.78,-0.49]	[-0.74,-0.20]
U(t),LFP(t+1)	-0.85	-0.60	-0.66	-0.79	-0.60
	(-0.89,-0.79)	(-0.70,-0.49)	(-0.75,-0.54)	(-0.84,-0.72)	(-0.73,-0.44)
	[-0.91,-0.73]	[-0.75,-0.41]	[-0.80,-0.44]	[-0.86,-0.67]	[-0.79,-0.31]
U(t),LFP(t)	-0.83	-0.59	-0.63	-0.69	-0.49
	(-0.86,-0.78)	(-0.66,-0.49)	(-0.71,-0.53)	(-0.75,-0.62)	(-0.63,-0.33)
	[-0.89,-0.73]	[-0.71,-0.41]	[-0.75,-0.46]	[-0.78,-0.57]	[-0.71,-0.21]
U(t),LFP(t-1)	-0.57	-0.29	-0.26	-0.31	-0.20
	(-0.64,-0.50)	(-0.38,-0.18)	(-0.37,-0.14)	(-0.43,-0.21)	(-0.39,-0.01)
	[-0.68,-0.44]	[-0.44,-0.10]	[-0.43,-0.07]	[-0.50,-0.14]	[-0.51, 0.11]
U(t),LFP(t-2)	-0.30	-0.00	0.04	-0.06	0.04
	(-0.38,-0.20)	(-0.12, 0.11)	(-0.09, 0.16)	(-0.20, 0.08)	(-0.20, 0.26)
	[-0.44,-0.13]	[-0.19, 0.19]	[-0.17, 0.24]	[-0.31, 0.16]	[-0.36, 0.38]
			Women		
U(t),LFP(t+2)	-0.48	-0.49	-0.60	-0.71	-0.21
	(-0.63,-0.27)	(-0.61,-0.38)	(-0.69,-0.50)	(-0.79,-0.61)	(-0.51, 0.14)
	[-0.70,-0.08]	[-0.68,-0.30]	[-0.74,-0.42]	[-0.82,-0.53]	[-0.65, 0.35]
U(t),LFP(t+1)	-0.72	-0.56	-0.64	-0.82	-0.31
	(-0.81,-0.56)	(-0.67,-0.44)	(-0.71,-0.55)	(-0.87,-0.75)	(-0.55, 0.01)
	[-0.86,-0.38]	[-0.73,-0.36]	[-0.76,-0.49]	[-0.89,-0.70]	[-0.67, 0.21]
U(t),LFP(t)	-0.76	-0.42	-0.47	-0.56	-0.30
	(-0.83,-0.65)	(-0.51,-0.32)	(-0.54,-0.39)	(-0.62,-0.50)	(-0.49,-0.05)
	[-0.86,-0.54]	[-0.56,-0.26]	[-0.58,-0.33]	[-0.66,-0.44]	[-0.59, 0.12]
U(t),LFP(t-1)	-0.53	-0.18	-0.15	-0.23	-0.11
	(-0.62,-0.43)	(-0.28,-0.08)	(-0.23,-0.05)	(-0.31,-0.14)	(-0.29, 0.10)
	[-0.67,-0.33]	[-0.33,-0.01]	[-0.29, 0.01]	[-0.36,-0.08]	[-0.40, 0.23]
U(t),LFP(t-2)	-0.27	0.01	0.02	-0.03	-0.05
	(-0.37,-0.15)	(-0.09, 0.12)	(-0.07, 0.12)	(-0.12, 0.07)	(-0.23, 0.12)
	[-0.43,-0.07]	[-0.16, 0.19]	[-0.14, 0.19]	[-0.18, 0.13]	[-0.32, 0.24]

Notes: Cross correlation of $z_{u,t}$ with $z_{\ell,t+s}$.

8.5.1 Cross-correlations of U-cyclical effects with U-age effects

Table 21: Cross-correlations of U-Cyclical and U-Age Effects, Men and Women aged 16-24

Lag	Men	Women
	Age: 16-19	
U(t),AGE(t+1)	-0.00	0.00
	(-0.34, 0.33)	(-0.27, 0.29)
	[-0.49, 0.47]	[-0.43, 0.43]
U(t),AGE(t)	-0.00	0.00
	(-0.32, 0.32)	(-0.26, 0.27)
	[-0.48, 0.46]	[-0.42, 0.42]
U(t),AGE(t-1)	0.00	0.00
	(-0.33, 0.33)	(-0.28, 0.28)
	[-0.48, 0.47]	[-0.42, 0.43]
	Age: 20-24	
U(t),AGE(t+1)	0.14	0.27
	(-0.06, 0.34)	(0.04, 0.46)
	[-0.17, 0.45]	[-0.13, 0.56]
U(t),AGE(t)	0.15	0.23
	(-0.04, 0.33)	(0.00, 0.43)
	[-0.16, 0.45]	[-0.16, 0.54]
U(t),AGE(t-1)	0.15	0.26
	(-0.04, 0.33)	(0.04, 0.46)
	[-0.15, 0.45]	[-0.12, 0.55]

Notes: Cross correlation of $z_{u,t}$ with $y_{u,g,t+s}$.

Table 22: Cross-correlations of U-cyclical and U-age effects, men older than 25 by education

Lag	LTHS	HS	SoCO	CO+
		Age: 25-34		
U(t),AGE(t+1)	0.00	0.00	-0.00	-0.00
	(-0.22, 0.22)	(-0.25, 0.27)	(-0.34, 0.33)	(-0.41, 0.41)
	[-0.34, 0.35]	[-0.39, 0.40]	[-0.49, 0.47]	[-0.56, 0.55]
U(t),AGE(t)	0.00	-0.00	-0.00	-0.01
	(-0.22, 0.22)	(-0.24, 0.26)	(-0.32, 0.32)	(-0.40, 0.41)
	[-0.34, 0.34]	[-0.38, 0.39]	[-0.48, 0.46]	[-0.56, 0.55]
U(t),AGE(t-1)	-0.00	-0.01	0.00	-0.01
	(-0.21, 0.22)	(-0.24, 0.25)	(-0.33, 0.33)	(-0.41, 0.41)
	[-0.35, 0.34]	[-0.38, 0.38]	[-0.48, 0.47]	[-0.56, 0.55]
		Age: 35-44		
U(t),AGE(t+1)	-0.02	0.22	0.14	0.19
	(-0.22, 0.20)	(0.03, 0.38)	(-0.06, 0.34)	(-0.06, 0.42)
	[-0.33, 0.34]	[-0.09, 0.48]	[-0.17, 0.45]	[-0.25, 0.53]
U(t),AGE(t)	-0.00	0.21	0.15	0.24
	(-0.21, 0.22)	(0.02, 0.37)	(-0.04, 0.33)	(0.00, 0.45)
	[-0.32, 0.36]	[-0.10, 0.47]	[-0.16, 0.45]	[-0.18, 0.56]
U(t),AGE(t-1)	0.01	0.20	0.15	0.29
	(-0.20, 0.23)	(0.03, 0.37)	(-0.04, 0.33)	(0.06, 0.48)
	[-0.31, 0.37]	[-0.09, 0.47]	[-0.15, 0.45]	[-0.11, 0.59]
		Age: 45-54		
U(t),AGE(t+1)	0.09	0.19	0.27	0.25
	(-0.10, 0.28)	(0.02, 0.34)	(0.05, 0.44)	(-0.04, 0.45)
	[-0.21, 0.40]	[-0.10, 0.44]	[-0.11, 0.54]	[-0.29, 0.56]
U(t),AGE(t)	0.03	0.12	0.26	0.25
	(-0.16, 0.22)	(-0.05, 0.28)	(0.04, 0.44)	(-0.03, 0.46)
	[-0.27, 0.35]	[-0.16, 0.38]	[-0.11, 0.54]	[-0.27, 0.57]
U(t),AGE(t-1)	-0.03	0.08	0.26	0.27
	(-0.20, 0.16)	(-0.09, 0.24)	(0.05, 0.44)	(0.01, 0.47)
	[-0.31, 0.28]	[-0.20, 0.33]	[-0.09, 0.54]	[-0.23, 0.57]
		Age: 55-64		
U(t),AGE(t+1)	-0.10	-0.16	-0.12	0.38
	(-0.27, 0.08)	(-0.34,-0.00)	(-0.34, 0.04)	(0.13, 0.53)
	[-0.38, 0.20]	[-0.45, 0.10]	[-0.51, 0.14]	[-0.17, 0.61]
U(t),AGE(t)	-0.19	-0.22	-0.23	0.26
	(-0.35, 0.00)	(-0.41,-0.07)	(-0.44,-0.06)	(0.01, 0.42)
	[-0.46, 0.13]	[-0.51, 0.04]	[-0.60, 0.04]	[-0.26, 0.51]
U(t),AGE(t-1)	-0.26	-0.28	-0.32	0.19
	(-0.41,-0.08)	(-0.45,-0.13)	(-0.53,-0.16)	(-0.04, 0.35)
	[-0.51, 0.05]	[-0.55,-0.03]	[-0.67,-0.06]	[-0.33, 0.44]
		Age: 65-79		
U(t),AGE(t+1)	-0.04	-0.14	0.04	0.17
	(-0.20, 0.12)	(-0.26,-0.01)	(-0.14, 0.19)	(-0.05, 0.33)
	[-0.30, 0.23]	[-0.33, 0.08]	[-0.28, 0.28]	[-0.28, 0.42]
U(t),AGE(t)	-0.06	-0.17	0.02	0.07
	(-0.22, 0.11)	(-0.30,-0.03)	(-0.18, 0.17)	(-0.17, 0.25)
	[-0.33, 0.22]	[-0.38, 0.06]	[-0.32, 0.27]	[-0.38, 0.35]
U(t),AGE(t-1)	-0.06	-0.18	0.02	0.02
	(-0.22, 0.10)	(-0.29,-0.07)	(-0.15, 0.16)	(-0.20, 0.19)
	[-0.33, 0.21]	[-0.36, 0.01]	[-0.28, 0.25]	[-0.40, 0.29]

Notes: Cross correlation of $z_{u,t}$ with $y_{u,g,t+s}$.

Table 23: Cross-correlations of U-cyclical and U-age effects, women older than 25 by education

Lag	LTHS	HS	SoCO	CO+
	Age: 25-34			
U(t),AGE(t+1)	-0.01	0.00	0.00	-0.00
	(-0.23, 0.23)	(-0.27, 0.28)	(-0.27, 0.29)	(-0.34, 0.33)
	[-0.36, 0.37]	[-0.42, 0.43]	[-0.43, 0.43]	[-0.49, 0.50]
U(t),AGE(t)	-0.01	0.01	0.00	-0.00
	(-0.23, 0.23)	(-0.26, 0.27)	(-0.26, 0.27)	(-0.33, 0.32)
	[-0.36, 0.37]	[-0.40, 0.41]	[-0.42, 0.42]	[-0.49, 0.49]
U(t),AGE(t-1)	-0.00	0.01	0.00	-0.00
	(-0.23, 0.23)	(-0.27, 0.28)	(-0.28, 0.28)	(-0.34, 0.33)
	[-0.36, 0.37]	[-0.41, 0.42]	[-0.42, 0.43]	[-0.50, 0.50]
	Age: 35-44			
U(t),AGE(t+1)	0.08	0.07	0.27	0.11
	(-0.15, 0.31)	(-0.19, 0.31)	(0.04, 0.46)	(-0.19, 0.38)
	[-0.30, 0.44]	[-0.34, 0.44]	[-0.13, 0.56]	[-0.37, 0.52]
U(t),AGE(t)	0.07	0.04	0.23	0.13
	(-0.16, 0.30)	(-0.21, 0.28)	(0.00, 0.43)	(-0.17, 0.39)
	[-0.30, 0.43]	[-0.36, 0.41]	[-0.16, 0.54]	[-0.36, 0.53]
U(t),AGE(t-1)	0.06	0.06	0.26	0.17
	(-0.16, 0.29)	(-0.20, 0.28)	(0.04, 0.46)	(-0.13, 0.42)
	[-0.31, 0.40]	[-0.36, 0.42]	[-0.12, 0.55]	[-0.32, 0.55]
	Age: 45-54			
U(t),AGE(t+1)	-0.32	-0.17	0.10	0.34
	(-0.49,-0.10)	(-0.42, 0.10)	(-0.19, 0.31)	(0.09, 0.55)
	[-0.58, 0.05]	[-0.54, 0.25]	[-0.36, 0.43]	[-0.08, 0.66]
U(t),AGE(t)	-0.28	-0.17	0.10	0.23
	(-0.46,-0.06)	(-0.42, 0.10)	(-0.17, 0.32)	(-0.01, 0.45)
	[-0.55, 0.08]	[-0.53, 0.25]	[-0.35, 0.44]	[-0.17, 0.57]
U(t),AGE(t-1)	-0.25	-0.17	0.15	0.22
	(-0.43,-0.03)	(-0.41, 0.10)	(-0.12, 0.36)	(-0.02, 0.43)
	[-0.52, 0.11]	[-0.52, 0.26]	[-0.30, 0.47]	[-0.17, 0.54]
	Age: 55-64			
U(t),AGE(t+1)	-0.33	-0.43	-0.23	0.00
	(-0.47,-0.16)	(-0.59,-0.24)	(-0.44,-0.02)	(-0.19, 0.20)
	[-0.54,-0.03]	[-0.66,-0.10]	[-0.57, 0.11]	[-0.32, 0.33]
U(t),AGE(t)	-0.29	-0.37	-0.18	-0.03
	(-0.44,-0.13)	(-0.53,-0.19)	(-0.38, 0.01)	(-0.22, 0.16)
	[-0.52, 0.00]	[-0.61,-0.07]	[-0.51, 0.14]	[-0.33, 0.30]
U(t),AGE(t-1)	-0.28	-0.32	-0.10	-0.01
	(-0.42,-0.12)	(-0.48,-0.16)	(-0.29, 0.08)	(-0.19, 0.17)
	[-0.50,-0.00]	[-0.57,-0.04]	[-0.43, 0.19]	[-0.30, 0.28]
	Age: 65-79			
U(t),AGE(t+1)	-0.41	-0.34	-0.11	-0.04
	(-0.54,-0.23)	(-0.47,-0.20)	(-0.24, 0.03)	(-0.28, 0.18)
	[-0.62,-0.10]	[-0.55,-0.11]	[-0.34, 0.13]	[-0.49, 0.32]
U(t),AGE(t)	-0.35	-0.29	-0.11	-0.06
	(-0.50,-0.17)	(-0.43,-0.14)	(-0.24, 0.04)	(-0.29, 0.17)
	[-0.58,-0.04]	[-0.51,-0.03]	[-0.34, 0.14]	[-0.50, 0.31]
U(t),AGE(t-1)	-0.31	-0.27	-0.08	-0.02
	(-0.45,-0.15)	(-0.40,-0.14)	(-0.21, 0.06)	(-0.26, 0.20)
	[-0.53,-0.02]	[-0.47,-0.05]	[-0.31, 0.15]	[-0.48, 0.33]

Notes: Cross correlation of $z_{u,t}$ with $y_{u,g,t+s}$.

8.5.2 Cross-correlations of LFP-cyclical effects with LFP-age effects

Table 24: Cross-correlations of LFP-cyclical and LFP-age effects, men and women aged 16-24

Lag	Men	Women
	Age: 16-19	
LFP(t),AGE(t+1)	0.00	0.00
	(-0.38, 0.37)	(-0.27, 0.28)
	[-0.52, 0.53]	[-0.41, 0.42]
LFP(t),AGE(t)	-0.00	0.00
	(-0.34, 0.33)	(-0.25, 0.26)
	[-0.48, 0.49]	[-0.39, 0.41]
LFP(t),AGE(t-1)	-0.00	0.01
	(-0.34, 0.34)	(-0.29, 0.29)
	[-0.49, 0.49]	[-0.43, 0.45]
	Age: 20-24	
LFP(t),AGE(t+1)	0.24	0.29
	(0.06, 0.40)	(0.18, 0.41)
	[-0.05, 0.49]	[0.09, 0.48]
LFP(t),AGE(t)	0.24	0.32
	(0.06, 0.41)	(0.20, 0.43)
	[-0.06, 0.50]	[0.12, 0.51]
LFP(t),AGE(t-1)	0.27	0.34
	(0.11, 0.43)	(0.22, 0.46)
	[-0.00, 0.53]	[0.13, 0.54]

Notes: Cross correlation of $z_{\ell,t}$ with $y_{\ell,g,t+s}$.

Table 25: Cross-correlations of LFP-cyclical and LFP-age effects, men older than 25 by education

Lag	LTHS	HS	SoCO	CO+
	Age: 25-34			
LFP(t),AGE(t+1)	0.01	-0.00	0.00	-0.02
	(-0.21, 0.22)	(-0.24, 0.24)	(-0.38, 0.37)	(-0.37, 0.35)
	[-0.35, 0.35]	[-0.37, 0.38]	[-0.52, 0.53]	[-0.54, 0.53]
LFP(t),AGE(t)	0.01	-0.00	-0.00	-0.01
	(-0.20, 0.20)	(-0.22, 0.22)	(-0.34, 0.33)	(-0.34, 0.33)
	[-0.33, 0.33]	[-0.34, 0.35]	[-0.48, 0.49]	[-0.52, 0.52]
LFP(t),AGE(t-1)	0.00	0.00	-0.00	-0.02
	(-0.19, 0.19)	(-0.21, 0.21)	(-0.34, 0.34)	(-0.35, 0.35)
	[-0.31, 0.32]	[-0.34, 0.34]	[-0.49, 0.49]	[-0.53, 0.52]
	Age: 35-44			
LFP(t),AGE(t+1)	0.28	0.22	0.24	0.14
	(0.15, 0.41)	(0.06, 0.36)	(0.06, 0.40)	(-0.10, 0.36)
	[0.07, 0.48]	[-0.03, 0.45]	[-0.05, 0.49]	[-0.26, 0.49]
LFP(t),AGE(t)	0.27	0.15	0.24	0.14
	(0.13, 0.40)	(-0.00, 0.32)	(0.06, 0.41)	(-0.12, 0.37)
	[0.04, 0.49]	[-0.10, 0.41]	[-0.06, 0.50]	[-0.29, 0.51]
LFP(t),AGE(t-1)	0.18	0.06	0.27	0.19
	(0.05, 0.31)	(-0.09, 0.21)	(0.11, 0.43)	(-0.04, 0.41)
	[-0.04, 0.40]	[-0.18, 0.31]	[-0.00, 0.53]	[-0.19, 0.54]
	Age: 45-54			
LFP(t),AGE(t+1)	0.16	0.23	0.39	0.31
	(0.02, 0.31)	(0.08, 0.38)	(0.23, 0.54)	(0.09, 0.51)
	[-0.07, 0.40]	[-0.02, 0.46]	[0.12, 0.61]	[-0.06, 0.62]
LFP(t),AGE(t)	0.16	0.19	0.35	0.28
	(0.02, 0.30)	(0.05, 0.33)	(0.19, 0.50)	(0.04, 0.48)
	[-0.08, 0.39]	[-0.05, 0.42]	[0.07, 0.59]	[-0.11, 0.60]
LFP(t),AGE(t-1)	0.10	0.15	0.36	0.30
	(-0.03, 0.24)	(0.00, 0.29)	(0.19, 0.50)	(0.07, 0.50)
	[-0.13, 0.34]	[-0.10, 0.39]	[0.08, 0.59]	[-0.07, 0.61]
	Age: 55-64			
LFP(t),AGE(t+1)	0.18	0.15	0.16	-0.07
	(0.04, 0.32)	(0.02, 0.29)	(0.03, 0.29)	(-0.23, 0.10)
	[-0.05, 0.41]	[-0.07, 0.38]	[-0.06, 0.37]	[-0.33, 0.21]
LFP(t),AGE(t)	0.19	0.15	0.13	-0.03
	(0.05, 0.32)	(0.01, 0.28)	(-0.00, 0.26)	(-0.19, 0.14)
	[-0.04, 0.41]	[-0.07, 0.37]	[-0.09, 0.34]	[-0.30, 0.26]
LFP(t),AGE(t-1)	0.13	0.12	0.11	0.01
	(0.00, 0.27)	(-0.01, 0.24)	(-0.01, 0.23)	(-0.15, 0.17)
	[-0.09, 0.35]	[-0.09, 0.33]	[-0.09, 0.31]	[-0.26, 0.28]
	Age: 65-79			
LFP(t),AGE(t+1)	0.17	-0.01	-0.26	-0.20
	(0.03, 0.31)	(-0.14, 0.12)	(-0.37,-0.15)	(-0.34,-0.04)
	[-0.06, 0.40]	[-0.22, 0.20]	[-0.43,-0.07]	[-0.43, 0.09]
LFP(t),AGE(t)	0.22	0.02	-0.22	-0.18
	(0.08, 0.35)	(-0.10, 0.14)	(-0.32,-0.11)	(-0.33,-0.02)
	[-0.01, 0.44]	[-0.18, 0.23]	[-0.39,-0.03]	[-0.42, 0.10]
LFP(t),AGE(t-1)	0.18	-0.00	-0.21	-0.17
	(0.05, 0.31)	(-0.12, 0.12)	(-0.32,-0.10)	(-0.32,-0.01)
	[-0.03, 0.38]	[-0.20, 0.20]	[-0.38,-0.03]	[-0.41, 0.12]

Notes: Cross correlation of $z_{u,t}$ with $y_{u,g,t+s}$.

Table 26: Cross-correlations of LFP-cyclical and LFP-age effects, women older than 25

Lag	LTHS	HS	SoCO	CO+
	Age: 25-34			
LFP(t),AGE(t+1)	0.00	-0.00	0.00	0.00
	(-0.24, 0.25)	(-0.28, 0.28)	(-0.27, 0.28)	(-0.22, 0.23)
	[-0.39, 0.39]	[-0.45, 0.44]	[-0.41, 0.42]	[-0.36, 0.37]
LFP(t),AGE(t)	0.01	-0.00	0.00	0.01
	(-0.23, 0.24)	(-0.27, 0.27)	(-0.25, 0.26)	(-0.22, 0.22)
	[-0.37, 0.38]	[-0.44, 0.43]	[-0.39, 0.41]	[-0.37, 0.37]
LFP(t),AGE(t-1)	0.01	-0.00	0.01	0.01
	(-0.23, 0.24)	(-0.30, 0.30)	(-0.29, 0.29)	(-0.22, 0.22)
	[-0.37, 0.38]	[-0.46, 0.45]	[-0.43, 0.45]	[-0.37, 0.36]
	Age: 35-44			
LFP(t),AGE(t+1)	0.29	0.26	0.29	0.19
	(0.11, 0.45)	(0.12, 0.39)	(0.18, 0.41)	(0.04, 0.35)
	[-0.01, 0.54]	[0.03, 0.47]	[0.09, 0.48]	[-0.07, 0.44]
LFP(t),AGE(t)	0.26	0.29	0.32	0.20
	(0.08, 0.43)	(0.15, 0.42)	(0.20, 0.43)	(0.04, 0.35)
	[-0.03, 0.53]	[0.06, 0.50]	[0.12, 0.51]	[-0.07, 0.44]
LFP(t),AGE(t-1)	0.27	0.35	0.34	0.18
	(0.09, 0.44)	(0.20, 0.49)	(0.22, 0.46)	(0.01, 0.35)
	[-0.03, 0.54]	[0.10, 0.56]	[0.13, 0.54]	[-0.10, 0.45]
	Age: 45-54			
LFP(t),AGE(t+1)	0.27	0.51	0.50	0.30
	(0.09, 0.43)	(0.39, 0.61)	(0.39, 0.59)	(0.03, 0.52)
	[-0.03, 0.52]	[0.30, 0.67]	[0.31, 0.64]	[-0.15, 0.63]
LFP(t),AGE(t)	0.24	0.48	0.47	0.28
	(0.07, 0.40)	(0.36, 0.59)	(0.36, 0.56)	(0.01, 0.51)
	[-0.05, 0.49]	[0.27, 0.65]	[0.28, 0.61]	[-0.17, 0.62]
LFP(t),AGE(t-1)	0.23	0.49	0.43	0.25
	(0.06, 0.38)	(0.36, 0.60)	(0.31, 0.53)	(-0.05, 0.50)
	[-0.05, 0.47]	[0.26, 0.66]	[0.22, 0.58]	[-0.24, 0.61]
	Age: 55-64			
LFP(t),AGE(t+1)	0.11	0.34	0.32	0.12
	(-0.08, 0.30)	(0.24, 0.44)	(0.21, 0.40)	(-0.10, 0.31)
	[-0.21, 0.41]	[0.18, 0.50]	[0.14, 0.46]	[-0.23, 0.43]
LFP(t),AGE(t)	0.03	0.24	0.23	0.08
	(-0.18, 0.23)	(0.13, 0.35)	(0.12, 0.33)	(-0.11, 0.26)
	[-0.31, 0.36]	[0.05, 0.42]	[0.05, 0.39]	[-0.23, 0.38]
LFP(t),AGE(t-1)	-0.05	0.13	0.11	0.01
	(-0.23, 0.14)	(0.01, 0.25)	(-0.01, 0.21)	(-0.17, 0.19)
	[-0.36, 0.25]	[-0.08, 0.32]	[-0.08, 0.28]	[-0.27, 0.30]
	Age: 65-79			
LFP(t),AGE(t+1)	-0.24	-0.19	-0.26	-0.09
	(-0.41,-0.05)	(-0.30,-0.07)	(-0.36,-0.14)	(-0.30, 0.12)
	[-0.52, 0.08]	[-0.37, 0.00]	[-0.43,-0.06]	[-0.42, 0.25]
LFP(t),AGE(t)	-0.23	-0.22	-0.26	-0.11
	(-0.42,-0.04)	(-0.35,-0.09)	(-0.37,-0.14)	(-0.32, 0.10)
	[-0.52, 0.09]	[-0.43,-0.00]	[-0.44,-0.05]	[-0.45, 0.25]
LFP(t),AGE(t-1)	-0.28	-0.35	-0.40	-0.17
	(-0.45,-0.10)	(-0.47,-0.22)	(-0.51,-0.28)	(-0.39, 0.08)
	[-0.55, 0.03]	[-0.54,-0.13]	[-0.58,-0.19]	[-0.52, 0.23]

Notes: Cross correlation of $z_{\ell,t}$ with $y_{\ell,g,t+s}$.

8.6 Education shares

Table 27: Parameter estimates of education share models for men

Param	LTHS	HS	SoCO	CO+
Meas age (25-34), std	0.38 (1.00)	0.36 (1.00)	0.34 (1.00)	0.39 (1.00)
	(0.33, 0.43)	(0.32, 0.41)	(0.30, 0.39)	(0.34, 0.44)
	[0.31, 0.47]	[0.29, 0.45]	[0.28, 0.43]	[0.32, 0.48]
Meas age (35-44), std	0.35 (1.00)	0.37 (1.00)	0.37 (1.00)	0.43 (1.00)
	(0.30, 0.41)	(0.32, 0.44)	(0.32, 0.44)	(0.36, 0.52)
	[0.28, 0.45]	[0.30, 0.49]	[0.29, 0.49]	[0.33, 0.58]
Meas age (45-54), std	0.38 (1.00)	0.38 (1.00)	0.37 (1.00)	0.41 (1.00)
	(0.33, 0.44)	(0.33, 0.43)	(0.32, 0.43)	(0.35, 0.48)
	[0.30, 0.48]	[0.30, 0.48]	[0.29, 0.47]	[0.32, 0.53]
Meas age (55-64), std	0.36 (1.00)	0.39 (1.00)	0.36 (1.00)	0.39 (1.00)
	(0.31, 0.42)	(0.34, 0.46)	(0.32, 0.42)	(0.34, 0.46)
	[0.29, 0.46]	[0.31, 0.50]	[0.29, 0.47]	[0.31, 0.51]
Meas age (65-79), std	0.35 (1.00)	0.37 (1.00)	0.36 (1.00)	0.39 (1.00)
	(0.30, 0.40)	(0.32, 0.43)	(0.31, 0.42)	(0.33, 0.45)
	[0.28, 0.44]	[0.30, 0.47]	[0.29, 0.46]	[0.30, 0.51]
Cohort shock, a=1, std	0.95 (1.00)	1.27 (1.00)	1.01 (1.00)	1.26 (1.00)
	(0.78, 1.18)	(1.05, 1.56)	(0.83, 1.26)	(1.04, 1.54)
	[0.69, 1.36]	[0.94, 1.79]	[0.73, 1.47]	[0.93, 1.78]
Age Group shock, $g > 1$, std	0.41 (1.00)	0.39 (1.00)	0.40 (1.00)	0.70 (1.00)
	(0.39, 0.43)	(0.37, 0.42)	(0.38, 0.42)	(0.67, 0.73)
	[0.37, 0.44]	[0.36, 0.43]	[0.36, 0.44]	[0.66, 0.74]

Notes: For each parameter, the first row displays the median and (prior), the second row displays the (68.0 percentile range), and the third row displays the [90.0 percentile range]

Table 28: Parameter estimates of education share models for women

Param	LTHS	HS	SoCO	CO+
Meas age (25-34), std	0.32 (1.00)	0.39 (1.00)	0.43 (1.00)	0.42 (1.00)
	(0.29, 0.37)	(0.34, 0.44)	(0.38, 0.48)	(0.37, 0.49)
	[0.27, 0.40]	[0.32, 0.48]	[0.35, 0.53]	[0.34, 0.53]
Meas age (35-44), std	0.33 (1.00)	0.38 (1.00)	0.37 (1.00)	0.41 (1.00)
	(0.29, 0.38)	(0.33, 0.45)	(0.32, 0.43)	(0.35, 0.49)
	[0.27, 0.42]	[0.30, 0.50]	[0.29, 0.49]	[0.31, 0.55]
Meas age (45-54), std	0.36 (1.00)	0.38 (1.00)	0.37 (1.00)	0.39 (1.00)
	(0.31, 0.41)	(0.33, 0.44)	(0.32, 0.42)	(0.34, 0.46)
	[0.29, 0.46]	[0.30, 0.49]	[0.29, 0.47]	[0.31, 0.51]
Meas age (55-64), std	0.35 (1.00)	0.38 (1.00)	0.38 (1.00)	0.39 (1.00)
	(0.30, 0.40)	(0.32, 0.44)	(0.33, 0.45)	(0.34, 0.45)
	[0.28, 0.45]	[0.30, 0.49]	[0.30, 0.49]	[0.31, 0.50]
Meas age (65-79), std	0.35 (1.00)	0.37 (1.00)	0.36 (1.00)	0.38 (1.00)
	(0.31, 0.41)	(0.32, 0.43)	(0.31, 0.42)	(0.33, 0.45)
	[0.28, 0.45]	[0.29, 0.47]	[0.29, 0.46]	[0.30, 0.50]
Cohort shock, a=1, std	0.82 (1.00)	1.21 (1.00)	1.01 (1.00)	1.63 (1.00)
	(0.66, 1.02)	(1.01, 1.49)	(0.82, 1.27)	(1.34, 2.02)
	[0.58, 1.19]	[0.90, 1.73]	[0.72, 1.51]	[1.20, 2.33]
Age Group shock, $g > 1$, std	0.36 (1.00)	0.52 (1.00)	0.48 (1.00)	0.69 (1.00)
	(0.35, 0.38)	(0.50, 0.54)	(0.46, 0.50)	(0.67, 0.72)
	[0.34, 0.40]	[0.48, 0.56]	[0.45, 0.52]	[0.65, 0.74]

Notes: See Table 27.

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