Job Ladders and Growth in Earnings, Hours, and Wages*

Joyce K. Hahn† Henry R. Hyatt‡ Hubert P. Janicki §

January 2021

Abstract

We use U.S. matched employer-employee data to study the evolution of earnings, hours, and wages. We distinguish "stayers" who remain with the same employer from workers who transition. Hires from nonemployment receive relatively low pay, and therefore lessen average earnings and wages. This negative effect of entrants from nonemployment is offset by growth from stayers, employer-to-employer transitions, and other separations from low-paying jobs. Stayers drive aggregate changes in earnings and wages.

JEL codes: J63, E24, J31, E32

Keywords: job ladder, business cycles, real wage stagnation

*Opinions and conclusions expressed in this paper are those of the authors alone and do not represent the views of the U.S. Census Bureau. We thank Mark Bils, David Card, Mary Daly, Jason Faberman, Bruce Fallick, Kyle Herkenhoff, Bart Hobijn, Christopher Huckfeldt, Marianna Kudlyak, André Kurmann, Erika McEntarfer, Kevin McKinney, Ryan Michaels, Seth Murray, Benjamin Pugsley, Richard Rogerson, Ayşegül Şahin, Benjamin Schoefer, James Spletzer, Stephen Tibbets, Lars Vilhuber, Larry Warren, Alexandria Zhang, and participants in the 2016 NBER Summer Institute CRIW workshop, the Fall 2016 Midwest Macro conference, the 2017 LEHD Summer Workshop, the 2017 and 2018 Allied Social Science Associations meetings, the 2018 IRS-Census workshop, the 2018 Search and Marching conference, the 2018 SED conference, the 2018 EEA-ESEM meetings, the 2018 SEA conference, the 2019 SoLE conference, the 2019 Arizona State University CASEE conference, and seminars at the U.S. Census Bureau and George Mason University for helpful comments and suggestions. All results have been reviewed to ensure no confidential data are disclosed (CBDRB-FY19-100 and CBDRB-FY20-194).

†Center for Economic Studies, U.S. Census Bureau, 4600 Silver Hill Road, Washington, DC 20233. E-mail: joyce.key.hahn@census.gov

‡Center for Economic Studies, U.S. Census Bureau, 4600 Silver Hill Road, Washington, DC 20233. E-mail: henry.r.hyatt@gmail.com

§Center for Economic Studies, U.S. Census Bureau, 4600 Silver Hill Road, Washington, DC 20233. E-mail: hubert.p.janicki@census.gov

1 Introduction

After robust growth in the late 1990s, real earnings in the U.S. were flat in the decade that followed the 2001 recession, and only showed signs of renewed increase in 2014. A number of papers have argued that this stagnation was due to historic lows in the employer-to-employer transition rate, which may have inhibited movement to higher-paying jobs. Since these transitions are associated with strong increases in earnings and wages, they may facilitate increases in aggregate compensation.

Many proponents of this argument have appealed to Topel and Ward (1992), who found that the earnings changes associated with moving to new employers accounted for about one-third of the cumulative earnings growth of young men.[1] While it is common to cite Topel and Ward (1992) to link the job ladder to cyclical and trend changes in earnings and wages, it is important to note that this seminal study only considered the earnings growth of labor market entrants, and did not attempt to relate its findings to contemporaneous aggregate changes. In this paper, we propose a novel extension of the Topel and Ward (1992) framework that incorporates the key insights of Daly and Hobijn (2016) on the role of transitions into and from nonemployment in the evolution of average earnings and wages.[2] Our extension allows us to identify the respective contributions of employment transitions and "stayers" who remain with the same employer in determining changes in aggregate earnings and wages.

Our main finding is that the job ladder has limited ability to explain sluggish earnings growth from 2001 to 2013. Entrants from nonemployment are paid less than incumbent workers. Their entry lowers average earnings, hours, and wages. This negative effect of entrants is offset by the earnings growth of stayers and employer-to-employer transitions, as well as increases due to "exiters" who separate to nonemployment. Our accounting framework shows that the net effect of

[1] Davis and Haltiwanger (2014) and Molloy, Smith, and Wozniak (2014) proposed this as a mechanism that may have contributed to the stagnation in earnings and wages that began in 2001. Studies including Mukoyama (2014), Haltiwanger et al. (2018), and Gertler, Huckfeldt, and Trigari (2019) have used the empirical findings of Topel and Ward (1992) to link employer-to-employer transitions to cyclical wage changes. Policymakers have also considered this argument, which appeared in the Economic Report of the President (2015). More generally, there is a strong correlation between aggregate employment transitions and growth in earnings and wages, see Faberman and Justiniano (2015), Karahan et al. (2017), Moscarini and Postel-Vinay (2017), and Hyatt and McElroy (2019).

[2] Specifically, we aggregate the contribution of employer-to-employer transitions to earnings growth as defined by Topel and Ward (1992) for all workers, and consider how this contribution varies over time. We decompose the residual from the Topel and Ward (1992) framework into components attributable to nonemployment following Daly and Hobijn (2016), as well as to stayers. Note that Daly and Hobijn (2016) used data from linked Outgoing Rotation Groups of the Current Population Survey and so did not analyze employer-to-employer transitions, but rather emphasized the distinction between workers undergoing nonemployment transitions and those who were continuously in employment.

employment transitions is small and relatively time-invariant. These results suggest that appealing to Topel and Ward (1992) and their argument regarding the importance of employer-to-employer transitions for life-cycle earnings gains should be done with caution when attempting to understand aggregate changes.

It is important to note that we obtain our main result while still confirming the key findings of Topel and Ward (1992) on the importance of employer-to-employer transitions for the earnings growth of young workers. When labor market entrants first transition into employment, they have earnings that are about half of the average among all workers and exhibit substantial growth over their initial years of work. We confirm the well-cited finding of Topel and Ward (1992) that recent labor market entrants obtain on the order of one-third of their cumulative earnings growth from employer-to-employer transitions: our estimates range from 36.3% to 41.9% for workers in their first seven years of employment. Our replication also includes hours data, which Topel and Ward (1992) lacked. We demonstrate that the hours increases associated with employer-to-employer transitions are especially important for the earnings growth of recent entrants.

The dynamics of entry cohorts are important for understanding why the substantial gains workers obtain from employer-to-employer transitions lead to small aggregate changes. The first job that a worker takes from nonemployment offers, on average, relatively low compensation. Workers tend to leave these low-paying jobs by separating either to nonemployment, or to a better match through an employer-to-employer transition. The earnings implications of employment transitions mostly cancel each other out, leaving little room to affect aggregate compensation.

Our findings on individual and aggregate changes in compensation provide guidance on the role of newly hired workers in cyclical wage adjustment. There has been renewed interest in this topic since Shimer (2005) argued that wage decreases can limit the surges in unemployment that occur during recessions. Our matched employer-employee data confirms the strong cyclicality of new hire wages as found in numerous studies starting with Bils (1985). It also confirms the finding of Gertler and Trigari (2009) that the excess cyclicality of new hires relative to stayers can be attributed almost entirely to time-invariant employer-employee match effects.

We integrate these match effects into our accounting framework and find a strong relationship between job matches and worker movements along the job ladder. Match effects drive the low earnings and wages of recent hires from nonemployment. As workers move up the job ladder, they shed their old jobs and move to higher-paying matches. When workers separate to nonemployment, their low-paying job matches dissolve. We demonstrate that match effects, while highly cyclical,

are related to a worker's propensity to separate. This result is important as most of the recent literature on cyclical wage adjustment has followed Shimer (2005) and assumed that separations are exogenous and therefore unrelated to wages.

The remainder of the paper proceeds as follows. In Section 2, we describe our data. In Section 3, we discuss changes over time in average earnings, hours, and wages. In Section 4, we describe our method for decomposing growth in earnings, hours, and wages into the contributions of stayers and transitioners. In Section 5, we illustrate how average earnings, hours, and wages evolve among all workers in terms of these contributions. We then present two extensions of our decomposition. In Section 6, we apply our method to understand earnings growth among entry cohorts. In Section 7, we assess job matches and cyclical changes. A conclusion follows in Section 8.

2 Data

We use matched employer-employee data from the Longitudinal Employer-Household Dynamics (LEHD) program at the U.S. Census Bureau, see Abowd et al. (2009). These data consist of total quarterly earnings reported by employers to U.S. states for the administration of unemployment insurance programs. Earnings include wages, salaries, tips, and bonuses, and are reported for the vast majority of private sector employment. We follow Abowd et al. (2009) and Hahn et al. (2017) in applying employment and earnings definitions to our matched employer-employee data.[3]

Since data availability varies by state, we use two datasets for our analysis. The first uses a one percent sample of a set of eleven states that consistently have earnings data available from 1994 to 2016.[4] Since most of these states do not collect hours data, we impute hours using models estimated on a second dataset composed of a one percent sample of a set of four states that have hours data available.[5] Note that employers report *hours paid* rather than *hours worked* as obtained

[3]For details on our employment and earnings concepts, see Appendix A. Note that our data do not track within-firm job changes, and so we can only identify employer-to-employer transitions. Note furthermore that start and end dates are not available in our matched employer-employee data, which has two important implications. First, employer-to-employer transitions may include some workers who had a brief spell of nonemployment. Second, we consider "full quarter" earnings: that is, earnings associated with jobs that spanned at least three quarters.

[4]These eleven states are California, Colorado, Idaho, Illinois, Kansas, Maryland, Montana, North Carolina, Oregon, Washington, and Wisconsin. Our regression estimates control for the duration of job tenure up to two years, and so we begin our time series in 1996.

[5]These four states are Minnesota, Oregon, Rhode Island, and Washington, see Kurmann, Spletzer, and McEntarfer (2016). Our imputation method assigns hours to workers with similar observable characteristics (Rubin, 1987). For details on our hours imputation, see Appendix B. For a comparison of our imputed hours and wage data with other available data on hours and wages, see Appendix C. Note that the data use agreement under which this research was conducted restricts the release of state-specific findings, and requires that estimates contain observations from at least three states. Any time series results for the four state dataset are therefore only shown starting in 2010 when at least

from household surveys. Earnings and wages are in real 2014 dollars. We winsorize our earnings, hours, and wage data at the 95th percentile.

We also consider how the earnings, hours, and wages of labor market entrants evolved over their first seven years. We present results for three entry cohorts: those who entered in 1996, 2003, and 2010, respectively. We define labor market entrants as workers age 25 or younger who had positive earnings in seven consecutive years. We require that entrants to had zero earnings in the two years prior to their first with positive earnings.

3 Motivating facts

3.1 Average earnings: 1996-2016

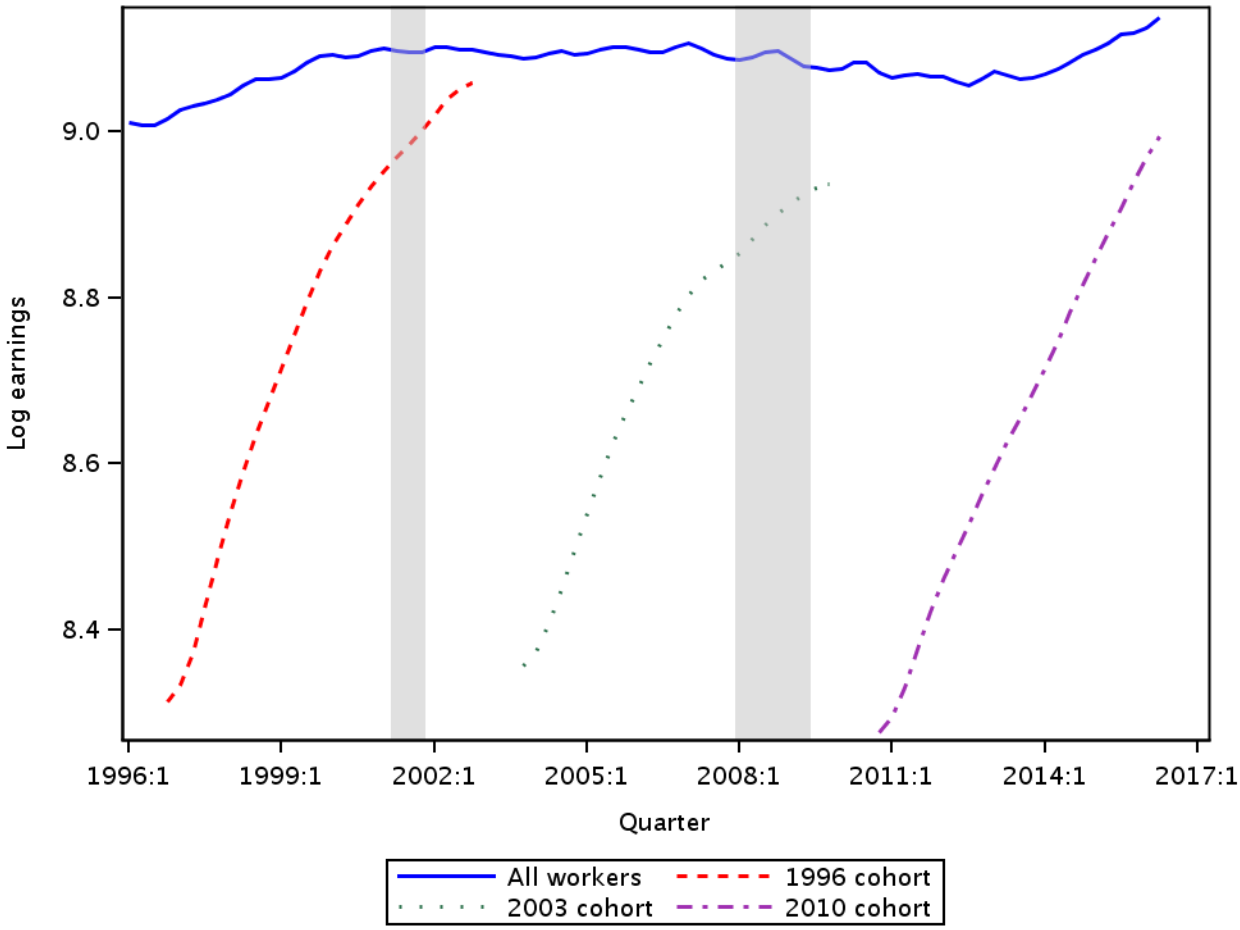
We now consider how average log earnings evolved over time, as shown in Figure 1. From the middle 1990s to the start of the 2001 recession, average quarterly earnings among all workers (solid line) increased by about ten percent: from 9.00 ($8,103) in 1996 to 9.10 ($8,855) in 2001.[6] Average log earnings remained relatively stable thereafter and would not exceed its peak in 2001 for more than a decade. Average log earnings were stable until the 2007-2009 recession, after which they fell to 9.06 ($8,604) in 2011, and then were stable until 2013. Starting in 2014, earnings increased by about five percent, reaching 9.12 ($9,136) in 2015, and remained at this level into 2016, where our time series ends.

While log earnings were relatively stable in aggregate, there were sizable changes for individual workers. Figure 1 shows how earnings evolved for three cohorts of labor market entrants: those who entered in 1996, 2003, and 2010, respectively. These labor market entrants started with relatively low earnings and had substantial growth over time. Each entry cohort started with average log quarterly earnings in the range of 8.27 to 8.33 ($3,905 to $4,146). Over their first seven years, the earnings of these entry cohorts about doubled, reaching the range of 8.94 to 9.06 ($7,631 to

three states are available. Because all states in our four state dataset have hours data available in the earlier years, the associated regression results are from an unbalanced panel of states that over-represents more recent years.

[6]For ease of exposition, throughout this paper we rely on the approximate relationship between hundredth changes in the log of a measure and percentage point changes, e.g. $9.10 - 9.00 \approx 10\%$. Note that the average of the log of an outcome in is not equal to the log of its average. Because of the skewness of the U.S. labor income distribution, the average of log earnings is less than the log of of average earnings. For example, average quarterly earnings in our 11 state dataset was about $10,800 in 1996 and rose to about $11,800 in 2001. Appendix Figure C1 presents average earnings in our 11 state dataset in levels rather than logs, as well as earnings measures from publicly available data sources. Our 11 state data series is highly correlated with published averages of employer-reported administrative records in the Quarterly Census of Employment and Wages and the Quarterly Workforce Indicators. Our estimates of average earnings are lower than these because we winsorize our earnings data at the 95th percentile.

Figure 1: Average log earnings (eleven states)



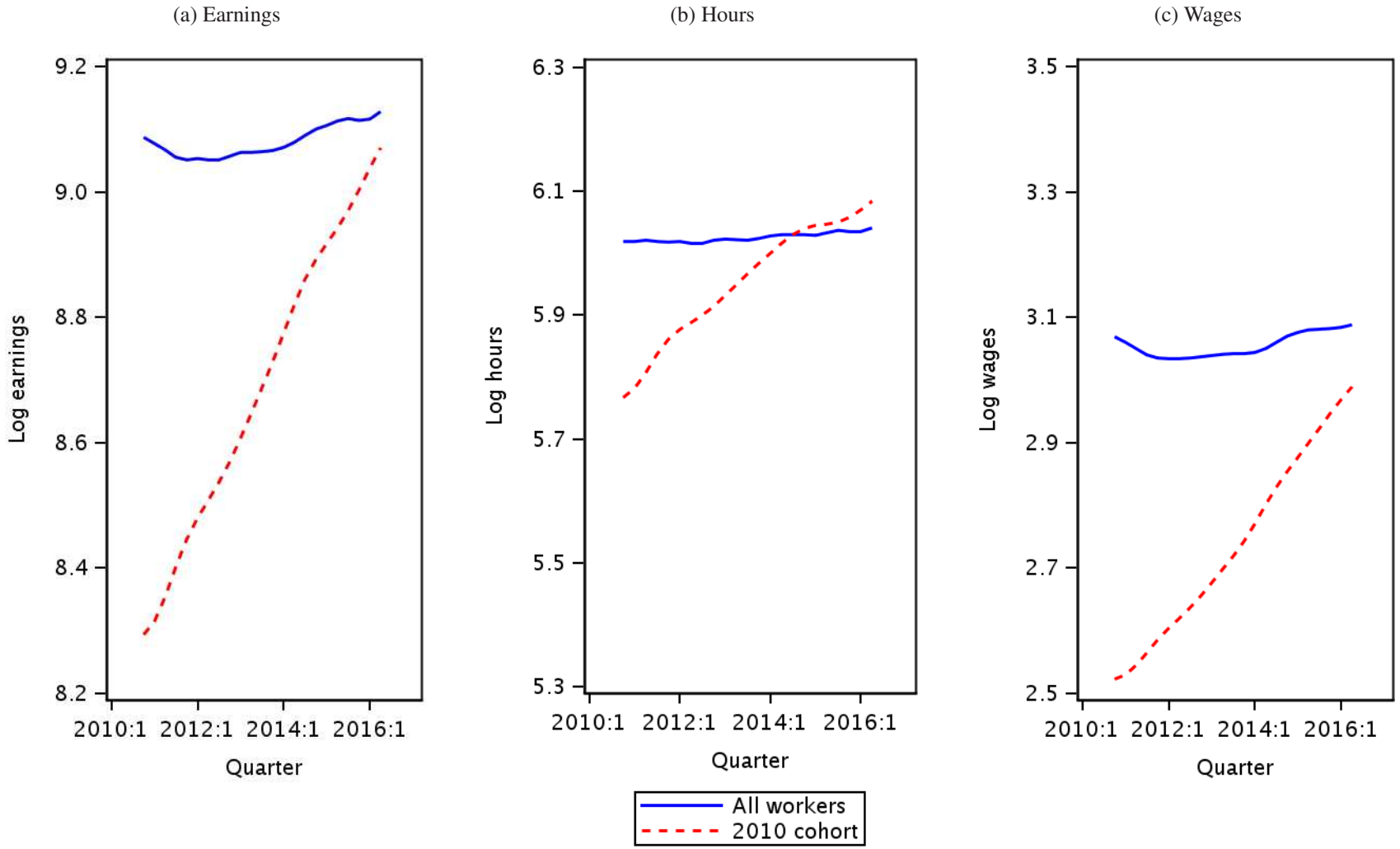
Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions.

$8,604). Figure 1 shows that the earnings of recent labor market entrants grew faster during better economic conditions. The earnings of the 1996 and 2003 cohorts grew more slowly during the 2001 and 2007-2009 recessions, respectively. In contrast, the 2010 entry cohort had steady growth over its first seven years during a sustained economic expansion.

3.2 Average earnings, hours, and wages: 2010-2016

Our four states with hours data allow us to measure growth in hours and wages starting in 2010. We show these results in Figure 2. Average earnings in our four states, shown in Figure 2(a), largely followed the patterns observed for our eleven state dataset. The evidence in the remaining panels of Figure 2 show that wages rather than hours were responsible for both the decrease in real earnings

Figure 2: Average log earnings, hours, and wages (four states)



Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12.

from 2010 to 2012 and the increase that occurred starting in 2014. Average log quarterly hours were mostly stable from 2010 to 2016, increasing by about two percent from 6.02 (412 hours) in 2010 to 6.04 (420 hours) in 2016.[7] In contrast, wages changed considerably. Average log hourly wages declined by about four percent from 3.07 ($21.54) in 2010 to 3.03 ($20.70) in 2012, and remained in the range of 3.03 to 3.04 ($20.91) until 2014, at which time it and surged, reaching 3.09 ($21.98) in 2016.[8]

Our states with hours data also allow us to assess how hours and wages contribute to earnings growth for the cohort of workers who first entered employment in 2010. Consistent with our findings from our eleven state dataset, earnings roughly doubled during their first seven years in the labor market, see Figure 2(a). Specifically, the earnings of the 2010 entry cohort earnings increased from 8.30 ($3,984) in 2010 to 9.12 ($9,136) in 2016. Over these years, the earnings of this entry cohort mostly caught up with the average among all workers.

The evolution of hours and wages of the 2010 entry cohort is shown in the remaining panels of Figure 2. Of a total earnings increase in log earnings of 0.83, about two-fifths was associated with log hours and three-fifths log wages. Average log hours increased from 5.78 (324 hours) in 2010 to 6.09 (441 hours) in 2016, see Figure 2(b). Growth in log hours slowed as this cohort spent more time in employment: from two to three percent per quarter during 2010 and 2011, to one to two percent from 2012 to 2014, and then zero to one percent during 2015 and 2016.

Average log hourly wages increased from 2.52 ($12.43) in 2010 to 3.03 ($20.70) in 2016, see Figure 2(c). Overall, the average wage increased by one to three percent in every quarter. Even in 2015 to 2016 it increased by two to three percent per quarter. The steady increase in average log wages implies that the modest curvature in the earnings trajectory of the 2010 entry cohort was driven by declining growth in hours.

4 Accounting framework

We now introduce a framework that allows us to understand the evolution of earnings, hours, and wages. We are especially interested in distinguishing changes attributable to stayers from those of employment transitions.

[7] Note that the average of log hours is not equal to the log of average hours. Over a comparable time period, average hours increased from 438 to 447, see Appendix Figure C2.

[8] Note that because of the skewness in the wage distribution, the average log wage is less than the log of the average wage. The average wage from our four states with hours data increased from $25.32 to $26.60 over a similar time period, see Appendix Figure C3.

Let the earnings, hours, or wage for worker i in time t be expressed as y_{it}. We denote the average for all workers at time t as $\bar{y}_t$ and growth in this aggregate from time $t-1$ to time t as $\Delta\bar{y}_t$. We use worker types defined in Hahn et al. (2017) and assign indicator variables for stayers s_{it}, employer-to-employer transitions q_{it}, entrants from nonemployment n_{it}, and incumbent workers exiting to nonemployment r_{it}. We moreover denote the total number of each worker type as S_t, Q_t, N_t, and R_t, respectively. The number of workers employed is then $D_{t-1} = S_t + Q_t + R_t$ at time $t-1$ and $D_t = S_t + Q_t + N_t$ at time t. Given this notation, we can express the change in the average from time $t-1$ to time t as:

$$\Delta\bar{y}_t = \underbrace{\frac{\Sigma_i s_{it} y_{it} + \Sigma_i q_{it} y_{it} + \Sigma_i n_{it} y_{it}}{D_t}}_{\text{earnings at time } t} - \underbrace{\frac{\Sigma_i s_{it} y_{it-1} + \Sigma_i q_{it} y_{it-1} + \Sigma_i r_{it} y_{it-1}}{D_{t-1}}}_{\text{earnings at time } t-1}. \tag{1}$$

Rearranging terms, we can express aggregate growth in terms of employment shares and average outcomes by worker type in times $t-1$ and t. This gives us:

$$\begin{aligned}\Delta\bar{y}_t = &\left(\frac{S_t}{D_t}\frac{\Sigma_i s_{it} y_{it}}{S_t} + \frac{Q_t}{D_t}\frac{\Sigma_i q_{it} y_{it}}{Q_t} + \frac{N_t}{D_t}\frac{\Sigma_i n_{it} y_{it}}{N_t}\right) - \\ &\left(\frac{S_t}{D_{t-1}}\frac{\Sigma_i s_{it} y_{it-1}}{S_t} + \frac{Q_t}{D_{t-1}}\frac{\Sigma_i q_{it} y_{it-1}}{Q_t} + \frac{R_t}{D_{t-1}}\frac{\Sigma_i r_{it} y_{it-1}}{R_t}\right).\end{aligned}$$

Because stayers and employer-to-employer transitions are employed in times $t-1$ and t, we can separate the change in their averages from the change in their shares. We can now express the change in the average $\Delta\bar{y}_t$ as:

$$\begin{aligned}\Delta\bar{y}_t = &\underbrace{\frac{\frac{S_t}{D_t} + \frac{S_t}{D_{t-1}}}{2}\frac{\Sigma_i s_{it}\Delta y_{it}}{S_t}}_{\text{stayers}} + \underbrace{\frac{\frac{Q_t}{D_t} + \frac{Q_t}{D_{t-1}}}{2}\frac{\Sigma_i q_{it}\Delta y_{it}}{Q_t}}_{\text{employer-to-employer}} + \\ &\underbrace{\frac{N_t}{D_t}\left(\frac{\Sigma_i n_{it} y_{it-1}}{N_t} - \tilde{y}_t\right)}_{\text{entrants from nonemployment}} - \underbrace{\frac{R_t}{D_{t-1}}\left(\frac{\Sigma_i r_{it} y_{it-1}}{R_t} - \tilde{y}_t\right)}_{\text{exiters to nonemployment}}\end{aligned} \tag{2}$$

where $\tilde{y}_t$ is the weighted average for stayers and employer-to-employer transitions,

$$\tilde{y}_t = \frac{S_t}{S_t + Q_t}\left(\frac{\Sigma_i s_{it}(y_{it} + y_{it-1})}{2S_t}\right) + \frac{Q_t}{S_t + Q_t}\left(\frac{\Sigma_i q_{it}(y_{it} + y_{it-1})}{2Q_t}\right).$$

The formulation for $\Delta\bar{y}_t$ in Equation (2) has an intuitive distinction between its terms, which we refer to as the respective *contributions* of stayers, employer-to-employer transitions, hires from

nonemployment, and incumbent workers exiting employment. Each contribution is basically a weighted average. For each of stayers and employer-to-employer transitions, the change in the average outcome is multiplied by the average share. Since hires from nonemployment and incumbent workers exiting employment move from having no earnings and not contributing to the average to having earnings and contributing to the average or vice versa, their contribution is a function of how different they are from the continuously employed in times $t-1$ and t (i.e., $\tilde{y}_t$) and their share. Note the more their average differs from $\tilde{y}_t$, the more they affect the average among all workers.

5 The evolution of average earnings, hours, and wages

5.1 Earnings

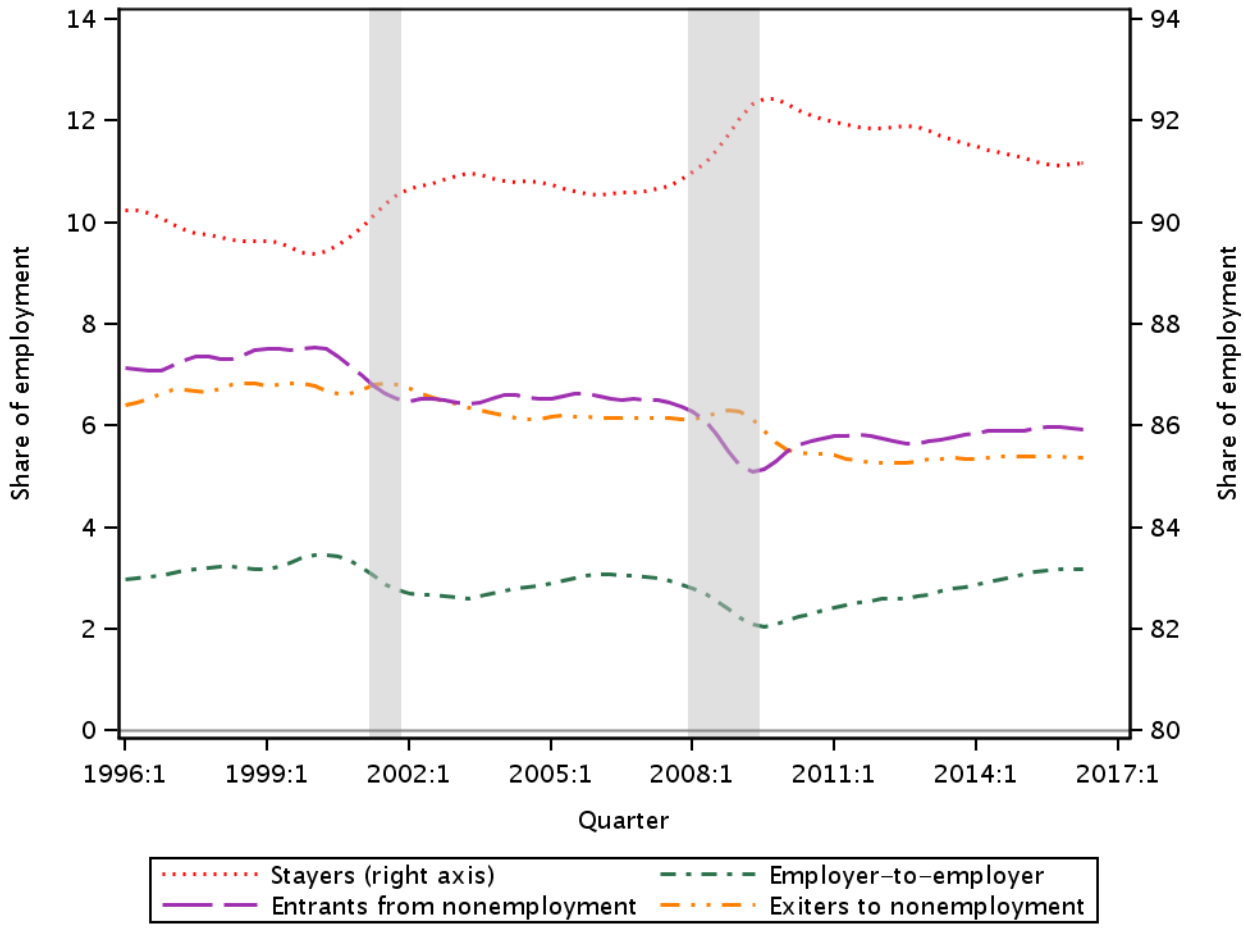
We now apply our accounting exercise to our eleven states of matched employer-employee data in order to understand how earnings evolved from 1996-2016. We begin by illustrating the components of the decomposition: the shares and earnings of stayers and transitioners.

When workers of a given type are more numerous, they naturally have a greater role in determining average earnings. Figure 3 shows the shares of stayers and transitioners, as they enter into the decomposition Equation (2).[9] In the time period we consider, the vast majority of workers were stayers. The employment share of job stayers mostly decreased during economic expansions and increased during and after the 2001 and 2007-2009 recessions. The share of job stayers reached a low of 89.4% in 2000, just before the 2001 recession. It reached a high of 92.4% at the end of the 2007-2009 recession.

In any given quarter, the share of workers who transitioned was relatively small. The employer-to-employer transition rate evolved procyclically. It increased during the late 1990s and reached a series high of 3.5% in 2000. In then fell during the 2001 recession, and reached 2.6% in 2003. During the 2007-2009 recession, the employer-to-employer transition rate declined, reaching a series low of 2.1% in 2009. The share of workers entering from nonempoyment ranged from 5.1%

[9]For stayers, we plot the average share at time $t-1$ and t, i.e., $(\frac{S_t}{D_t}+\frac{S_t}{D_{t-1}})/2$. Similarly, for employer-to-employer transitions, we plot $(\frac{Q_t}{D_t}+\frac{Q_t}{D_{t-1}})/2$. For workers entering employment from nonemployment, we plot $\frac{N_t}{D_t}$. For workers exiting employment to nonemployment, we plot $\frac{R_t}{D_{t-1}}$. Note that, prior to seasonal adjustment and the application of a Henderson filter, $(S_t+Q_t+R_t)/D_{t-1}=1$ and $(S_t+Q_t+N_t)/D_t=1$ so the sum of the four shares exceeds one in any given quarter. For separate plots of the share of stayers at the beginning and end of the quarter, $\frac{S_t}{D_t}$ and $\frac{S_t}{D_{t-1}}$, respectively, as well as the respective shares of employer-to-employer transitions, $\frac{Q_t}{D_t}$ and $\frac{Q_t}{D_{t-1}}$, see Appendix Figure D1. In most quarters, the number of entrants from nonemployment exceeds the number of exiters to nonemployment, and so $D_t > D_{t-1}$ and therefore $\frac{S_t}{D_t} < \frac{S_t}{D_{t-1}}$ and $\frac{Q_t}{D_t} < \frac{Q_t}{D_{t-1}}$.

Figure 3: Share of employment transitions (eleven states)



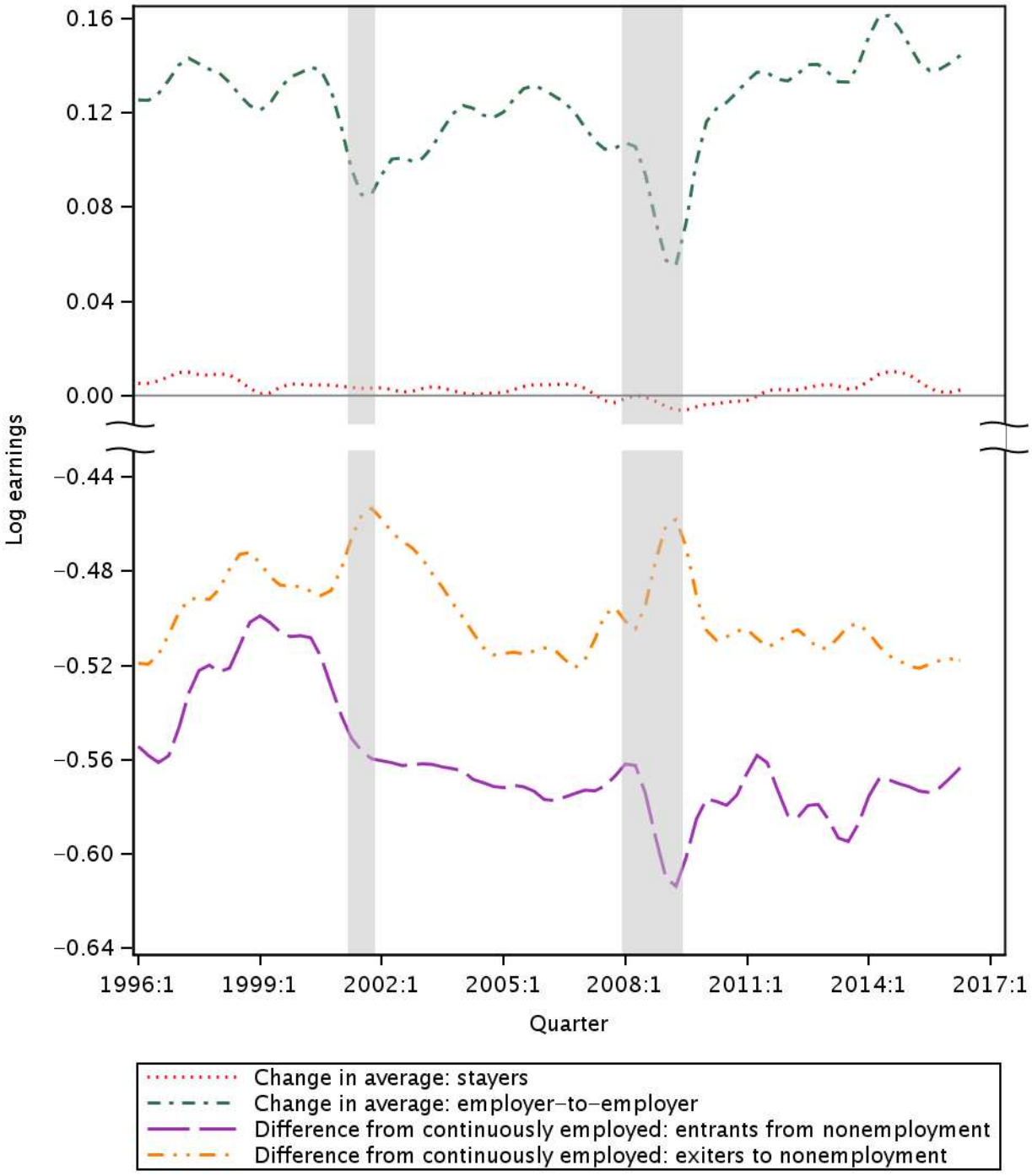
Notes: All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions.

to 7.6% of employment. Entrants from nonemployment were more numerous during expansions, and less so during contractions. Workers exiting to nonemployment accounted for 5.3% to 6.9% of employment, and this share increased during the 2001 and 2007-2009 recessions.

In Figure 4, we show the earnings of stayers and transitioners in terms of how they influence average earnings as in Equation (2).[10] The changes in earnings of stayers and employer-to-employer transitions contribute directly to changes in average earnings among all workers. Stayers had small

[10]For stayers, we plot the change in earnings $\frac{\Sigma_i s_{it}\Delta y_{it}}{S_t}$. For employer-to-employer transitions, we plot the change in earnings $\frac{\Sigma_i q_{it}\Delta y_{it}}{Q_t}$. For entrants from nonemployment, we plot earnings relative to the average of the continuously employed $\frac{\Sigma_i n_{it} y_{it-1}}{N_t} - \tilde{y}_t$, and, analogously, for exiters to nonemployment, we plot $\frac{\Sigma_i r_{it} y_{it-1}}{R_t} - \tilde{y}_t$. The log earnings of stayers and transitioners are shown in Appendix Figure D4.

Figure 4: Earnings changes and relative earnings (eleven states)



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions.

earnings changes in any given quarter, which evolved procyclically. In both 1997 and 2014, the earnings changes of stayers reached 1.0%. In the 2007-2009 recession, the earnings of stayers declined, reaching a series low of -0.6% in 2009. Workers who had an employer-to-employer transition experienced larger earnings gains than stayers. Earnings gains associated with moves to new employers were greater in expansions than contractions. The earnings changes of employer-to-employer transitions reached a series low of 5.5% at the end of the 2007-2009 recession. It reached a series high of 16.1% in 2014.

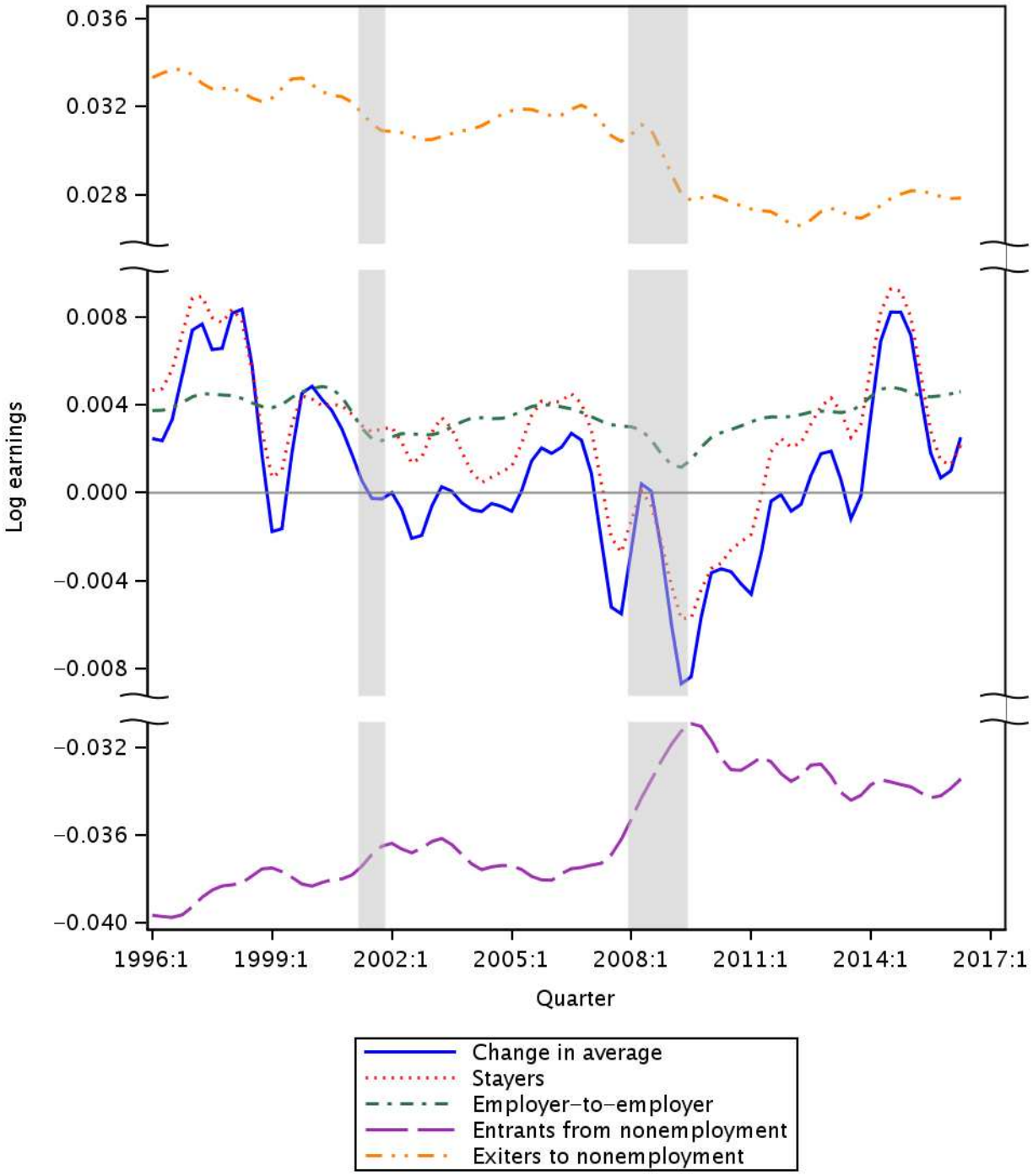
Entrants from and exiters to nonemployment influence average earnings in the extent to which their earnings differ from the earnings of continuously employed workers. The earnings of workers transitioning into and out of nonemployment were substantially lower than those of incumbent workers. Entrants from nonemployment earned 49.9% to 61.3% less than incumbent workers. The relative earnings of entrants from nonemployment fell during the 2001 and 2007-2009 recession, which is consistent with the literature on the excess cyclical sensitivity of the earnings of new hires, which starts with Bils (1985). These differences determine, in light of Equation (2), how entrants from nonemployment affect average earnings. Since workers transitioning into employment from nonemployment tend to earn much less than continuously employed workers, they lessen average earnings. A larger differential implies more of a decrease.

The average earnings of workers separating to nonemployment was 45.3% to 52.1% lower than the average of incumbent workers. The gap between exiters to nonemployment and incumbent workers narrowed during the 2001 and 2007-2009 recessions, consistent with the findings of Mueller (2017) on increases in the earnings of job separators during economic downturns. The earnings of workers transitioning into and from nonemployment were persistently lower than those of incumbent workers. Equation (2) provides guidance on how exiters affect average earnings. Since workers exiting to nonemployment earn much less than continuously employed workers, their exits cause average earnings to increase.

We now describe the results of our decomposition Equation (2). Figure 5 shows how average earnings evolve in terms of the contributions stayers and employment transitions. It is useful to first consider the overall evolution of earnings (solid line).[11] Average earnings grew slowly over these two decades, at an average rate of 0.1% per quarter, and changes in any given quarter ranged from -0.9% to 0.8%. Earnings growth is concentrated in the later years of economic expansions. During and after the recessions of 2001 and 2007-2009s, average earnings declined. From the start

[11]The change in average earnings is the first difference of the average earnings series for all workers from Figure 1.

Figure 5: Decomposition of growth in average log earnings (eleven states)



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions.

of our time series in 1996 until the 2001 recession, real earnings changes reached as high as 0.8% per quarter. From the middle of the 2001 recession and through the following "jobless recovery" real earnings fell slightly (by 0.2% of less each quarter). After a brief expansion, real earnings fell again during and after the 2007-2009 recession, by as much as 0.9%. From the middle of 2014 to the middle of 2015, earnings increased rapidly, by as much as 0.8% per quarter.

Our framework allows us to attribute changes in overall earnings to the earnings changes of stayers, workers undergoing employer-to-employer transitions, and nonemployment entrants and exiters. Note that, by Equation (2), the overall change in earnings is the sum of the contributions of stayers, employer-to-employer transitions, hires from nonemployment, and separations to nonemployment.

The change in average earnings closely tracked the contribution of stayers (dotted line). Stayers on average contributed 0.3 percentage points per quarter to earnings growth. The contribution of stayers usually exceeded growth in average earnings by a small amount (the differences ranged from 0.0 to 0.4 percentage points). Stayers contributed as much as 0.9 percentage points to earnings growth during expansions, and to losses of up to 0.6 percent during and after contractions. The surges in earnings growth in the late 1990s and middle 2010s coincided in timing and magnitude with the contribution of stayers. There is a correlation of 0.96 between the change in average earnings and the contribution of stayers. We conclude that changes in earnings were driven by stayers.

The strong relationship between the stayer contribution and overall earnings changes leaves little room for a strong net effect of transitions on changes in earnings. The average difference between overall earnings growth and the contribution of stayers is 0.3 percentage points, and so the contribution of employer-to-employer and nonemployment transitions sums to -0.3 percentage points in the average quarter. The net contribution of transitions to earnings growth is always in the narrow range of -0.4 to 0.0 percentage points.[12]

The small net contribution of employment transitions occurs despite the fact that the magnitudes of each transition type are usually larger than that of stayers. Employer-to-employer transitions (dash-dot line) contributed 0.4 percentage points to quarterly growth in average earnings. This contribution was procyclical and ranged from 0.1 to 0.5 percentage points. Employer-to-employer transitions involve substantial earnings gains, although relatively few workers undergo an employer-to-employer transition. The quarterly contribution of hires from nonemployment (long

[12]Note that because our decomposition is exhaustive, the net contribution of transitions to earnings growth is identically equal to the difference between the change in earnings and the contribution of stayers.

dash line) subtracts 3.1 percent to 4.0 percent. Workers exiting employment (dash-dot-dot line) contribute 2.7 to 3.4 percent each quarter.

Because the contributions of transitions each end up cancelling each other out in aggregate, the correlation between the contributions of transitions and aggregate earnings growth are decidedly lower than that associated with stayers. The correlation between earnings growth and the contribution of employer-to-employer transitions is 0.82, that of hires from nonemployment is -0.47, and that of separations to nonemployment is 0.36.

The key take-away of Figure 5 is that the job ladder involves a dynamic process of labor market entry, employer-to-employer transitions, and eventual exit.[13] The sizeable earnings implications of worker movements onto, up, and off of the job ladder tend to mostly offset each other. As a result, aggregate earnings growth largely follows the contribution of job stayers.

5.2 Earnings, hours, and wages

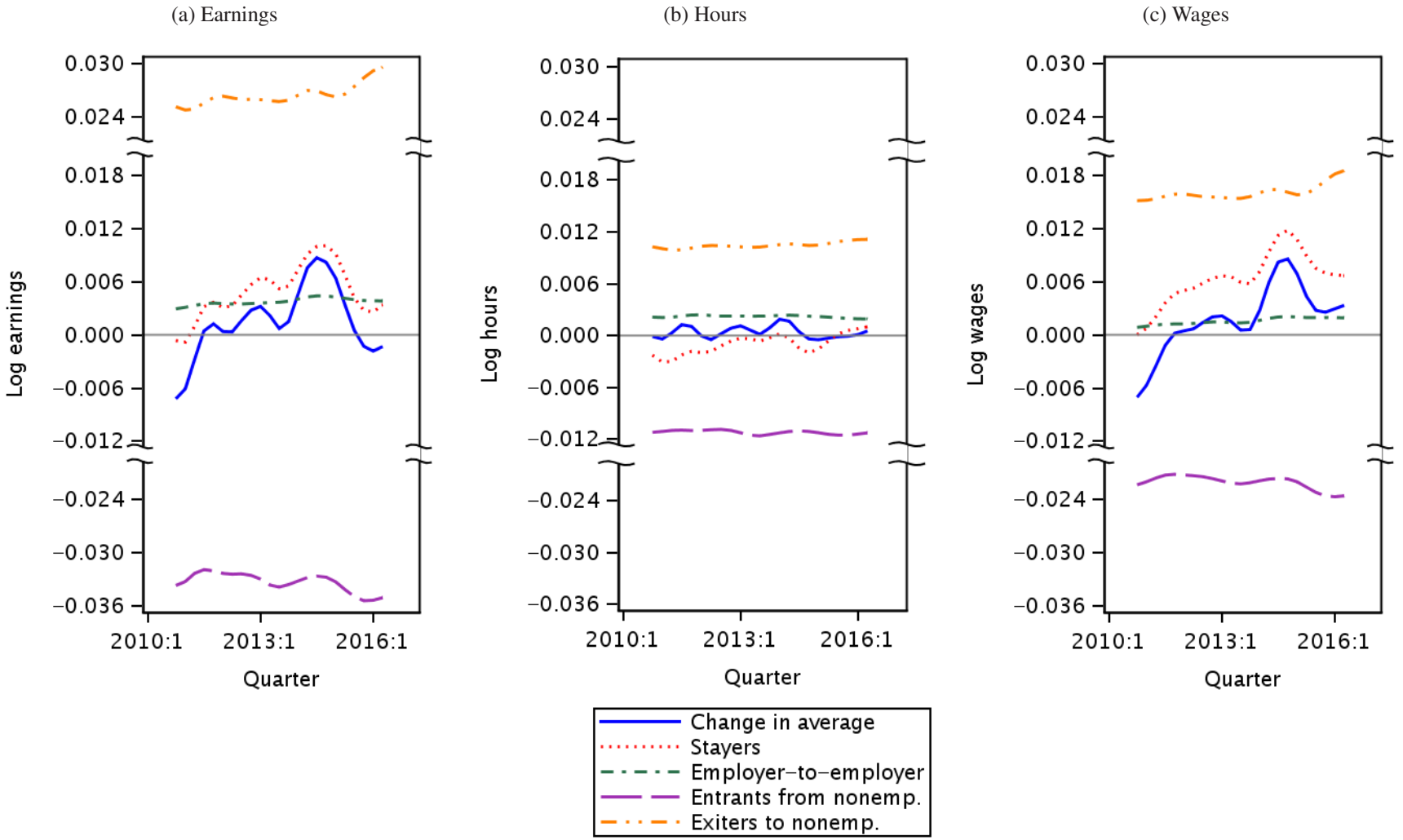
Our four state dataset allows us to apply our accounting framework to understand changes in hours and wages from 2010 to 2016. Results are shown in Figure 6.[14] While our time series is shorter, we can consider the declines in averages earnings and wages that occurred from 2010 to 2012, and the increases that occurred starting in late 2014. Earnings the four states with hours data are shown in Figure 6(a). Overall earnings changed from -0.1 to 0.9 percentage points. Hires from nonemployment earned less than incumbent workers, and subtracted about 3.2 to 3.6 percentage points from earnings in each quarter. Workers exiting employment to nonemployment also earned less than incumbent workers, and add 2.5 to 3.0 percentage points to average earnings. Employer-to-employer transitions added 0.3 to 0.4 percentage points to earnings each quarter. Stayers added 0.0 to 1.0 percentage points to average earnings, and this contribution varied over time. These earnings results are broadly similar to those in Figure 5 for years 2010-2016. Both the decrease in earnings from 2010 to 2012 and the increase from 2014 to 2016 were driven by the contribution of stayers.

Figure 6(b) shows the contributions of stayers and transitioners to hours growth. Consistent with the trend in overall hours shown in Figure 2(b), the average hours increased by only 0.9 per-

[13] These patterns have been confirmed by Hahn et al. (2017) using Job-to-Job Flow statistics published by the U.S. Census Bureau. These results have also been confirmed by Berson et al. (2020) using data for France and Italy.

[14] For the shares of stayers and employment transitions, see Appendix Figure D2(a). For the average earnings, hours, and wages of stayers and transitioners, see Appendix Figure D5. For changes in earnings, hours, and wages for stayers and employer-to-employer transitions, as well as differences between nonemployment entrants and exiters relative to continuously employed workers, see Appendix Figure D6. For decomposition results on a longer time series of mostly imputed wage data, see Appendix Figure E1.

Figure 6: Decomposition of growth in average log earnings, hours, and wages (four states)



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12.

centage points over this time period. Hours changes in any given quarter were small and in the range of -0.1 percent to 0.2 percent. The contributions of stayers and transitioners were stable over this time period. Stayers contributed -0.1 to 0.1 percentage points to growth in average hours, employer-to-employer transitions added about 0.2 percentage points, hires from nonemployment subtracted 1.1 to 1.2 percentage points, and separations to nonemployment added 1.0 to 1.1 percentage points.

Figure 6(c) shows the contiributions of stayers and transitioners to growth in average wages. Results for wages are qualitatively similar to those for earnings, but there are differences in mangitude. Hires from nonemployment had lower wages than incumbent workers and subtracted 2.1 to 2.4 percentage points from average wages. Workers exiting employment to nonemployment had lower wages than incumbent workers and so their departure added 1.5 to 1.9 percentage points to wages. Employer-to-employer transitions added 0.1 to 0.2 percentage points to average wages. Stayers added on average about 0.6 percentage points to average wages, and this contribution varied considerably over time, and ranged from 0.0 to 1.1 percentage points. Stayers have especially high wage growth during 2015, when their contribution to average wages exceeded one percentage point.

A key finding of our decomposition is the existence of an hours job ladder that matters at least as much as a job ladder for wages. As seen Figure 6, workers changing employers lead to gains in hours that usually exceed those of wages. These results imply the existence of a job ladder where workers leave jobs with limited hours to take ones that offer more hours. While a discussion of the mechanisms responsible for an active job ladder in hours is beyond the scope of this paper, our finding does imply the existence of frictions or adjustment costs that make changing hours within a job more costly for a worker than moving to a job with a preferred hours schedule. These results echo findings on rigidities in hours worked by Altonji and Paxson (1986) and Chetty et al. (2011), and suggest that abstracting from an hours choice in the on-the-job search literature following Burdett (1978) and Jovanovic (1979) is a significant limitation.

Another finding is that stayers drive wage growth in addition to earnings growth. We find a correlation of 0.91 between changes in earnings and the contribution of stayers. While this correlation is lower than the analogue from our eleven state dataset (0.96), it far exceeds the correlation of the contribution of any transition type, which are 0.40 for employer-to-employer transitions, 0.32 for separations to nonemployment, and 0.37 for hires from nonemployment. We find a correlation of 0.79 between wage growth and the contribution of stayers. This correlation exceeds the

correlations between wage growth and the contribution of any transition type: 0.42 for employer-to-employer transitions, 0.70 for separations to nonemployment, and -0.37 for hires from nonemployment. Furthermore, we see that the declines in earnings and wages in the years that follow the 2007-2009 recession and the increases in the middle 2010s were driven by stayers.

Our results show a strongly balanced relationship in aggregate between the reduction in average earnings, hours, and wages associated with hires from nonemployment and the gains provided by the other components of our decomposition. This finding suggests that new hires from nonemployment start with low earnings and quickly make gains as job stayers and as they move up the job ladder. We are able to assess this mechanism by considering the earnings, hours, and wages of cohorts of workers entering the labor market.

6 Entry cohorts

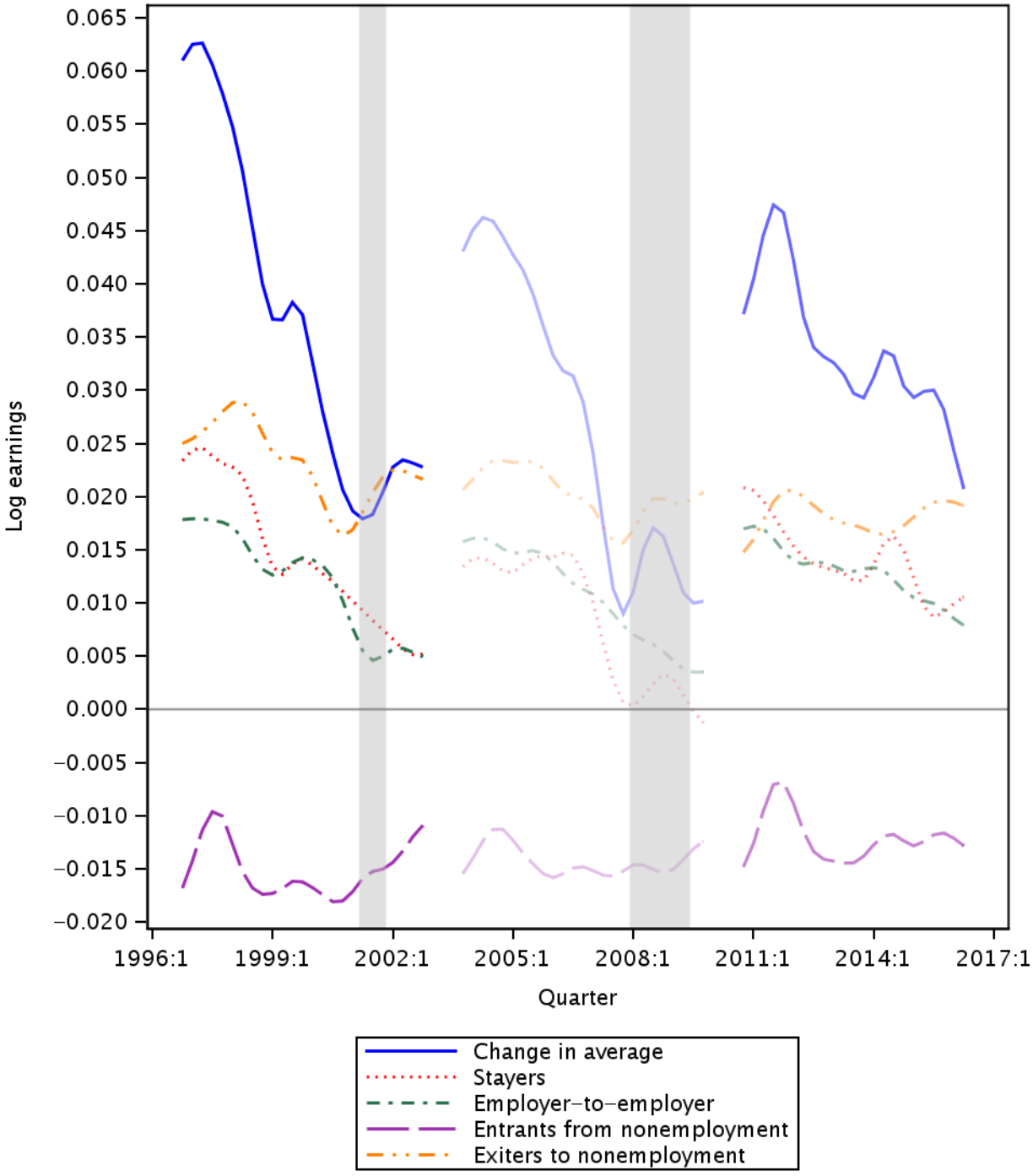
We now consider the earnings growth of recent labor market entrants. Analyzing the dynamics of recent entrants allows us to further understand why the sizeable contributions employment transitions lead to little overall growth in earnings, hours, or wages. The drag on earnings induced by hires from nonemployment is largely offset by gains from stayers, employer-to-employer transitions, and separations to nonemployment from low-paying jobs. Our analysis of entry cohorts links these channels at the micro level. We consider groups of workers who entered the labor market in years 1996, 2003, and 2010, respectively, and how their earnings evolved during their first seven years of work.

Figure 7 shows the quarterly earnings changes for these three entry cohorts (solid lines).[15] Earnings growth was most rapid shortly after entry, when the quarterly increases reached 4.6% to 6.3%. In the last year of each time series, earnings growth was 1.0% to 2.4% per quarter. Aggregate conditions had some impact on the earnings of these entry cohorts. The 1996 cohort had especially high earnings growth during the late 1990s when average real earnings had its largest sustained increase. The 2003 cohort exhibited low growth during the recession years of 2007-2009. The 2010 entry cohort had strong earnings growth during a sustained economic expansion.

Stayers and employer-to-employer transitions accounted for much of the earnings growth of each cohort, as shown in Figure 7. The contributions of employer-to-employer transitions and stay-

[15]For the shares of stayers and employment transitions, see Appendix Figure D3. For the earnings of stayers and transitioners, see Appendix Figure D7. For the earnings changes of stayers and employer-to-employer transitions, as well as the difference between entrants from and exiters to nonemployment and the continuously employed, see Appendix Figure D9.

Figure 7: Decomposition of growth in average log earnings, by entry cohort (eleven states)



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. Years 1996-2002 present results for the 1996 entry cohort, years 2003-2009 present results for the 2003 entry cohort, and years 2010-2016 present results for the 2010 entry cohort.

ers were similar in magnitude and decline over time. In the first three years, stayers contributed 1.3 to 2.5 percentage points to earnings growth. In these early years, employer-to-employer transitions contributed 1.3 to 1.8 percentage points to earnings growth. In later years, stayers contributed 0.0 to 1.6 percentage points to earnings growth, while employer-to-employer transitions contributed 0.3 to 1.4 percentage points. The contribution of stayers responded more to aggregate conditions than the other components of the decomposition. Compared to the other two cohorts, the 1996 entry cohort exhibited relatively high earnings growth during its first few years of entry, when real earnings were increasing in aggregate. This differential earnings increase was driven by stayers. The 2003 entry cohort's low earnings growth during the 2007-2009 recessions was driven by lower growth from stayers.

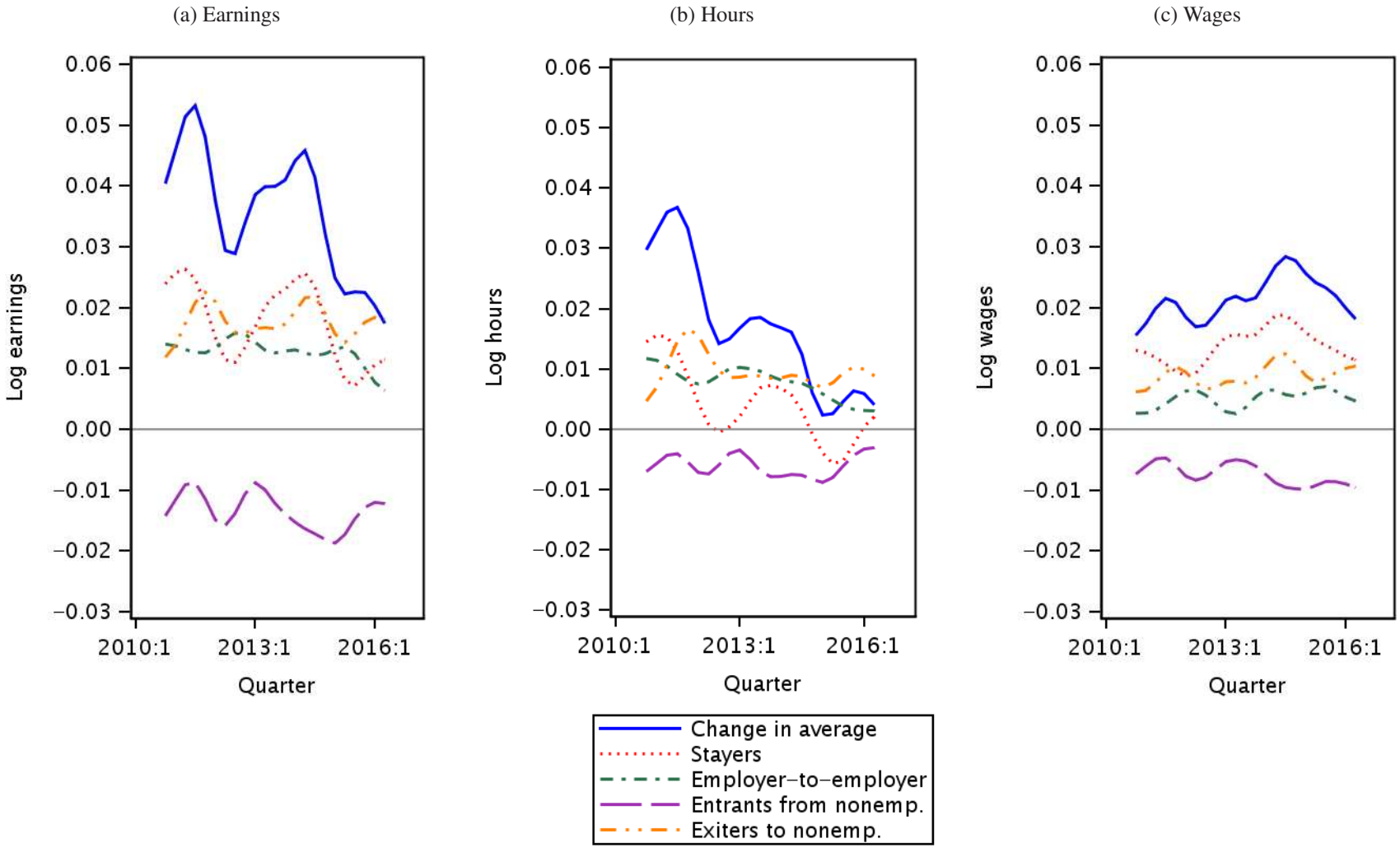
Although we require entry cohorts to have positive earnings in each year, we allow workers to have short spells of nonemployment, which our decomposition method also measures. The role of nonemployment in earnings growth is also shown in Figure 7. When members of any given cohort enter employment from nonemployment, they have low earnings relative to incumbents in that same cohort. Nonemployment entrants account for about 1.5 percentage points lower average earnings in any given quarter. Likewise, workers exiting employment to nonemployment have relatively low earnings, and their exit accounts for 1.0 to 1.8 percentage points higher earnings each quarter.

Figure 8 shows how earnings, hours, and wages evolved for the set of workers who entered the labor market in 2010 in terms of our decomposition framework.[16] As shown in Figure 8(a), quarterly earnings growth after entry reached as high as 5.3%. Earnings growth was lower but still robust until 2016, and always was at least 1.7% per quarter. The largest observed gains were driven by the contribution of stayers. Figures 8(b) and 8(c) show the respective contributions of hours and wages. The especially rapid earnings growth immediately after entry was driven by hours growth among stayers, employer-to-employer transitions, and exiters to nonemployment. This implies that members of this entry cohort whose initial jobs offer relatively low hours were especially likely to gain hours in those jobs, or else leave those jobs.

Figure 8(b) shows that hours growth among stayers was initially high, but soon declined. In contrast, employer-to-employer transitions served as a source of substantial hours growth - 0.7 to 1.1 percentage points - in the first three years this cohort worked, and this declined in the fifth

[16]For the shares of stayers and employment transitions, see Appendix Figure D2(b). For the earnings of stayers and transitioners, see Appendix Figure D8. For the earnings changes of stayers and employer-to-employer transitions, as well as the difference between entrants from and exiters to nonemployment and the continuously employed, see Appendix Figure D10.

Figure 8: Decomposition of growth in earnings, hours, and wages, 2010 entry cohort (four states)



Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12.

and sixth year. Hires from nonemployment started in relatively low hours jobs, which subtracted 0.3 to 0.9 percentage points from the hours growth of entry cohorts. Workers exiting relatively low hours jobs to nonemployment consistently contributed 0.5 to 1.7 percentage points to hours growth. Labor market entrants cycled rapidly thorough jobs that offer low hours, leaving them either other employers or to nonemployment.

In contrast to hours, Figure 8(c) shows that wage growth was relatively stable over time, and ranged from 1.5% to 2.8% per quarter. Stayers were the main driving force of wage growth of these entrants. In each quarter, entrants contributed 0.9 to 2.0 percentage points to wage growth, and this increases in later years. Employer-to-employer transitions played a modest role in the wage growth of these entry cohorts, with a contribution of 0.3 to 0.7 percentage points. Entrants from nonemployment tended to enter with relatively low wages, subtracting 0.5 to 1.0 percentage points from the growth of average wages. Exiters to nonemployment also had low wages, and so added 0.6 to 1.2 percentage points to growth in average wages.

We consider the sources of total earnings growth for these entry cohorts in Table 1. Specifically, we present the first and last observed average log outcome: the difference between these indicates the amount of growth in earnings, hours, or wages. We also sum the respective contributions of stayers and employment transitions to understand their cumulative effect. Average earnings of these entry cohorts increased by 62% to 83% over their first seven years of work. The earnings growth of stayers provided a total earnings increase of 22 to 42 percentage points. Employer-to-employer transitions provided an increase of 26 to 31 percentage points. Entry from nonemployment subtracted 31 to 40 percentage points. Separations to nonemployment provided an increase of 45 to 56 percentage points. The cumulative earnings growth of the 2003 entry cohort was 14 to 18 percentage points lower than the other cohorts, and this difference was driven by stayers, whose total contribution is 9 to 13 percentage points less.

Where comparable, our estimates are quite close to those reported by Topel and Ward (1992), who only measured the cumulative effect of earnings changes associated with employer-to-employer transitions, and compare this to total earnings growth. Our decomposition is more comprehensive in that it permits analogues for stayers and nonemployment transitions. Our Table 1 indicates that earnings growth over the first seven years was 0.62 to 0.83. Topel and Ward (1992) report that workers in their sample had a cumulative increase in log earnings in their first five years of work of 0.602.[17] Topel and Ward (1992) reported that the cumulative growth associated with employer-

[17]See Topel and Ward (1992), Table VII (page 461): our tracking the first seven years of labor market entry allows us to make a rough comparison to the sum of their columns "0-2.5" and "2.5-5", 0.316+0.286=0.602.

Table 1: Growth in the log earnings, hours, and wages by entry cohorts

	Eleven states			Four states		
Cohort	1996	2003	2010	2010	2010	2010
Outcome	Earnings	Earnings	Earnings	Earnings	Hours	Wages
First quarter	8.27	8.33	8.28	8.29	5.78	2.52
Last quarter	9.06	8.94	9.04	9.12	6.09	3.03
Difference	0.80	0.62	0.76	0.83	0.32	0.52
Stayers	0.35	0.22	0.31	0.42	0.07	0.35
Employer-to-employer	0.29	0.26	0.31	0.31	0.19	0.12
Entrants from nonemp.	-0.40	-0.37	-0.31	-0.35	-0.16	-0.19
Exiters to nonemp.	0.56	0.51	0.46	0.45	0.23	0.23

Notes: Earnings and wages are in 2014 constant dollars.

to-employer transitions was 0.234.[18] Our estimates indicate cumulative earnings growth of 0.26 to 0.31. The share of cumulative earnings growth over the first five years of labor market experience in Topel and Ward (1992) was $0.234/0.602 \approx 38.8\%$. This is within the range of our estimates over the first seven years, 36.3% to 41.9%.[19]

The 2010 entry cohort from our four states with hours data allows us to further decompose the relative contributions of hours and wages. Earnings increased by 83%, hours increased by 32%, and wages increased by 52%. Stayers and employer-to-employer transitions had different roles in cumulative earnings growth. Employer-to-employer transitions contributed more to earnings growth through changes in hours (19 percentage points) than changes in wages (12 percentage points). Stayers, by contrast, contributed more to wage growth (35 percentage points) than hours growth (7 percentage points). Hires from nonemployment contributed somewhat more to lower wages (19 percentage points) than lower hours (16 percentage points). Separators to nonemployment contributed about equally (23 percentage points) to both higher earnings and wages.

These results provide key insights into how average earnings, hours, and wages evolve over time. Our decomposition results in Section 5 show that the small changes in these averages occur despite sizeable contributions of particular workers to growth or declines in earnings. Our analysis of entry cohorts shows how workers enter the labor market from nonemployment with relatively low earnings. They then experience rapid growth. Recent labor market entrants exhibit substantial

[18] Again, see Topel and Ward (1992), Table VII (page 461), 0.143+0.091=0.234.

[19] The strong agreements of our estimates from 1996-2016 to the estimates of Topel and Ward (1992) for 1957-1972 indicates that career ladders and life-cycle earnings growth were similar in these decades. This evidence suggests employer-to-employer transitions primarily moved workers out of low-paying initial matches. More generally, it is possible that a similarly small net effect of employment transitions on earnings growth may have occurred in the decades that precede those of our analysis datasets.

growth in earnings as stayers, as well as through employer-to-employer transitions. Also, workers separate to nonemployment from low-paying jobs, increasing earnings, hours, and wages. In aggregate, in the typical quarter there are numerous entrants from nonemployment who lower average earnings, hours, and wages. This analysis of entry cohorts illustrates why the contributions of stayers and employment transitions mostly offset each other in aggregate.

7 Earnings, wages, and the unemployment rate

We now turn to an old topic: cyclical wage adjustment. This issue is of central importance to labor economics. As Shimer (2005) argued, wage declines may mitigate the increase in unemployment that occurs during recessions. More recently, there has been a substantial effort including Pissarides (2009) and Schoefer (2015) to reconcile this argument with empirical evidence which indicates that the wages of new hires are highly procyclical, and the wages of stayers are less cyclical.

Our decomposition offers a new perspective on this question, and provides guidance on how to interpret the highly cyclical earnings of recent hires. We first estimate a regression model on our matched employer-employee data, and confirm the finding of Gertler and Trigari (2009) that the excess cyclical sensitivity of new hire wages relative to stayers is accounted for by employer-employee match effects. We then incorporate our regression estimates into our decomposition. The dynamic process by which workers move onto, up, and off of the job ladder moves workers through low-paying job matches.

7.1 New hire earnings and wages

To understand cyclical changes in new hire earnings and wages, we rely on the following empirical specification:

$$y_{it} = u_t(\gamma_1 + q_{it}\gamma_2 + n_{it}\gamma_3) + x_{it}\beta + \upsilon_{it}. \tag{3}$$

where y_{it} denotes earnings or wages for worker i at time t, u_t is the unemployment rate, x_{it} is a row vector of time-varying observable characteristics, and υ_{it} is the residual.

γ_1 captures changes associated with the unemployment rate for all workers with earnings at time t. We also include parameters γ_2 and γ_3, which capture how new hires from another employer q_t and those from nonemployment n_t, respectively, in time t may experience differential changes

with the unemployment rate. Note these interaction terms mean γ_1 can be interpreted as the change specific to stayers while γ_2 and γ_3 are measures of excess cyclicality for new hires relative to stayers.

Marginal effects for our row vector of time-varying observable characteristics are given by vector β, which includes age, age squared, job tenure, and dummy variables indicating whether a worker is newly hired from another employer or nonemployment, dummy variables indicating whether it is the last quarter of a specific employer-employee match (with separate dummy variables and parameters for whether job spells are followed by employment or nonemployment), as well as time trends and seasonal effects that are specific to each worker type (i.e. stayers, hires from another employer, and hires from nonemployment). Time invariant worker characteristics such as sex, race, ethnicity, and level of education completion are not included as they are collinear with our fixed effects.

We assume the residual is additively separable into two components:

$$\upsilon_{it} = \alpha_{it} + \varepsilon_{it}, \tag{4}$$

where ε_{it} is the i.i.d. error term and α_{it} is an effect that persists over time. We allow α_{it} to take one of two forms. First, for comparison to most of the literature, we follow Bils (1985) and assume $\alpha_{it} = \alpha_i$, that is, each person has a time invariant effect.[20] Second, we follow a specification explored by Gertler and Trigari (2009), which allows $\alpha_{it} = \alpha_{ij}$ for any match between person i and employer j that exists at time t. This empirical strategy avoids biased results if the estimated person effect differs from the true match effect $\hat{\alpha}_i - \alpha_{it}$ and this deviation is related to the dependent variable of interest y_{it} and the unemployment rate. There is ample recent evidence to suggest that using person effects alone result in biased estimates of cyclicality since the distribution of matches changes over the business cycle. Haltiwanger et al. (2018) and related studies find movement from worse to better job matches is procyclical, suggesting average match effects may be higher when the unemployment rate is lower. Moreover, we assume match effects are related to the dependent variables of our regressions. This extension captures both persistent and transitory components of cyclicality: the match effect α_{ij} is the permanent component that lasts throughout a job spell and γ_2 and γ_3 are transitory excess cyclicalities that disappear after one quarter.[21]

[20] We use person-specific fixed effects here. For the results of an empirical strategy that estimates the first difference of Equation (3), see Appendix Table E1.

[21] The match term will pick up a variety of effects. The match effect that we estimate is a combination of the firm-specific effect and idiosyncratic component specific to an employer-employee match, see Card et al. (2018). The broader literature on firm effects starting with Abowd, Kramarz, and Margois (1999) emphasizes job quality as a

Table 2: Unemployment rate regressions: worker-level earnings and wages

	Eleven states				Four states			
Outcome	Earnings		Wages		Earnings		Wages	
Fixed effect	Person	Match	Person	Match	Person	Match	Person	Match
Stayers (γ_1)	-1.42***	-0.85***	-0.92***	-0.65***	-1.72***	-0.80***	-0.97***	-0.35***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Employer-to-employer (γ_2)	-1.54***	-0.53***	-1.08***	-0.24***	-1.63***	-0.80***	-0.86***	-0.11
	(0.03)	(0.05)	(0.03)	(0.03)	(0.08)	(0.15)	(0.06)	(0.12)
Entrants from nonemp. (γ_3)	-0.96***	-0.12***	-0.71***	-0.22***	-1.05***	0.03	-0.36***	0.24***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)	(0.11)	(0.04)	(0.08)
N (millions)	29.9	29.9	29.9	29.9	2.8	2.8	2.8	2.8
R^2	0.779	0.920	0.646	0.747	0.836	0.944	0.861	0.944

Notes: Earnings and wages are in 2014 constant dollars. Both the eleven state and four state datasets have non-imputed earnings data. Our four state dataset has non-imputed wage data while our eleven state dataset has mostly imputed wage data.

Table 2 presents our regression results for earnings and wages, respectively, of all workers employed in time t. Each table provides regression estimates from our four state and eleven state datasets. Note that both datasets do not include imputed earnings observations and that our four state dataset contains no imputed hours observations while our eleven state dataset contains partially imputed hours data.

Consistent with previous findings of Bils (1985) and the related literature, we find stayer earnings and wages are procyclical. In response to a one percent increase in the unemployment rate, stayer earnings in our four state dataset decrease by 1.72 percent with person-specific fixed effects and 0.80 percent with match-specific fixed effects. When considering the larger eleven state dataset, the response of stayers is slightly smaller in the person-specific regression but consistent with the four state results when controlling for match effects. For wages, we find similar magnitudes of cyclicality among stayers. Wages in the four state dataset decline by 0.97 percent and 0.35 percent with person- and match-specific fixed effects, respectively. Regressions run with our eleven state dataset lead to estimates that are the same in sign and close in magnitude, despite relying on imputed hours data to construct the wage variable.

We also find that earnings and wages of recent hires are procyclical. In the four state dataset, earnings for workers changing employers decrease by 3.35 ($= 1.72 + 1.63$) percent with person-specific fixed effects and 1.60 ($= 0.80 + 0.80$) percent with match-specific fixed effects in response to a one percent increase in the unemployment rate. Meanwhile, earnings for hires from nonemployment decrease by 2.77 ($= 1.72 + 1.05$) percent and 0.77 ($= 0.80 - 0.03$) percent in the person- and match-specific regressions, respectively. Results from the eleven state dataset are similar in magnitude. Our results indicate that employer-employee match effects account for most of the excess cyclical sensitivity of new hire earnings to the unemployment rate, confirming the findings of Gertler and Trigari (2009).

measure of firm quality (the part which is comment across workers at a particular firm), as well as a measure of the idiosyncratic component (which is specific to the employer-employee match). There is a subtle distinction between two components of match "quality" that are emphasized in the literature on cyclical labor costs. Our match effects will be determined in part by persistent labor costs as in Kudlyak (2014). They will also be influenced by the productivity of the match, and a small number of papers have attempted to distinguish between these, including Martins, Solon, and Thomas (2012), Hagedorn and Manovskii (2013) and Gertler, Huckfeldt, and Trigari (2019). Our results do not allow us to distinguish between match quality and the cost of labor. Readers should note that both the match quality distribution and the unemployment rate may be endogenous to broader economic conditions and appropriate caution is warranted in the interpretation of our results.

7.2 Extending our accounting framework

To incorporate our parameter estimates into our decomposition, we first-difference our regression Equation (3) and aggregate each regression component over all workers.

For employer-to-employer transitions, we express their average growth in earnings, hours, and wages as:

$$\frac{\Sigma_i q_{it} \Delta y_{it}}{Q_t} = \frac{\Sigma_i q_{it} \Delta x_{it} \hat{\beta}}{Q_t} + \frac{\Sigma_i q_{it} \Delta l_{it} \hat{\gamma}}{Q_t} + \frac{\Sigma_i q_{it} \Delta \hat{\alpha}_{it}}{Q_t} + \frac{\Sigma_i q_{it} \Delta \hat{\varepsilon}_{it}}{Q_t} \tag{5}$$

where $\Delta x_{it} = x_{it} - x_{it-1}$ is the change in the vector of observable characteristics from time $t-1$ to time t with parameter estimates $\hat{\beta}$, $\Delta l_{it} = l_{it} - l_{it-1}$ is the analogous change in the unemployment vector $l_{it} = [u_{it} \; q_{it} u_{it} \; n_{it} u_{it}]$ with parameter estimate vector $\hat{\gamma} = [\gamma_1 \; \gamma_2 \; \gamma_3]'$, $\Delta \hat{\alpha}_{it} = \hat{\alpha}_{it} - \hat{\alpha}_{it-1}$ is the change in estimated match effects, and $\Delta \hat{\varepsilon}_{it} = \hat{\varepsilon}_{it} - \hat{\varepsilon}_{it-1}$ is the change in the estimated residual.

For hires from nonemployment, we compare their earnings with those of all other workers and obtain the following relationship for their average growth:

$$\begin{aligned} \left(\frac{\Sigma_i n_{it} y_{it-1}}{N_t} - \tilde{y}_t \right) = \left(\frac{\Sigma_i n_{it} x_{it-1}}{N_t} - \tilde{x}_t \right) \hat{\beta} + \left(\frac{\Sigma_i n_{it} l_{it-1}}{N_t} - \tilde{l}_t \right) \hat{\gamma} + \\ \left(\frac{\Sigma_i n_{it} \hat{\alpha}_{it-1}}{N_t} - \tilde{\alpha}_t \right) + \left(\frac{\Sigma_i n_{it} \hat{\varepsilon}_{it-1}}{N_t} - \tilde{\varepsilon}_t \right) \end{aligned} \tag{6}$$

where $\tilde{x}_t$ is a row vector of average observable characteristics, $\tilde{l}_t$ is a row vector of average unemployment rates interacted with worker type, $\tilde{\alpha}_t$ is an average of fitted match effects, and $\tilde{\varepsilon}_t$ is an average of fitted residuals. The average of each element, generically denoted by $\tilde{g}_t$, is

$$\tilde{g}_t = \frac{S_t}{S_t + Q_t} \left(\frac{\Sigma_i s_{it} (g_{it} + g_{it-1})}{2 S_t} \right) + \frac{Q_t}{S_t + Q_t} \left(\frac{\Sigma_i q_{it} (g_{it} + g_{it-1})}{2 Q_t} \right).$$

For incumbents exiting employment, we have the following relationship for average growth:

$$\begin{aligned} \left(\frac{\Sigma_i r_{it} y_{it-1}}{R_t} - \tilde{y}_t \right) = \left(\frac{\Sigma_i r_{it} x_{it-1}}{R_t} - \tilde{x}_t \right) \hat{\beta} + \left(\frac{\Sigma_i r_{it} u_{it-1}}{R_t} - \tilde{u}_t \right) \hat{\gamma} + \\ \left(\frac{\Sigma_i r_{it} \hat{\alpha}_{it-1}}{R_t} - \tilde{\alpha}_t \right) + \left(\frac{\Sigma_i r_{it} \hat{\varepsilon}_{it-1}}{R_t} - \tilde{\varepsilon}_t \right). \end{aligned} \tag{7}$$

We can do the same for stayers and express their average change, weighted by their average share, as follows:

$$\frac{\Sigma_i s_{it} \Delta y_{it}}{S_t} = \frac{\Sigma_i s_{it} \Delta x_{it} \hat{\beta}}{S_t} + \frac{\Sigma_i s_{it} \Delta l_{it} \hat{\gamma}}{S_t} + \frac{\Sigma_i s_{it} \Delta \hat{\varepsilon}_{it}}{S_t}. \tag{8}$$

Note that, by construction, stayers never have any change in match effects (since they are constant for any employer-employee combination), so the contribution of match effects for stayers is zero throughout the time series.

7.3 Match effects and unemployment

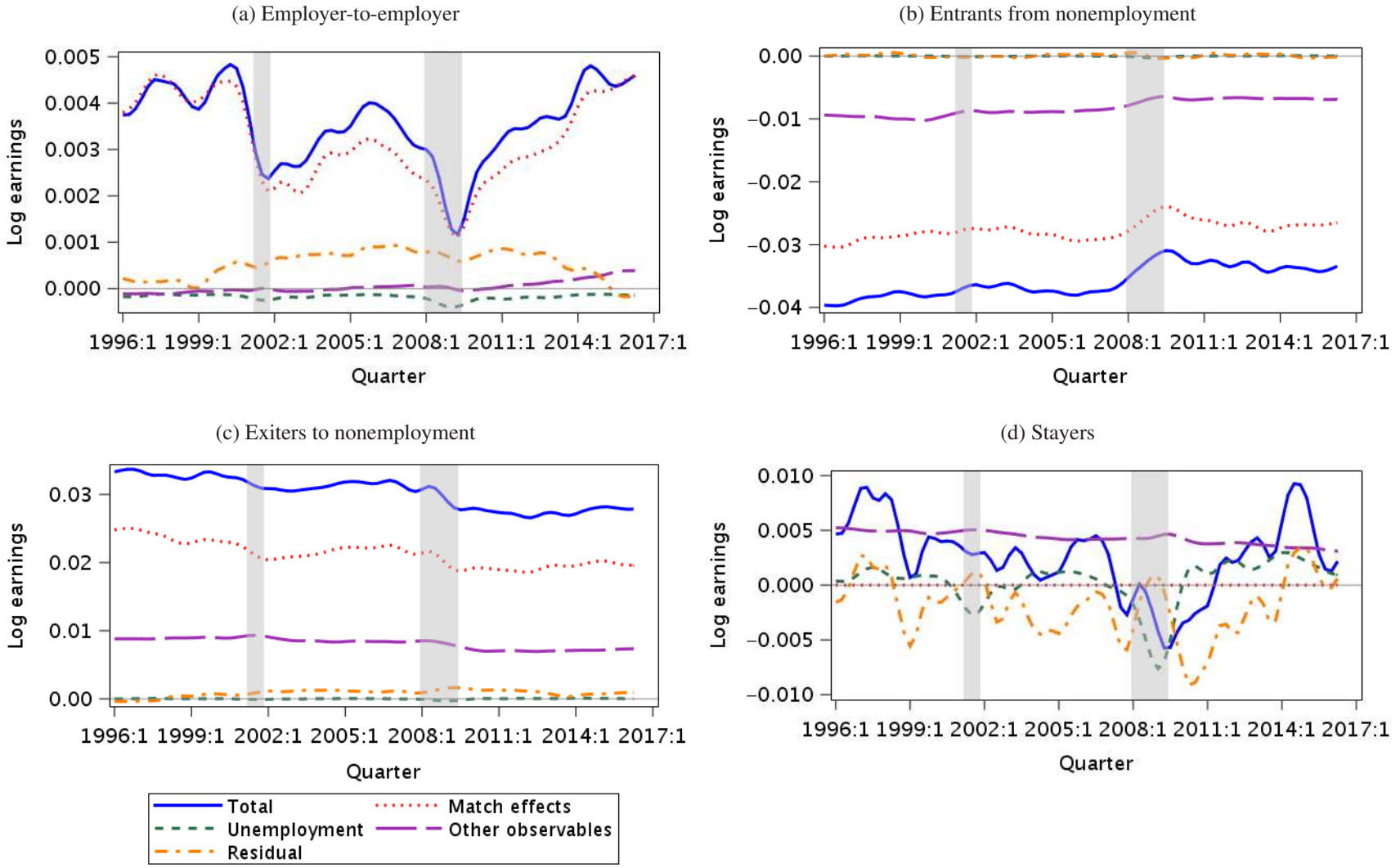
Having integrated the fitted values of our regression into Equation (2), we now characterize the role of match effects and the unemployment rate in the evolution of earnings and wages. Our results for earnings, which use our eleven state dataset, are shown in Figure 9. In Figure 9(a), we show the overall contribution of employer-to-employer transitions to earnings growth, along with the contribution of each of the components from our estimation of Equation (3).[22] Match effects (dotted line), track the contribution of employer-to-employer transitions to earnings growth (solid line). The gains provided by match effects were slightly offset by the unemployment contribution (short dash line), which captures any transitory excess cyclicality of employer-to-employer transitions, and ranged from -0.4 to -0.1 percentage points. While changes associated with other observable characteristics (long dash line) typically provided gains, they are small in magnitude. Lastly, changes attributed to the residual (dash-dot line) were roughly the same in magnitude as those associated with the unemployment rate but generally positive.

Figure 9(b) shows the contribution of hires from nonemployment (solid line) and finds it had a negative effect on growth in aggregate earnings. These losses were driven by the contribution of match effects (dotted line), which accounted for 72.8% to 80.0% of the contribution of hires from nonemployment. Other model covariates played much smaller roles. The unemployment rate (short dash line) had a generally negative effect as low as -0.3 percentage points, reflecting the transitory excess sensitivity of hires from nonemployment to the unemployment rate. Other observable characteristics (long dash line) subtracted 0.7 to 1.0 percentage points. Meanwhile, changes attributed to the residual (dash-dot lines) were generally positive but are small, ranging from 0.0 to 0.1 percentage points. Figure 9(c) shows the contribution of separations to nonemployment (solid line) and finds it is had a positive effect on growth in aggregate earnings. This contribution was also driven by match effects (dotted line).

Lastly, we consider how the stayer contribution to earnings evolved in Figure 9(d). Match effects (dotted line) cannot contribute to earnings growth of stayers by construction. We find the unemployment rate and observable characteristics do not capture the variability found in the total con-

[22]The solid lines in Figure 9 are the components of the decomposition, also shown in Figure 5.

Figure 9: Log earnings growth: regression-based decomposition (eleven states)



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. "Total" indicates the total contribution for each worker type.

tribution line. The unemployment rate added 0.2 to 0.4 percentage points to earnings growth during expansions but subtracted 0.1 to 0.7 percentage points during recessions. Meanwhile, changes in observable characteristics contributed 0.4 percentage points. These characteristics include job tenure and age which increase over time and are associated with earnings increases. By contrast, the residual, which necessarily includes anything not captured in Equation (3), exhibits substantial cyclicality relative to the other series. In magnitude, it was mostly negative (from -1.0 to 0.0 percentage points) and greater in magnitude than the earnings changes associated with changes in the unemployment rate and other observable characteristics. The exceptional contributions of stayers to earnings growth in the late 1990s and middle 2010s were driven by residual factors.[23]

Our four states that provide data on hours worked allow us to analyze wage growth as shown in Figure Figure 10.[24] While our time series is shorter, the results for wages are similar to the analogous earnings results discussed above. Employer-to-employer transitions are shown in Figure 10(a) and indicate that match effects closely tracked the contribution of employer-to-employer transitions to wage growth. Match effects similarly accounted for the contribution of hires from nonemployment and separations to nonemployment, shown in panels (b) and (c), respectively, of Figure 10. The wage growth of stayers that occurs in the middle 2010s was driven by the estimated residual from our regression model, as shown in Figure 10(d).

In summary, we find that employer-employee match effects drive the contributions of hires from nonemployment as they lower average earnings and wages. Likewise, we find that match effects drive the contribution of employer-to-employer transitions to earnings and wage growth. As workers change employers, the old match effect dissolves and a new one emerges. We also show that separations to nonemployment tend to occur for jobs with low match effects. These results imply that hires from nonemployment start in relatively low-paying job matches, and frequently move out of these matches via employer-to-employer tranisitons and separations to nonemployment.

These results provide guidance on how to interpret the strong cyclicality of new hire earnings and wages documented by Bils (1985) and many others. Our data confirms the excess cyclical sensitivity of new hire earnings. However, these newly hired workers are very likely to separate -

[23] An exhaustive attempt to model the determinants of earnings changes is beyond the scope of this paper. It is worth pointing out that the residual represents features of the process not captured in the empirical specification in Equation (3). The residual is persistently negative for most of the time series–except during growth episodes of the late 1990s and middle 2010s. This persistent negative contribution most likely reflects the fact that we only allow returns to job tenure to increase and do not have a corresponding time from exit series. Furthermore, there may be labor productivity growth or nonlinearities in the effect of the unemployment rate.

[24] For the corresponding decomposition of earnings for these four states, see Appendix Figure E3. For results from a longer time series from our eleven states that relies on mostly imputed wage data, see Appendix Figure E4.

Figure 10: Log wage growth: regression-based decomposition (four states)

Notes: Wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. "Total" indicates the total contribution for each worker type. See text for details.

either to better matches, or to nonemployment. Most labor market search models follow Shimer (2005) and assume that all separations are exogenous and therefore unrelated to wages or match quality. This assumption is also present in models that target new hire wages as developed by Pissarides (2009) and Schoefer (2015). Our findings show the importance of including endogenous separations in models that target new hire earnings and wages, as in the recent work of Gertler, Huckfeldt, and Trigari (2019).

8 Conclusion

We use matched employer-employee data to investigate how the recent slowdown in the job ladder relates to sluggish wage and earnings growth in the U.S. from 2001 to 2013. We propose an accounting framework that decomposes changes in average earnings, hours, and wages into growth for stayers, employer-to-employer transitions, and nonemployment transitions. We find that the direct gains from employer-to-employer transitions are of distinctly secondary importance relative to the earnings changes of stayers. If the pace of the job ladder is the main determinant of changes in aggregate earnings and wages, it can only be due to indirect mechanisms that influence the compensation of stayers rather than the direct returns to changing employers.[25]

We show the importance of career ladders for growth in earnings, hours, and wages for individuals. We confirm the key findings of Topel and Ward (1992) on the importance of employer-to-employer transitions in life-cycle earnings growth. By extending the Topel and Ward (1992) accounting framework to include nonemployment, we show that life-cycle gains from stayers, employer-to-employer transitions, and separations to nonemployment offset the very low initial earnings of entry cohorts. These gains were relatively time-invariant, and strong even during the 2001 and 2007-2009 recessions. We conclude that the substantial life-cycle gains for individual workers are mostly distinct from changes in aggregate earnings and wages.

Our results help to illustrate the relationship between new hire wages and the job ladder. We attribute the excess cyclicality of new hire earnings and wages compared to stayers to a permanent component that persists through an employer-employee match. We confirm the earlier findings of Gertler and Trigari (2009). Incorporating our estimated match effects into our decomposition provides guidance on the role of the job ladder in how new hire earnings and wages influence

[25]Such mechanisms may include efficiency wages that reduce employee turnover (Salop, 1979) or job offers that are not taken but lead to increases in labor compensation (Postel-Vinay and Robin, 2002). Models such as Lise and Robin (2017) and Moscarini and Postel-Vinay (2019) may prove helpful starting points for assessing the direct and indirect effects of the job ladder on earnings and wages over the business cycle.

labor costs. Matches involving recently hired workers are the ones most likely to dissolve, either through employer-to-employer transitions, or through separations to nonemployment. Most of the models that target new hire wage cyclicality follow Shimer (2005) and assume no job heterogeneity, endogenous separations, or on-the-job search. The recent work of Gertler, Huckfelt, and Trigari (2019) is an exception, and our results highlight the importance of this work. We show that, while highly cyclical, new hire wages are highly subject to endogenous separations - both to nonemployment, and to other employers.

In summary, we propose a framework that incorporates several different methods that measure how earnings and wages evolve over time: the accounting method of Topel and Ward (1992), the extensive vs. intensive margins of Daly and Hobijn (2016), and the Gertler and Trigari (2009) match effects extension of the Bils (1985) wage-unemployment specification. Taking it to the data, we find these channels have limited ability to account for the earnings stagnation in the U.S. from 2001 to 2013. The large increases in earnings in the late 1990s and middle 2010s are driven by stayers, in a way that is mostly unrelated to changes in the unemployment rate. What mechanisms account for the large estimated residual that we obtain when the earnings of job stayers surge? We hope this paper provides motivation for future work and perhaps a set of moments that can be used to estimate formal models.

References

[1] Abowd, John, Bryce Stephens, Lars Vilhuber, Fredrik Andersson, Kevin McKinney, Marc Roemer, and Simon Woodcock. 2009. "The LEHD Infrastructure Files and the Creation of the Quarterly Workforce Indicators." In *Producer Dynamics: New Evidence from Micro Data*, ed. Timothy Dunne, J. Bradford Jensen, and Mark Roberts. Chicago, IL: University of Chicago Press: 149-230.

[2] Abowd, John, Francis Kramarz, and David Margolis. 1999. "High Wage Workers and High Wage Firms." *Econometrica* 67(2): 251-333.

[3] Abraham, Katharine, James Spletzer, and Jay Stewart. 1998. "Divergent Trends in Alternative Wage Series." In: *Labor Statistics Measurement Issues*, ed. John Haltiwanger, Marilyn Manser, and Robert Topel. Chicago, IL: University of Chicago Press: 293-325.

[4] Altonji, Joseph, and Christina Paxson. 1986. "Job Characteristics and Hours of Work." In: *Research in Labor Economics*, Vol. VIII (Part A), ed. Ronald Ehrenberg. Greenwich, CT: JAI Press.

[5] Berson, Clemence, Eliana Viviano, and Marta de Philippis. 2020. "Job-to-Job Flows and Wage Dynamics in France and Italy." Banque de France Working Paper #756.

[6] Bils, Mark. 1985. "Real Wages over the Business Cycle: Evidence from Panel Data." *Journal of Political Economy* 93(4): 666-689.

[7] Burdett, Kenneth. 1978. "A Theory of Employee Search and Quits." *American Economic Review* 68(1): 212-220.

[8] Card, David, Ana Rute Cardoso, Joerg Heining, and Patrick Kline. "Firms and Labor Market Inequality: Evidence and Some Theory" *Journal of Labor Economics* 2018 36(S1): 13-70.

[9] Champagne, Julien, André Kurmann, and Jay Stewart. 2017. "Reconciling the Divergence in Aggregate U.S. Wage Series." *Labour Economics* 49(1): 27-41.

[10] Chetty, Raj, John Friedman, Tore Olsen, and Luigi Pistaferri. 2011. "Adjustment Costs, Firm Responses, and Micro vs. Macro Labor Supply Elasticities: Evidence from Danish Tax Records," *Quarterly Journal of Economics* 126(2): 749-804.

[11] Daly, Mary, and Bart Hobijn. 2016. "The Intensive and Extensive Margin of Real Wage Adjustment." Federal Reserve Bank of San Francisco Working Paper #2016-04.

[12] Davis, Steven, and John Haltiwanger. 2014. "Labor Market Fluidity and Economic Performance." NBER Working Paper #20065.

[13] Economic Report of the President. 2015. "Achievements and Challenges in the U.S. Labor Market." Available at: `https://obamawhitehouse.archives.gov/sites/default/files/docs/2015_erp_chapter_3.pdf`.

[14] Faberman, R. Jason, and Alejandro Justiniano. 2015. "Job Switching and Wage Growth." *Chicago Fed Letter* 337.

[15] Flood, Sarah, Miriam King, Steven Ruggles, and J. Robert Warren. 2017. Integrated Public Use Microdata Series, Current Population Survey: Version 5.0. [dataset]. Minneapolis, MN: University of Minnesota.

[16] Gertler, Mark, Christopher Huckfeldt, and Antonella Trigari. 2019. "Unemployment Fluctuations, Match Quality, and the Wage Cyclicality of New Hires." Forthcoming, *Review of Economic Studies*.

[17] Gertler, Mark, and Antonella Trigari. 2009. "Unemployment Fluctuations with Staggered Nash Wage Bargaining." *Journal of Political Economy* 117(1): 38-86.

[18] Hagedorn, Marcus, and Iourii Manovskii. 2013. "Job Selection and Wages over the Business Cycle." *American Economic Review* 103(2): 771-803.

[19] Hahn, Joyce, Henry Hyatt, Hubert Janicki, and Stephen Tibbets. 2017. "Job-to-Job Flows and Earnings Growth." *American Economic Review: Papers & Proceedings* 107(5): 358-363.

[20] Haltiwanger, John, Henry Hyatt, Lisa Kahn, and Erika McEntarfer. 2018. "Cyclical Job Ladders by Firm Size and Firm Wage." *American Economic Journal: Macroeconomics* 10(2): 52-85.

[21] Hyatt, Henry, and Tucker McElroy. 2019. "Labor Reallocation, Employment, and Earnings: Vector Autoregression Evidence." *Labour* 33(4): 463-487.

[22] Jovanovic, Boyan. 1979. "Firm-specific Capital and Turnover." *Journal of Political Economy* 87(5): 972-990.

[23] Karahan, Fatih, Benjamin Pugsley, Ryan Michaels, Ayşegül Şahin, and Rachel Schuh. 2017. "Do Job-to-Job Transitions Drive Wage Fluctuations Over the Business Cycle?" *American Economic Review: Papers & Proceedings 2017* 107(5): 353-357.

[24] Kudlyak, Marianna. 2014. "The Cyclicality of the User Cost of Labor." *Journal of Monetary Economics* 68(1): 53-67.

[25] Kurmann, André, Erika McEntarfer, and James Spletzer. 2016. "Downward Wage Rigidity in the United States: New Evidence from Worker-Firm Linked Data." Unpublished draft, Drexel University.

[26] Lise, Jeremy, and Jean-Marc Robin. 2017. "The Macrodynamics of Sorting between Workers and Firms." *American Economic Review* 107(4): 1104-1135.

[27] Martins, Pedro, Gary Solon, and Jonathan Thomas. 2012. "Measuring What Employers Do about Entry Wages over the Business Cycle: A New Approach." *American Economic Journal: Macroeconomics* 4(4): 65-55.

[28] Moscarini, Giuseppe and Fabien Postel-Vinay. 2017. "The Relative Power of Employment-to-Employment Reallocation and Unemployment Exits in Predicting Wage Growth." *American Economic Review: Papers & Proceedings* 107(5): 364-368.

[29] Moscarini, Giuseppe, and Fabien Postel-Vinay. 2018. "The Cyclical Job Ladder." *Annual Review of Economics* 10(1): 165-188.

[30] Moscarini, Giuseppe, and Fabien Postel-Vinay. 2019. "The Job Ladder: Inflation vs. Reallocation." Unpublished draft, Yale University.

[31] Molloy, Raven, Christopher Smith, and Abigail Wozniak. 2014. "Declining Migration within the U.S.: The Role of the Labor Market." NBER Working Paper #20065.

[32] Mueller, Andreas. 2017. "Separations, Sorting, and Cyclical Unemployment." *American Economic Review* 107(7): 2081-2107.

[33] Mukoyama, Toshihiko. 2014. "The Cyclicality of Job-to-Job Transitions and Its Implications for Aggregate Productivity." *Journal of Economic Dynamics and Control* 39(1): 1-17.

[34] Pissarides, Christopher. 2009. "The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer?" *Econometrica* 77(5): 1339-1369.

[35] Postel-Vinay, Fabien and Jean-Marc Robin. 2002. "Equilibrium Wage Dispersion with Worker and Employer Heterogeneity," *Econometrica* 70(6): 2295-2350.

[36] Rubin, Donald. 1987. *Multiple Imputation for Nonresponse in Surveys*. New York: Wiley-Interscience Press.

[37] Salop, Stephen. 1979. "A Model of the Natural Rate of Unemployment." *American Economic Review* 69(1): 117-125.

[38] Schoefer, Benjamin. 2015. "The Financial Channel of Wage Rigidity." Unpublished draft, University of California, Berkeley.

[39] Shimer, Robert. 2005. “The Cyclical Behavior of Equilibrium Unemployment and Vacancies.” *American Economic Review* 95(1): 25-49.

[40] Topel, Robert, and Michael Ward. “Job Mobility and the Careers of Young Men.” *Quarterly Journal of Economics* 107(2): 439-479.

Appendices

A Definitions

This appendix provides definitions of employment and earnings concepts used in this paper and follows the notation in Abowd et al. (2009) and Hahn et al. (2017). Let w_{ijt} denote earnings for individual i from employer j in time t. If an individual has reported earnings from an employer in a given quarter and $w_{ijt} > 0$, then we infer the individual worked for the employer at some point during the quarter of interest and call this employer-employee combination a job.

A.1 Basic employment concepts

Following Hahn et al. (2017), we consider the subset of jobs that span two consecutive quarters. Formally, these are:

$$b_{ijt} = \begin{cases} 1, & \text{if } w_{ijt-1} > 0 \text{ and } w_{ijt} > 0 \\ 0, & \text{otherwise.} \end{cases}$$

Moreover, we only allow workers to have at most one job per quarter. Since LEHD administrative records lack employment start and end dates, we cannot distinguish between a worker holding multiple jobs and a worker transitioning between jobs in a given quarter. We therefore determine where workers are earning the most and call this the dominant job. Formally, this is:

$$d_{ijt} = \begin{cases} 1, & \text{if } b_{ijt} = 1 \text{ and} \\ & w_{ijt} + w_{ijt-1} > w_{ikt} + w_{ikt-1} \forall k \\ & \text{s.t. } b_{ikt} = 1 \text{ and} j \neq k \\ 0, & \text{otherwise.} \end{cases}$$

We then compare dominant employers across quarters and identify when a job transition has occurred.

For the study of earnings, it is also useful to introduce the concept of full quarter jobs. Full quarter jobs span three consecutive quarters, such that:

$$f_{ijt} = \begin{cases} 1, & \text{if} w_{ijt-1} > 0 \text{ and } w_{ijt} > 0 \text{ and } w_{ijt+1} > 0 \\ 0, & \text{otherwise.} \end{cases}$$

For these jobs, we assume employees worked the entire middle quarter and use total earnings from that quarter as their quarterly earnings rate.

We can now define four employment concepts: stayers, employer-to-employer transitions, workers exiting to nonemployment, and hires from nonemployment. We can also define earnings associated with these concepts. Note that while all full quarter jobs are consecutive quarter jobs, not all consecutive quarter jobs are full quarter jobs. We therefore restrict our employment concepts to subsets where full quarter earnings are available for times $t-1$ and t for stayers and employer-to-employer transitions, time t for workers exiting employment, and time $t-1$ for workers entering employment.

A.1.1 Stayers

Stayers are workers who do not change employers and thus have the same dominant job in times t and $t+1$. Formally,

$$s_{ijt} = \begin{cases} 1, & \text{if } d_{ijt} = 1 \text{ and } d_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

Since stayers are employed by the same employer in times $t-1$, t, and $t+1$, they at minimum have full quarter earnings observations in time t.

A.1.2 Employer-to-employer transitions

Workers undergoing an employer-to-employer transition exhibit a change in dominant job, moving from an old dominant job in time t to a new dominant job in time $t+1$. Note that in time t, they are receiving earnings from both jobs, suggesting they separated from the old employer and started employment with the new employer in the same quarter. Hahn et al. (2017) consequently refer to these transitions as "within-quarter" employer-to-employer transitions.[26] For this paper, we consider the subset of these transitions where full quarter earnings are available for both the old

[26]Note we consider transitions where earnings from the old employer are observed in the quarter immediately preceding the first quarter when earnings at the new employer are observed to be incumbent workers exiting employment and hires from nonemployment since they commonly contain short spells of nonemployment. Hahn et al. (2017) refer to these transitions as "adjacent-quarter" employer-to-employer transitions. However, the findings reported in this paper are not sensitive to whether adjacent-quarter transitions are categorized as employer-to-employer transitions or nonemployment transitions. Note these transitions exclude spurious employer identifier changes using the methodology outlined in Abowd et al. (2009).

and new dominant job. Formally, our employer-to-employer transitions are those where:

$$q_{ijkt} = \begin{cases} 1, & \text{if } d_{ijt} = 1 \text{ and } d_{ikt+1} = 1 \\ & \text{and } f_{ijt-1} = 1 \text{ and } f_{ikt+1} = 1 \\ & \text{and } j \neq k \\ 0, & \text{otherwise.} \end{cases}$$

A.1.3 Nonemployment transitions

There are two types of nonemployment transitions. If a worker had a dominant job in time t but not in time $t+1$, then the worker transitioned from employment to nonemployment. Likewise, if a worker does not have a dominant job in time t but does in time $t+1$, then the worker transitioned from nonemployment into employment during time t. For this analysis, we consider the subset of nonemployment transitions that have full quarter earnings observations.

Incumbent workers exiting employment in time t are those where:

$$r_{ijt} = \begin{cases} 1, & \text{if } d_{ijt} = 1 \text{ and } f_{ijt-1} = 1 \\ & \text{and } d_{ilt+1} \neq 1 \forall l, \\ 1, & \text{if } d_{ijt} = 1 \text{ and } f_{ijt-1} = 1 \\ & \text{and } d_{ikt+1} = 1 \text{ and } f_{ikt} = 0 \text{ and } f_{ikt+1} = 0 \\ 0, & \text{otherwise.} \end{cases}$$

Hires from nonemployment into employment in time t have full quarter earnings when:

$$n_{ikt} = \begin{cases} 1, & \text{if } d_{ikt+1} = 1 \text{ and } f_{ikt+1} = 1 \\ & \text{and } d_{ilt} \neq 1 \forall l \\ 1, & \text{if } d_{ijt} = 1 \text{ and } f_{ijt-1} = 1 \\ & \text{and } d_{ikt+1} = 1 \text{ and } f_{ikt} = 0 \text{ and } f_{ikt+1} = 0 \\ 0, & \text{otherwise.} \end{cases}$$

A.2 Earnings

Since the data do not include employment start or end dates, we do not know if earnings were received for work completed throughout the entire quarter or simply a portion of it. We therefore rely on a "full quarter" earnings concept that underlies the published LEHD data; see Abowd et al. (2009) and Hahn et al. (2017). When jobs span three consecutive quarters, we assume employees

worked the entire middle quarter and take the total earnings from that quarter to be their quarterly earnings rate. All data are winsorized at the 95th percentile.

When both quarters in a consecutive quarter pair have full quarter earnings, we use the average of the two as earnings for that job. Otherwise, if only one has full quarter earnings, then we use that quarterly earnings rate. Earnings are therefore defined as follows:

$$e_{ikt} = \begin{cases} \frac{w_{ikt}+w_{ikt+1}}{2}, & \text{if } d_{ikt}=1 \text{ and } f_{ikt}=1 \text{ and } f_{ikt+1}=1 \\ w_{ikt}, & \text{if if } d_{ikt}=1 \text{ and } f_{ikt}=1 \text{ and } f_{ikt+1}=0 \\ w_{ikt+1}, & \text{if if } d_{ikt}=1 \text{ and } f_{ikt}=0 \text{ and } f_{ikt+1}=1 \\ 0, & \text{otherwise.} \end{cases}$$

This helps to ensure symmetry. Consider the following example. For a stayer in time t whose dominant job spans four quarters from time $t-2$ to time $t+1$, we calculate earnings change from time t to time $t+1$ as the difference between the average of full quarter earnings from times t and $t-1$ and the average of full quarter earnings from times $t+1$ and t. Since full quarter earnings for time t cancel, earnings change ends up being the difference in full quarter earnings between quarters $t+1$ and $t-1$, divided by two. Now, take the case of an employer-to-employer transition where the old job spans from time $t-2$ to time t and the new job spans from time t to time $t+2$. Earnings change is equal to the difference between the full quarter earnings for the new job in time $t+1$ and the old job in time $t-1$. Both calculations thus use full quarter earnings from the same quarters to estimate earnings growth, despite being for different types of employment transitions.

Finally, we note that each definition presented in this section has an hours and a wage analog, which we do not list here to save space and avoid redundancy. To calculate wages, each positive earnings measure is divided by hours.

B Hours imputation

For observations without hours data in our eleven state dataset, we impute hours values using models estimated on our four states dataset, which has data on hours *paid* between 1994 and 2016. The underlying microdata starts in 1994, but since we use a two year measure of job tenure in our imputation, we omit the first two years from our analysis so our hours imputation is not biased. Models are estimated separately for each worker type c and are simulated from the posterior predictive distribution of parameters. Imputed values of hours are then drawn, see Rubin (1987).

The model takes the following form:

$$h_{itc} = Z_{itc}\sigma_Z^c + M_{itc}\sigma_M^c + G_{itc}\sigma_G^c + Q_{itc}\sigma_Q^c + \mu_{itc}^c$$

where h_{itc} denotes log hours for worker i of worker type c at time t. The matrix Z_{itc} is a vector of worker-specific demographics (i.e. sex, age, age-squared, level of completed education, race, and tenure) with marginal effects σ_Z^c, M_{itc} is a vector of employer characteristics (i.e. industry group, firm age group, and firm size category) and worker earnings (and earnings-squared and earnings-cubed) with marginal effects σ_M^c, G_{itc} is a vector of geography characteristics (i.e. the number of average hours worked and the unemployment rate in the employer's state) with marginal effects σ_G^c, Q_{itc} is a vector of quarter characteristics (i.e. quarter dummies and the number of Fridays in quarter with a lead and a lag) with marginal effects σ_Q^c, and μ_{itc}^c is an i.i.d. error term. All continuous variables are defined in logs.

Point estimates from a diagnostic regression are provided in Table B1, where c is defined over stayers, employer-to-employer transitions, and hires from nonemployment, for exposition. The regressions estimated in the model are done on a finer level of disaggregation before any averaging detailed in Appendix A is done.

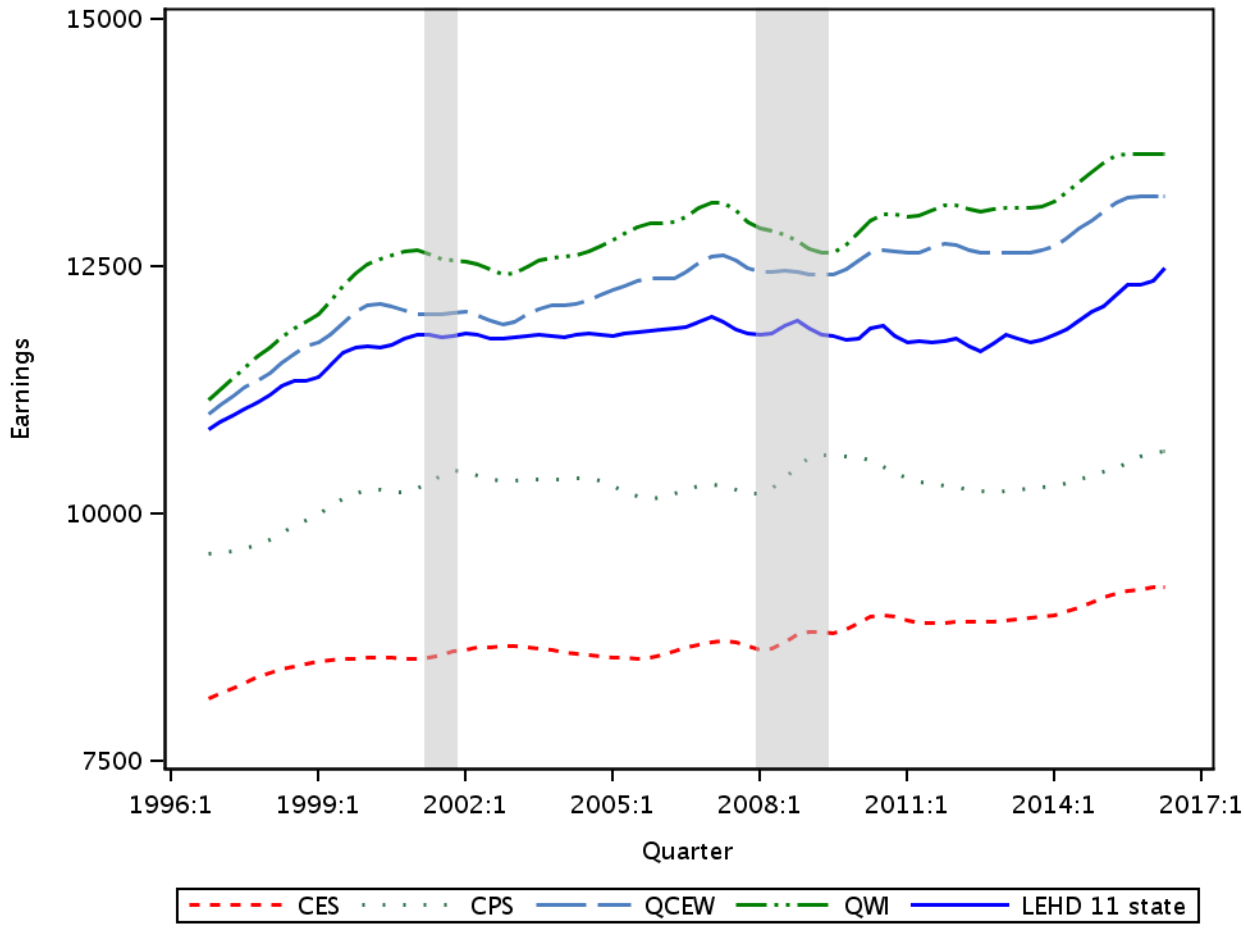
Our hours imputation does have some limitations. We do not allow for state-fixed effects that account for systematic differences in hours across states beyond those accounted for by observable explanatory variables, such as worker demographics and firm characteristics. Furthermore, if states have idiosyncratic components that have an effect on cyclical fluctuations on earnings, hours, and wages, then these components are magnified here. In Appendix C, we further evaluate the quality of our hours imputation by comparing our average hours and wages series with those available from other sources.

Table B1: Hours imputation: point estimates from diagnostic regression

	Stayers	Emp.-to-emp.	Entrants
Earnings	11.50***	6.789***	11.72***
	(0.058)	(0.392)	(0.225)
Earnings^2	-1.060***	-0.519***	-1.074***
	(0.007)	(0.045)	(0.026)
Earnings^3	0.032***	0.012***	0.032***
	(0.000)	(0.002)	(0.001)
Tenure	-0.015		
	(0.000)		
Age	-0.006***	-0.010***	-0.007***
	(0.000)	(0.000)	(0.000)
Age^2/1000	0.054***	0.095***	0.063***
	(0.000)	(0.000)	(0.000)
State avg. hours worked	-0.006***	-0.006***	-0.006***
	(0.000)	(0.002)	(0.001)
State unemployment rate	-0.004***	-0.001	-0.002***
	(0.000)	(0.001)	(0.000)
No. of Fridays	0.005***	-0.001	-0.001
	(0.001)	(0.003)	(0.002)
R^2	0.599	0.667	0.727

Notes: Variables included in the diagnostic regression but not in the table above include a quadratic function of time, as well as dummy variables for worker demographics (i.e. sex, race, and level of completed education) and destination firm characteristics (i.e. industry group, firm age group, and firm size category).

Figure C1: Average earnings in the U.S.



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. CES indicates the Current Employment Statistics' average weekly earnings series for production and nonsupervisory employees in the private sector, multiplied by 13. CPS indicates the Current Population Survey's median usual weekly earnings series for full-time wage and salary workers in all industries and occupations who are 16+ years old, multiplied by 13. QCEW indicates the Bureau of Labor Statistics' average weekly earnings series of all employees in the private sector, multiplied by 13. QWI indicates the LEHD Quarterly Workforce Indicators' average monthly earnings series of employees with stable jobs, (i.e. worked with the same firm throughout the quarter), multiplied by 3. LEHD 11 state indicates the average earnings series from our eleven state dataset.

C Comparability of LEHD earnings, hours, and wages to other U.S. data sources

Figure C1 shows the trend in earnings for our eleven state dataset and compares it with other series available from the Current Employment Statistics (CES), the CPS, and the Quarterly Census of Employment and Wages (QCEW). While there are notable differences among them, all trend

upward and exhibit sharp gains during the late 1990s.[27] Our series (solid line) shows higher levels of wage and salary compensation from employers than others do, with the exception the LEHD Quarterly Workforce Indicators (LEHD QWI) average monthly (full-quarter) earnings line (long dash-dot-dot line). At the same time, average earnings from our eleven state dataset tracks both the Average Weekly Wage published as part of the Quarterly Census of Employment and Wages (QCEW) (long dash-medium dash line) and LEHD QWI series fairly closely, with correaltions of 0.90 and 0.94, respectively.[28] This suggests the differences seen in the figure can generally be attributed to differences in data sources and tabulation strategies.

In Figure C2, we present our imputed hours series from our eleven state dataset alongside hours series available from the CES and CPS.[29] We also include our non-imputed hours series from our four state dataset, which starts in 2011Q3 since hours data for our four state dataset are only complete beginning in that quarter. Overall, our imputed hours series (solid line) appears to be comparable to the three outside hours series between 2000 and 2014. It lies consistently above the CES line (dash line) and below the two CPS lines (dotted and dash-dot lines) and exhibits similar behaviors, with all series indicating that hours remained constant until the 2007-2009 recession when they declined. While the CES, CPS (full-time), and CPS lines exhibit larger drops in hours than our imputed hours series, all show a slight recovery in hours after 2010. After 2014, our imputed series shows a sharp gain in hours while the other lines are mostly flat. We believe this difference is not related to the quality of our hours impute since our non-imputed series (dash-dot-dot line) also increases at a similar rate.

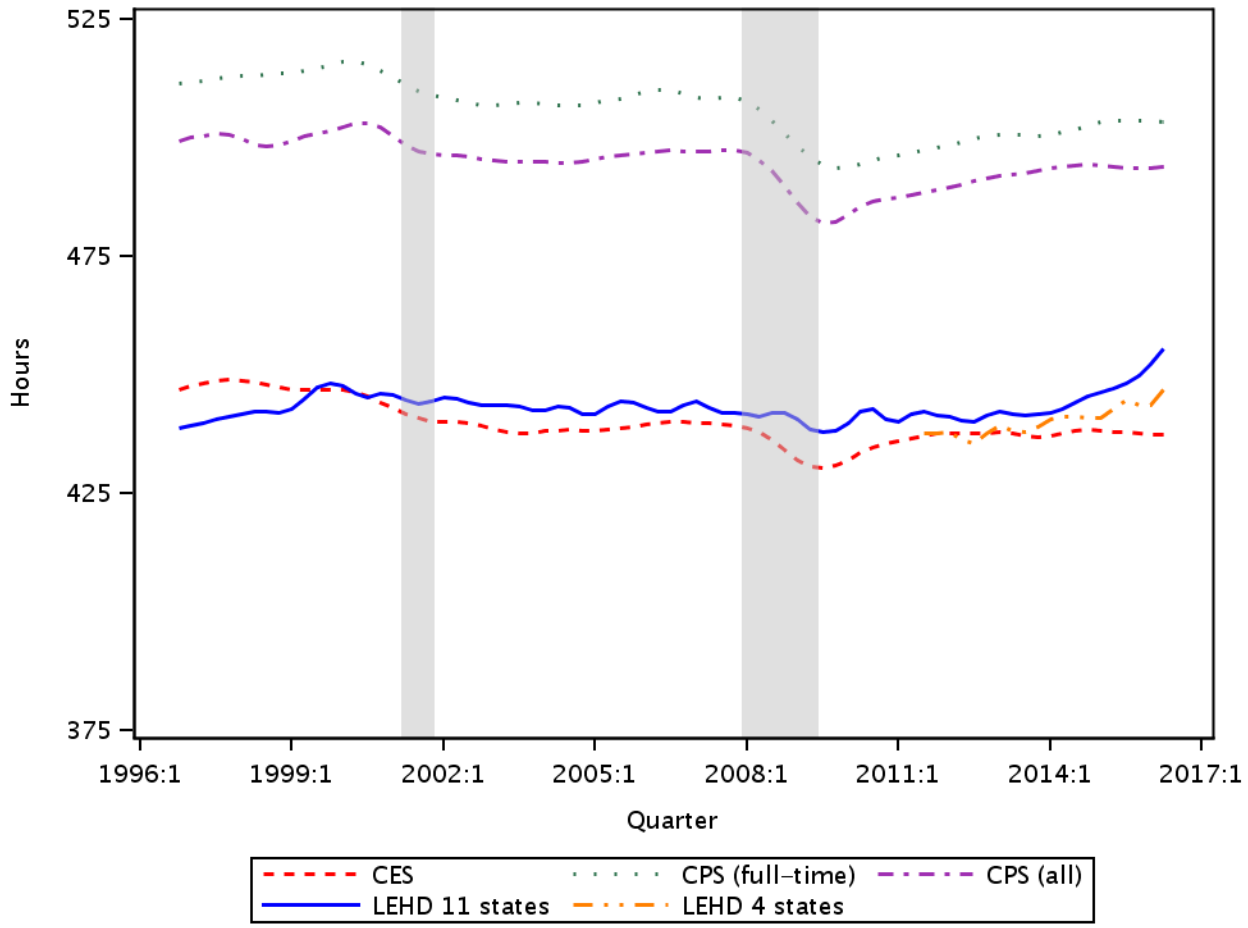
Figure C3 shows our imputed wage series from our eleven state dataset as well as other wage series available from the CES and Employer Costs for Employee Compensation (ECEC). Also included is our non-imputed wage series from our four state dataset, again only starting in 2011Q3 when hours data begin to be complete. Our imputed wage series (solid line) is similar to the others in the figure, with all lines suggests wages rose during the late 1990s and were subsequently flat.

[27] Differences among earnings series have been noted by Abraham, Spletzer, and Stewart (1998) as well as Champagne, Kurmann, and Stewart (2017).

[28] We expect our series to be most similar to the Average Weekly Wage series (QCEW) created as part of the Quarterly Census of Employment and Wages program and the Average Monthly Earnings series from LEHD's QWI (LEHD QWI). These data series rely on use universe-level, employer-reported total wage and salary payments calculated from administrative records used in the adminsitration of state unemployment insurance records. Differences primarily lie in the types of jobs included in the average. The QCEW series counts jobs where workers are employed during the week of the 12th in the third month of the quarter while the LEHD QWI series includes all jobs that span at least three consecutive quarters. Our series is essentially a subset of the latter as it includes all *dominant* jobs that span at least three consecutive quarters. Our eleven state series is somewhat lower than the QCEW and QWI because we winsorize our data at the 95th percentile.

[29] The CPS hours series is created from microdata available from IPUMS (Flood et al., 2017).

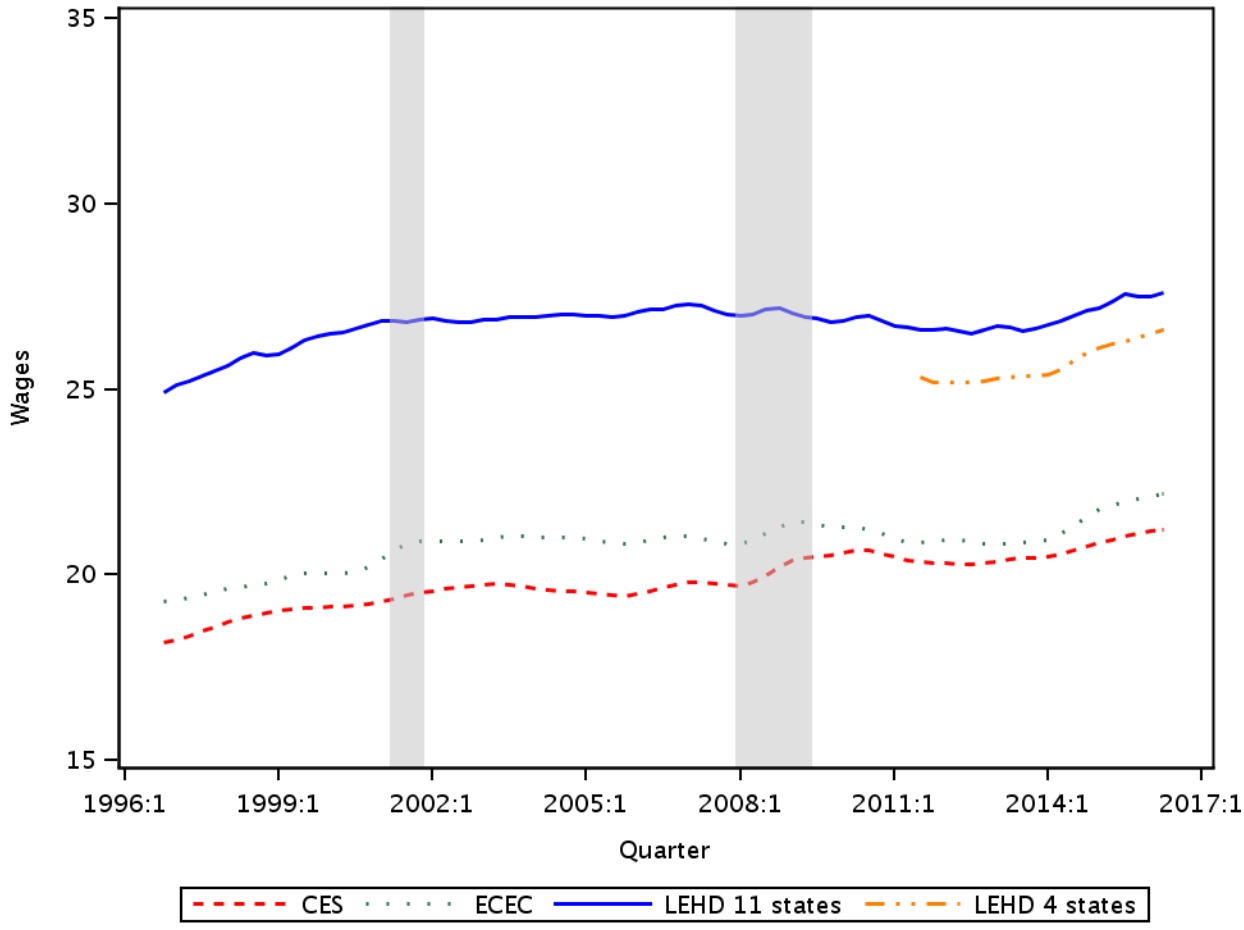
Figure C2: Average hours in the U.S.



Notes: All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. CES indicates the Current Employment Statistics' average weekly hours series for production and nonsupervisory employees in the private sector, multiplied by 13. CPS (Full-Time) indicates the average total hours at work series for workers in all industries who are 16+ years, multiplied by 13. CPS indicates the Current Population Survey's hours worked last week series, multiplied by 13, calculated directly from CPS microdata (see Appendix B). LEHD 11 state indicates the average earnings series from our eleven state dataset. LEHD 4 state indicates the average non-imputed hours series from our four state dataset.

While the other series show a slight increase in wages during the Great Recession, our imputed series suggests wages remained roughly the same. However, all lines do display a small rise in wages at the end of the time series. Our imputed series is substantially higher than the others, with the exception of the ECEC's total compensation line (dash-dot line), but it is similar in level to our non-imputed series (dash-dot-dot line).

Figure C3: Average wages in the U.S.



Notes: Wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. CES indicates the Current Employment Statistics' average hourly earnings series for production and nonsupervisory employees in the private sector. ECEC indicates the Employer Costs of Employee Compensation Survey's cost per hour worked (wages and salaries) series of all private industry employees for all occupations. LEHD 11 State indicates the average earnings series from our eleven state dataset. LEHD 4 State indicates the average non-imputed wage series from our four state dataset.

D Additional descriptive evidence

D.1 Employment shares

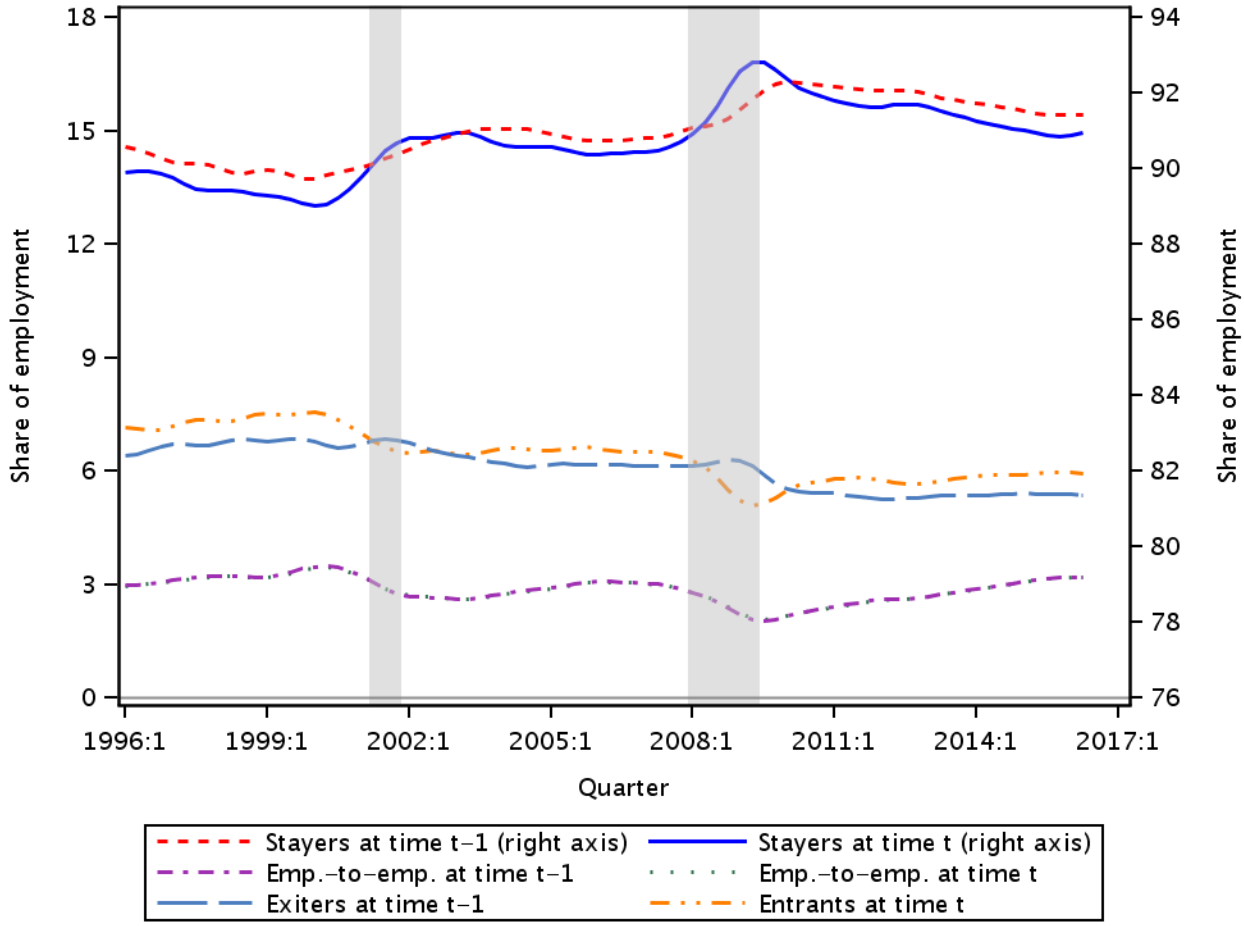
We here describe how the stayer and transitioner shares of employment evolved over time. Figure D1 shows the average employment shares among all workers in our eleven state dataset. Figure D2(a) shows how they evolved among all workers in our four state dataset.

Stayers S_t and employer-to-employer transitions Q_t contribute to employment at times $t-1$ and t. Exiters R_t only contribute to employment at time $t-1$ and entrants N_t only contribute to employment at time t, as $S_t + Q_t + R_t = D_{t-1}$ and $S_t + Q_t + N_t = D_t$. Note that employment growth implies that stayers and employment transitions decline as a share of employment from time $t-1$ to time t. This occurs because if entrants exceed exiters, then $N_t > R_t$, and so $D_t > D_{t-1}$, and consequently $S_t/D_t < S_t/D_{t-1}$ and $Q_t/D_t < Q_t/D_{t-1}$.

As we show in Figure D1, from 1996 to 2016, the vast majority of workers were job stayers, and therefore had the same employer its beginning (i.e., time $t-1$) and end (i.e., time t). Measured in terms of beginning of quarter employment, the share of job stayers S/D_{t-1} had an average of 91.0%. As employment generally grew during these years, the average share of job stayers at the end of the quarter S_t/D_t averaged 90.7%. Our results from our four state dataset, shown in Figure D2(a), allow us to consider years 2010-2016. The shares of job stayers were higher, averaging 92.1% (S_t/D_{t-1}) and 91.3% (S_t/D_t). These are close to the averages that we obtain for the same period from our 11 state dataset in Figure D1, which are 91.8%, and 91.4%, respectively: job stayers had a higher share toward the end of our time series.

The share of stayers declined during expansions and increased during contractions. As shown in Figure D1, both stayer series reached their lowest values in 2000, when S_t/D_{t-1} reached 89.7%, and S_t/D_t reached 89.0%. Stayers had their highest share of employment at the end of the 2007-2009 recession and the beginning of the subsequent expansion. In our eleven state dataset, S_t/D_{t-1} reached a maximum of 92.3% in 2010. S_t/D_t reached its highest value of 92.8% in 2009. The differences in timing and magnitude of the stayer share between these two series is driven by the dynamics of the denominator. Because employment declined sharply during the 2007-2009 recession, during these years the employment share of stayers was greater at the end of the quarter, i.e., $S_t/D_t > S_t/Dt-1$. Our four state dataset confirms that the shares of job stayers were high just after the end of the 2007-2009 recession. In Figure D2(a), the employment shares of job stayers were at their maximum values in 2010: 92.7% (S_t/D_{t-1}) and 92.1% (S_t/D_t).

Figure D1: Share of employment transitions, 1996-2016 (eleven states)



Notes: All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. "Stayers at time $t-1$" indicates the number of stayers divided by employment in time $t-1$. "Stayers at time t" indicates the number of stayers divided by employment in time t. "Emp-to-emp. at time $t-1$" indicates the number of employer-to-employer transitions divided by employment in time $t-1$. "Emp-to-emp. at time t" indicates the number of employer-to-employer transitions divided by employment in time t. "Exiters at time $t-1$" indicates the number of incumbent workers exiting employment divided by employment in time $t-1$. "Entrants at time t" indicates the number of hires from nonemployment divided by employment in time t.

The employment shares of employer-to-employer transitions were much smaller and evolved procyclically. As shown in Figure D1, from 1996 to 2016 between 2.0% and 3.5% of workers transitioned from employer-to-employer in any quarter, and the average across quarters was 2.9%. Because these shares were small, the different denominators D_t vs. D_{t-1} usually yielded percentages that were identical at the tenth of a decimal place. The share of employer-to-employer transitions reached a high of 3.5% in 2000. The share of employer-to-employer transitions reached lows of 2.1% (Q_t/D_{t-1}) and 2.0% (Q_t/D_t) at the end of the 2007-2009 recession. Our four state dataset confirms that the share of employer-to-employer transitions were low just after the end of the 2007-2009 recession. In Figure D2(a), the employer-to-employer transition rate starts at its minimum value of 2.1% in 2010. It subsequently increased, and it averaged 2.8% (in both the four state and eleven state datasets) from 2010-2016.

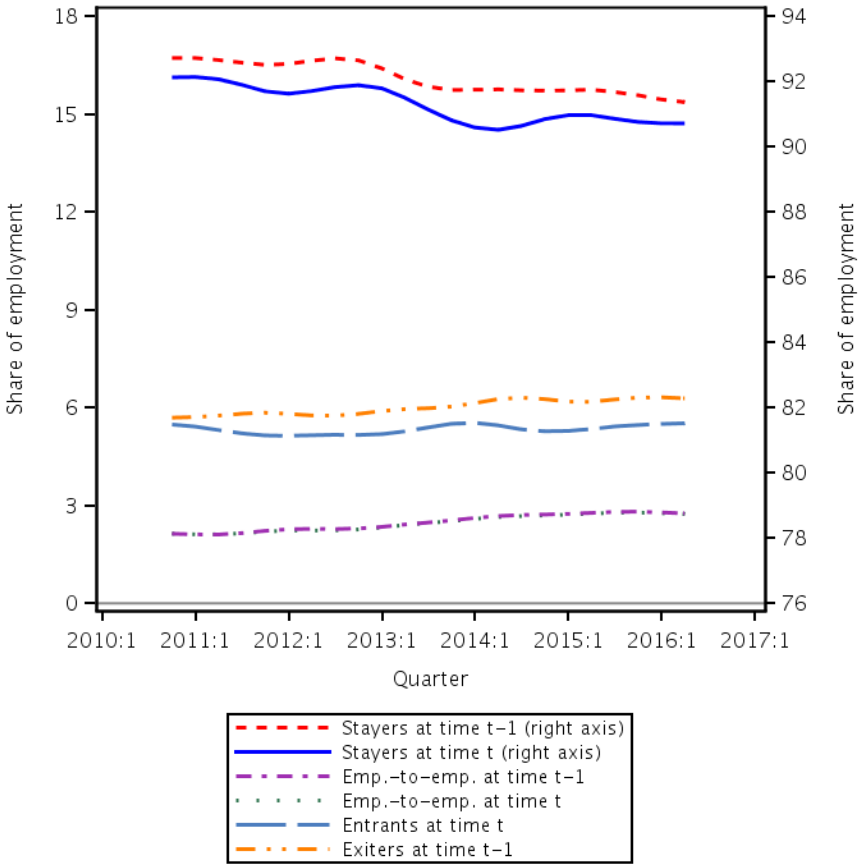
Of workers employed at the beginning of any quarter 1996-2016, on average 6.1% exited to nonemployment from 1996-2016, as shown in Figure D1. The share of exiters surged during the 2001 and 2007-2009 recessions, when it reached 6.8% and 6.3%, respectively. The share of exiters declined after the 2001 and 2007-2009 recession. It ranged from 6.4% to 6.8% prior to the 2001 recession and was much lower - in the range of 5.3% to 5.9% - after the 2007-2009 recession. Our four state dataset confirms the low exit rate in the years that followed the 2007-2009 recession. Figure D2(a) shows an exit rate of 5.1% to 5.5% for 2010-2016.

Of workers employed at the end of any quarter 1996-2016, on average 6.4% had just been hired from nonemployment, as shown in Figure D1. The rate at which workers entered from nonemployment declined sharply during and after the recessions of 2001 and 2007-2009, reaching lows of 6.5% and 5.1%, respectively. The employment share of entrants was ranged from 7.1% to 7.5% prior to the 2001 recession, and was in the lower range of 5.1% to 6.0% after the 2007-2009 recession. Our four state dataset shows that the employment share of entrants ranged from 5.7% to 6.3% from 2010-2016, see Figure D2(a).

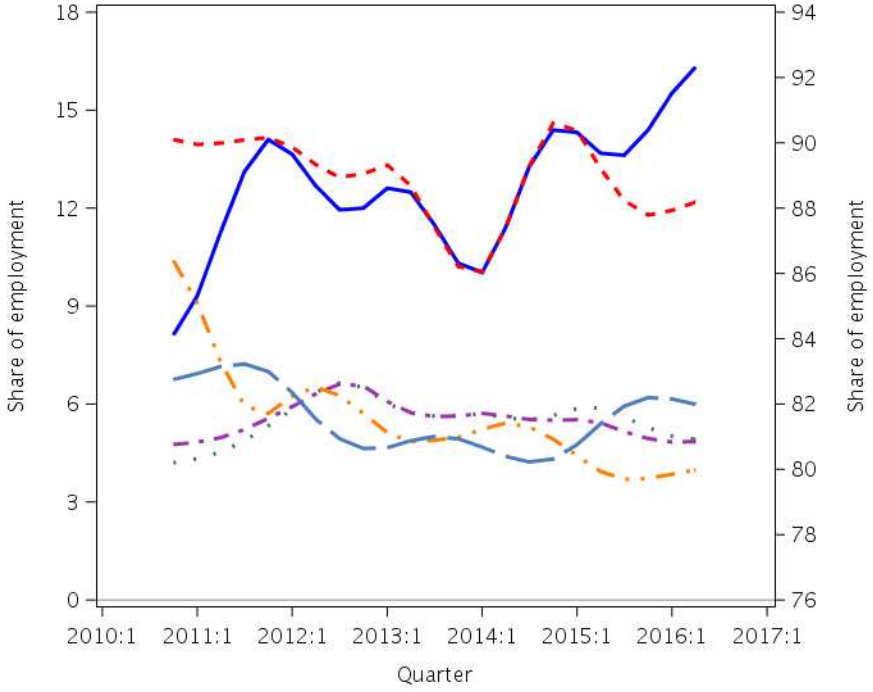
We now describe the transition dynamics of entry cohorts. The employment shares of stayers and transitions are shown in Figures D2(b) and D3 for our four state and eleven state datasets, respectively. Note that we start each series in the fourth quarter of their respective entry year, by which time all workers have entered employment at least once. While transition rates are small in any individual quarter, note that all transition rates series sum to well over 100%. This implies that workers in these entry cohorts had, on average, at least one employer-to-employer transition and at least one transition involving a spell of nonemployment.

Figure D2: Share of employment transitions, 2010-2016 (four states)

(a) 4-State Data



(b) 4-State Cohort Data



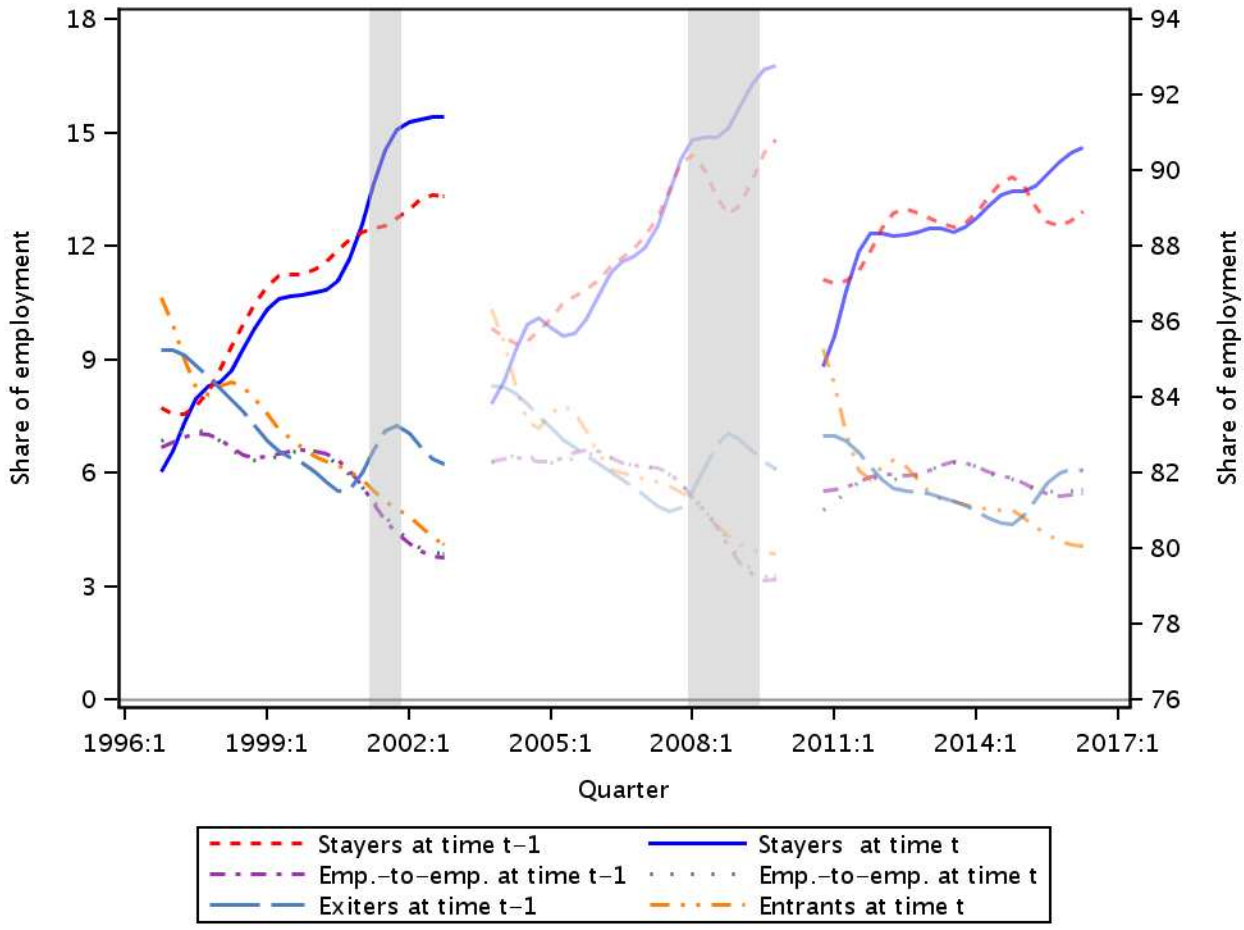
Notes: All results have been seasonally-adjusted and Henderson-filtered using x12. "Stayers at time $t-1$" indicates the number of stayers divided by employment in time $t-1$. "Stayers at time t" indicates the number of stayers divided by employment in time t. "Emp-to-emp. at time $t-1$" indicates the number of employer-to-employer transitions divided by employment in time $t-1$. "Emp-to-emp. at time t" indicates the number of employer-to-employer transitions divided by employment in time t. "Exiters at time $t-1$" indicates the number of incumbent workers exiting employment divided by employment in time $t-1$. "Entrants at time t" indicates the number of hires from nonemployment divided by employment in time t.

As entry cohorts spent longer in the labor market, they were more likely to be stayers. Note that in the first year, many workers were still entering, and so the initial D_t values better reflect the employment share of stayers than the much lower values of D_{t-1} in the initial quarter. To characterize the employment share of entrants, we therefore consider S_t/D_t (solid lines). See results from our eleven state dataset in Figure D3. In their first year, 82.1% of the 1996 cohort were stayers, 83.8% of the 2003 cohort were stayers, and for the 2010 cohort, 84.8% were stayers. Over time these shares increase to 91.4%, 92.8%, and 90.6%, respectively. Some of the increase in the share of job stayers for the 1996 and 2003 cohorts appears driven by the 2001 and 2007-2009 recessions. The relatively low growth among the 2010 cohort in the share of job stayers may be attributed to the economic expansion that occurred during their first seven years in the labor market. Our four state dataset offers additional evidence on workers who entered in 2010, see Figure D2(b). The increase in the share of stayers was somewhat larger, and increased from 84.1% in 2010 to 92.3% in 2016.

The share of employer-to-employer transitions declined over time for each of these entry cohorts. Results from our eleven state dataset are shown in Figure D3. Again, we focus on rates normalized by end of quarter employment, Q_t/D_t. The employer-to-employer transition rate started at 6.8% for the 1996 entry cohort, 6.3% for the 2003 entry cohort, and 5.0% for the 2010 entry cohort. The lower employer-to-employer transition rates for the 2003 and 2010 entry cohorts likely were caused by the lower employer-to-employer transition rate that prevailed when they entered the labor market. The 1996 entry cohort reached its maximum employer-to-employer transition rate of 7.2% in 1997, and steadily decline thereafter, reaching 3.9% in 2002. The 2003 entry cohort reached its maximum of 6.5% in 2005, and then declined to 3.3% in 2009. The 2010 entry cohort reached its maximum of 6.3% in 2013, and then declined to 5.5% in 2015 and 2016. Our four state dataset offers additional evidence on workers who entered in 2010, see Figure D2(b), and here we find an even more dramatic arc. The employer-to-employer transition rate in this dataset was initially 4.2%, reached a high of 6.7% in 2012, and then declined to 4.9% in 2016.

The entry rate of these entry cohorts naturally declined over time. Results from our eleven state dataset are shown in Figure D3. For the 1996 entry cohort, the share of entrants was initially 10.6%, and declined to 4.1% in 2002. For the 2003 entry cohort, the share of entrants was initially 10.3%, and declined to 3.9% in 2009. For the 2010 entry cohort, the share of entrants was initially 9.3%, and declined to 4.0% in 2016. The 2010 entry cohort from our four state dataset, shown in Figure D2(b), had a decline in its entry rate from 10.4% in 2010 to 4.0% in 2016.

Figure D3: Share of employment transitions, by cohort, 1996-2016 (eleven states)



Notes: All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. Years 1996-2002 present results for the 1996 entry cohort, years 2003-2009 present results for the 2003 entry cohort, and years 2010-2016 present results for the 2010 entry cohort.

The exit rate of recent entry cohorts followed a U-shaped pattern. Results from our eleven state dataset are shown in Figure D3. The 1996 entry cohort had an initial exit rate of 9.3%, which declined to 5.5% in 2000, and increased to 7.2% in 2001. The 2003 entry cohort had an initial exit rate of 8.3%, which declined to 5.0% in 2007, and increased to 7.0% in 2008. The 2010 entry cohort had an initial exit rate of 7.0%, which declined to 4.7% in 2014, and increased to 6.1% in 2016. The 2010 entry cohort from our four state dataset, shown in Figure D2(b), started with an exit rate of 7.0%, which declined to 4.3% in 2014, and increased to 6.2% in 2015 and 2016. The increase in the exit rate toward the end of the time series reflects our sample selection criterion that

required positive earnings in each of a span of several years, which we implemented to conform to the sample selection method of Topel and Ward (1992). The presence of positive earnings in the later years of our analysis dataset likely reflects a higher degree of employment attachment as in the earlier years. For example, our 2010 cohort is required to have positive earnings in all years 2010-2016. Workers employed in 2013 must have positive earnings in 2014, 2015, and 2016 to be included in our sample - but positive earnings in 2016 may be followed by zero earnings in the following years.

D.2 Earnings, hours, and wages

D.2.1 All workers

In Figure D4, we show average log quarterly earnings, hours, and wages for stayers and transitioners in our eleven state dataset for years 1996-2016. Note that hours and wages in our eleven state dataset are mostly imputed. In Figure D5, we show data from our four states that provide hours data, which does not include any imputed data on hours or wages.

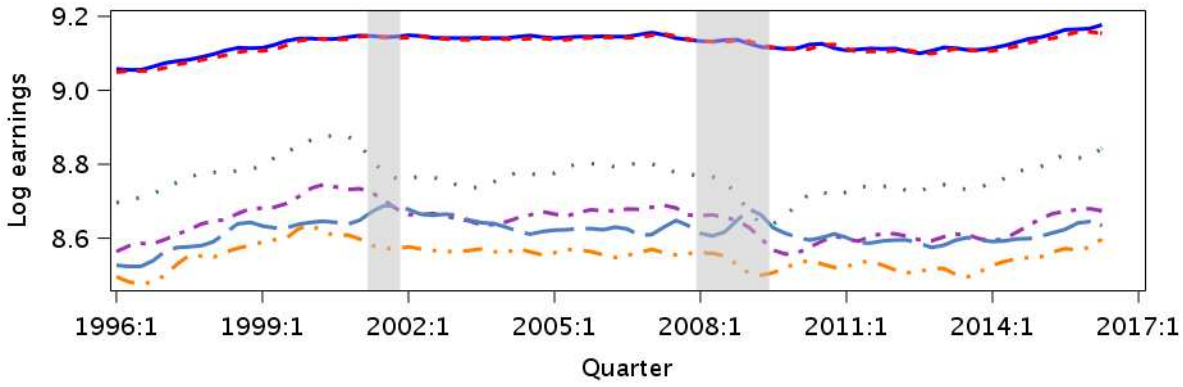
We show the evolution of the earnings, hours, and wages of job stayers in Figure D4. For stayers, we show, for each outcome y_t, its average at the beginning of the quarter $\frac{\Sigma_i s_{it} y_{it-1}}{S_t}$, and at the end of the quarter $\frac{\Sigma_i s_{it} y_{it}}{S_t}$. Results for earnings are shown in Figure D4(a). Average earnings, measured at the beginning of the quarter, was 9.12 ($9,136), and at the end of the quarter, it was 9.13 ($9,228). In our four state dataset, shown in Figure D5(a), average quarterly log earnings was 9.11 ($9,045) at the beginning of the quarter, and 9.12 at the end of the quarter.

Changes in stayer earnings are determined by changes in hours and wages. In our eleven state dataset, shown in Figure D4(b), average log quarterly hours was about 6.02 (407 hours). In our four state dataset, shown in Figure D5(b) average log quarterly hours was 6.04 (420). In our eleven state dataset, shown in Figure D4(c), the average of log wages was 3.10 ($22.20). In our four state dataset, shown in Figure D5(c) average log wages were 3.07 ($21.54) at the start of the quarter, and 3.08 ($21.75) at the end of the quarter.

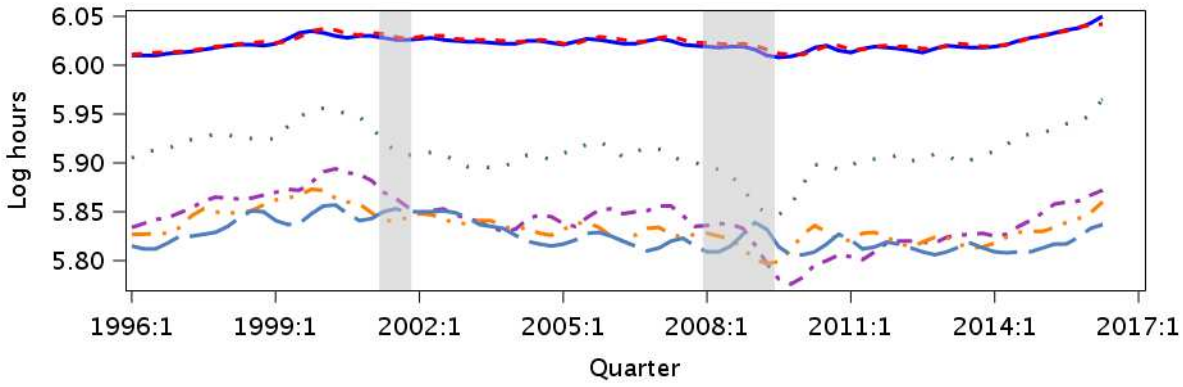
For employer-to-employer transitions, we consider average log at the beginning of the quarter $\frac{\Sigma_i q_{it} y_{it-1}}{Q_t}$ its value at the end of the quarter was $\frac{\Sigma_i q_{it} y_{it}}{Q_t}$. Employer-to-employer transitions led to substantial earnings increases. In our eleven state dataset, shown in Figure D4(a), average earnings for employer-to-employer transitions was 8.65 ($5,710) at the beginning of the quarter, and 8.77 ($6,438) at the end of the quarter. In our four state dataset, shown in Figure D5(b), average earnings was 8.60 ($5,432) at the beginning of the quarter, and 8.75 ($6,311) at the end of the quarter.

Figure D4: Average quarterly log earnings, hours, and wages for stayers and transitioners, 1996-2016 (eleven states)

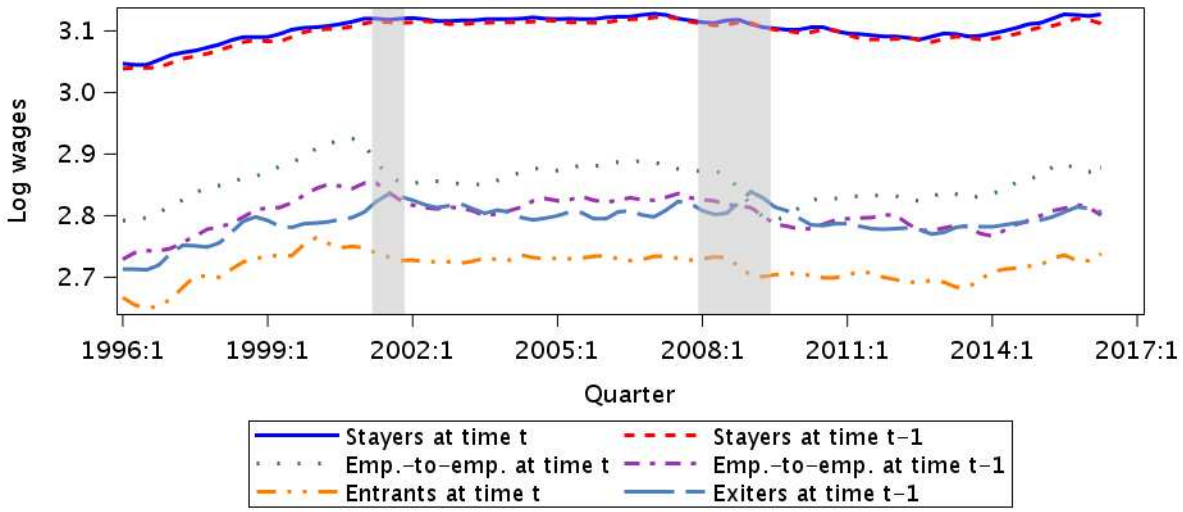
(a) Earnings



(b) Hours



(c) Wages



Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions.

The earnings gains associated with employer-to-employer transitions can be attributed to increases in both hours and wages. In our eleven state dataset, shown in Figure D4(a), average hours for employer-to-employer transitions was 5.84 (344) at the beginning of the quarter, and 5.91 (369) at the end of the quarter. Results from our four state dataset, shown in Figure D5(b), show average hours of 5.84 at the beginning of the quarter, and 5.93 (376) at the end of the quarter. In our eleven state dataset, shown in Figure D4(a), average wages for employer-to-employer transitions was 2.80 ($16.44) at the beginning of the quarter, and 2.86 ($17.46) at the end of the quarter. Results from our four state dataset, shown in Figure D5(c), show average wages of 2.76 ($15.80) at the beginning of the quarter, and 2.82 ($16.78) at the end of the quarter.

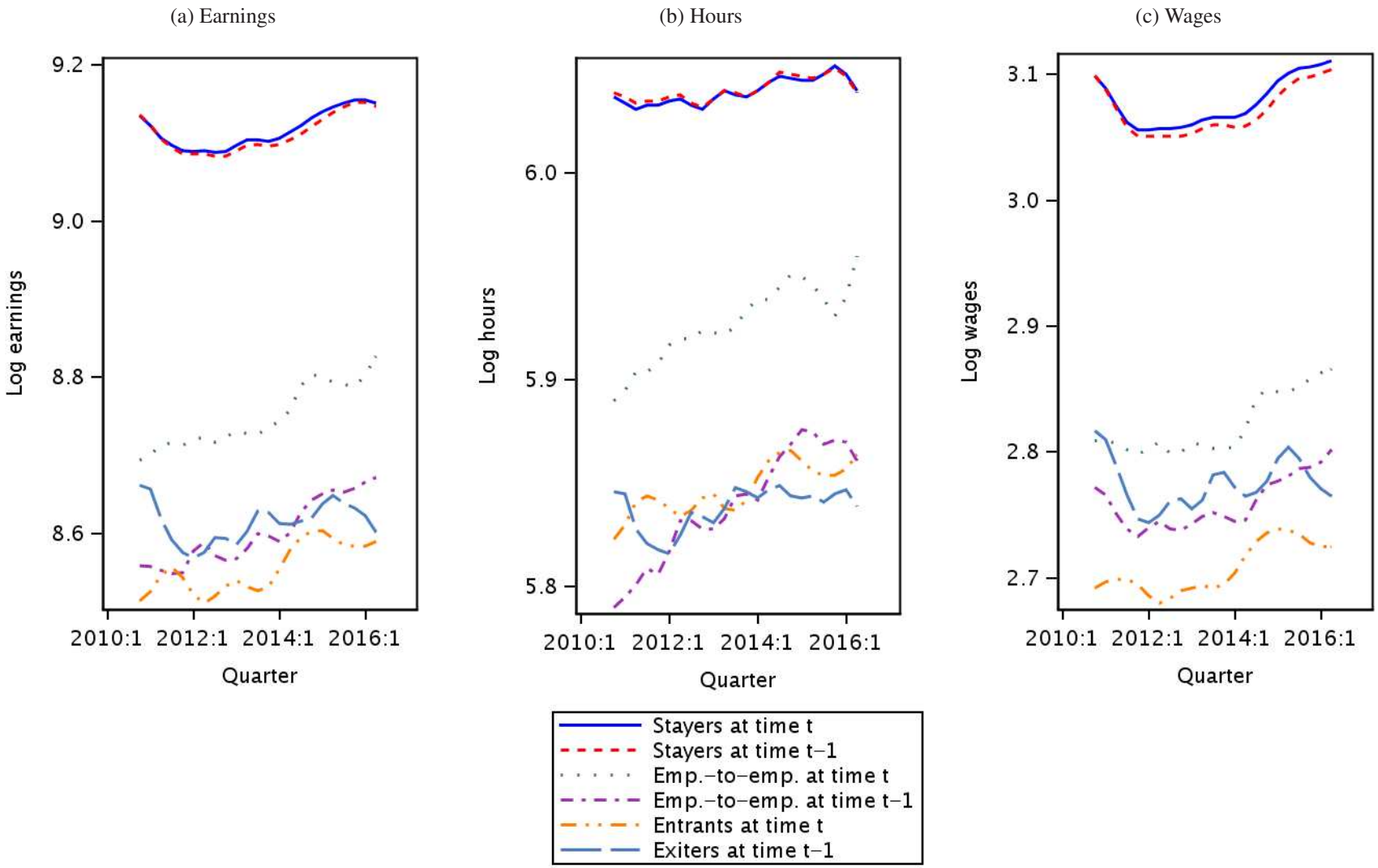
For entrants, we plot $\frac{\Sigma_i n_{it} y_{it-1}}{N_t}$. In our eleven state dataset, see Figure D4(a), average earnings of entrants was 8.55 ($5,167), while in our four state dataset, see Figure D5(a), average earnings was 8.56 ($5,219). In our eleven state dataset, see Figure D4(b), average hours of entrants was 5.83 (341), while in our four state dataset, see Figure D5(b), average hours was 5.85 (347). In our eleven state dataset, see Figure D4(c), average wages of entrants was 2.72 ($15.18), while in our four state dataset, see Figure D5(c), average wages was 2.71 ($15.03).

For exiters, we plot $\frac{\Sigma_i r_{it} y_{it-1}}{R_t}$. In our eleven state dataset, see Figure D4(a), average earnings of exiters was 8.62 ($5,541), while in our four state dataset, see Figure D5(a), average earnings was 8.61 ($5,486). In our eleven state dataset, see Figure D4(b), average hours of exiters was 5.83 (341), while in our four state dataset, see Figure D5(b), average hours was 5.84 (344). In our eleven state dataset, see Figure D4(c), average wages of exiters was 2.79 ($16.28), while in our four state dataset, see Figure D5(c), average wages was 2.77 ($15.96).

In Figure D6, we provide additional detail on the changes in earnings, hours, and wages, as they enter into the main decomposition Equation 2 for our four states with hours data. For stayers, we plot the change $\frac{\Sigma_i s_{it} \Delta y_{it}}{S_t}$. Stayers had small changes in earnings, hours, and wages. Earnings changes of job stayers ranged from 0.0% to 1.1% (Figure D6(a)), and were driven by changes in wages, which similarly ranged from 0% to 1.3% (Figure D6(s)). Hours changes for stayers were relatively small and ranged from -0.3% to 0.1% (Figure D6(b)).

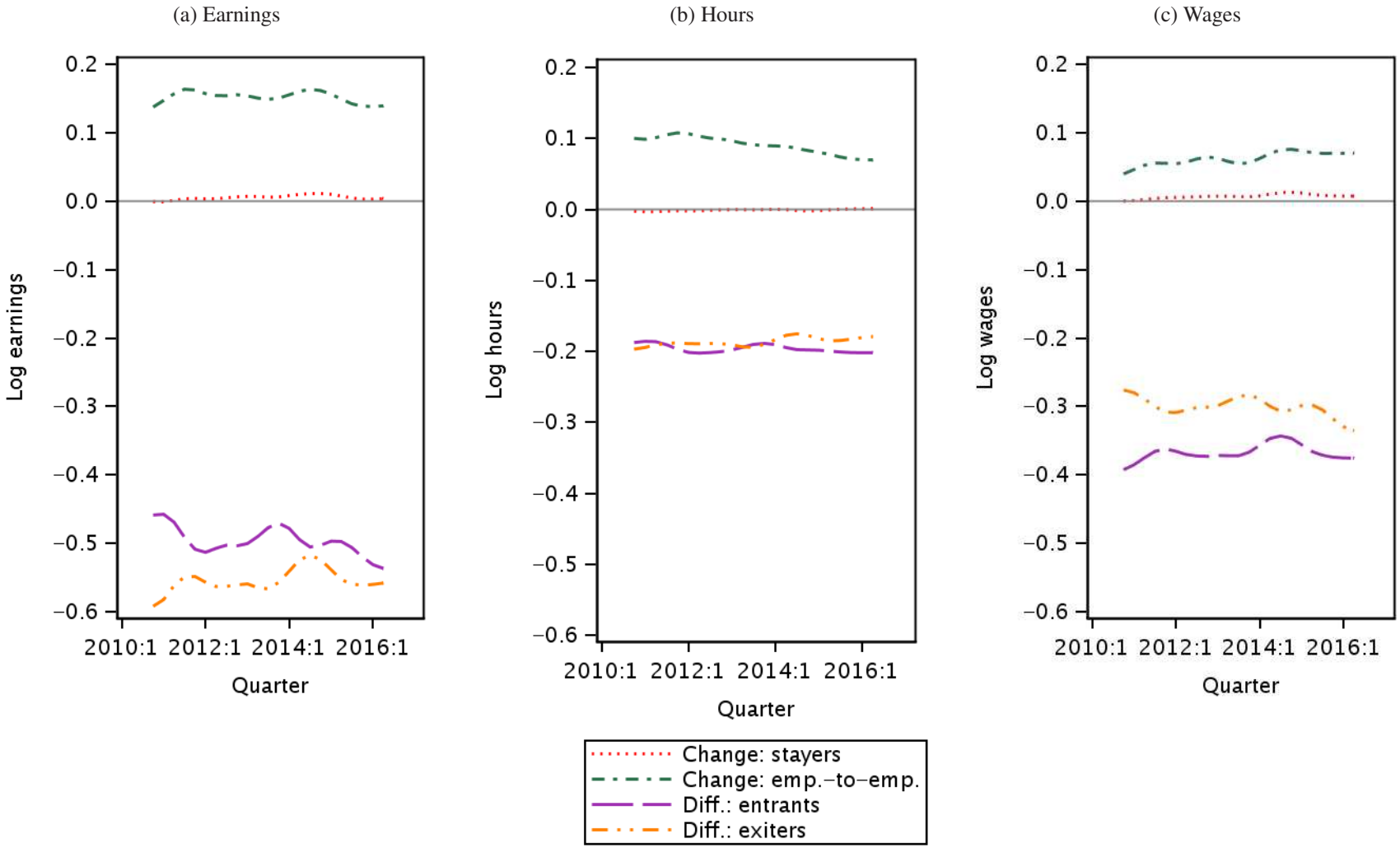
For employer-to-employer transitions, we plot the change in earnings $\frac{\Sigma_i q_{it} \Delta y_{it}}{Q_t}$. Employer-to-employer transitions were associated with larger changes in earnings, hours, and wages. Earnings changes associated with employer-to-employer transitions ranged from 13.8% to 16.3%, and averaged 15.2%, see Figure D6(a). These earnings gains were due to increases in both hours and wages. Hours increases associated with employer-to-employer transitions ranged from 7.0% and

Figure D5: Average quarterly log earnings, hours, and wages for stayers and transitioners, 2010-2016 (four states)



Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12.

Figure D6: Average quarterly log earnings, hours, and wages changes for stayers and transitioners, 2010-2016 (four states)



Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12.

10.8%, and averaged 9.1%, see Figure D6(b). These hours increases declined slightly over time. Wage increases for employer-to-employer transitions were somewhat smaller and still substantial, see Figure D6(c). These increases ranged from 4.0% to 7.6%, and averaged 6.2%.

Entrants and exiters had lower average earnings, hours, and wages than incumbent workers. For entrants from nonemployment, we plot earnings relative to the average of the continuously employed $\frac{\Sigma_i n_{it} y_{it-1}}{N_t} - \tilde{y}_t$. Entrants from nonemployment had earnings that were 51.8% to 59.2% lower than incumbent workers, and were on average 55.5% lower, see Figure D6(a). These differences were due to both the lower earnings and wages of entrants. Entrants had hours that were 17.5% to 19.6% lower than incumbent workers, see Figure D6(b). Wage differentials were larger and ranged from 34.3% to 39.2%, see Figure D6(c).

For exiters to nonemployment, we plot $\frac{\Sigma_i r_{it} y_{it-1}}{R_t} - \tilde{y}_t$. Exiters to nonemployment had earnings that were 45.8% to 53.7% lower than incumbent workers, see Figure D6(a). These differences were due to both the lower hours and wages of exiters. Exiters had hours that were 18.6% to 20.2% lower than incumbent workers, see Figure D6(b). Wage differentials were larger and ranged from 27.6% to 33.5%, see Figure D6(c).

D.2.2 Entry cohorts

We show the earnings of entry cohorts in Figures D7 and D8 for our eleven state and four state datasets, respectively. We provide details on the transformations of average earnings, hours, and wages as they enter into our main decomposition Equation (2) in Figures D9 and D10 four our eleven state and four state datasets, respectively. Note that we begin our analysis in the fourth quarter of the entry year for each cohort, by which quarter all members of the cohort have worked at least once. We proceed to explain these figures in detail, but first, the reader should note a few patterns from these figures. First, the earnings, hours, and wages of entry cohorts increased over time, and these increases are reflected by job stayers and workers undergoing each type of transition. Second, there is a widening gap between the earnings job stayers and transitioners. Third, earnings outcomes were affected by the 2001 and 2007-2009 recessions.

Job stayers generally had higher earnings, hours, and wages than transitioners. For stayers, we show, for each outcome y_t, its average at the beginning of the quarter $\frac{\Sigma_i s_{it} y_{it-1}}{S_t}$, and at the end of the quarter $\frac{\Sigma_i s_{it} y_{it}}{S_t}$. These are presented in Figures D7 and D8. Note that end of quarter earnings generally exceed beginning of quarter earnings by a small amount. For ease of exposition, we focus on end of quarter stayer earnings $\frac{\Sigma_i s_{it} y_{it}}{S_t}$. In our eleven state dataset, members of entry

cohorts started with average log quarterly earnings of 8.28 ($3,944) to 8.35 ($4,230), see Figure D7. Average earnings associated with stayers increased substantially over time and reached 8.96 ($7,785) to 9.08 ($8,778). Job stayers in the 2010 entry cohort in our four state dataset had similar changes in average earnings. As shown in Figure D8(a), the average earnings of stayers increased from 8.28 to 9.09 ($8,866).

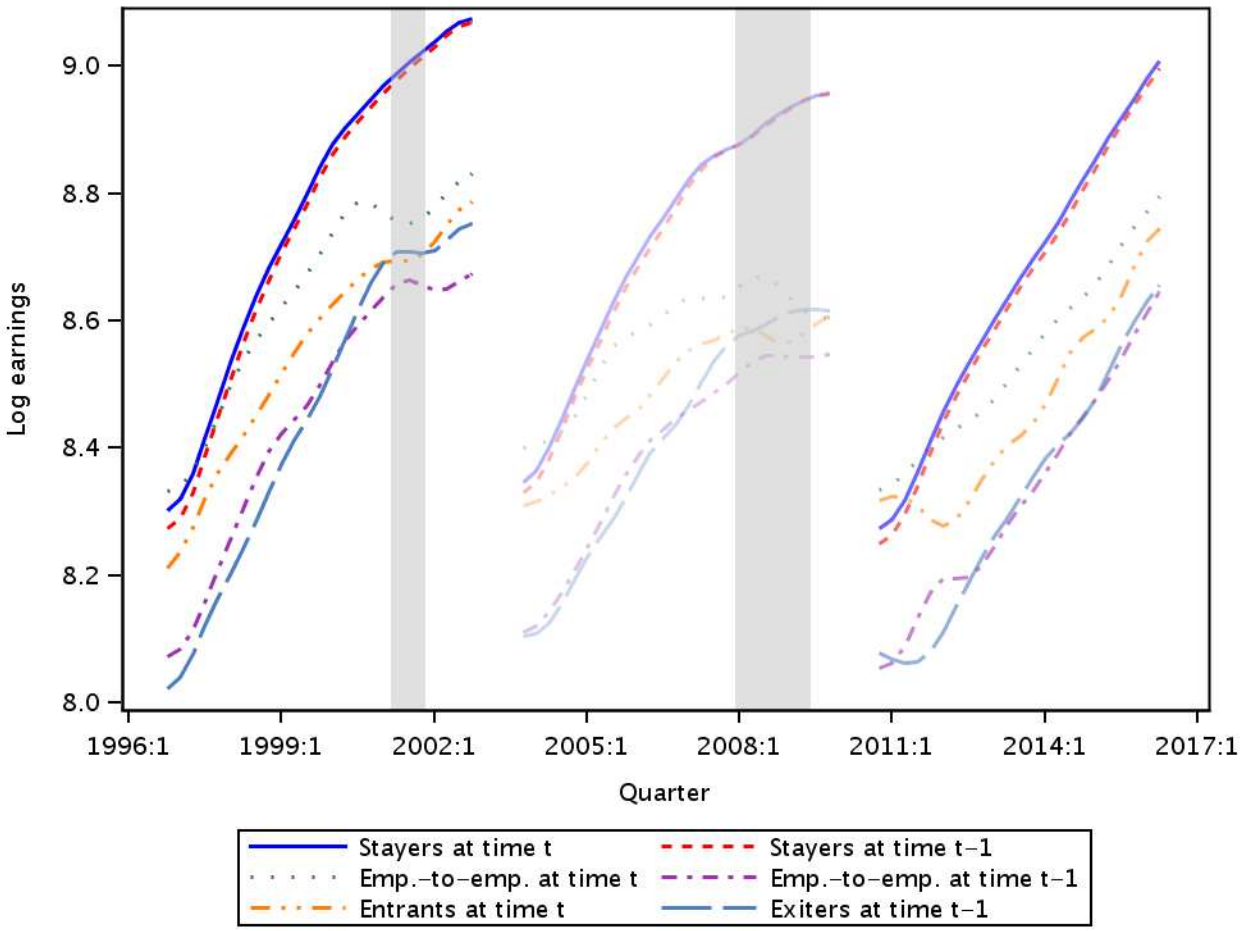
The earnings changes of stayers are shown in Figures D9 and D10(a). Specifically, we plot the change in earnings $\frac{\Sigma_i s_{it} \Delta y_{it}}{S_t}$. Stayers had small changes in earnings. For the 1996 cohort, earnings changes ranged from 0.6% to 3.0%, for the 2003 cohort, these ranged from -0.1% to 1.7%, and in the eleven (four) state dataset were 1.0% (0.8%) to 2.4% (3.0%) for the 2010 cohort. The largest changes occurred in the year of and following the year of entry.

Our four states with hours data provide information on how job stayer earnings changed over time in terms of hours and wages. The average log quarterly hours of job stayers increased over time from 5.76 (317) to 6.10 (446), see Figure D8(b). In any given quarter, hours changes of stayers were small, in the range of -0.6% to 1.8%, see Figure D10(b). The hourly wage of job stayers also increased substantially, from 2.52 ($12.43) to 2.73 ($19.89), see Figure D8(c). The wage changes of stayers in the 2010 entry cohort were larger and in the range of 1.0% and 2.1%, see Figure D10(c). Most of the earnings gains that this entry cohort experienced as job stayers were due to wage growth rather than hours growth.

For employer-to-employer transitions, we consider average log outcome at the beginning of the quarter $\frac{\Sigma_i q_{it} y_{it-1}}{Q_t}$ its value at the end of the quarter was $\frac{\Sigma_i q_{it} y_{it}}{Q_t}$ in Figures D7 and D8. In their first year of work, employer-to-employer transitions moved workers from employers where they earned in the range of 8.07 ($3,197) to 8.11 ($3,328) to new employers where they earned 8.30 ($4,023) to 8.40 ($4,477). In their seventh year, they continued to move workers to higher-paying employers, albeit from a higher base. These moved workers from employers where they earned 8.55 ($5,167) to 8.67 ($5,825) to employers where they earned 8.67 to 8.83 ($6,836). The earnings changes declined over time, from 25.0% to 32.1% to 10.3% to 14.1%, see Figures D9 and D10(a).

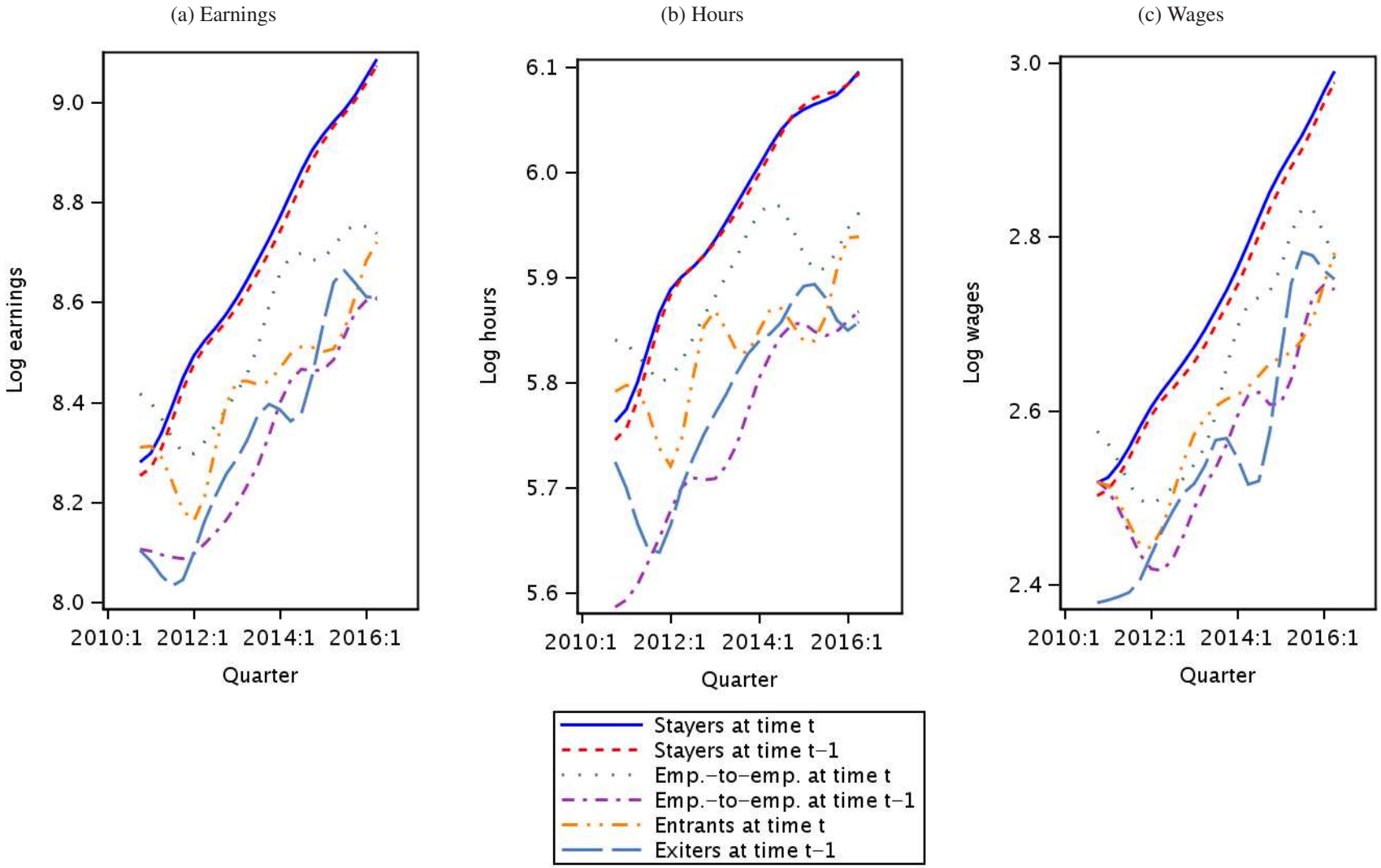
Our four states with hours data provide additional information on the hours and wage changes associated with employer-to-employer transitions. In the 2010 entry cohort's first year in the labor market, average log quarterly hours increased from 5.59 (268) to 5.80 (330) through this mechanism, see Figure D8(b). This suggests that employer-to-employer transitions were generally moving workers between employers where they work part-time. In their seventh year, log quarterly hours moved workers from employers that offered 5.87 (354) to 5.97 (392). Thus, after seven

Figure D7: Average quarterly log earnings for stayers and transitioners in the U.S., by cohort, 1996-2016



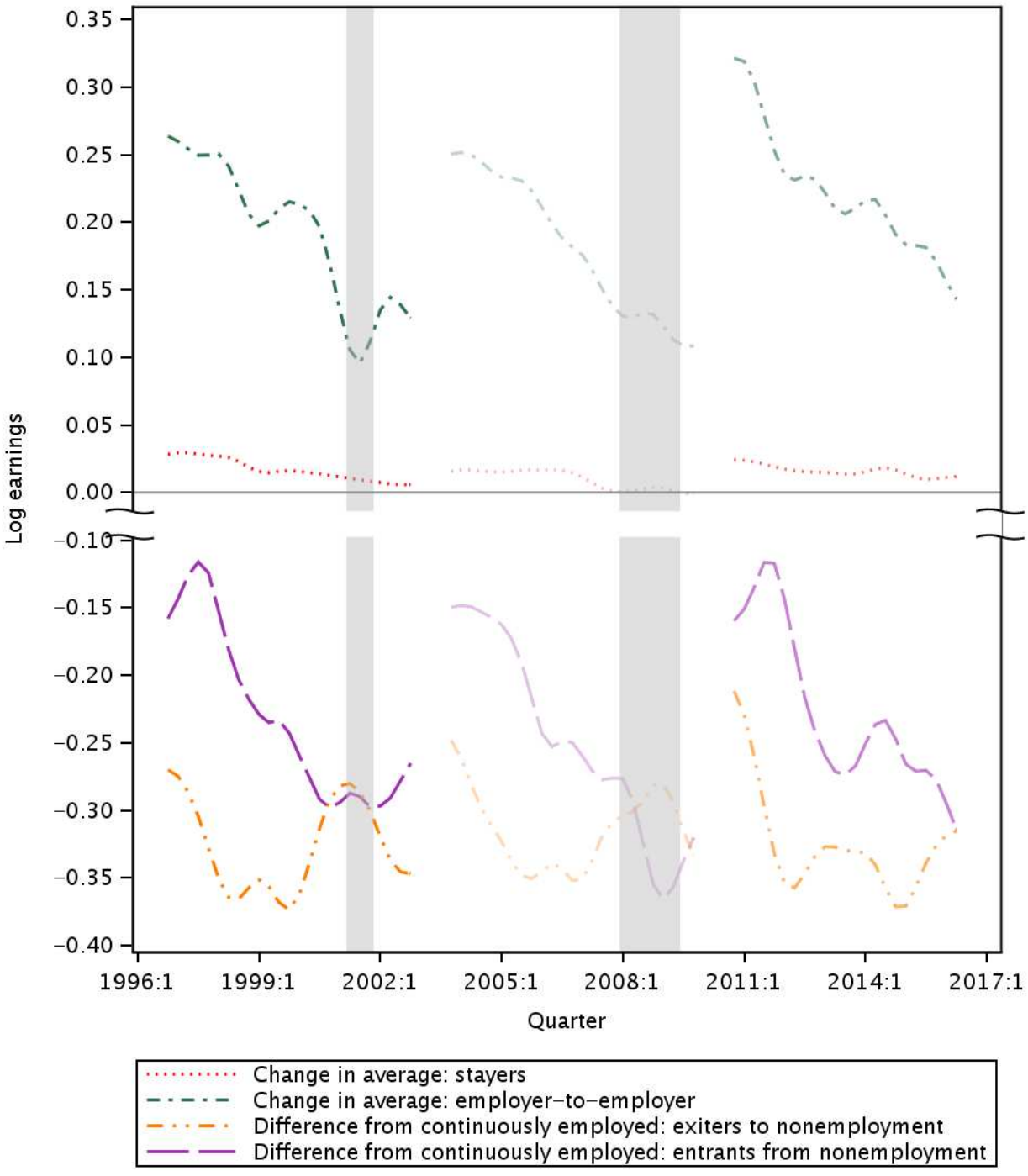
Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. Years 1996-2002 present results for the 1996 entry cohort, years 2003-2009 present results for the 2003 entry cohort, and years 2010-2016 present results for the 2010 entry cohort.

Figure D8: Average quarterly log earnings, hours, and wages for stayers and transitioners in the U.S., by cohort, 2010-2016



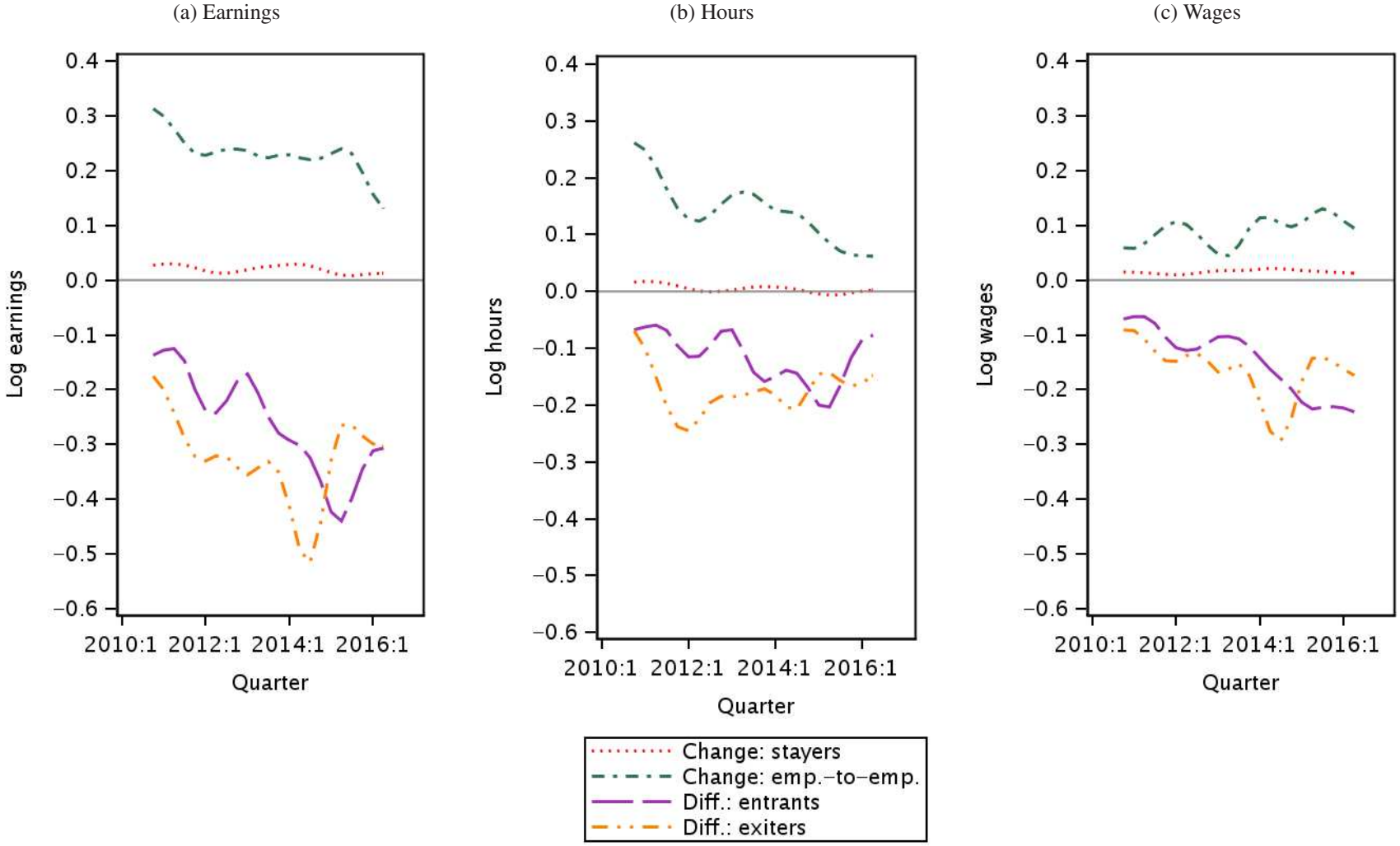
Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions.

Figure D9: Earnings changes and relative earnings, by cohort, 1996-2016



Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. Years 1996-2002 present results for the 1996 entry cohort, years 2003-2009 present results for the 2003 entry cohort, and years 2010-2016 present results for the 2010 entry cohort.

Figure D10: Average quarterly log earnings, hours, and wages changes for stayers and transitioners in the U.S., 2010 entry cohort, 2010-2016



Notes: Earnings and wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12.

years, employer-to-employer transitions are moving workers into jobs that offer close to full-time hours. Hours increases averaged 14.2% and declined over time, see Figure D10(b). In the 2010 entry cohort's first year, employer-to-employer transitions moved workers from jobs that paid on average 2.75 ($11.25) to those that paid 2.83 ($12.06), see Figure D8(c). In their seventh year, these transitions moved workers 2.56 ($15.64) to those that paid 2.64 ($16.95). Wage changes averaged 9.1% and were relatively stable over time, see Figure D10(c).

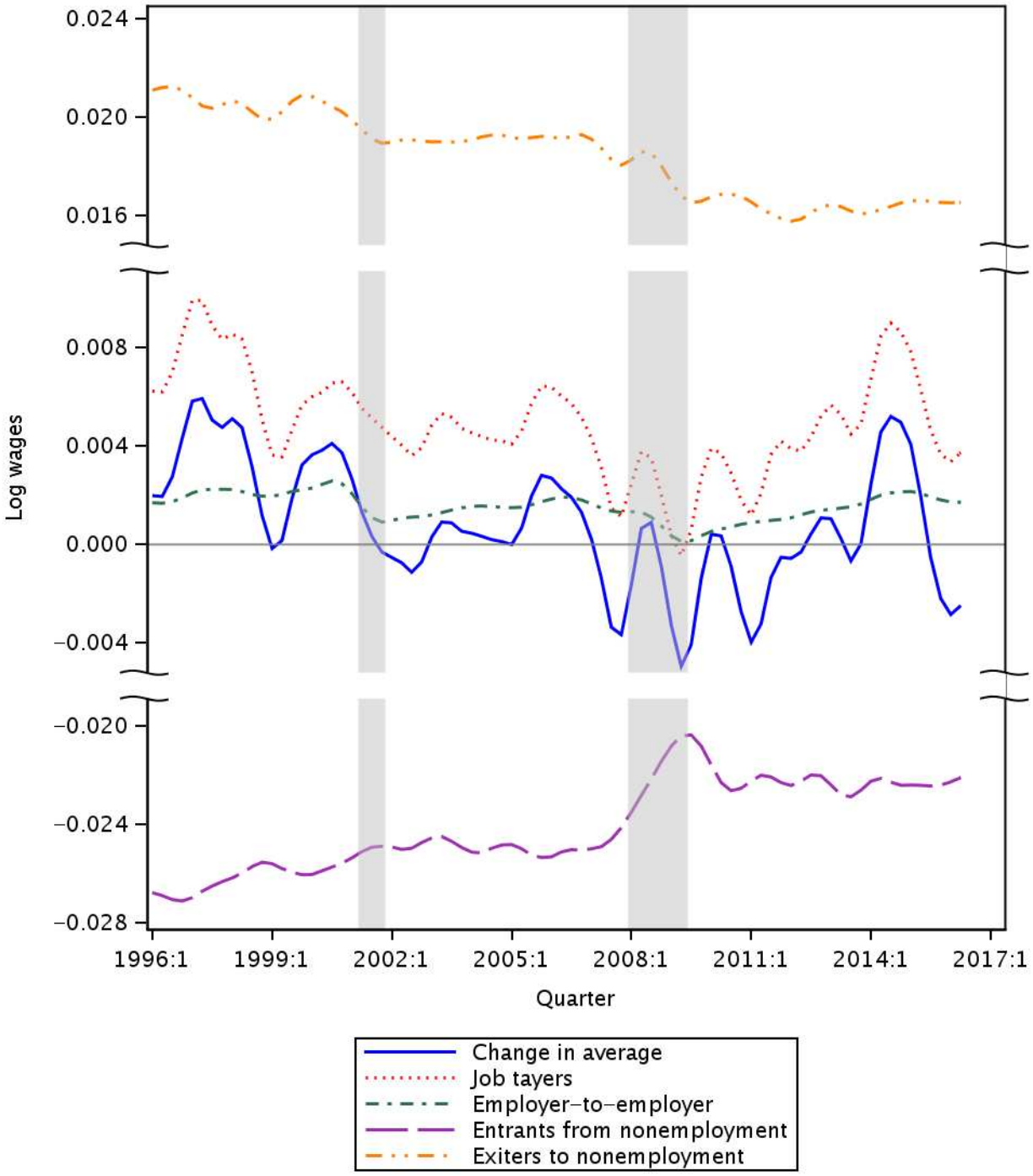
The earnings, hours, and wages of workers entering employment from nonemployment were relatively low for these entry cohorts. For entrants, we plot $\frac{\Sigma_i n_{it} y_{it-1}}{N_t}$ in Figures D7 and D8. At the start of the time series, average log quarterly earnings of entrants was 8.21 ($3,678) to 8.32 ($4,105). The earnings of entrants increased over time. In their seventh year, entrants earned 8.61 ($5,486) to 8.79 ($6,568). Entrants earned 11.6% to 44.0% less than incumbent workers, and these differences increased over time, see Figures D9 and D10(a).

For entry cohorts, exiters frequently earned less than entrants in any particular year after entry. Note that this contrasts with average earnings among all workers, among whom exiters tend to earn more than entrants. For exiters, we plot $\frac{\Sigma_i r_{it} y_{it-1}}{R_t}$ in Figures D7 and D8. Initially, exiters earned 8.02 ($3,041) to 8.11 ($3,328). Workers who exited employment after seven years earned 8.61 ($5,486) to 8.75 ($6,311). Entrants earned 17.5% to 51.5% less than incumbent workers, and these differences increased over time, see Figures D9 and D10(a).

E Additional regression and decomposition results

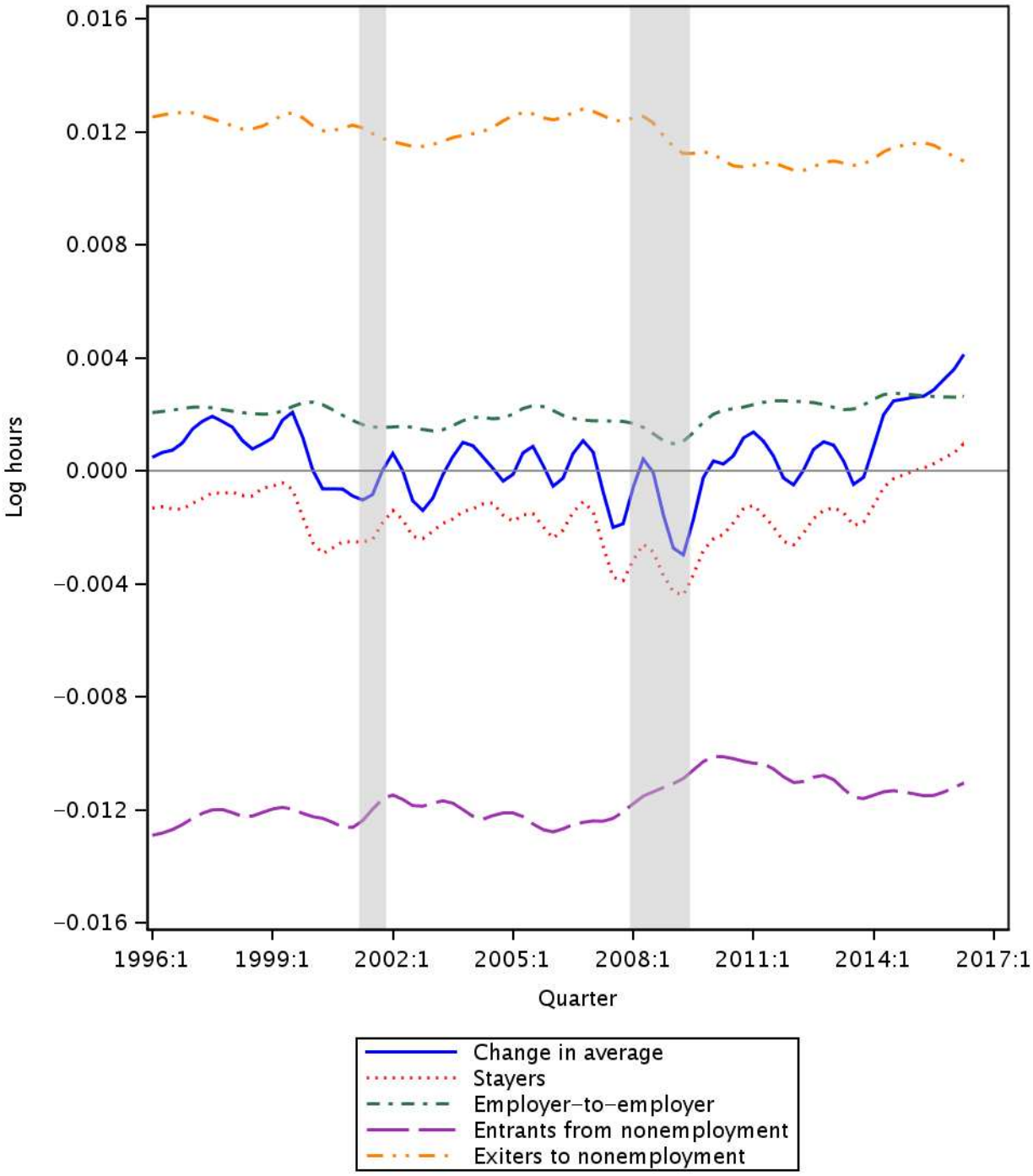
We now briefly compare our basic regression results to those found in the existing literature. A first difference specification following Bils (1985) and is commonly found in the literature. Estimated coefficients for this specification are found in Table E1. A survey of previous studies by Pissarides (2009) concludes the wages of new hires decline by three percent for every one percentage point increase in the unemployment rate. We find wages respond from 2.22 percent ($= 2.00 + 0.22$) to 3.21 percent ($= 2.73 + 0.48$), in line with previous studies. There are fewer reference points for how hours respond to the unemployment rate but we find it is in the range of 1.3 percent to 4.4 percent. Since the change in earnings is approximately the sum of the response of hours and wages, it is larger than both.

Figure E1: Decomposition of growth in average log wages (eleven states)



Notes: Wages are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. Wage data is mostly imputed.

Figure E2: Decomposition of growth in average log hours (eleven states)



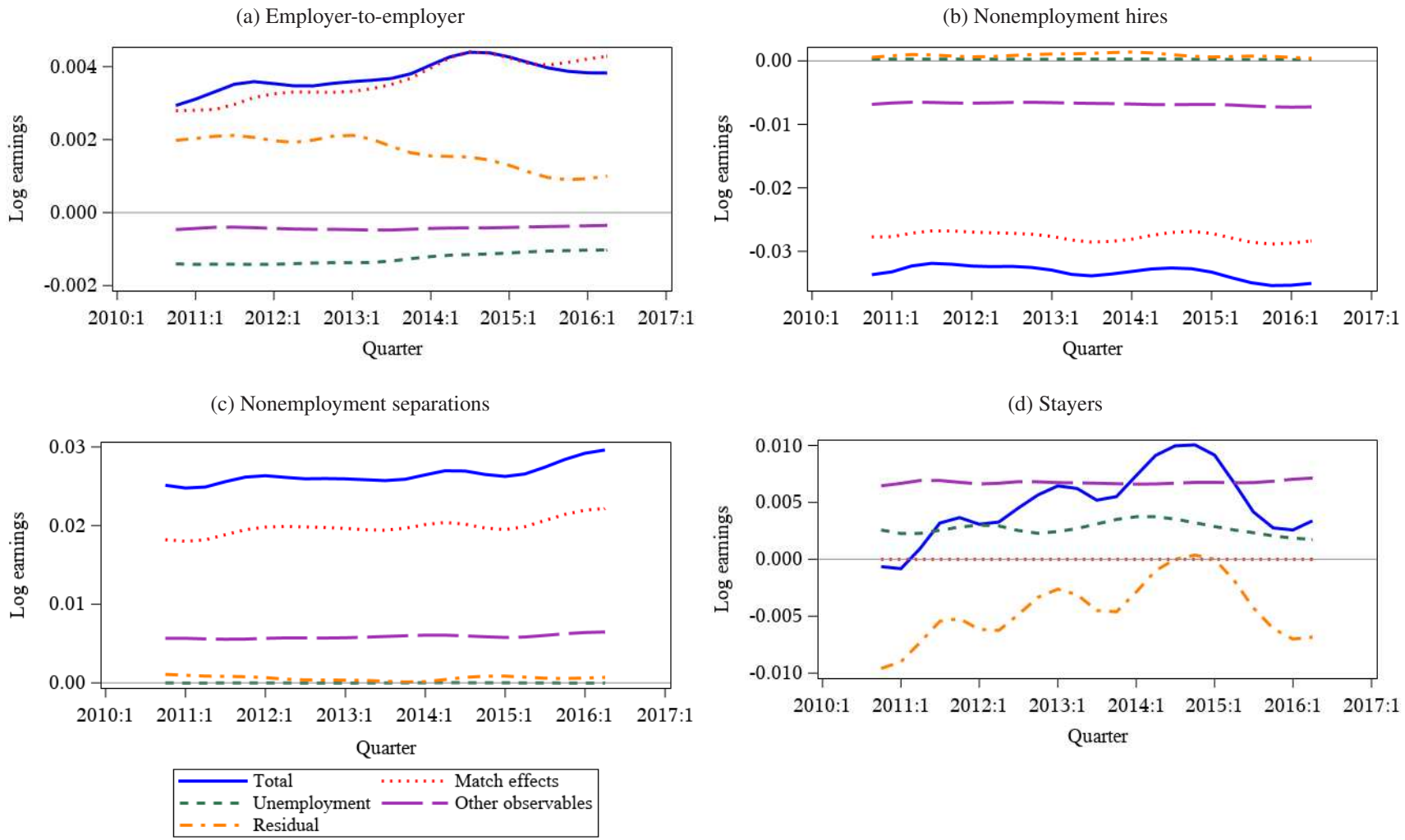
Notes: Earnings are in 2014 constant dollars. All results have been seasonally-adjusted and Henderson-filtered using x12. Hours data is mostly imputed.

Table E1: First-difference of earnings, hours, and wages regressed on the unemployment rate

	Eleven states		*Four states*	
Outcome	Earnings	Wages	Earnings	Wages
Stayers (γ_1)	-0.67***	-0.48***	-0.66***	-0.22***
	(0.02)	(0.03)	(0.05)	(0.03)
Employer-to-employer (γ_2)	-5.09***	-2.73***	-2.95***	-2.03***
	(0.10)	(0.18)	(0.33)	(0.24)
Entrants from nonemployment (γ_3)	-4.50***	-2.70***	-6.04***	-2.00***
	(0.08)	(0.14)	(0.22)	(0.16)
N (millions)	29.0	29.0	2.7	2.7
R^2	0.019	0.001	0.026	0.010

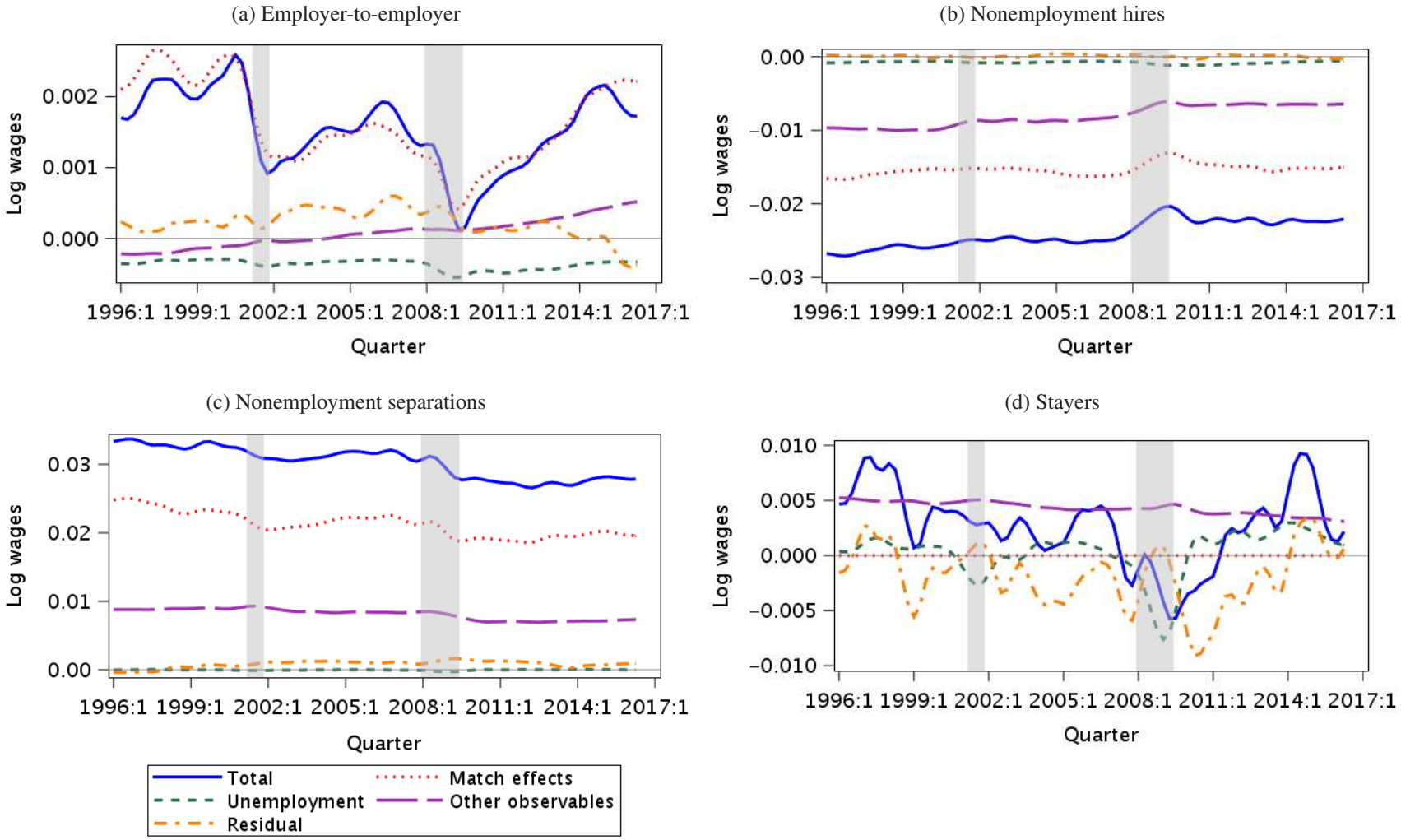
Notes: Earnings and wages are in 2014 constant dollars. Both the eleven state and four state datasets have non-imputed earnings data. Our four state dataset has non-imputed wage data while our eleven state dataset has mostly imputed wage data.

Figure E3: Log earnings growth: regression-based decomposition



Notes: All series are log earnings series from our four state data set and are presented in 2014 constant dollars. They have been seasonally-adjusted and Henderson-filtered using x12. Shaded areas indicate recessions. Total indicates the total contribution for each worker type. See text for details.

Figure E4: Log wage growth: regression-based decomposition



Notes: All series are log wages series from our eleven state data set and are presented in 2014 constant dollars. They have been seasonally-adjusted and Henderson-filtered using x12. Note that wages have been imputed for this data set. Shaded areas indicate recessions. Total indicates the total contribution for each worker type. See text for details.