

# The Dynamics of Gender Earnings Differentials: Evidence from Establishment Data\*

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## Abstract

We use a unique match between the 2000 Decennial Census of the United States and the Longitudinal Employer Household Dynamics (LEHD) data to analyze how much of the increase in the gender earnings gap over the lifecycle comes from shifts in the sorting of men and women across high- and low-pay establishments and how much is due to differential earnings growth within establishments. We find that for the college educated the increase is substantial and, for the most part, due to differential earnings growth within establishment by gender. The between component is also important. Differential mobility between establishments by gender can explain approximately thirty percent of the overall gap widening for this group. For those with no college, the, relatively small, increase of the gender gap over the lifecycle can be fully explained by differential moves by gender across establishments. The evidence suggests that, for both education groups, the between-establishment component of the increasing wage gap is entirely driven by those who are married.

JEL codes J16, J31

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## Introduction

Women have made remarkable progress in the labor market throughout the past century, resulting in clear convergence in human capital investment and employment prospects and outcomes relative to men (Blau and Kahn, 2016). However, remaining gender differences in pay still persist and, as shown by Goldin (2014), the gender earnings gap increases over the working life, especially so for college graduates.<sup>1</sup>

At the same time, recent studies have shown that there are large earnings differential across firms and establishments, and that sorting of workers into high- and low-paying establishments contributes to earnings inequality in the US<sup>2</sup> and other countries.<sup>3</sup> Since men are more likely to work in high paying firms and appear to capture a larger part of the establishment premium than women (Card, Cardoso, and Kline, 2016), these establishment earnings differentials tend to add to the gender pay gap. In this paper we use a unique match between the 2000 Decennial Census of the United States and the Longitudinal Employer Household Dynamics (LEHD) data to analyze how much of the increase in the gender earnings gap over the life cycle comes from shifts in the sorting of men and women across high- and low-pay establishments over the early part of their working life and how much is due to differential earnings growth within establishment.

The novelty with respect to other studies based on matched employer-employee data, is to focus on the *age dynamics* of the gender pay gap rather than its cross-sectional average. In addition, the data match to the 2000 Census of the United States allows us to study how the widening of the wage gap and its determinants vary by education, occupation and marital status, something that cannot be typically done with matched data, at least in the United States, but that can help gain a better understanding of the potential mechanisms. The drawback of our data, as we will discuss later, is that while the matched data cover several years of an individual work

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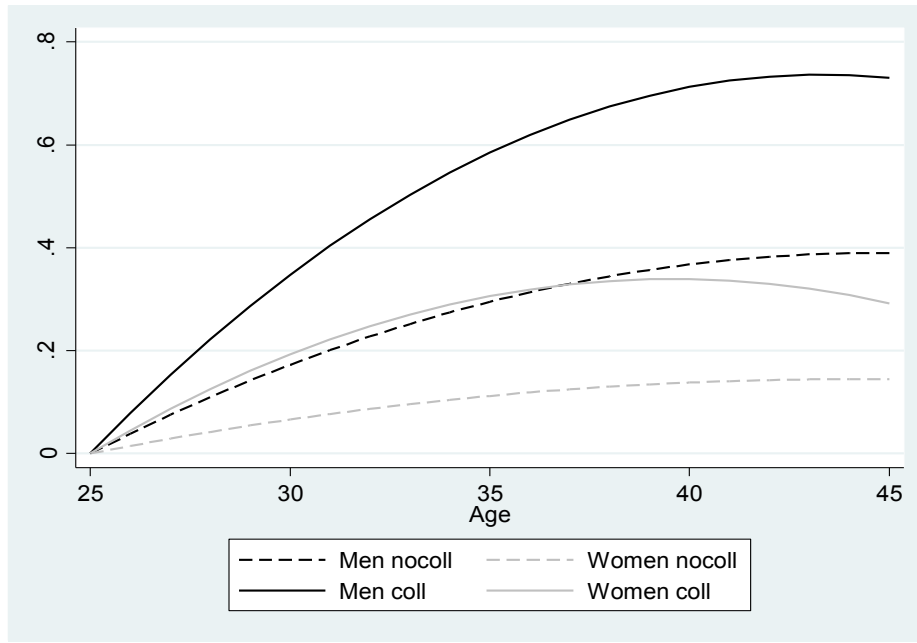
<sup>1</sup> For the cohort born in the early 1960s, controlling for work time and education, the difference increases from 10 log points at age 25, to 30 log points at age 40 (see Goldin, 2014, Figure 1B). The decline is even larger for earlier cohorts. Manning and Swaffield (2008) find similar results for the UK.

<sup>2</sup> See Abowd, Creedy, and Kramarz (2002) establishing a large earnings variation across establishments in the US, even for the same worker. Barth, Bryson, Davis, and Freeman (2016) and Song, Price, Guvenen, Bloom, and von Wachter (2015) study the contribution of establishment and firm pay to the increase in the earnings dispersion.

<sup>3</sup> See Card, Heining, and Kline (2013) for Germany and Félix and Portugal (2016) for Portugal.

history (from 1995 to 2008), the demographic variables are only observed at one point in time (in 2000).

*Figure 1. Predicted earnings-age profiles by education and gender.*



*Notes:* The lines represent the log point differences of predicted earnings by age/gender/education relative to a 25-year old of the same gender and education. The predicted values are obtained from running separate regressions of log earnings on age and its square for each gender/education bin. All models include time dummies. Average profiles are calculated on the matched sample from the largest 26 PMSA's in the US, see data section for details on sample construction.

Figure 1 shows the predicted earnings-age profiles by gender and education based on our data. We group workers in two education categories: those who are not college graduates and college graduates. Predicted earnings by age are measured relative to a 25-year-old worker of the same gender and education. There are striking differences in earnings profiles by education, and the comparison of black and grey lines for each group shows that the gender earnings gap widens with age for both education groups.<sup>4</sup> The widening of the gender earnings gap is largest for college graduates in our data. For this group there is a 44 log-points male-female difference in earnings growth between age 25 and 45. For those without college the gap is smaller, equal to 25 log points, but still sizable. This pattern is consistent with Goldin's (2014) evidence based on

<sup>4</sup> The regressions are based on 15 million observations; see the summary table in the Appendix. The standard errors of the estimates are thus so small that we have chosen not to draw the confidence intervals around the curves.

cross-sectional data and the analysis in Goldin et al. (2017) based on repeated cross-sectional observations of one specific cohort in our data.

A rising age-earnings profile may be due to the combination of two different processes. The first concerns the career path *within an employer*, involving wage raises and promotions over time.<sup>5</sup> The second concerns *sorting into high- versus low-paying employers*. It may be optimal to accept a job in a low-paying establishment early on, and then climb the ladder to better paying establishments over time, as those opportunities arise.<sup>6</sup> Both mechanisms are a function of a worker's cost of effort that, given the prevailing gender norms, might be higher for women. For example, gender differences may arise within firms because of competition for higher positions within the hierarchy (Lazear and Rosen, 1990). The prevalence of convex reward profiles in working time, at least in some occupations, also contributes to the widening of the gender pay gap (Goldin, 2014). Job search and investment in career-enhancing employer changes may also be more difficult to combine with family obligations for women and this might lead firms to adopt monopsonistic discrimination in their wage setting (Barth and Dale-Olsen, 2010).<sup>7</sup> Gender differences can be further exacerbated if household roles and market wages are tied through employers' beliefs about female labor force attachment and cost of work effort (Albanesi and Olivetti, 2009).<sup>8</sup>

In a companion paper we document that movements within and across establishments contribute to the expanding gender earnings gap in the decade and a half after schooling ends, for narrowly defined cohort and education groups (see Goldin et al. 2017).

In this paper we quantify the importance of career movements within and across establishments using a full decomposition analysis of the establishment and individual fixed effects. The different sources of earnings growth at the individual level are estimated separately by gender and education, while establishment fixed effects are estimated separately by gender

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<sup>5</sup> Due to firm-specific versus general human capital investment (Becker, 1964) or to delayed payments as a solution to agency problems (Lazear, 1981).

<sup>6</sup> Obviously, for this to be a relevant channel of growing gender earnings differentials, there has to be a distribution of earnings across establishments, even for the same individual. See Groshen (1988) for an early contribution.

<sup>7</sup> See Manning, 2002, Green, Machine and Manning, 1996. Another frictional mechanism emphasized in this literature, has to do with employers' disutility of hiring women (Black, 1995, Bowlus and Eckstein, 2002, Flabbi, 2010).

<sup>8</sup> See Albanesi and Olivetti (2009) for an equilibrium model of statistical discrimination whereby firms' traditional beliefs about household roles, by lowering the incidence and 'generosity' of high-powered labor contracts offered to women, can lead to a large and persistent gender wage gap. Alternative feedback mechanisms explored in the literature rely on job segregation into piece-rate jobs (Francois, 1998), and on-the-job training (Dolado, Garcia-Penalosa and de la Rica, 2013).

only. To resolve the methodological challenges of identifying separately the linear terms for calendar year, time, cohort, and age, we assume that the time effects for each PMSA and education group are the same for men and women. With this assumption we may directly identify the difference between the linear term in men's and women's earnings growth by age, conditional on being in the same job; i.e. conditional on the full set of individual, establishment and match effects. Next, we separate out the cohort versus the linear age effect among men by defining cohorts as spanning ten years. Finally, we are able to disentangle age effects within establishments from seniority effects by using individuals who have more than one job in our panel.

One important advantage of our data is that we can identify directly the within-job difference in earnings profile over time between men and women. This difference arises from the combined effects of differences in wage raises and promotions within the same employer.<sup>9</sup> While we cannot distinguish between internal promotions and earnings growth within job category in our data, we are able to distinguish between differential seniority profiles, which is experienced within the current job, but lost when changing employer, and differential development in the within establishment earnings distribution that is not lost when changing job, e.g. as one changes from a top position in one firm to a top position in another firm.

Our findings show that among workers without a college degree, there is only a small male advantage in within establishment earnings growth over the first 10 to 15 years of working life. However, by age 45 women catch up with men in terms of the within establishment earnings growth. Among workers with a college degree, on the other hand, the male-female difference in establishment earnings growth are huge. Over the first 15 years, from age 25 to 40, men's within-establishment earnings growth is 33 log points higher than women's. Unlike the non-college educated, college women do not catch up by age 45 (something that can be due by differences in

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<sup>9</sup> Lazear and Rosen (1990) develop a theoretical model of promotions in job ladders where women are paid the same as men within jobs, but where higher separation rates among women induces higher ability thresholds for promotions for women than men. Data on job-titles is necessary to sort out the mechanisms behind lower earnings growth within the same employer. According to Blau and De Varo (2007), the empirical literature on gender differences in promotions has so far produced mixed results and differs widely in terms of both type of data and the sample of firms and individuals used. Booth, Francesconi, and Frank (2005) use the British Household Panel Survey with information on promotions within the same employer, and find that women are promoted at about the same rate as men, but that they receive smaller wage gains associated with the promotions. Blau and De Varo (2007) in their study of promotion and pay for new hires in a sample of US establishments find that women have lower probabilities of promotion than men, but that wage gains associated with promotions do not differ much between men and women, a result which is consistent with the evidence from McCue (1996) who uses data from the PSID.

the timing of births by education). By the time they reach age 45 the difference is still 30 log points. A fraction of this difference is due to higher returns to seniority among men, 0.1 log points per year of seniority, and the remaining part is due to earnings growth within establishment that is carried over also to new jobs in other establishments.

Our most novel results concern the development of the establishment earnings premium over time for the same individual. For employees without a college degree, the widening of the gender gap in terms of the establishment earnings premium adds up to 5.4 log points from age 25 to 45. Note that this is the main source of the total widening of the gap for this group since women catch up with men in terms of within establishment earnings growth by age 45. Among college-educated workers, the gender gap across establishments widens by 11 log points from age 25 to 45. As noted above, college educated workers experience a considerable widening of the within establishment earnings gap, and the across establishment expansion constitutes 27 percent of the total widening of the gender wage gap for this group. Strikingly, we find that the widening of the across establishment earnings gap is almost entirely arising from a widening of the gap for the married. Both never-married men and never-married women are similar to married men in terms of how the establishment pay premium varies over time. Suggestive evidence based on the publicly available US 2000 Census suggests that most of the difference in earnings growth for married women occurs concurrently with the arrival of children.

Our paper contributes to a recent literature that explores the role of productivity differences across establishments as a source of gender earnings differentials. Early contributions in this vein are the study by Barth and Mastekaasa (1996) and Kimberly, Hellerstein, Neumark and Troske (2003) who show that a gender earnings differential persists even after controlling for gender differences in human capital and sex segregation within occupation, industry and establishment based on early version of the matched data for Norway and the United States, respectively.<sup>10</sup> More recently, Card, Cardoso and Kline (2016) show that firm-specific pay premiums explain just over one-fifth of the average gender earnings gap in Portugal and interpret

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<sup>10</sup> The paper by Bayard, Hellerstein, Neumark and Troske (2003) uses an earlier version of our data that matched the 1990 Sample Edited Detail File (consisting of all household responses to the 1990 Decennial Census long form) to establishment records in the 1990 Standard Statistical Establishment List.

it in light of differential bargaining power between men and women.<sup>11</sup> Other authors have used matched employer/employee data to explore the role of gender segregation and pay structure for explaining the cross-sectional wage gap in Spain (Amuedo-Dorantes and Sara De la Rica, 2006), Denmark (Gupta and Rothstein, 2005), Germany (Heinze and Wolf, 2009), Finland (Korkeamäki and Kyyrä, 2006) and a for cross-section of nine European countries (Simon, 2012). All these papers focus on the cross-sectional gender pay gap. The novelty in our paper is that we focus on the widening gender pay gap by age.

Our paper also contributes to the literature on the importance of distinguishing between job separations into non-employment, versus job-to-job separations in the analysis of gender differences in earnings growth and job transitions. While as discussed above, separations into non-employment may have negative effects on within establishment earnings growth, separations to other jobs may have the effect of improving earnings. Studies of separation rates find that gender differences in the probability of leaving a job tend to disappear once we control for observable characteristics (Blau and Kahn, 1981) and attachment to the labor force (Light and Ureta, 1990, 1992). Royalty (1998) shows the existence of gender differentials in the destination state. Women are more likely to leave a job for non-employment, while men are more likely to move from one job to the next (see also Manning 2002). There is also an earlier literature emphasizing differences in turnover rates (based on longitudinal data) as an important source of gender differentials in earnings growth for young workers. For example, Loprest (1992) shows that women gain less, in terms of wage growth, from switching jobs. Bowlus (1997) finds significant gender differences in quit rates “for personal reasons” that account for 20%–30% of the gender wage differential.

The remaining of the paper is organized as follows. Section 2 describes our data set and key variables. Section 3 discusses our estimation strategy. Finally, the main findings of our analysis are summarized in Section 4.

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<sup>11</sup> In particular, they show that bargaining and sorting based on measured productivity account for about 80% of the overall impact of firm-specific pay premiums on the gender earnings gap.

## 2. Data and Definition of Key Variables

Our analysis relies on a unique combination of the Longitudinal Employer-Household Dynamics (LEHD) database and the 2000 Decennial Census of Population (one in six long form). Both datasets are confidential and housed by the U.S. Census Bureau in the Research Data Centers (RDC). As the current combination of these two restricted access data sets has barely ever been used in previous empirical literature, this section will provide a detailed summary of the construction of our data platform.

The LEHD is based on quarterly, worker-level, filings by private-sector U.S. firms in the context of the administration of state unemployment insurance (UI) benefit programs. The data identify all employees of an establishment and their quarterly compensation on a month-to-month basis. UI earnings include wages, salary and taxable bonuses and are not top-coded.<sup>12</sup> The state UI system covers about 95% of private sector employment. Thus our analysis is fully representative of private firms within the geographical areas we study (see Hyatt et al., 2014; Stevens, 2007). The LEHD is longitudinally linked at both the firm and employee levels, making it possible to analyze how firm employment and employee earnings evolve over time, within and across all establishments. The LEHD vintage used in this paper includes 23 states with varying initial dates of coverage, starting from 1991, and runs through 2008.

To manage the enormous number of person and firm fixed effects required to estimate our models, we focus on the largest PMSAs in the U.S. in terms of population as of 1991. Of the 50 largest U.S. PMSAs, 26 were located in 18 of the 23 LEHD covered states available to us. Specifically, these PMSAs are located in CA, CO, GA, FL, HI, ID, IL, MD, NC, NJ, NM, OR, RI, SC, TX, UT, VA and WA. We further reduce our analysis sample by using annual data from 1995 to 2008 and selecting workers who worked more than two quarters per year and earned at least \$2,000 per quarter, on average, during the year. The last restriction removes from the sample very short and sporadic employment relationships as well as any short-term contractor type arrangements, and directs our study towards the more permanent work arrangements. All dollar values are inflated to 2008 values using the all-urban-consumers-CPI published by the BLS. Finally, we focus on individuals in their prime working age. That is, for each individual, we only use observations when the person is aged 25-44.

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<sup>12</sup> See Abowd et al. 2002 for an in-depth discussion of the benefits and shortcomings of this data.



The LEHD records limited information about workers in the snapshot individual characteristics file (ICF). This includes age, gender, race, place of birth, and citizenship status. Through the employment history files (EHF), we can also discern their earnings and job-by-job employment histories. Moreover, using the unique person identifiers (PIKs), we are able to match people in the LEHD to the individual-level records contained in the long-form responses of the 2000 Decennial Census of Population.<sup>13</sup> The long-form was given to a random sample of 1-in-6 households and is nationally representative. This process allows us to match almost exactly 1-in-6 of our LEHD workers with added Census details from the Person File. The LEHD-Census match thus includes more detailed and comprehensive information about each individual in our sample (e.g., level of education, occupation, marital status, class of worker, etc.) and their respective families (e.g., family composition, detailed characteristics of their spouse, and household income by source). In the current study we mainly extract individual-level characteristics, that is, educational attainment, marital status and race. It is worth emphasizing that while the LEHD longitudinally follows the same individuals over time across jobs, the 2000 Census is obviously just a snapshot. To the extent that the person's marital status, education or occupation changes, either before or after 2000, we will not be able to capture that. When conducting analyses within specific industries (finance, health, tech and retail) we utilize the LEHD's detailed industry classification containing both NAICS and SIC codes. When conducting analyses for specific occupations (managers, professional and sales) we utilize the 3-digit level 2000 Census reported occupations to group persons into the broad groups.<sup>14</sup>

We estimate fixed effects based on the full LEHD sample and use them in our analysis, which is based on the LEHD-Census matched sample.

A few final details about the Census RDC data sets are worth noting. First, all observation counts in the paper are disguised and rounded to the nearest 100 according to Census Bureau disclosure restrictions. Second, we generally use the establishment ID (based on the State Tax ID and the establishment number) to identify work establishments and to track them over time. The

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<sup>13</sup> The Census Bureau has created the unique person identifiers (PIKs) based on Social Security Numbers (SSNs). These PIKs allow the linking of individuals across demographic surveys, censuses and administrative records.

<sup>14</sup> Specifically, the information about each person's occupation is derived from the 2000 Decennial Census and pertains to the 3-digit occupation that was determined by the Census Bureau based on the person's long-form response to two questions: "What kind of work was this person doing?" (for example: registered nurse, personnel manager, supervisor of order department, auto mechanic, accountant), and "What were this person's most important activities or duties?" (for example: patient care, directing hiring policies, supervising order clerks, repairing automobiles, reconciling financial records).

LEHD also includes firm identifiers, but unlike establishment IDs those are not fully consistent over time within a given firm. For example, if another firm acquires an establishment, the firm ID will change, even though the workers within that establishment would all continue their employment with the company. Due to the sheer size and scope of these data it would be practically impossible to try to follow each of the firms over time while taking into account all merger activity and other corporate restructuring. Moreover, we believe that the establishment level tracking is more relevant for the current purpose because the type of job-to-job moves that is the focus of this paper may involve changes between establishments within a firm as well.

The dependent variable in our models is the natural logarithm of earnings, where earnings are measured as the average quarterly earnings during the year (over the quarters that the person was working). Another key variable is the establishment size, where the size corresponds to the LEHD reported number of employees minus the sample mean. We also include a squared-term in age, where the age refers to the person's age during the year of observation minus 35. Since the regression specification includes establishment and person fixed effects, most of the other time-invariant person and establishment characteristics are absorbed by those fixed effects. However, our cross-sectional model for the person fixed effect includes time-invariant individual characteristics such as age, years of education (minus 12), and race dummies.

### 3. Methodology

Our aim is to compare the age-earnings profiles of men and women, both within and between employers. Consider first the following earnings equation for individual  $i$  at time  $t$  in establishment  $j$ :

$$(1) \quad \ln w_{it} = \beta_0 + \beta_1 \text{Age}_{it} + \beta_2 \text{Age}_{it}^2 + \beta_3 \ln \text{Size}_{j(i,t)t} + \psi_{ij(i,t)} + \gamma_t + \varepsilon_{it}$$

where  $\psi_{ij(i,t)} = \alpha_i + \varphi_{j(i,t)} + \xi_{ij(i,t)}$  is a job-specific effect that is further decomposed into an individual effect,  $\alpha_i$ , an establishment effect,  $\varphi_{j(i,t)}$ , and an orthogonal match effect  $\xi_{ij(i,t)}$ , where  $j(i,t)$  identifies the establishment  $j$  where individual  $i$  is employed at time  $t$ . A job is defined as a combination of an individual and an establishment. Note that even if  $\xi_{ij(i,t)}$  is defined orthogonal

to  $\alpha_i$  and  $\varphi_{j(i,t)}$  it can be correlated with the covariates in (1) that vary within a job.  $\gamma_t$  is a year fixed effect, and  $\varepsilon_{it}$  is an error term, assumed to be orthogonal to the other variables.

The *within employer age-earnings profile* describes the earnings profile over time for an individual who stays in the same job, conditional on the firm size, and is defined by the  $\beta_1$  and  $\beta_2$  coefficients of equation (1). We estimate the earnings equation separately by region and educational group.

In addition to the age-earnings profile within jobs, an individual may experience earnings growth from job changes. Different jobs may involve different establishment effects,  $\varphi_{j(i,t)}$ , and different earnings-size premiums,  $\beta_3 \ln Size_{j(i,t)t}$ . Establishment size may vary either within the same establishment over time, or as the individual changes establishment. We define the *establishment earnings premium* as:

$$(4) \quad \chi_{j(i,t)t} = \beta_3 \ln Size_{j(i,t)t} + \varphi_{j(i,t)}$$

consisting of the time varying size term (defined throughout as deviation from the sample mean), and the unobserved establishment fixed effect.

We assess the importance of the establishment component of earnings on earnings growth over a worker's career by estimating, on the full panel of individuals and by gender, the auxiliary regression of the establishment specific earnings premium as a function of age and age squared:

$$(5) \quad \chi_{j(i,t)} = b_1 Age_{it} + b_2 Age_{it}^2 + u_{it}$$

where we allow the residual term,  $u_{it}$ , to include a fixed individual effect to account for heterogeneity across individuals in terms of establishment affiliation, for instance due to cohort effects. Equation (5) describes the average career during the observation period of our panel in terms of the establishment earnings premium of individuals over time. It represents the combined average effect of changing earnings premiums as firms grow or decline, and as workers move across establishments that differ by establishment specific earnings premiums.

For simplicity we drop the index (i,t) on j in the following, identifying the establishment of individual i at time t as establishment j.

### 3.1 Identification

#### *Cohort effects, time effects, and age profiles within jobs*

Consider the within employer earnings profiles first. We have excellent panel data where we can follow workers over time, both within and across employers, but we still face the standard problem of disentangling the linear trends in age, time, and cohort effects. It is not trivial to identify age, time and cohort effects in panel models with fixed individual and establishment effects, so since this is a key part of our endeavor, we elaborate our modeling strategy in some detail. Our identification strategy is to assume identical time effects for men and women within the same education group and the same locality defined by PMSA. The time effects thus represent all local variations in the supply and demand for each educational group, and all differences in earnings growth over time between men and women within the same education group and PMSA is used to identify differences in the earnings-age and cohort profiles between men and women. Furthermore, we define cohort effects by decade, and identify the age effect from earnings growth within the same cohort.

Let  $\gamma_t = dt + \tilde{\gamma}_t$ ,  $t = 0, \dots, 10$  be the linear projection of the time dummies on  $t$  (conveniently set to zero at the start of our panel), plus deviations from the linear trend,  $\tilde{\gamma}_t$ . Note that within the same job we have  $(Age_{ijt} - \overline{Age}_{ij.}) = t - \overline{t}_{ij.}$ , and we are thus not able to identify  $\beta_1$  and  $d$  separately from within job variation. A strategy for identification is thus to omit the linear term for Age from equation (1) and estimate<sup>15</sup>:

$$(1') \ln w_{it} = \tilde{\beta}_0 + \beta_2 Age_{it}^2 + \beta_3 \ln Size_{jt} + \tilde{\psi}_{ji} + (\beta_1 + d)t + \tilde{\gamma}_t + \varepsilon_{it},$$

where  $\tilde{\beta}_0 = \tilde{\gamma}_0 + \beta_0$ ,

$$(2) \tilde{\psi}_{ji} = \tilde{\alpha}_i + \varphi_j + \chi_{ij}$$

and

$$(3) \tilde{\alpha}_i = \beta_1 Age_{i0} + a_i + c_t$$

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<sup>15</sup> The introduction of the linear term  $t$  is done for expositional reasons. In practice we implement this estimation using year dummies only. This does not change the argument in any way, and the linear term of the year dummies may be recovered from the dummies.

where  $c_\tau$  and  $a_i$  represent a decomposition of the individual effect,  $\alpha_i$ , into one effect reflecting worker  $i$ 's cohort and the other the worker's fixed effect within his cohort.

### *Different earnings profiles by gender*

Allowing the parameters of the earnings equation to vary across genders, we have:

$$(1'') \quad \ln w_{it} = \beta_0 + (\beta_1 + \beta^w_1 G) Age_{it} + (\beta_2 + \beta^w_2 G) Age^2_{it} + (\beta_3 + \beta^w_3 G) \ln Size_{jt} + \psi^G_{ji} + dt + \tilde{\gamma}_t + \varepsilon_{it}$$

Where  $G$  is a dummy variable taking the value 1 for women. Note that all parameters except for the time effects are allowed to vary by gender. We still have  $(Age_{ijt} - \overline{Age}_{ij.}) = (t - \overline{t}_{ij})$ , but since  $(Age_{ijt} - \overline{Age}_{ij.})G$  is not collinear with  $t - \overline{t}_{ij}$ , we are now able to identify  $\beta^w_1$  directly by adding the interaction term to the within job equation. We may thus estimate:

$$(1''') \quad \ln w_{it} = \tilde{\beta}_0 + \beta^w_1 G Age_{it} + (\beta_2 + \beta^w_2 G) Age^2_{it} + (\beta_3 + \beta^w_3 G) \ln Size_{jt} + \tilde{\psi}^G_{ji} + (\beta_1 + d)t + \tilde{\gamma}_t + \varepsilon_{it}$$

where  $\tilde{\beta}_0 = \tilde{\gamma}_0 + \beta_0$ ,

$$(2') \quad \tilde{\psi}^G_{ji} = \tilde{\alpha}_i + \varphi^G_j + \chi_{ij}$$

and

$$(3') \quad \tilde{\alpha}_i = \beta_1 Age_{i0} + a_i + c^G_\tau$$

Where  $Age_{i0}$  is age at the beginning of our panel ( $t=0$ ), and where both the establishment fixed effect and the cohort effects can vary by gender. We implement this by estimating (1''') on the full sample, retrieve the job fixed effects, next estimate (2') by gender, retrieve the individual fixed effects and then estimate (3') by gender to obtain  $\beta_1$  and the gender specific cohort effects.

We estimate the parameters of this model by PMSA and report average estimators over all PMSA's.<sup>16</sup> We estimate all parameters separately for each education group, gender and

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<sup>16</sup> The sample sizes are very large and standard errors are thus not a great concern for the parameters of interest in this paper, see data section for details.

PMSA, with the exception of the time effects that are assumed to be equal across gender within each education/PMSA cell, and establishment fixed effects that are assumed to be equal for each education group, but allowed to vary across gender (and PMSA, of course).

### *Seniority-earnings profiles*

Consider the possibility that there is an establishment specific earnings growth, in addition to the age profile that the individual obtains from (potentially) being in the labor market for one more year. The existence of both a distinct seniority-earnings profile associated with time spent at the same employer, and a more general experience-earnings profile associated with time spent in the labor market has been linked to both the distinction between the development of specific versus general skills (Becker 1964), and to the existence of delayed compensation schemes within firms (Lazear 1995). In this section we allow the age earnings profiles to be decomposed into a seniority profile and a general age-earnings profile.

Empirically, it is difficult to identify the effect of seniority on earnings, in particular because a match entailing a positive earnings premium for the worker is likely to last longer than matches with lower pay. Access to establishment data with many workers per establishment may solve this difficulty by identifying the effect comparing workers within the same employer only (Barth 1997). With panel data we may follow workers over time, and may control for individual fixed effects as well. However, in this setting we run into the difficulty that we cannot identify separate linear terms for age, seniority or time in the within job regression. In the following we outline how we identify separate age and seniority profiles for each gender. Again, we rely on the assumption of equal time effects for men and women with the same education group in the same PMSA to tease out the difference in age profiles between men and women. Next, we rely on individuals with more than one job to identify the seniority profiles separately from the age profiles. In order to simplify the exposition, we ignore all variables that vary independently within each job, such as age squared and firm size. Consider the within job earnings equation:

$$(6) \quad \ln w_{it} = \beta_0 + (\beta_1 + \beta^w_1 G) Age_{it} + (\beta_2 + \beta^w_2 G) S_{ijt} + dt + \psi^G_{ji} + e_{it}$$

Where S is the number of years in current establishment. This time we have  $(Age_{ijt} - \overline{Age}_{ij.}) = (S_{ijt} - \overline{S}_{ij.}) = (t - \overline{t}_{ij})$ , and  $(Age_{it} - \overline{Age}_{i.})G = (S_{ijt} - \overline{S}_{ij.})G$  as well. We may rewrite (6) in the following way:

$$(6') \ln w_{it} = \beta_0 + (\beta_1 + \beta_2 + d)t + (\beta^w_1 + \beta^w_2)G Age_{it} + \beta_1 Age_{i0} + \beta_2 S_{i0} + \psi^G_{ji} + e_{it}$$

From which it is clear that we can identify  $(\beta_1 + \beta_2 + d)$  and  $(\beta^w_1 + \beta^w_2)$  only from the within job equation, since  $Age_{i0}$  and  $S_{i0}$  are fixed characteristics of the job and subsumed into the job fixed effect. Since we have individuals with more than one job, we may obtain  $\beta_2$  and  $\beta^w_2$  from estimating the gender specific equations

$$(7) \quad \tilde{\psi}^G_{ji} = \tilde{\alpha}_i + \beta^G_2 S_{i0} + \varphi^G_j + \chi_{ij}$$

and  $\beta_1$  from the remaining individual fixed effect

$$(8) \quad \tilde{\alpha}_i = \beta_1 Age_{i0} + a_i + c^G_\tau$$

A complication is added since we only observe seniority from the beginning of our panel. This means that the  $Age_0$  variable captures the effect of seniority at the beginning of the panel as well. We make a correction for this by estimating how much seniority grows every year in our panel for each gender-education group, and calculate  $\beta_1$  from the equation  $\hat{b}_1 = (\beta_1 + \widehat{\beta}_2 \hat{\tau})$ , where  $b$  is coefficient for  $Age_0$  in (8), and  $\tau$  is the coefficient for  $t$  in a regression of seniority on  $t$  in our panel<sup>17</sup>.

We implement the identification strategy by estimating (6') on the full sample, where  $\beta_1 Age_{i0} + \beta_2 S_{i0}$  is subsumed in the fixed job effects, (note that for estimation purposes (6') is identical to (1'''), the difference is in the interpretation of the coefficient), retrieve the job fixed effects, and estimate (7) by gender, retrieve the individual fixed effects and estimate (8) by gender to obtain  $\beta_1$  and the gender specific cohort effects as laid out above.

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<sup>17</sup> The coefficient  $\tau$  is estimated to be 0.18, 0.21, 0.30 and 0.29 for no-college women, college women, no-college men, and college men respectively in our panel.

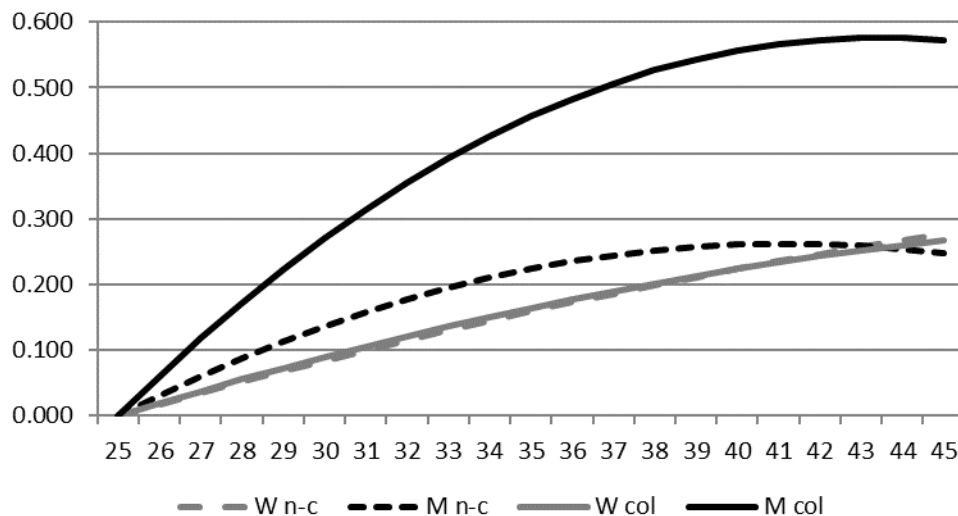
## 4. Results

### *I. A large part of the increasing earnings gap occurs within establishments*

Figure 2 shows the predicted age-earnings profiles obtained from separate regressions with fixed individual and establishment effects. The model includes year effects as well. The figure illustrates the evolution of earnings over time for someone who remains in the same establishment, relative to a 25 years old person of the same gender and educational group in the same establishment.

The first result is that for college-educated workers, a considerable part of the growth in the gender earnings gap occurs within establishments. Again we find a much steeper profile for college-educated workers, in particular for men. Non-linear payment schemes and competition over jobs within the establishment (as suggested by Goldin, 2014) may be one mechanism behind this differential within-employer earnings growth.

*Figure 2 Within Establishment Earnings Profiles*



Note: Predicted values from separate regressions for each educational level. The model also includes individual and establishment fixed effects and  $\ln$  establishment size with gender interactions, see methods section for details on the estimation method. Average profiles calculated on the matched sample from the largest 26 PMSA's in the US.



For workers without a college degree, the gap is increasing over the first 10 years, and then narrowing over time as the earnings profile for men flattens out considerably. At age 45 women have more than caught up with the earnings growth of men. In contrast to the case of men, women without a college degree actually have a slightly steeper earnings profile than women with a college degree.

Table 2 quantifies the size of the gender earnings gap within establishments for different age groups, relative to a 25 years old person of the same gender and education. Among the non-college educated workers, we find that men have faster earnings growth within establishments until the age of 35, but that women catch up in terms of earnings growth after that, and by 45 their growth has surpassed men's by .03 log points.

For the college educated workers, men have faster earnings growth up to the age of 40, followed by some catching up by women between ages 40 and 45 as the male earnings profile flattens out. At age 45, college educated men have had on average .3 log points higher accumulated earnings growth than similarly educated women.

*Table 2 Gender pay gap within establishments by education and age*

	No college			College		
	Women	Men		Women	Men	
30	0.085	0.137	0.053	0.090	0.271	0.181
35	0.159	0.224	0.065	0.164	0.456	0.292
40	0.224	0.261	0.038	0.224	0.557	0.333
45	0.278	0.248	-0.030	0.268	0.572	0.304

Note: Log point difference from a 25 years old individual of the same gender and education. Calculated from predicted values from separate regressions of ln earnings each educational level, see Figure 2.

## *II Seniority and age profiles*

Next we decompose the within establishment earnings growth into components that are due to seniority, versus due to changes in the relative position within employers, conditional on seniority. In previous literature, this distinction has been used to retrieve the return to general versus specific human capital (Becker 1964), but also to analyze the agency problems and to

provide estimates of delayed compensation schemes (Lazear 1992). Table 3 displays the estimated returns to seniority. Note that these estimates control for both the establishment and individual fixed effects, and as such control for both the possible correlation between a high paying job and seniority, which has been a significant concern in the previous literature (see e.g. Barth 1997), and the possible correlation between individual fixed effects and the likelihood of staying in the same establishment versus changing jobs. We find that men have a higher return to seniority, i.e. a steeper earnings profile within establishments, than do women, particularly among the college educated. For college educated employees, the internal careers matter significantly as a source of the differential earnings development over time.

*Table 3 The return to seniority by gender and education*

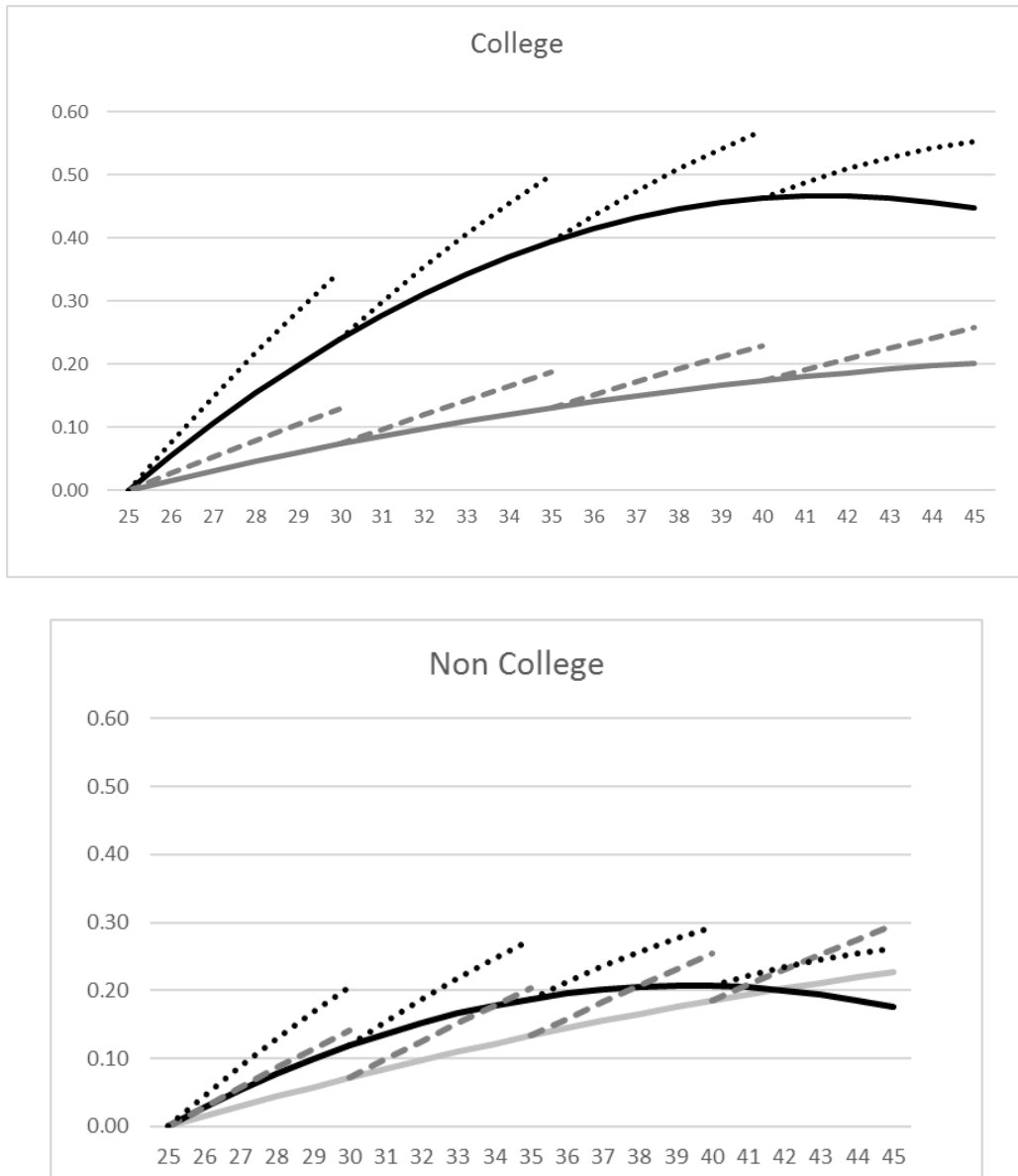
	No college			College	
Women	Men	Difference	Women	Men	
0.0139	0.0172	0.0033	0.0112	0.0213	0.0100

Note: Estimated coefficient for seniority in the full model specification per the model of equation (6), estimated from job-effect equations (equation (7) above).

Conditional on seniority and the establishment fixed effect, the age profile measures the improvement in the relative position within the establishment that a person experiences even when changing jobs. An example of a positive within-establishment earnings change would be a person low in the earnings hierarchy of one establishment who changes jobs to a position higher up in the earnings hierarchy of another establishment. What we do is to decompose the within establishment earnings growth into a part that is lost when a person changes jobs (the returns to seniority) and a part that is not lost when a person changes jobs (returns to age, conditional on seniority). The age profile conditional on seniority is calculated by subtracting the returns to seniority multiplied by the average increment of seniority by years of age from the linear term of the within establishment age profile as displayed in Figure 2. As an illustration, figure 3 shows the age profiles (solid lines), for given seniority, and the additional returns to seniority, for a person changes job three times during the 20 years from 25 to 45 years of age. Whereas Figure 2 summarizes the average path for an average job change pattern, Figure 3 illustrates the effects of seniority versus the age profile over time. The seniority and age profiles both contribute to the

widening of the within establishment earnings gap over time, particularly for the college educated workers.

Figure 3 Seniority and Age

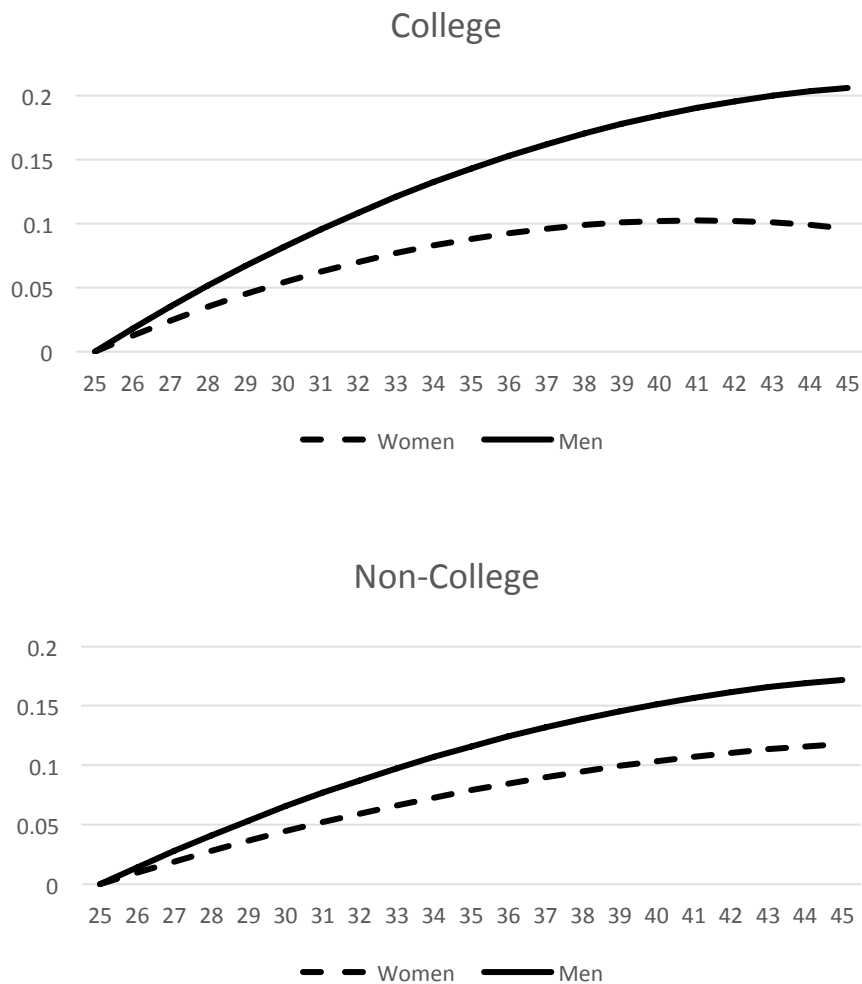


Note: Solid lines: earnings age profiles conditional on seniority within the establishment. Dotted lines: earnings seniority profiles. Predicted values from separate regressions for each educational level. Black lines: Men. Grey lines: Women. The model also includes individual and establishment fixed effects and ln establishment size with gender interactions, see methods section for details on the estimation method. Average profiles calculated on the matched sample from the largest 26 PMSA's in the US.

### III. The gap between establishments increases over time

We label the sum of the coefficient of the fixed establishment effect and the component of earnings that is attributable to firm size, the “earnings premium of the establishment”. This earnings premium measures how much more (or less) the employer pays over and above the average establishment in the economy. The widening of the gap in this premium as individuals age represents a key finding in this paper: it shows the differential contribution for men and women coming from job-to-job changes during their prime working age years.

Figure 3 Predicted Establishment Earnings Premium



Note: Predicted establishment earnings premium – age profiles relative to a 25 years old of the same education and gender. Predicted values from separate regressions for each gender and educational level. The establishment earnings

premium includes the fixed establishment effect and the earnings premium due to firm size. The model also includes individual fixed effects, see methods section for details on the estimation method. Average profiles calculated on the matched sample from the largest 26 PMSA's in the US.

We report in Table 4 the result of the education-specific regressions that we run as follows. First, we estimate the fixed firm effects on the full set of workers, with interaction terms that allows for differential earnings-age profiles within firms by educational group. Next, we regress the earnings premium of the establishment where a person works on his/her age and age squared, conditional on an individual fixed effect. Note that the earnings premium only changes if a person changes job, and that a person who stays in the same job during the whole observation period will have a constant earnings premium.

*Table 4 Growth in establishment earnings premium over time*

	No College			College		
	Women	Men	Difference	Women	Men	Difference
30	0.045	0.066	0.021	0.054	0.082	0.028
35	0.079	0.116	0.037	0.088	0.143	0.055
40	0.104	0.152	0.048	0.102	0.185	0.083
45	0.118	0.172	0.054	0.096	0.206	0.110

Note: Log point difference in the establishment earnings premium from a 25 years old individual of the same gender and education. Calculated from predicted values from separate regressions of ln earnings each educational level, see Figure 3.

We may now compare the magnitude of average earnings growth due to within-establishment versus between-establishment earnings differences. Table 5 reports the earnings growth between establishments relative to the total earnings growth. Note that all coefficients are estimated conditional on individual fixed effects. We find that, for women, the share of earnings growth from age 25 to 45 that is attributable to the growth of the establishment earnings component is about 30 percent for the non-college educated and about 26 percent for the college educated. For men, the share is about 41 percent for workers without a college degree, and about 27 percent for college educated workers.

Up to the age of 40, about 56 percent of the gap in earnings growth between non-college educated men and women, and about 20 percent of the gap between college-educated men and women, are due to differential growth in the establishment component of pay. The remaining parts are due to differential earnings growth within establishments. By the time our individuals reach age 45, the share is much larger: about 225 percent for non-college and about 27 percent for college educated workers. The reason for the very large number for the non-college educated workers is that by the time they reach 45, women catch up and even surpass men with respect to the within-establishment earnings growth (see figure 2), whereas the establishment component still displays a widening up to 45 years of age (figure 3).

*Table 5 Share of growth due to establishment earnings premium, percent*

	No College			College		
	Women	Men	Difference	Women	Men	Difference
30	34	32	29	38	23	13
35	33	34	36	35	24	16
40	32	37	56	31	25	20
45	30	41	225	26	26	27

Note: Log point difference in the establishment earnings premium from a 25 years old individual of the same gender and education (table 3) relative to the sum of the within and between earnings growth (table 2 and table 3).

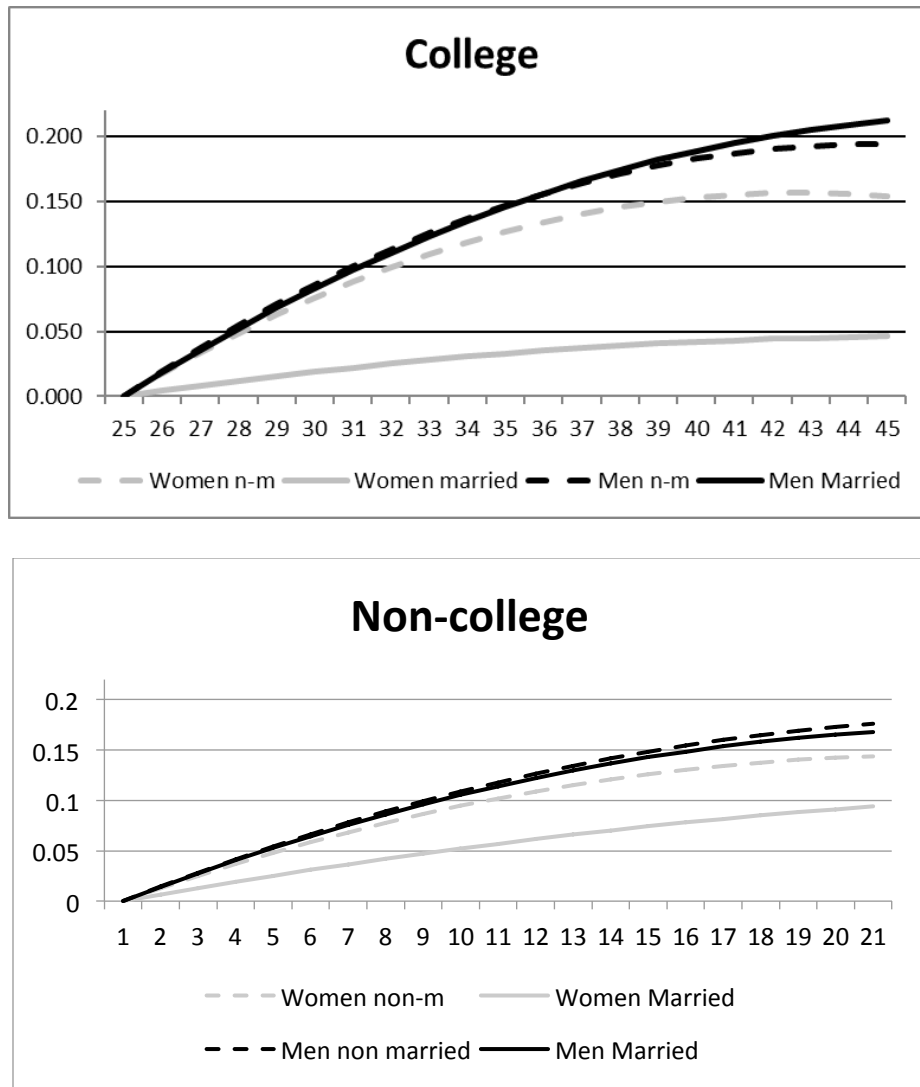
*IV. The growing gender earnings gap between establishments is almost entirely due to a widening of the gap among married workers*

We further investigate the role of marital status in explaining the widening of the gender earnings gap arising from earnings differentials across establishments. Figure 4 displays the predicted establishment earnings premium by age for married and non-married men and women. Interestingly, although not surprisingly, the bulk of the increase in the establishment earnings gap over the life cycle is driven by the behavior of married men and women. Consider college educated workers first. The earnings path for married and nonmarried men is very similar, but so is also the earnings path of non-married women. The difference in the growth of the establishment component of pay seems to be entirely driven by the lower growth among married

women. For non-college works, the pattern is similar, but less pronounced. Again, the dominant part of the difference between men and women arise from lower growth among married women.

Figure 4. Predicted establishment earnings premiums by age.

By gender, education and marital status



Note: Predicted values from separate regressions for each gender and educational level. Dependent variable: Establishment earnings premium. Average profiles calculated on the matched sample from the largest 26 PMSA's in the US, see data section for details.

### *V) Children*

The finding that the gender difference in the widening of the establishment earnings premium is mainly due to the difference between married women and the rest, strongly suggests that the arrival of children matters for the different careers of men and women across establishments. Currently we do not have access to the match between husbands and wives in our data, and cannot pursue this issue within the elaborate modelling framework we have used so far. We thus end this paper with an exercise on the publicly available IPUMS version of the 2000 long form Decennial Census, comparing age-earnings profiles between genders with different marital status and number of children in the 2000 cross section.

More specifically, we compare the age-earnings profile of men and women in eight types of households. The first is households composed of two college educated workers, the second is households with a college educated women and a non-college educated husband, the third is households with a college educated man a non-college educated wife, the fourth is households with two non-college educated persons. Then there are four types of single households from each combination of gender and education.

Figure 5 shows the estimated age-earnings profiles for men and women in the different types of households. The estimates are based on OLS  $\ln$  earnings regression on the 2000 Census IPUMS cross section sample. The first graph 5a illustrates earnings profiles for college educated women. The upper panel, CC, shows the earnings profiles of college educated couples with (dotted lines) and without (solid lines) children. The striking result is that the widening of the of the gap between college educated men and women who are married to college educated spouses is almost entirely due to a widening of the gap between men and women who have children in the household.

Consider next the CN households, where the woman is college educated and the man is not. Two observations stand out. The first is that there is very little gender differential in such households. The second is that the difference in the profiles between households with and without children is small. Still, whatever widening there is, again is located with the households with children only.

Comparing men and women in single college educated households replicates the pattern of college-college households with respect to the widening of the gap: Only among the singles with children do we observe a widening over time. However, the location of the curves in terms of



levels are quite different, probably reflecting a combination of selection into marriage among the college educated and the burden of being a single care taker of children. We note that the widening of the gender gap over time for households with children is less pronounced for single households, possibly reflecting specialization in the households that is possible for the couples only.

Figure 5a Earnings profiles for men and women different households, Census data 2000

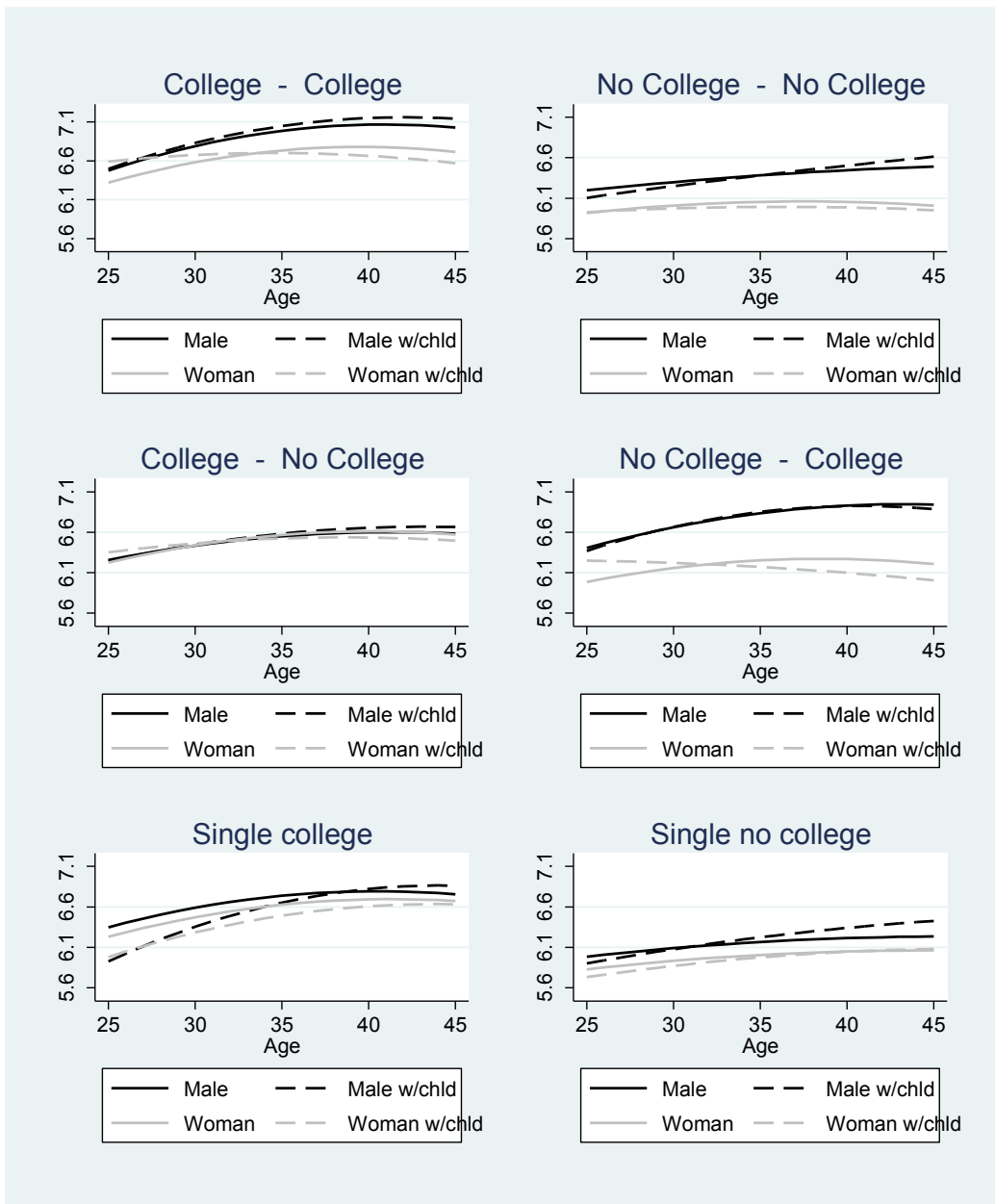


Figure 5b illustrates the predicted earnings profiles for non-college educated women in different households. In the non-college - non-college households, the difference between those with and without children is less pronounced. However, the pattern is still that the widening over time is larger in households with children. This pattern is striking in the non-college-college households. Women without a college degree and with children, married to a man with a college degree, have a declining earnings profile over time and see a huge widening of the earnings gap over time.

### **Discussion and conclusions**

The gender earnings gap widens considerably during the first two decades of working life. This widening is much stronger among college-educated workers than among workers without a college degree. Men with a college degree experience twice as much relative earnings growth from 25 to 45 years of age as do women with a college degree. In comparison, the difference between the earnings growth of men and women without a college degree is minimal, only 2.4 log points over the 20 years. The widening of the gender earnings gaps over early careers can be decomposed in a *within-* and a *between-establishment component*. The first captures gender differentials in wage growth coming from climbing the job-ladder within an establishment. The second captures gender differences in wage growth coming from switching establishments.

In terms of earnings growth *within establishments*, college educated men stand out with a significantly higher earnings growth than all the other groups. The within establishment earnings growth may be attributed to higher earnings growth within the same establishment, and/or to better placements within establishments when being hired into new establishments. Men have both steeper seniority profiles within establishments, on average longer seniority, and experience a steeper age-earnings profile within establishments, conditional on seniority.

The allocation of workers *between* establishments and its change over time also adds significantly to the widening of the gender earnings gap, especially for the college educated. Men climb the establishment ladder faster than women. From 25 to 45 years of age, the establishment earnings component grows by 21 log points among college educated men, and by 10 log points for college educated women. The gender difference in the growth of the establishment component can arise from two sources. Differences in the probability of job-to-job transitions, and differences in the earnings gain associated with such job changes. Note that a voluntary job move is likely to be

associated with earnings gains, whereas involuntary or “tied” moves are more likely to be associated with an earnings loss. What we account for in this paper is the combined result of such differences.

We find that almost all the difference in the growth of the establishment component of pay across genders is due to differences by marital status. Whereas the difference between men and women in the growth of the establishment component is small among non-married employees, there is a large widening of the gender gap for the married. This pattern is particularly strong among college educated workers: At 45 years of age, a married college educated man has gained more than 20 log points of earnings, whereas a married college educated woman gains on average less than 5 log points. We supplemented our analysis with an analysis of overall earnings growth in the 2000 cross section for individuals with different partner status in terms of education; the results show that the widening of the earnings gap is particularly strong among college-college couples with children. Overall, our result suggests that among married couples, the household division of labor and child caring responsibilities tend to limit women’s career choices with respect to job-to-job changes, relative to men’s and this is an important determinant of the widening of the gender earnings gap. The richness of our data may allow for further exploration and (potentially) identification of the mechanisms at work.

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