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The changing gender gap across the wage distribution in the UK

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Discussion Paper No. 01-56

The Changing Gender Gap Across the Wage Distribution in the U.K.

Bernd Fitzenberger and Gaby Wunderlich

ZEW

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Wirtschaftsforschung GmbH

Centre for European
Economic Research

Non-technical Summary

This paper investigates the level and the dynamics of the gender wage gap in the United Kingdom during the time period from 1975 to 1995. Our empirical analysis is based upon data from the General Household Survey (GHS), which provides a large representative cross-section for each year. We contribute descriptive evidence on the development of the gender wage gap for different skill groups and full- and part-time employees in the U.K. Moreover, and in contrast to most previous studies, we analyze the entire wage distribution and not only differences in mean wages between men and women. Thereby, we obtain stylized facts on the dynamics of the gender wage gap across the entire wage distribution.

Our focus is not to provide a causal examination. We rather try to identify the macroeconomic trends of wages apart from life cycle and cohort effects implementing a model which takes the impact of age, time, and birth cohort simultaneously into account. That is, we decompose the raw wage growth which we observe separately for three skill groups of full-time employed men and full-time, and part-time employed women into growth due to macroeconomic forces, growth due to the evolution along the individual's life cycle, and growth due to changing characteristics of successive birth cohorts. The aim of this procedure is to compare the macroeconomic wage trends of men and women independent from the effects of aging and cohort membership.

The gender wage gap for **full-time** employed females decreased considerably during the time period from 1975 to 1995. The reduction in the gender gap for full-timers was strongest in the lower part of the wage distribution for all skill groups. This is in contrast to **part-time** employed females: the reduction was much smaller for medium skilled part-time employed females than for medium skilled full-time employed females. The gender wage gap basically remained constant for low- and high skilled part-time employed females. The occurrence of increasing wage inequality between women choosing different working time arrangements will have to be investigated in more detail by future research.

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The Changing Gender Gap Across the Wage Distribution in the U.K.¹

Bernd Fitzenberger² and Gaby Wunderlich³

Abstract: This paper contributes descriptive evidence on the development of the gender wage gap for different skill groups and full- and part-time employees in the U.K. The empirical analysis is based upon the General Household Survey from 1975 to 1995 and therefore provides evidence on an exceptionally long period. Our focus is not to provide a causal examination. We rather attempt to identify the macroeconomic trends of wages apart from life cycle and cohort effects implementing a model which takes into account the impact of age, time, and birth cohort simultaneously. Moreover, quantile regression is used to distinguish between various points of the entire wage distribution. We conclude that the wage gap between full-time employed females and full-time employed males has closed considerably during the observation period. The gap has closed mostly in the lower part of the wage distribution. In contrast, part-time employed women did not catch up relative to full-time employed men.

Keywords: Gender Wage Gap, Quantile Regression, Cohort Analysis

JEL Classification: J16, J31, J71

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1 Introduction

In recent years, numerous studies on the gender wage gap in the U.K.¹ have been presented and it has been documented that on average the gender wage gap for full-time employed females has been decreasing since the 70's, while no improvement for part-time employed females has been found. Based on international comparisons, Blau and Kahn (1996, 1997) argue that the gender wage gap has been decreasing in most industrialized countries despite a tendency for increasing wage dispersion among male workers, see also Altonji and Blank (1999). Since average formal educational attainment is lower for females than for males one would expect an increasing gender wage gap when wage inequality among males rises. Thus, Blau and Kahn (1997) interpret the reduction in the gender wage gap as women "swimming upstream".

In the light of the sharp increase in wage inequality among males in the U.K. this paper analyzes empirically the changing distribution of wages for full-time employed males as well as for full-time and part-time employed females of different skill groups. We analyze gender differences at different points of the wage distribution thus providing a comprehensive description of the gender wage gap across the entire wage distribution. For the U.K., a detailed distributional analysis of the type provided in this paper is missing. Our analysis extends upon standard decomposition exercises merely analyzing the average gender wage gap.

In particular, our analysis addresses the following issues:

- How do wages differ over the life cycle between male and female workers? Do women benefit less from wage growth over their life cycle, and is this possibly due to interruptions in the accumulation of human capital during the child rearing phase or due to the lack of career possibilities?
- Do the data confirm that the disproportionate increase of the formal education level of females is associated with a reduction of the gender wage gap?
- If the sociological role model of women has changed towards a higher labor force participation and higher formal education levels, one should observe a narrowing gender wage gap. Such changes are likely to have a stronger effect on regular full-time jobs compared to part-time jobs, since full-time jobs reflect stronger labor market attachment. In addition, birth cohort effects on female wages could be operating such that younger cohorts benefit disproportionately from a reduction of the gender wage gap, since younger cohorts have better chances to obtain higher formal skill levels and are more strongly attached to the labor market.
- If institutional or social efforts (equal pay legislation, affirmative action programs) to improve the relative earnings of women result in a reduction of the gender wage gap, it would again be likely that those policies have a stronger effect on regular full-time jobs compared to part-time jobs. Since the share of males in part-time employment is very small it is difficult to compare female part-time workers with male workers.

¹See, for example, Bell and Ritchie (1998), Harkness (1996), Joshi and Paci (1998), Manning and Robinson (1998), and some of the papers in Gregg and Wadsworth (1999a).

The empirical strategy of the paper is to estimate a parsimonious descriptive model describing life cycle, birth cohort, and time effects on wages for different groups of workers defined by their formal education level and employment status. Various tests are performed as to whether cohort effects exist and whether time trends are uniform across cohorts and across the wage distribution. The differences in the estimated time trends are interpreted as changes in the gender wage gap between male and female workers of the same age and the same formal skill level. Our findings should be interpreted as stylized facts on the gender wage gap in the U.K. over the time period from 1975 to 1995. In order to address the inherent identification problem between age, year, and birth cohort effects (see Heckman and Robb, 1985), this paper builds on the modelling approach introduced by MaCurdy and Mroz (1995) and applied in Fitzenberger et al. (2001) and Gosling et al. (2000) to study the wage structure for males only. We have also used this approach in our companion paper Fitzenberger and Wunderlich (2000) on gender wage differences in West Germany.

Gosling et al. (2000) analyze the changing distribution of male wages in the U.K. between the late 70's and the mid 90's. It is well known that male wage inequality increased strongly over that period. Analyzing the conditional wage distribution by formal education level, year of birth ($\equiv$ cohort), and age by using quantile regressions, Gosling et al. show that about one third of the increase in male wage inequality can be attributed to the rise in wage differences between different education groups, one third to a slowdown of growth in entry wages ($\equiv$ wages earned when entering the labor market) for younger birth cohorts, and the final third to an increase in the unexplained wage dispersion within groups of workers defined by education, age, and cohort.

Our main results are the following: Corresponding to results in the literature, the gender wage gap for full-time employed females decreased considerably during the time period from 1975 to 1995. The reduction was much smaller for medium skilled part-time employed females, and the gender wage gap basically remained constant for low- and high skilled part-time employed females. The reduction in the gender gap for full-timers was strongest in the lower part of the wage distribution for all skill groups. However, wage growth itself proved particularly strong for high skilled full-time employed females thus also reflecting increasing returns to education for females. In contrast, low- and medium skilled part-timers did not gain relative to their male counterparts and thus for these women the gap to the upper part of the male wage distribution even increased.

The remainder of the paper is structured as follows: The findings of the recent literature on the gender wage gap in the U.K. are discussed in section 2. Section 3 describes the data used for the empirical analysis. Some basic descriptive evidence on the gender wage gap in the entire distribution is presented in section 4. Our empirical framework to test for uniformity of wage trends and to identify cohort effects is developed in section 5. Making use of this framework, section 6 describes the main empirical results obtained in this paper. Section 7 provides our conclusions. The final appendix describes the empirical framework in more detail and comprises tables and figures referred to when discussing the empirical results.

2 The Gender Wage Gap in Britain

The traditional strategy of investigating the gender pay gap (first proposed by Blinder, 1973 and Oaxaca, 1973 and extended by Juhn/Murphy/Pierce, 1993) is to decompose the mean wage differential between males and females into differences due to observed individual wage determining characteristics, differences in rewards to these characteristics, and an unexplained share. This strategy, which is usually based on Mincer-type earnings equations, is applied to the British case in various studies (for a brief overview see Joshi/Paci, 1998: pp34). Changes in the gender wage gap are then identified by looking at changes of these components or comparing the relative wage position of females within the male wage distribution between at least two points in time. The findings obtained by previous studies differ, because they use different data and model specifications and compare cross sections in different years.² But in general, they find that the average full-time gender gap has narrowed substantially between the 70's and the 90's, whereas the average part-time gender gap remained constant at best.

Gender related policy changes have occurred during the observation period, starting with the decisive Equal Pay Act of 1970 ratified in 1975 which attempted to prevent gender related wage differences for the same work. These policies appear to have contributed to reducing gender wage differentials in the British labor market.³ In addition, the overall gap in educational attainment has closed, as younger and better educated female cohorts replaced older and less educated cohorts dropping out of the labor force. But according to Desai et al. (1999) there is now a clear distinction between the levels of qualification of full-time and part-time employed women. Another trend influencing pay rates decisively is that average employment tenure increased tremendously for females. Maternity Rights legislation (1987, amended in 1993) has enabled far more women than before to return to the same employer after the birth of children (Desai et al. 1999, Gregg/Wadsworth 1999b).

Desai et al. (1999)⁴ find that the average wage gap of all men and full-time employed women has narrowed from 43 percent in 1975 to 24 percent in 1995.⁵ In terms of the aforementioned Blinder–Oaxaca decomposition, the characteristics component has declined from 12 percent to 5 percent, the rewards component has declined from 28 percent to 12 percent, and the unexplained part of the gap increased from 3 percent to 7 percent. In contrast, the mean wage gap between all men and part-time employed women has risen from 46 percent in 1975 to 55 percent in 1995. The share of the pay gap due to differences in characteristics increased from 3 percent to 15 percent, the share due to their rewards increased from 33 percent to 53 percent.⁶

²Most studies use cross sectional micro data, see for comparatively new evidence, inter alia, Desai et al. (1999), Blackaby et al. (1997), and Harkness (1996). The studies of Makepeace et al. (1998) and Joshi/Paci (1998) are based on cohort data. To our knowledge, the only recent studies using panel data are Bell/Ritchie (1998) using the New Earnings Survey and Manning/Robinson (1998) using the British Household Panel Study.

³See Wright/Ermish (1991) for an overview of the studies investigating this in the 70's and 80's.

⁴We use this study as reference because it is congruent with our data and observation period.

⁵Using the General Household Survey and controlling for education, age, job tenure, industry, region, and children.

⁶The latter result is somewhat confusing, because adding both numbers leads to a negative unexplained share of 13 percent.

Gender wage differentials are partly related to differences in actual labor market experience which contributes to the individual's human capital. An additional explanation for age-earnings profiles is offered by Manning (2000). Using a simple search model, he shows that a substantial share of the rise in earnings over the life cycle and virtually all the earnings gap between men and women can be explained in this way. In this framework, the narrowing of the gender wage gap has to be attributed to the convergence of male and female labor market transition rates.

When investigating the gender wage gap, it is necessary to make a distinction between full-time and part-time employment, because the latter jobs are primarily female and might, for various reasons, exhibit a "systematic" wage penalty. It is often assumed that gross hourly wage offers are independent from hours worked (with the exception of overtime hours). But this is not necessarily the case. Ermish/Wright (1991) find strong evidence that women receive lower wage offers in part-time jobs than in full-time jobs. When controlling for self selection into these two types of jobs, they show that a woman with given education and employment characteristics generally receives a lower wage in part-time than in full-time employment.

Trying to explain this finding, Ermish/Wright (1991) argue that the supply function for part-time workers may be distinct from that of full-timers: Several characteristics of part-time jobs, such as a better possibility to reconcile family and employment allow a substitution of higher wages for these characteristics.⁷ This causes a compensating wage differential due to unmeasured characteristics of the job or workplace. Further arguments for a full-time/part-time wage gap are based on higher fixed costs for part-time jobs, labor market segmentation after having worked full- or part-time for a while, stronger monopsony power of employers in local labor markets because of a lower mobility of part-time workers, and the impact of different individual characteristics on the choice to work full-time or part-time.

In their overview on the gender gap in the British labor market, Desai et al. (1999, for a more detailed analysis see Harkness, 1996) emphasize that the pattern of change in the gender pay gap depends very much on whether a woman works full-time or reduced hours. All the relative gain in pay made by women compared to men is due to full-time employed women. In 1974 full-time employed women earned, on average, 60 percent, whereas part-time employed females earned 65 percent of male average wages. In 1994, full-timers reached nearly 80 percent and part-timers still remained at 65 percent of the average male wage. Harkness (1996) finds that when estimating different specifications for full-time and part-time employed women, supply and demand factors completely explain the wage gap between these two groups. That is, the gap is due to differences in characteristics.

A deficiency of a descriptive analysis of the change in the average gender pay differentials is that the findings may be caused by selection or composition effects. This might be due to a changing distribution of individual characteristics like education and tenure, or to a changing self selection regarding employment in general as well as full-time and part-time jobs over time (e.g. if the availability of child care facilities or individual mobility has improved). Demand side factors, such as structural and techno-

⁷Individuals jointly maximize their utility from working over the wage rate and other attributes of the job or workplace.

logical change, market power, or union coverage (see Bell/Ritchie, 1998) are important as well. Furthermore, rising wage inequality could mean that simple comparisons of average wages of men and women give a misleading impression of the change in the labor status of women (Desai et al. 1999: 177). Blau/Kahn, (1997) convincingly argue that wage dispersion and gender wage differentials are closely linked. For instance, if returns to human capital rise, women will see a fall in their relative earnings due to their lower stock of human capital. Additionally, the wage gap differs across the entire wage distribution, and the various quantiles progress differently over time (for a descriptive analysis see Harkness, 1996). Overall wage inequality has changed as well as have returns to education, experience, and job tenure (e.g. Gosling et al. 2000, Gregg/Wadsworth, 1999b, and Manning, 2000). Moreover, (re)entry wages have declined (Gregg/Wadsworth, 2000).

In contrast to the numerous studies using the traditional average wage gap decomposition technique, little attempt has been undertaken to account for differences in the gender gap across the entire wage distribution. Blackaby et al. (1997) extend the method of Juhn/Murphy/Pierce (1993) and analyze the gap at the 10% and the 90% percentile for the time period from 1973 to 1991. Their results indicate that the wage gap has narrowed mostly in the lower part of the wage distribution (see also Harkness, 1996). This is particularly striking in light of the strong increase in wage dispersion for males (Gosling et al. 2000) suggesting that British women are indeed “swimming upstream” (Blau/Kahn, 1997). When the dynamics of the gender wage gap differ across the distribution, results on the average gender gap can be quite misleading.

The focus of this paper is not to provide a causal examination of the gender wage gap. We rather attempt to identify the macroeconomic trends of wages, independent from life cycle (i.e. experience, job search, and tenure) effects as well as cohort effects for different skill groups, and at various points of the wage distribution. Implementing a framework which allows to consider the entire wage distribution, we contribute descriptive evidence of the gender wage gap at different points of the wage distribution. Such evidence can not be obtained by traditional decomposition techniques.

3 The General Household Survey (GHS)

The General Household Survey (GHS) was started in 1971. It is conducted by the Office of Population Censuses and Surveys based on a random sample of the population living in private (post-coded) households in the U.K. and it covers around 10,000 households. Between 1971 and 1996/97 interviews were carried out annually. Each household member above age 15 is interviewed. The survey response rate amounts to roughly 66 per cent. For this study, we use the repeated annual cross-sections from 1975 to 1995/96. The GHS data are often used for analyses of wages because they contain consistent information on usual weekly earnings, the individual’s highest formal education level, and various other important individual characteristics.

We use data on individuals between age 20 (age 25 for high skilled individuals) and 60 for whom valid information on educational attainment, wage, age, gender, working hours, and employment is available. All other observations are dropped. The age

interval for high skilled persons is reduced because these individuals usually finish full time education in their mid twenties. We compute log weekly earnings deflated to 1975 by the consumer price index and we distinguish three groups by gender and employment status: full-time employed men (M), full-time employed women (F(F)), and part-time employed women (F(P)).

We use the usual weekly earnings and working hours reported in the GHS (see Manning, 2000).⁸ Full-time employment is defined as working more than 35 hours a week. The part-time share within the group of females with valid wages varies between 30.30 and 37.22 percent and the share of women amongst all employees with valid wages, irrespective of whether the job is full- or part-time, varies between 42.06 and 52.31 percent. Both shares grow over time.

The GHS provides detailed information about each respondent’s educational background. Information on the highest educational qualification of each person is available for the period 1975 to 1982. From 1983 the GHS contains a list of all qualifications each individual has obtained. The questions about obtained qualifications changed slightly in 1988 and again in 1994. From this information we extracted the highest qualification of each person. However, the skill variable exhibits two structural breaks in 1983 and 1994 which results in an increase of missing answers between the two years. There is also a change in the questionnaire for 1988, but this is not visible in the data. Unsurprisingly, the non-response behavior is correlated across several questions, namely employment, wage, qualification, and working time. Thus, dropping individuals with missing wages reduces missing observations in qualification as well. We split the employment status groups by skill level into

- (U) low skilled individuals who report to have no or an “other” qualification,
- (H) high skilled individuals with qualifications above A-level, and
- (M) medium skilled individuals who constitute the remaining category.

The skill composition of the work force has changed remarkably during the observation period. The share of low skilled men and women (according to our definition) amongst employed persons with valid wage information dropped from 59.40 percent in 1975 to 21.35 percent in 1995. The share of the high skilled increased from 10.23 percent in 1975 to 27.48 percent in 1995.

The sizes of our subsamples, defined by gender, employment status, and skill level, varies between 6,132 observations (high skilled full-time working women) and 34,474 observations (medium skilled full-time employed males). Table 1 in the appendix shows the detailed numbers of observations by year, gender, skill level, and employment status. In our subsequent empirical analysis, we pool all cross-sections from 1975 to 1995.

⁸Even though we can define employment status based on working hours, it is not possible to construct hourly wages which are consistently defined over time, see Gosling et al. (2000).

4 Descriptive Evidence

This section presents the basic trends in wages for full-time working males, and for full-time and part-time working females over the time period from 1975 to 1995. At this point, we develop an overall picture about wage trends over this period. Therefore we do not control for participation changes and composition bias which presumably are serious problems for females in general and even more so for part-time working females. The unconditional curves discussed in this section portray a combination of time, age, and cohort effects. In the course of the paper, we will show how the composition of these effects differs across skill groups, various quantiles of the conditional wage distribution, and male as well as female full-time and part-time employees.

Figures 1 to 3 (see appendix) depict the trends in unconditional weekly log wages and cumulated growth rates of log wages of full-time working men, full-time working women, and part-time working women (cumulated growth rates are relative to 1975). Within each group, we distinguish the 20%-, 50%-, and 80%-quantiles of the wage distribution. This gives an impression of what happened at different points of the distribution and offers some provisional evidence of the development of wage dispersion.

Figure 1 shows wage levels and cumulated wage growth for the three groups by employment status and gender. Here, we pool the three skill groups. The left panel of the graphs shows the usual picture of wage level differences between the status groups with full-time employed men showing the highest wage level at every quantile and every point in time, followed by full-time employed females. The wage levels of part-time working females are the lowest. This is to be expected, since we investigate weekly wages. The wage distribution of full-time working females is more compressed than the distribution of males and part-time working females.

Cumulated wage growth is depicted in the right panel of figure 1. It is evident that wage growth was typically positive for all status groups and that wage dispersion has increased for all groups (because wage growth is higher at higher quantiles). There is a small spike in the curves in the beginning of the observation period. This spike is also found in other studies based on different data sets (for example, see Blackaby, 1997: 258 and Machin, 1999: 190). In the upper two graphs (full-timers), wage dispersion started to increase in the beginning of the eighties, whereas for part-timers we observe growing dispersion over the entire period. Full-time working women have made the largest gains over time. Their cumulated growth rates amount to 50 percent (in logarithms) at the 20%-quantile, 55 percent at the median, and 75 percent at the 80%-quantile. For full-time employed men and part-time employed women, the growth rates are roughly the same at the different quantiles. They amount to about 25 percent at the 20%-quantile, 40 percent at the median, and 50 percent at the 80%-quantile.

Among other things, wage dispersion may increase or decrease with a change in the distribution of skills which are paid differently.⁹ Figure 2 exhibits wage trends by educational level. It is apparent that aggregating different skill levels within employment status groups hides important differences in growth rates. The location of wage distri-

⁹For an overview on the debate about increasing wage dispersion in the U.K., see Blackaby et al. (1997).

bution is positively related with skill level for all three status groups. Wage dispersion increases considerably less within skill groups compared to the trends shown in figure 1. For high skilled males, all skill groups of full-time employed females, and medium skilled part-time employed females wage dispersion does not change by an important magnitude. Thus, in the case of full-time employed females wage inequality increases for the most part not within, but between skill groups.

Furthermore, we find that especially for full-timers wage growth is strongest for high skilled individuals: High skilled full-time working females gain around 60 percent (in logarithms) with only small differences across the distribution. High skilled men exhibit a cumulated growth rate of 40 percent at all three quantiles in 1995. In contrast to high skilled men, wage inequality has risen for medium and low skilled men. For full-time employed medium and low skilled females, the pictures are nearly identical. Both groups exhibit a wage growth of around 40 percent at all three quantiles in 1995 and wage inequality has risen only marginally. It has to be emphasized that wage growth of high skilled full-time employed females is one third larger than wage growth of medium and low skilled full-time working females.

Part-time working women of all skill groups exhibit the weakest wage growth over time in comparison to male and female full-timers. Except for the medium skilled, the curves seem to have more pronounced ups and downs compared to the other groups. The growth rate of high skilled females varies the most at the lowest quantile. The cumulation rate amounts to 25 percent (in logarithms) in 1981 and decreases by nearly 40 percentage points in the following three years. Nevertheless, in 1995 cumulative wage growth of part-timers is always positive. The low skilled face growth rates of 5 percent at the 20%-quantile, 13% at the median, and 26 percent at the 80%-quantile. Wage inequality has therefore increased within this group. The growth rates of the medium skilled amount to 25 percent at 20% quantile and median, and 20 percent at the 80% quantile. Because the ranking of the quantiles often reverses during the observation period, there is no indication of changing wage inequality.

As mentioned before, wage growth of high skilled part-timers is very volatile. Starting in 1985, the curves of the median and the 80% quantile exhibit more continuity. In 1995 the 80% quantile exhibits a growth rate of 30 percent, median and 20% quantile 20 percent. The comparison of cumulative wage growth of males and females with the same educational level shows that the gender wage gap has narrowed for full-timers and has increased for part-timers. This finding is in line with previous studies referred to in section 2.

Figure 3 exhibits the differences in cumulated growth rates of full-time employed females versus full-time employed males, and part-time employed females versus full-time employed males. These differences are calculated separately for the three skill levels and the three quantiles. The effects in the lower part of the wage distribution of full-timers are particularly interesting with women at the 20%-quantile gaining the most. For all skill groups the cumulated wage growth is roughly 20 percentage points higher compared to full-time employed males at the 20%-quantile. This is in line with Blackaby et al. (1997: 258) who find that the reduction in the gender wage gap is strongest at the lowest quantiles of the earnings distribution.

Also, the median of low and medium skilled full-time employed females exhibits stronger growth than males. The cumulated difference amounts to roughly 10 percentage points. In the case of high skilled females, wage growth at the median and the 20%-quantile are 20 percentage points ahead of their male counterparts. For the low skilled and the high skilled, changes at the 80%-quantile are less than changes for the median and the 20%-quantile during the whole period whereas in the group of medium skilled, the median and the 80%-quantile move in a very similar fashion below the 20% quantile.

These results indicate that, for all skill groups of full-time employees, the gender wage gap has narrowed mostly in the lower part of the wage distribution. The literature often attributes the narrowing of the gender wage gap to policy changes which were implemented in the beginning of the 70's: "It can be seen [...] that the gender gap only began to narrow around 1973 most probably reflecting the fact that the [Equal Pay] Act gave employers a five year time scale to bring wages for comparable jobs into line" (Blackaby et al., 1997: 258). Nevertheless, it is puzzling that these policies should have been most successful in the lower parts of the wage distribution for all skill groups considered. Also, the gains for females were not concentrated in the 70's making it unlikely to attribute them (solely) to the Equal Pay Act.

The comparison of wage growth rates of part-time females and full-time males shows a completely different pattern: The gender gap has increased but the pattern of growth differences varies across skill levels. One may speculate that, because of the female dominance within the part-time segment of the labor market, institutional restrictions apply to a much smaller extent, which allows employers to pay females a lower wage over time compared to the mostly full-time working males.

5 Empirical Model

This section presents the empirical framework to investigate the movement of the entire wage distribution for synthetic cohorts over time. A cohort is defined by the year of birth of the worker. Regarding the rising labor force participation rates of females, it is often argued that the behavior of females has changed such that younger cohorts are more attached to the labor market.

We investigate wages over the years 1975 to 1995 for different cohorts stratified by gender and skill levels. We use the framework that was first developed in MaCurdy and Mroz (1995) to analyze wage trends in the United States. It was also applied by Fitzenberger et al. (2001), Fitzenberger and Wunderlich (2000), and Gosling et al. (2000). This section outlines the basic empirical approach. Further methodological details can be found in the appendix.

In order to decompose between- and within-shifts in the wage distribution, we estimate various quantile regressions. Testing for uniformity across cohorts and across quantiles for given cohorts allows us to investigate whether the entire wage distribution has shifted uniformly over time. Alternatively, it could be the case that wage trends differ across cohorts indicating the presence of "cohort effects" and by quantiles indicating a trend towards increasing or decreasing within group wage dispersion. In providing

a parsimonious representation of trends in the entire wage distribution, we are able to pin down precisely the differences in wage trends across groups of workers defined by gender, skill level, and employment status. Since the estimates are based on all years of observation, we are not restricted to a pointwise comparison of one-dimensional summary measures of average wage differences in two particular years as it is often done in the literature, see section 2.

5.1 Decomposing Age, Cohort, and Time Effects

Based on longitudinal data, we intend to separate the wage patterns into age, cohort, and time effects. The age effect describes how wages of a given cohort change as the cohort ages. The time effect describes how macro economic shocks shift wages for a given cohort. Cohort effects summarize the difference between cohorts. Of course, it is well known that the three effects cannot be identified separately. More specifically, the linear effects of time, cohort, and age are not separately identified without further prior assumptions (however, higher order polynomials are identified). This is due to the fundamental identity that links birth year c , age a , and calendar time t

$$(1) \quad t = c + \alpha.$$

Let the logarithm of the wage w for a cohort c at age α be represented as

$$(2) \quad \ln[w(c, \alpha)] = g(t, \alpha) + u$$

where u is a residual component. Alternatively, $\ln(w)$ can be represented as a function of α and t (or even as a function of c and t):

$$(3) \quad g(c, \alpha) \equiv g(t - \alpha, \alpha) \equiv f(t, \alpha)$$

$g(c, \alpha)$ specifies the longitudinal (cohort) profile for a given cohort c over age. $f(t, \alpha)$ specifies the cross-sectional age profile at a given t . Our empirical analysis uses a polynomial representation for $g(c, \alpha)$, which is additively separable in cohort, time, and age effects

$$(4) \quad g(c, \alpha) = G + K(c) + A(\alpha) + B(c + \alpha),$$

where $A(a)$ and $B(c + \alpha) \equiv B(t)$ are low order polynomials in α and t , respectively.

We assume that successive cohorts enter the labor market at the age α_e and that $\alpha_e = 20$ years for low- and medium skilled workers and $\alpha_e = 25$ years for high skilled workers due to the longer education period for the latter group. For the empirical analysis, we actually define the variable α as the deviation from the labor entry age α_e and the variable t as deviation from the year 1975. Hence cohort $c = 0$ is the cohort entering the labor market in 1975.

The specification of the cohort effect $K(c)$ differs between those cohorts born before 1955 (1950) (i.e. those who are older than 20 (25) in the first sample year 1975) and younger cohorts born after 1950 (1955):

$$(5) \quad K(c) = \gamma_{b2} \cdot c_b^2 + \gamma_{b3} \cdot c_b^3 + \gamma_{a2} \cdot c_a^2$$

where $c_a = 0$ and $c_b = c$ are for cohorts born before 1955 as well as $c_a = c$ and $c_b = 0$ for cohorts born after 1955 (1950). We make this distinction since we do not observe labor market entries for older cohorts. The choice of polynomials is justified, since the analysis does not intend to make out-of-sample predictions.

Equation (4) allows for linear terms in α and t but not in c . It is clear that, formally, the linear terms are not identified, i.e. the coefficient on α estimates $(a_1 - \gamma_1)$ and the coefficient on t identifies $(b_1 + \gamma_1)$, where a_1 , b_1 , and γ_1 are the unknown coefficients of the linear terms in α , t , and c , respectively. As an identifying assumption, the linear cohort effect γ_1 is set to zero. This assumption is motivated by equation (4) – see also equation (12) in the appendix – which for a given cohort allows a separation of changes over time into a pure age and a pure time effect; both are common to all cohorts in the labor market. In the light of this condition, setting the linear cohort term to zero is quite natural based on the following argument. If $K(c) = 0$, i.e. only a linear cohort term exists, then the entire cross-section profile $f(\alpha, t)$ exhibits purely parallel shifts over time, a situation one would not naturally characterize by “cohort effects”.¹⁰

Note that the sum of two effects can be identified without additional assumptions. For instance, the sum of age and time effects is identified and yields the longitudinal profile (cohort profile) $A(\alpha) + B(t)$ for each cohort as the change over time and age relative to the cohort specific level $G + K(c)$. The shape of these longitudinal profiles differs between cohorts, since each cohort experiences the time (macroeconomic) effect at a different point of the life cycle.

An important issue is that of separability of the three effects as assumed in equation (4). It is not clear from the outset that the labor market outcomes can be represented by such an additive function. We denote this restriction as the hypothesis of a uniform insider trend $\mathbf{H}_{\text{UI}}$, since specification (4) implies that the cohort profiles depend only upon age and time relative to the cohort specific $K(c)$, defining the level at the entry into the labor market. This hypothesis can be tested without further identifying restrictions. We use specific interaction terms of α and c for this test (see appendix). In testing the separability restrictions, it is important to use robust estimators for the variance-covariance matrix of the parameters. To this end, we use a block bootstrap procedure that controls for a fairly general pattern of correlation in the error term (see appendix).

¹⁰Here, our approach differs from Gosling *et al.* (2000) who implicitly set the linear time effect to zero. Though both identification strategies provide equivalent representations of the data, we find it more natural to set the linear cohort effect to zero for the following reason. If $K(c)$ in equation (4) only comprises a linear term, the cross-section age profile in wages is simply shifted in a parallel fashion across years without any changes in the observed age related wage differentials. We perceive such a model with a pure location shift of the cross-sectional age profile over time as a model “without cohort effects”.

Only if the separability hypothesis cannot be rejected is it justified to consider age, cohort, and time effects as being separate effects – conditional on our identifying assumption for the linear terms. Otherwise, the “age” effects depend also on cohort and calendar year and so on. A stronger restriction on the specification $g(c, \alpha)$ would be $K(c) = 0$. We denote this as uniform growth hypothesis $\mathbf{H}_U$, since under this hypothesis no level differences between cohorts exist. This hypothesis is tested separately for the cohorts born before 1951 and those born afterwards.

5.2 Estimating Quantile Regressions

The literature typically investigates movements in mean log wages based on least squares regressions. This allows one to measure how the mean of the conditional wage distribution differs across workers with different socio-economic characteristics and how that mean changes over time. However, it is also of great interest to measure differences within groups and their movement over time. Another group of more descriptive studies, see among others OECD (1996), describes the time trends in quantile differences of wages for some broadly defined groups of workers (such as full-time working males or females) in order to analyze trends in wage dispersion on a fairly aggregated level. However, it is rarely analyzed whether within-group wage dispersion differs across workers with different characteristics.

Quantile regressions, developed by Koenker and Bassett (1978), provide a very useful tool to study wage differences across and within groups of workers with different socio-economic characteristics and how they evolve over time. In this respect, quantile regressions combine the two approaches outlined in the previous paragraph. In addition, quantile regressions exhibit certain robustness properties due to the insensitivity of empirical quantiles to outliers in wages.

For general $\theta \in (0, 1)$, we estimate conditional quantiles of wages

$$(6) \quad q_\theta(\ln[w_{i,t}]|c, \alpha, \beta^\theta) = g^\theta(c, \alpha, \beta^\theta) + \bar{u}_t^\theta,$$

where $q_\theta(\ln[w_{i,t}]|c, \alpha, \beta^\theta)$ denotes the θ -quantile of the wage in cohort-age-cell (c, α) ($\equiv$ cohort-year-cell (c, t) where $t = c + \alpha$). The vector β^θ comprises the coefficients in equation (4) relating to the set of regressors. In the empirical analysis, we model the following quantiles: $\theta = 0.2, 0.5, 0.8$ (20%-, 50%-, and 80%-quantile). We also use orthogonalized time dummies in order to model cyclical movements of employment around its trend. We start the estimation with the most general formulation of the model, including interaction terms of age, time, and cohort. We then search for the most parsimonious specification that is compatible with our data. The empirical estimates and graphical illustrations are presented in the next section.

Time, age, and cohort effects in quantile regression reflect the differences in the conditional wage distribution across different years, age, and cohorts. For instance, if cohorts differ by the dispersion in school quality, the cohort effects at different quantiles of wages should mimic these effects.

6 Empirical Results

Based on the empirical framework introduced above, this section discusses the estimated specifications and then presents the empirical results.

6.1 Estimated Specifications for Wage Equations

Depending on the degree of uniformity in wage growth imposed, we estimate several specifications (model 1 to 4) of equation (12, appendix) for the 20%-, 50%-, and 80%-quantile for males, full-time working females, and part-time working females by skill groups (U), (M), and (H).

The estimation results of the preferred final specifications for several subgroups can be found in tables 2-4 (for figures and tables see appendix). The standard error estimates are obtained by a block bootstrap procedure as described in the appendix. We will postpone the discussion of the differences between the individual subgroups to the next subsection describing the preferred specifications by means of graphical illustrations.

The most general specification (model 1) is given by

$$(7) \quad \begin{aligned} g(c, \alpha) = & G + a_1\alpha + a_2\alpha^2 + a_3\alpha^3 + b_1t + b_2t^2 + b_3t^3 + b_4t^4 + b_5t^5 \\ & + \gamma_{b2}c_b^2 + \gamma_{b3}c_b^3 + \gamma_{a2}c_a^2 + \sum_{j=1}^4 \rho_j R_j, \end{aligned}$$

where the age polynomial is of order 3, the time polynomial of order 5, and $c_b = (1-\delta)c$, and $c_a = \delta c$ are the cohort terms before and after 1975. R_j are additional regressors defined in the appendix. These regressors allow model 1 to be a non-separable variant of $g(c, \alpha)$. In addition, all specifications include the cyclical year dummies which are orthogonalized with respect to the polynomial in time. Models 2 to 4 are restricted versions of model 1:

Model 2: $\rho_j = 0$ for $j = 1, \dots, 4$ (H_{UI} imposed),

Model 3: $\rho_j = 0$ for $j = 1, \dots, 4$, and $\gamma_{a2} = 0$ (H_U imposed), and

Model 4: $\rho_j = 0$ for $j = 1, \dots, 4$, and $\gamma_{a2} = 0$ (H_U imposed), and $\gamma_{b2} = \gamma_{b3} = 0$.

Models 2 to 4 impose separability of wage growth into age and time effects.

The most restricted version, model 4, assumes that wage growth is uniform across cohorts, both during and before the sample, i.e. there are no ‘‘cohort effects’’ for those cohorts entering the labor market before the start of the sample in 1975. Under this scenario, wage growth can be described by a fixed cross-section age profile of wages which moves in parallel fashion over time. Thus, the cross-section age profile corresponds to the true life cycle profile experienced by each cohort. In this situation, we do not consider cohort effects to be operating, which motivates the identifying assumption that the linear cohort effect in models 1 to 4 is arbitrarily set to zero and therefore

can be completely ascribed to the age and time profiles. However, while for low and medium skilled males model 4 is typically not justified by the data, this is always the case for high skilled males and – to our great surprise – for females.

In contrast, model 3 restricts wage growth to be uniform across all cohorts only during the sample period. Wages of new cohorts entering the labor market grow at the same rate as wages for older cohorts apart from life cycle effects. Nevertheless, it is possible that cross-section age profiles of wages change over time due to “cohort effects” before the start of the sample. Model 2 allows “cohort effects” to operate both for the cohorts entering the labor market before and during the sample period. However, it still restricts wage growth to be uniform across cohorts after the cohort has entered the labor market.

To test the wage growth hypotheses H_{UI} and H_U we carry out a sequence of Wald tests. Starting from model 1, we test consecutively whether models 2 to 4 provide a sufficient description of the data. These test results determine the preferred models which are reported in tables 2-4 and on which the illustrations of wage profiles in the following subsection are based. Building analogously on the preferred specifications, we calculate several tests investigating uniformity of the preferred coefficient estimates across quantiles (available upon request).

Turning to the results for the uniform wage growth hypotheses (H_{UI} and H_U), we test the restrictions implied by models 2, 3, and 4. We find that separability of age and time effect in model 1 is never rejected by the data. In the following, it is therefore possible to construct life cycle wage profiles and macroeconomic time trends for all groups considered. However, the results on the additional restrictions differ by gender and skill group.

For men both of skill groups (U) and (M), model 3 is appropriate with cohort effects operating during the sample period for those who have entered the labor market before the sample period. Men of skill group (H) are best represented by model 4 without any cohort effects. The aforementioned models apply to all estimated quantiles. That means, as far as low and medium skilled males are concerned, cohort effects – which lead to parallel shifts of the life cycle earnings profile over time – do exist, and entry wages of older low and medium skilled males who started working before the beginning of the observation period in 1975 do not simply differ across cohorts by the estimated time trends. The cohort effects for (U) and (M) are such that older cohorts, who were in the labor market before 1975, exhibit somewhat higher wages compared to younger cohorts, see figure 8 in the appendix. Therefore, the wage difference between older and younger workers observed in one year increases over time contributing to the rise in male wage inequality. This corresponds to results reported by Gosling et al. (2000).

Surprisingly, we do not find any cohort effects for full-time and part-time working females. In this case, model 4 (respectively model 4 without an age term of third order) is the preferred model and applies to all quantiles. It is especially surprising that for women, in particular for women who started working *during* the observed 21 years, cohort effects are nonexistent. In our empirical framework, the skill upgrading of females starting in the sixties and seventies seems to have no impact per se on wage differences across cohorts. Though unlikely, it is however possible that composition and selection

effects interfere since we have not controlled for the latter. Composition- and selection effects are likely in the case of females, because their employment patterns and labor market attachment has changed very much during the last three decades. An example for selection effects is employment mobility, i.e. self selection into nonemployment, full-, and part-time employment. Another possible explanation for this finding might be that women of the same skill level but different ages are much closer substitutes compared to males. In the case of perfect substitutability in labor demand, it is plausible to find no cohort effects with our approach since changes across cohorts affect all women in the labor market thus being measured as a time effect.

To complete the results on model specification, we have tested whether the quantile regression estimates differ significantly by quantiles. We mostly find significant differences even though these differences are often not economically meaningful. Instead of providing detailed test statistics (these test results are available on request), we choose to present this aspect by means of graphical illustrations of our preferred estimated models across quantiles in the next subsection. This way, we can focus on the economically important differences.

6.2 Graphical Illustrations

In the following, we present graphical illustrations of the preferred estimated models corresponding to the test results presented in the previous subsection. These graphical illustrations (see appendix) prove convenient to describe the findings of this paper. Since uniform insider wage growth (H_{UI}) is accepted for all specifications, it is meaningful to construct profiles of life cycle wage growth and time trends for all groups. Then we analyze male-female wage differentials in estimated time trends in order to investigate to what extent full-time and part-time working women were able to improve their wage positions compared to men.

Life Cycle Profiles

The positive relationship between earnings and experience is typically explained by an increasing stock of human capital during employment. Manning (2000) puts forward an alternative hypothesis for this finding, namely that more time in the labor market increases the chance of finding a better match which tends to be associated with higher earnings. “A substantial if not the larger part of the rise in earnings over the life cycle in Britain can be explained by a simple search model, and virtually all the earnings gap between men and women can be explained this way” (Manning, 2000: 261). Indeed, there are pronounced differences between life cycle profiles of men and women, full-time and part-time employed women, and skill groups. If the whole range of years from 1975 to 1995 is taken into consideration, life cycle profiles of part-timers are negative in most cases, which is in stark contrast to the profiles of male and female full-timers who exhibit a positive wage growth over the life cycle. Comparing the shapes of male and female life cycle profiles, it becomes obvious that the profile is always concave for men but partly convex for women (see also Manning, 2000).

We find for full-time employed males and females that wage growth over the life cycle

is steepest for the medium skilled (see figure 6). For men it amounts to around 60 percent (in logarithms) for all quantiles, for females to 41 percent at the median, 50 percent at the 80%-quantile, and 38 percent at the 20%-quantile. For all full-time employed medium skilled females wage growth is negative between age 35 and 50. Surprisingly, a pronounced wage growth of 50 percent over the life cycle is observable for low skilled males at all three quantiles. Wages of equivalently skilled females exhibit a growth of 10 percent at age 60, their profile is extremely flat. Turning to high skilled full-time working males and females, we detect an increasing dispersion of wages over the life cycle, which was less visible for the other skill groups. In the case of men, cumulated growth at the median amounts to 40 percent at age 60, with the 80%-quantile 15 percentage points above and the 20%-quantile 14 percentage points below that number. Women experience a cumulated wage growth at the median of 35 percent at age 60, with the 80%-quantile 5 percentage points above and the 20%-quantile 20 percentage points below.

Life cycle profiles of part-timers turn out to be located below the line depicting zero growth, the only exception are the high skilled at the 80%-quantile (see figure 7). All profiles are convex from the beginning and most of them exhibit a (local) minimum after 10-20 years (varying by skill level) after labor market entry. The loss at this minimum amounts to roughly 20 percent for low skilled, 60 percent for medium skilled at the 20%- and 50%-quantiles, and 30 percent, respectively 70 percent for high skilled female part-timers at the 50%- and 20%-quantile respectively. The maximum is achieved in most cases at age 50 but only the profile of low skilled at the 20%-quantile crosses the zero line to become positive for a moment.

The job search hypothesis (inter alia Manning, 2000) together with the decline in (re-)entry wages (Gregg/Wadsworth, 2000) may offer an explanation for the partly convex shape of female life cycle profiles, and especially part-time employed females. Women, who interrupt employment more frequently than men because of family responsibilities, may accept re-entry jobs with lower returns to their human capital characteristics, because of less job search capital. This job may be used as a stopping-place to get used to employment again, rebuilding human capital, and above all, searching for a better paid job. However, also the traditional human capital explanation for gender differences in age-earnings profiles is applicable. Job interruptions result in depreciation of human capital. Due to a higher likelihood of job interruptions and, therefore, human capital depreciation, females experience less favorable wage growth while aging.

Time Trends

Figure 4 and 5 depict the estimated macro economic time trends for male and female wage distributions, distinguished by employment status and skill level. Based upon the acceptance of the uniform wage growth hypothesis, these time trends summarize the shifts in the wage distribution within and between the skill groups over time and entry wage growth in settings without cohort effects for cohorts entering the labor market after 1974 (all settings!). Later we will use the estimated time trends which are separable from age and cohort effects to describe how the gender wage gap changed during the observation period.

Broadly speaking, the figures correspond to the descriptive evidence in section 4. Men and women experience rather different wage trends over time, and there are further differences between full-time and part-time working females as well as across skill groups. In general, the curves peak in the early nineties, some of them showing a severe decline afterwards. The time trends of full-time employed males and females exhibit a steady growth until this peak, while the curves of female part-timers do not rise (they even fall in some cases) until the mid 80's.

The steepest time trends are observable for high skilled female full-timers, especially in the lower part of the distribution. Their growth rate amounts to 60 percent in 1995, whereas the growth rate at the median amounts to 50 percent and at the 80%-quantile to 45 percent. Another distinctive feature of this skill group is therefore a decline in wage inequality. This is in contrast to all other gender-employment-skill groups, in particular the high skilled full-time employed males, for whom wage inequality remains constant. Their wage growth rates amount to 30 percent in 1995. The result at the top quantile of the high skilled females is possibly related to glass-ceiling effects.

Low and medium skilled women also exhibit a steeper macro economic time trend than their male counterparts. Women of these groups attain similar cumulated growth rates (between 30 and 40 percent) in 1995. There is a small increase in wage inequality for both groups. For unskilled and medium skilled full-time working males we observe a growth in wage inequality as well. The 80%-quantile of low skilled males exhibits a cumulated growth of 25 percent, the median of 10 percent, and the 20%-quantile roughly of 1 percent in 1995. The 80%-quantile of medium skilled males exhibits 28 percent, the median 14 percent, and the 20%-quantile 10 percent in 1995.

All in all, we find a clear ranking of time trends by skill level for male and female full-time employees, which is not the case for life cycle profiles. Cumulated macroeconomic growth rises with an increasing skill level. For all groups, the estimated time trends also reflect the growth of entry wages during the observation period due to the uniformity of wage growth across cohorts. We find stagnating male wages from the beginning of the observation period until roughly 1980, and for high skilled males again from 1992 onwards. For low and medium skilled males, wages decline in the 90's. This is also the case for medium and high skilled females. Only low skilled full-time employed females exhibit positive wage growth throughout the observation period.

For part-timers, the time trends cannot be uniformly ranked across the wage distribution and across skill levels, as is the case for full-timers. Furthermore, the curves at the 50%-quantile and the 20%-quantile cross several times within all skill groups, indicating less continuity in the lower part of the wage distribution. For all skill groups, the within wage distribution does not change in a significant way until 1985. Then a period of strong growth follows for all skill groups and quantiles, and starting in the early 90's we observe once again a slowdown or even a decline in wages. The period of strong growth is accompanied by increasing wage inequality. During the period of decline in the 90's, this applies to low skilled part-timers as well. Until 1995, the 80%-quantile has grown by 23 percent relative to 1975, the median by 10 percent, and the 20%-quantile by -4 percent. In contrast, within the medium skilled group, the quantiles differ only by 6 percentage points in 1995. The 80%-quantile and the median exhibit a cumulated growth rate of 25 percent, and the 20%-quantile of 19 percent. For high

skilled part-timers, the 20%-quantile exhibits a very striking shape. Between 1988 and 1994, the curve catches up very quickly (1988: 0 percent and 1994: 30 percent), i.e. wage inequality decreases from below. In 1995, the 80%- and 20%-quantiles exhibit a cumulated growth of roughly 30 percent and the median of 12 percent. The figures show that the upper part of the wage distribution for all skill groups moves much more continuously than the lower part.¹¹

Completing the comparison of macro economic time trends across gender-employment-skill groups, this paragraph summarizes the changes in the gender gap over time (see figure 9). We compute differences in time trends of full-time employed females versus full-time employed males as well as part-time employed females versus full-time employed males of the same skill level and quantile. These differences reflect the cumulated change in the relative position of the same quantile in the female and male wage distribution over time.

Interestingly, female full-timers have been able to close the gap the most in the lower part of the wage distribution. The 20%-quantile exhibits the strongest reduction for all skill groups and over the whole period. Considering the year 1995, women at the 20%-quantile of skill group (U) experienced a reduction of the gap by 35 percentage points, women of skill group (H) by 30 percentage points, and women of skill group (M) by 22 percent. At the median and the 80%-quantile, the effects are very similar for skill groups (U) and (M). Low skilled females at the 50%- and 80%-quantile catch up by 25 percentage points and medium skilled women by 20 percentage points. Least successful were high skilled females in the upper part of the wage distribution who catch up by only 13 percent possibly due to glass-ceiling effects. The median exhibits a change of 18 percent. Starting in the mid 90's, the difference increases again for this skill group.

The picture is different for part-timers. From 1975 to 1985, the gap between part-time employed females and full-time employed males increases. In the following years, the wage difference decreases but starts to increase again from 1993 to 1995 for the median and the 20%-quantile. In 1995 the net change amounts to 8 percent at the 80%-quantile, 0 percent at the median and -5 percent at the 20%-quantile. Medium skilled women face a stagnating wage gap until about 1985. In the following years, the gap decreases at all quantiles by 10 percentage points until 1995. The case of high skilled part-timers is rather complex. The curve at the 80%-quantile is very flat and reaches the zero line in 1995. At the median, we observe first an increase but then a decline below zero after 1982. Until 1995 the wage gap at this quantile grew by 20 percentage points. The 20%-quantile exhibits an exceptional shape, as already discussed. The gap between female part-timers and male full-timers in skill group (H) at the 20%-quantile increases by 20 percentage points until 1988 and shrinks again by 20 percentage points until 1995.

¹¹This might be related to the selectivity of employment changes such that employment for workers in the lower part of the wage is more volatile. We will investigate this issue in future research.

7 Conclusions

We investigate the changes in the gender wage gap in the U.K. during the time period 1975 to 1995 based on the earnings information in the General Household Survey. Our goal is to provide a comprehensive descriptive analysis of the level and the dynamics of the gender wage gap across the entire wage distribution taking into account life cycle and birth cohort effects. It is preferable to investigate the entire distribution for males and females because of shortcomings of conventional decomposition techniques which only analyze differences in mean wages and which therefore may neglect distributional aspects. In addition, distributional and compositional effects may be confounded. Therefore, we use quantile regressions to separate the trends for different wage distribution quantiles by skill level, cohort, age, and employment status.

Corresponding to results in the literature, our analysis shows that the gender wage gap for full-time employed females decreased considerably during the time period from 1975 to 1995. The reduction was much smaller for medium skilled part-time employed females, and the gender wage gap basically remained constant for low- and high skilled part-time employed females. In addition to the general improvement for full-time working females, we find stark distributional differences. The reduction in the gender gap for full-timers was strongest in the lower part of the wage distribution for all skill groups, and it was weakest in the upper part of the wage distribution for high skilled women. This implies that full-time employed women improved their wage position relative to full-time employed males, even though wage dispersion for full-time employed increased considerably both across and within skill groups, see Gosling *et al.* (2000). Low skilled women experienced a higher cumulated wage growth than high skilled males. Thus, despite lower formal education levels full-time employed women in the U.K. have been able to “swim upstream” against an increasing wage dispersion (Blau and Kahn, 1997). For high skilled full-time employed females, wage growth proved particularly strong, thus also reflecting increasing returns to education for females. This is in stark contrast to the results in our companion paper for West Germany, Fitzenberger and Wunderlich (2000), where the gender gap for full-time employed females also decreased considerably between 1975 and 1995, however the reduction declined with an increasing skill level. This difference between the two countries is even more striking, since for West Germany we did not observe a strong increase in male wage inequality to the same extent as for the U.K.

In contrast, part-time employed females did not “swim upstream” the same way as full-timers. Low- and medium skilled part-timers did not gain relative to their male counterparts. Thus, the gap to the upper part of the male wage distribution even increased. Similarly, high skilled part-time employed females experienced an increasing gender gap relative to high skilled males. Among the part-time employed women, we do not observe a clear trend of increasing returns to education, neither do we observe for all females a clear trend of increasing wage dispersion within skill groups in contrast to the well known facts for full-time employed males (Gosling *et al.*, 2000).

Future research will have to determine the reasons for the differences between full-time and part-time employed females. It will be of particular interest to investigate whether institutional efforts (Equal Pay Act, affirmative action programs) to reduce the gender

wage gap are more successful for full-time employed females. In future research, we also plan to analyze the sensitivity of our results to the neglected issue here that the selectivity with regard to employment (part-time and full-time) is ignored.

A Appendix

A.1 Methodological Details of the Empirical Approach

The goal of the empirical analysis is to analyze trends in the wage distribution by skill group, gender, and employment status. We investigate movements in wages for synthetic cohorts over time. Testing for uniformity across cohorts allows us to investigate whether wages move uniformly over time. Alternatively, it could be the case that wage trends differ across cohorts, which would then indicate the presence of “cohort effects”. Under certain conditions, which will be discussed later, a cohort effect designates a movement of the entire life cycle profile for a given cohort relative to other cohorts. In providing a parsimonious representation, we are able to pin down precisely the differences in wage trends across groups of workers defined by gender, skill level, and employment status. Furthermore, we explicitly take into account the possibility of cyclical effects.

A.1.1 Characterizing Wage Profiles

We denote the age of a person by α and the calendar time by t . A cohort c can be defined by the year of birth. The variables age, cohort, and calendar year are linked by the relation $t = c + \alpha$. Frequently researchers investigate empirically the cross-sectional relation between age and wages in a given year and trends in this relationship over time:

$$(8) \quad \ln[w(t, \alpha)] = f(t, \alpha) + u \quad .$$

The deterministic function f measures the systematic variation in $\ln(w)$, and u reflects cyclical or transitory phenomena. Movements of f as a function of t describe how cross-section age profiles (“age-earnings profiles”) shift over time. The cross-sectional relation f as a function of age does not describe the “life cycle” profile for any cohort, or, put differently, the cross-section relation may very well be the result of “cohort effects”. Wage profiles can also be expressed as a function of cohort and age

$$(9) \quad g(c, \alpha) \equiv g(t - \alpha, \alpha) \equiv f(t, \alpha)$$

where the deterministic function g describes how age-earnings profiles differ across cohorts. Holding age constant, $g(c, \alpha)$ describes wages for different cohorts over time. Holding the cohort constant yields the profile experienced by a specific cohort over time and age. The latter can be interpreted as the actual wage profile, because it reflects the movement over the actual life cycle for a given cohort.

The different parameterizations $g(c, \alpha)$ and $f(t, \alpha)$ are equivalent representations of the same relationship. Without further assumptions, “pure life cycle effects” due to aging or “pure cohort effects” cannot be identified. Since we focus on wage trends for a given

cohort over time, we use the cohort representation in equation (9) as the perspective of our analysis.

A.1.2 Testing for Uniform Changes over Time

Our analysis investigates whether time trends in wages are uniform across cohorts, in the sense that every cohort experiences the same time trend and the same age related change. The latter is interpreted here as the life cycle effect ($\equiv$ “pure age effect”). Despite the identification issues discussed above, the existence of a uniform time trend across cohorts is a testable implication in the framework presented here. If such a uniform time trend is found, it is designated as the macroeconomic trend for the group considered.¹² However, as can be seen from the empirical results, the uniform time trends found differ by skill level, gender, and employment status.

Two notions of changes over time prove useful: First, changes for a given cohort in the labor market over time (“insider trend”), and second, changes over time experienced by successive cohorts when entering the labor market (“entry trend”). The insider trend is given by

$$(10) \quad \frac{\partial g}{\partial t}|_c = \frac{\partial g}{\partial \alpha}|_c \equiv g_\alpha(c, \alpha) \equiv g_\alpha,$$

resulting from the simultaneous change of time and age. Alternatively, holding age constant yields the change observed over different cohorts at a given age. For the age at labor market entry, α_e , the entry trend is given by

$$(11) \quad \frac{\partial g}{\partial t}|_{\alpha=\alpha_e} = \frac{\partial g}{\partial c}|_{\alpha=\alpha_e} \equiv g_c(c, \alpha_e) = g_c(t - \alpha_e, \alpha_e) \equiv e(t) \quad .$$

Again, this results from two effects, a change of cohort and time.

Now, two testable separability conditions arise. If the changes over time can be characterized as the sum of a pure aging effect and a pure time effect in the following way,

$$(12) \quad g_\alpha = a(\alpha) + b(t) = a(\alpha) + b(c + \alpha),$$

the life cycle effect is independent of the calendar year t . This condition is designated as the “uniform insider trend hypothesis”, which we denote by H_{UI} . It implies that each cohort faces the same wage change over the life cycle due to aging $a(\alpha)$ and that economy wide shifts $b(t)$ are common to all cohorts in the same year, however, they occur at different points during the life cycle of each cohort. If the separability condition (12) holds, we can construct a “life cycle profile” independent of the calendar

¹²If no uniform trend is found, the average across age groups combines age, time, and cohort effects.

year and a macroeconomic time trend independent of age. Condition (12) is violated if interaction terms of α and t enter the specification of g_α .

Integrating back the derivative condition (12) with respect to α yields an additive form for the systematic component of the wage function $g(c, \alpha)$:

$$(13) \quad g(c, \alpha) = G + K(c) + A(\alpha) + B(c + \alpha)$$

where $G + K(c)$ is the cohort specific constant of integration. H_{UI} can be tested by investigating whether “interaction terms” $R(\alpha, t)$ enter specification (13), which are constructed as integrals of interaction terms of α and t in g_α .

If, in addition to H_{UI} , the entry trend equals the macroeconomic time trend,

$$(14) \quad e(t) = b(t),$$

a stronger hypothesis can be formulated. We designate this hypothesis as the “Hypothesis of uniformity in the insider trend and the entry trend” and denote it as H_U . Under this hypothesis the life cycle profile of each new labor market cohort is a parallel shift of the profile of the previous cohort corresponding to the uniform time trend $b(t)$ for all cohorts already in the labor market. Again, this is a testable implication. Given specification (13), condition (14) implies that $K(c)$ is equal to zero for the cohorts entering the labor market during the period of observation.

A.1.3 Implementation of Tests

The hypothesis H_{UI} requires equation (13) to hold against a more general alternative, whereas the (stronger) hypothesis H_U additionally requires $K_{a2} = 0$ (no cohort effect after 1976). Formally, it is also possible to test the hypothesis that $K_{b2} = 0$ and $K_{b3} = 0$. This test of equation (14) for older cohorts is not directly based on the entry age α_e , because these cohorts are only observed in the data during a later phase of their life cycle.

In order to formulate a test of H_{UI} , we consider the interaction terms $\alpha t, \alpha t^2, \alpha^2 t$, and $\alpha^2 t^2$ in the derivative g_α . The implied non-separable variant of $g(c, \alpha)$ expands (13) by incorporating the integrals of these interaction terms which are denoted by $R_1, \dots, R_4$. For instance, R_1 is given by

$$(15) \quad R_1 = \int \alpha t d\alpha = \int \alpha(c + \alpha) d\alpha = c\alpha^2/2 + \alpha^3/3 \quad .$$

Consequently, the most general formulation of equation (13) also involves $R_1 - R_4$ and the orthogonalized year dummies. The formal test of H_{UI} is a test in order to indicate whether or not $R_1 - R_4$ is significant. The test of the stronger hypothesis H_U is a test of whether or not both $R_1 - R_4$ and $c\alpha^2$ are significant.

Only if the separability condition H_{UI} holds is it meaningful to construct an index of a life cycle profile, as a function of pure aging $A(\alpha)$, and a linear macroeconomic trend index $B(t)$. Otherwise, a different wage profile would apply for each cohort. As pointed out above, it is important to recognize that neither the level nor the coefficient on the linear term are identified for these indices in a strict econometric sense.

A.1.4 Block Bootstrap Procedure for Inference

In the context of this study, we allow for the error terms being dependent across individuals within cohort–year–cells and across adjacent cohort–year–cells. The dependence is assumed to take the form of rectangular m –dependence across time and across cohorts. We use a flexible Block Bootstrap approach allowing for standard error estimates, which are robust against fairly arbitrary heteroskedasticity and autocorrelation of the error term (see Fitzenberger (1998) for this method in the time series context as well as Fitzenberger and Wunderlich (2000) and Fitzenberger et al. (2001) for applications in the context of estimating wage equations). The Block Bootstrap approach employed here extends the standard bootstrap procedure in that it draws blocks of observations to form the resamples. For each observation in a block, the entire vector comprising the endogenous variable and the regressors is used (design–matrix bootstrap), i.e. we do not draw from the estimated residuals. We draw two–dimensional blocks of observations with a block length of eight in the cohort and six in the time dimension with replacement until the resample has become at least as large as the resample size. Accordingly, standard error estimation takes account of error correlation both within a cohort–year–cell and across pairs of cohorts and time periods which are at most seven years in the cohort dimension and five years in the time dimension apart. Contrasting the results discussed in section 6 with conventional standard error estimates (the latter are not reported here) indicates that allowing for correlation between the error terms within and across cohort–year–cells (when forming the blocks) changes the estimated standard errors considerably. In the absence of a clear cut decision rule for the choice of block size, we experimented to a certain degree with slightly smaller and larger blocks without causing changes in the substance of the results.

A.2 Tables and Figures

Table 1: Absolute numbers of observations; grouped by sex, employment status, skill level, and year

	Males			Females					
	Full-time			Full-time			Part-time		
Year	U	M	H	U	M	H	U	M	H
1975	3357	1955	551	1170	558	132	1989	707	287
1976	3133	1970	537	1044	580	145	1913	730	246
1977	2713	1873	781	971	520	183	1643	691	314
1978	2570	1986	724	844	589	217	1622	739	317
1979	2438	1827	702	817	621	206	1606	715	314
1980	2186	1915	752	789	665	240	1650	745	353
1981	2137	1858	753	713	725	217	1477	829	346
1982	1674	1490	697	564	615	201	1207	703	342
1983	1434	1472	697	515	606	187	1060	701	295
1984	1222	1421	687	465	593	261	913	694	305
1985	1265	1280	1033	430	639	292	961	875	272
1986	1129	1562	876	428	750	297	924	931	377
1987	1152	1603	965	441	764	364	992	949	365
1988	1065	1544	885	423	821	353	926	901	343
1989	1031	1635	948	413	836	363	870	1018	398
1990	916	1489	876	360	793	341	825	935	389
1991	922	1549	879	397	819	407	754	1005	341
1992	839	1562	909	303	850	454	738	1147	400
1993	661	1483	892	243	811	397	683	1119	398
1994	611	1529	797	287	817	385	577	1120	371
1995	565	1461	873	245	794	490	602	1109	377
	33020	34474	16814	11853	14766	6132	23932	18345	7150

Numbers for high skilled individuals include age group 20-24. Table contains observations with valid wage, skill level, and employment status information from the General Household Survey.

A.3 Tables and Figures

Table 2: Parameter Estimates of Wage Specifications for Skill Group (U) – Males M , Full-Time $F(F)$ and Part-Time $F(P)$ Working Females (Standard Errors in Parentheses – Preferred Final Specification Only)

Skill Group	(U) Low Skilled								
Quantile	$\theta = 0.2$			$\theta = 0.5$			$\theta = 0.8$		
Group	M	$F(F)$	$F(P)$	M	$F(F)$	$F(P)$	M	$F(F)$	$F(P)$
Specification	(3)	(4)	(4)	(3)	(4)	(4)	(3)	(4)	(4)
<i>Intercept</i>	3.363	3.021	2.160	3.603	3.256	2.755	3.832	3.474	3.257
	(.022)	(.026)	(.120)	(.023)	(.026)	(.119)	(.029)	(.039)	(.105)
α	.385	.060	-.512	.385	.104	-.455	.348	.112	-.488
	(.028)	(.011)	(.089)	(.029)	(.016)	(.133)	(.037)	(.026)	(.127)
α^2	-.112	-.011	.374	-.111	-.020	.281	-.081	-.022	.262
	(.017)	(.002)	(.043)	(.016)	(.003)	(.064)	(.021)	(.005)	(.059)
α^3	.011		-.065	.011		-.044	.006		-.038
	(.002)		(.006)	(.002)		(.009)	(.003)		(.008)
t	.312	.962	-.350	.311	.551	.167	.253	.303	.029
	(.173)	(.261)	(.877)	(.136)	(.188)	(.533)	(.178)	(.238)	(.474)
t^2	-.887	-1.956	.741	-1.143	-1.004	-.827	-.642	-.270	.029
	(.614)	(.888)	(2.520)	(.506)	(.754)	(1.477)	(.653)	(.860)	(1.453)
t^3	1.074	1.914	-.897	1.691	1.044	.907	.869	.321	-.126
	(.794)	(1.205)	(3.218)	(.742)	(1.106)	(1.807)	(.964)	(1.237)	(1.893)
t^4	-.533	-.815	.643	-.975	-.471	-.295	-.508	-.158	.204
	(.523)	(.699)	(1.845)	(.460)	(.670)	(.989)	(.601)	(.749)	(1.086)
t^5	.090	.125	-.169	.191	.076	.017	.090	.026	-.069
	(.111)	(.144)	(.386)	(.101)	(.142)	(.197)	(.133)	(.160)	(.225)
c_b^2	-.046			-.045			-.053		
	(.011)			(.011)			(.012)		
c_b^3	-.006			-.006			-.008		
	(.002)			(.002)			(.002)		

The estimate of the covariance matrix is obtained using a Block Bootstrap Procedure (500 resamples for skill groups (U) and (M) and (H)). The blocks allow for dependence across six adjacent time periods and across eight adjacent cohorts. Cyclical time effects are not reported.

Table 3: Parameter Estimates of Wage Specifications for Skill Group (M) – Males M , Full-Time $F(F)$ and Part-Time $F(P)$ Working Females (Standard Errors in Parentheses – Preferred Final Specification Only)

Skill Group	(M) Medium Skilled								
Quantile	$\theta = 0.2$			$\theta = 0.5$			$\theta = 0.8$		
Group	M	$F(F)$	$F(P)$	M	$F(F)$	$F(P)$	M	$F(F)$	$F(P)$
Specification	(3)	(4)	(4)	(3)	(4)	(4)	(3)	(4)	(4)
<i>Intercept</i>	3.366	3.094	2.644	3.621	3.309	3.407	3.882	3.470	3.698
	(.042)	(.061)	(.188)	(.033)	(.037)	(.104)	(.035)	(.051)	(.128)
α	.583	.438	-1.111	.571	.546	-1.033	.541	.698	-.225
	(.041)	(.034)	(.148)	(.029)	(.036)	(.128)	(.038)	(.048)	(.067)
α^2	-.200	-.230	.622	-.176	-.280	.493	-.124	-.340	.040
	(.028)	(.022)	(.082)	(.021)	(.021)	(.078)	(.025)	(.027)	(.017)
α^3	.023	.035	-.094	.018	.042	-.067	.007	.048	
	(.005)	(.004)	(.013)	(.003)	(.003)	(.013)	(.004)	(.004)	
t	.399	.355	.506	.175	-.156	-.035	-.085	-.082	-.383
	(.302)	(.425)	(1.234)	(.235)	(.286)	(.659)	(.166)	(.439)	(.921)
t^2	-1.200	-.377	-1.795	-.616	1.054	.533	.158	.704	1.159
	(.833)	(1.354)	(2.319)	(.680)	(1.028)	(2.019)	(.528)	(1.624)	(2.618)
t^3	1.555	.259	2.331	.981	-1.345	-.969	.105	-.811	-1.019
	(1.004)	(1.982)	(3.829)	(.864)	(1.522)	(2.571)	(.738)	(2.434)	(3.204)
t^4	-.821	-.044	-1.159	-.553	.761	.724	-.092	.468	.486
	(.549)	(1.311)	(1.971)	(.493)	(.984)	(1.426)	(.437)	(1.587)	(1.733)
t^5	.149	-.007	.195	.101	-.157	-.176	.010	-.102	-.101
	(.111)	(.320)	(.373)	(.102)	(.232)	(.287)	(.091)	(.376)	(.342)
c_b^2	-.042			-.062			-.085		
	(.018)			(.015)			(.018)		
c_b^3	-.005			-.009			-.017		
	(.005)			(.004)			(.004)		

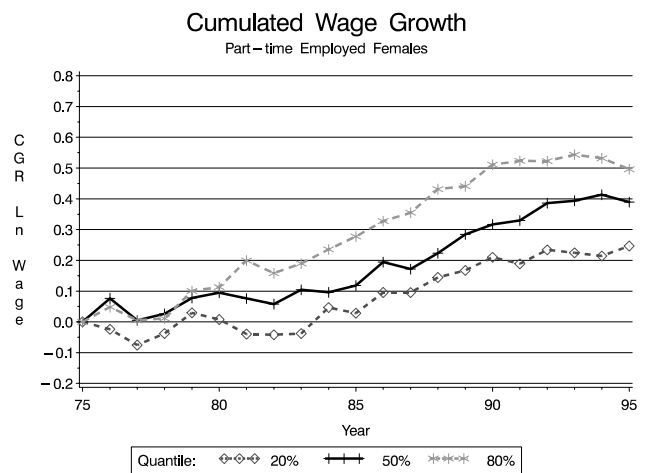
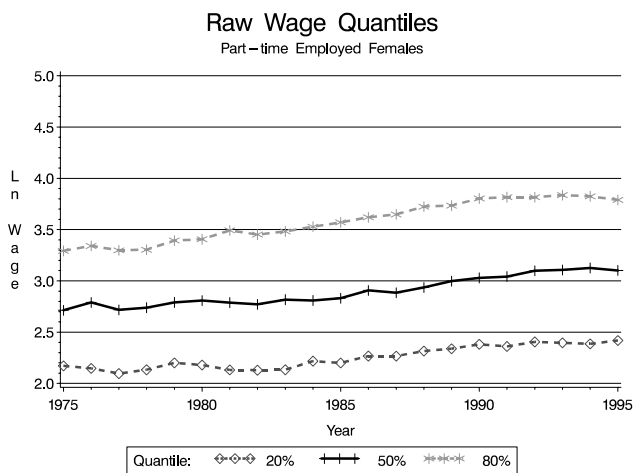
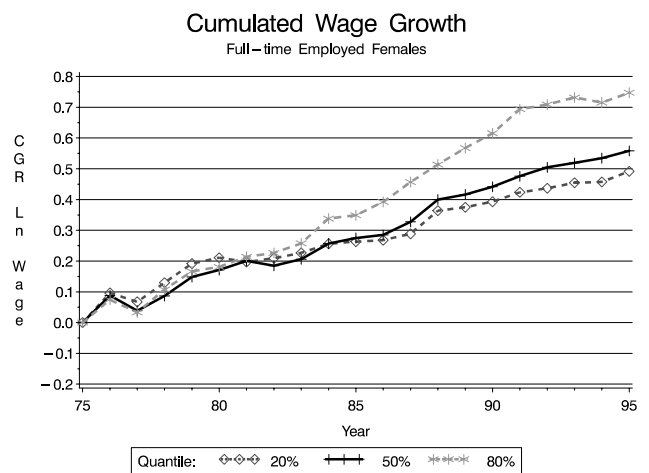
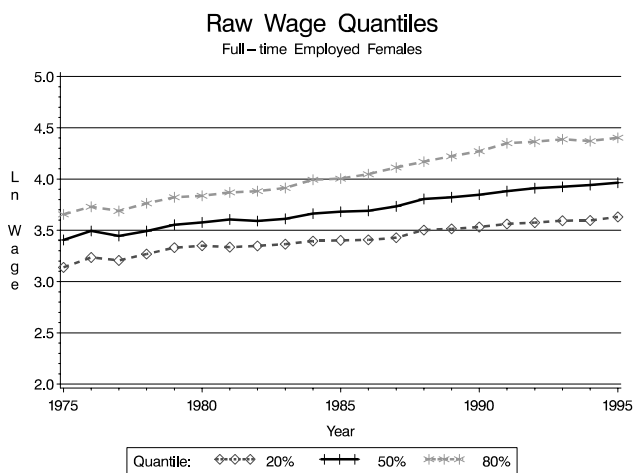
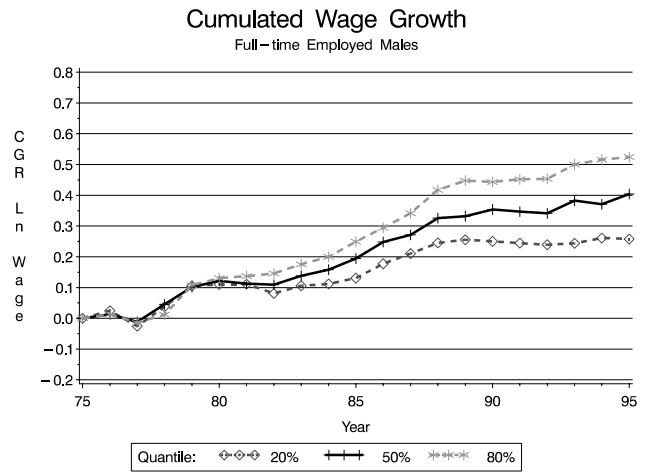
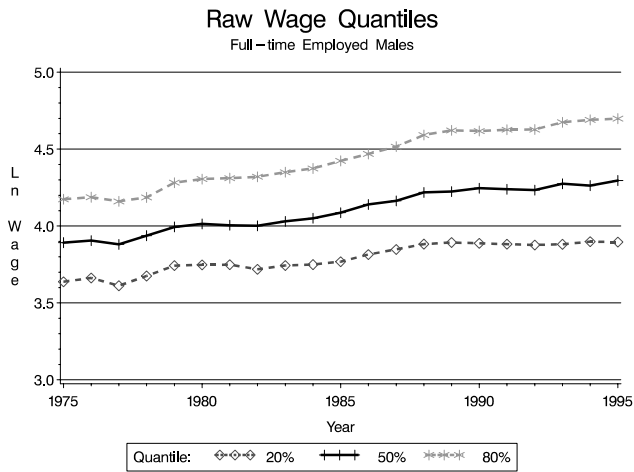
The estimate of the covariance matrix is obtained using a Block Bootstrap Procedure (500 resamples for skill groups (U) and (M) and (H)). The blocks allow for dependence across six adjacent time periods and across eight adjacent cohorts. Cyclical time effects are not reported.

Table 4: Parameter Estimates of Wage Specifications for Skill Group (H) – Males M , Full-Time $F(F)$ and Part-Time $F(P)$ Working Females (Standard Errors in Parentheses – Preferred Final Specification Only)

Skill Group	(H) high skilled								
Quantile	$\theta = 0.2$			$\theta = 0.5$			$\theta = 0.8$		
Group	M	$F(F)$	$F(P)$	M	$F(F)$	$F(P)$	M	$F(F)$	$F(P)$
Specification	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
<i>Intercept</i>	3.729	3.395	3.401	3.973	3.701	3.891	4.212	3.970	3.998
	(.034)	(.089)	(.218)	(.039)	(.080)	(.109)	(.047)	(.037)	(.055)
α	.414	.263	-1.673	.450	.410	-.815	.506	.452	-.001
	(.026)	(.042)	(.192)	(.017)	(.027)	(.129)	(.026)	(.028)	(.057)
α^2	-.134	-.122	1.174	-.135	-.195	.579	-.140	-.241	.056
	(.022)	(.043)	(.154)	(.015)	(.027)	(.117)	(.025)	(.028)	(.044)
α^3	.011	.015	-.227	.011	.028	-.110	.011	.039	-.011
	(.005)	(.010)	(.033)	(.003)	(.007)	(.027)	(.006)	(.007)	(.009)
t	.190	1.022	-.210	-.116	.358	.143	-.347	-.210	.257
	(.339)	(.632)	(1.464)	(.354)	(.675)	(.948)	(.348)	(.382)	(.579)
t^2	-.463	-1.675	1.871	.355	-.483	-.003	1.040	1.564	-.501
	(1.112)	(1.731)	(4.957)	(1.059)	(1.875)	(3.321)	(1.102)	(1.190)	(1.878)
t^3	.729	1.437	-3.539	-.137	.503	-.432	-.869	-2.318	.579
	(1.494)	(2.135)	(6.493)	(1.346)	(2.231)	(4.335)	(1.497)	(1.470)	(2.531)
t^4	-.380	-.456	2.393	.036	-.109	.518	.374	1.492	-.176
	(.875)	(1.188)	(3.601)	(.759)	(1.184)	(2.418)	(.884)	(.789)	(1.491)
t^5	.063	.032	-.523	-.010	-.017	-.155	-.068	-.334	.001
	(.185)	(.242)	(.713)	(.156)	(.231)	(.482)	(.187)	(.153)	(.316)

The estimate of the covariance matrix is obtained using a Block Bootstrap Procedure (500 resamples for skill groups (U) and (M) and (H)). The blocks allow for dependence across six adjacent time periods and across eight adjacent cohorts. Cyclical time effects are not reported.

**Figure 1: Wage Quantiles and Cumulated Wage Growth (All Skill Levels)
1975 – 1995**



**Figure 2: Wage Quantiles and Cumulated Wage Growth by Skill Level
1975 – 1995**

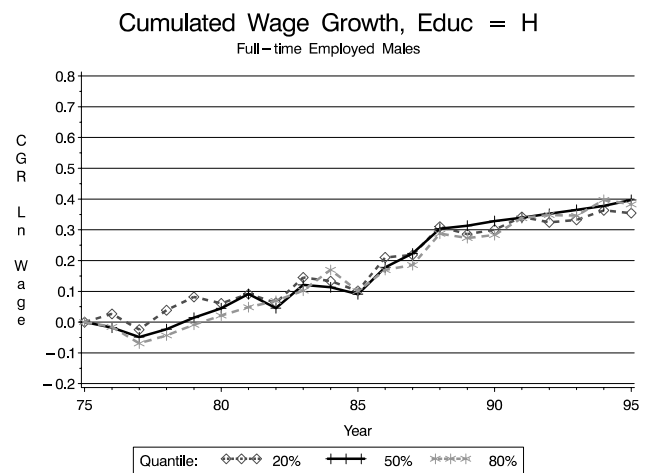
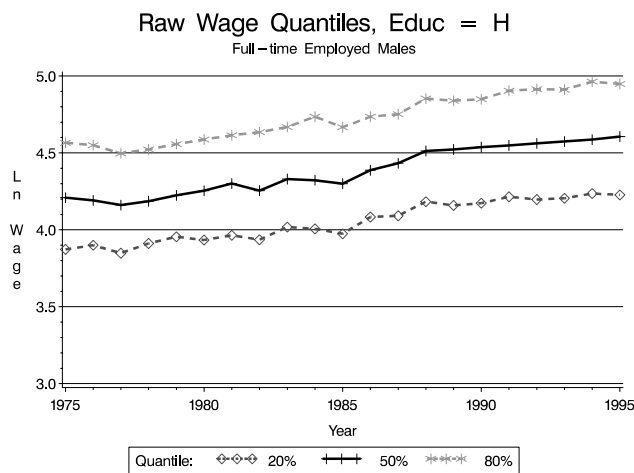
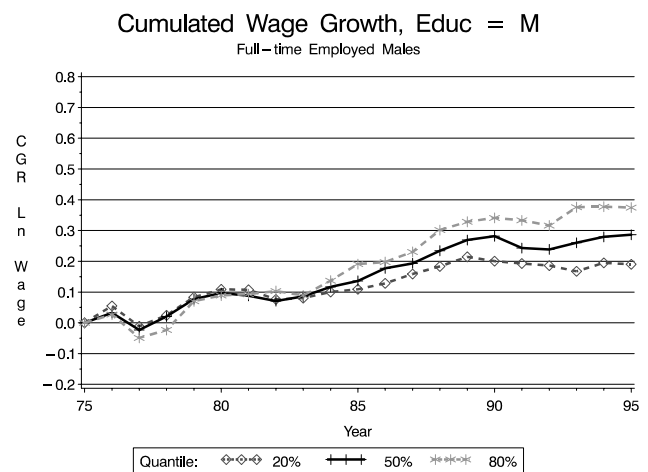
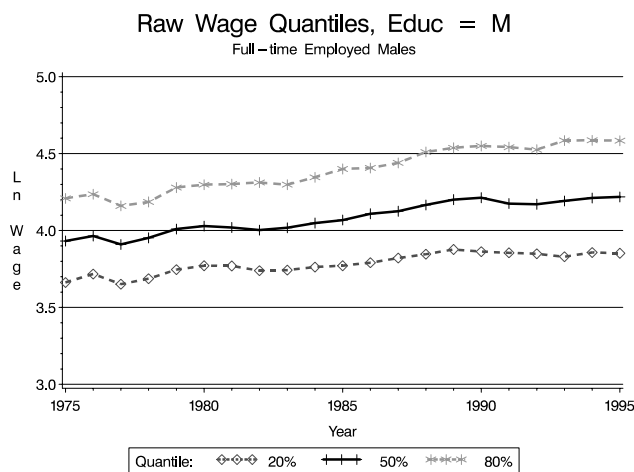
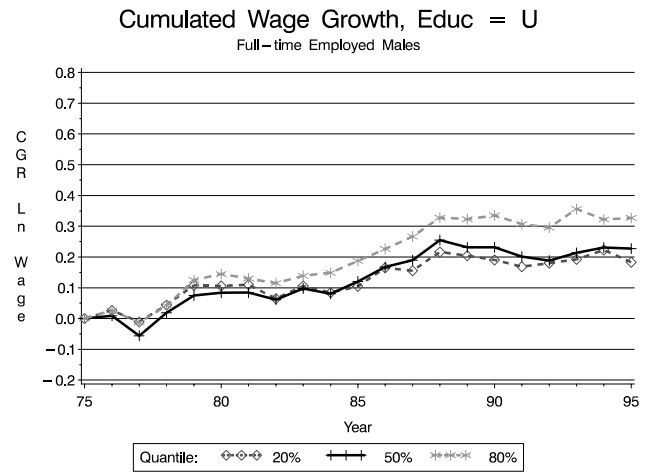
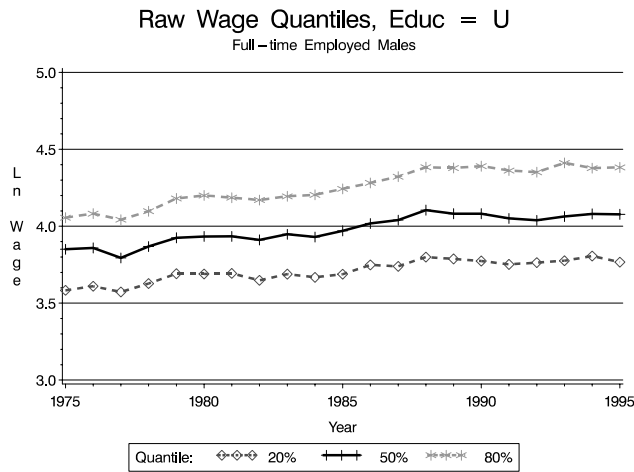


Figure 2 continued: Wage Quantiles and Cumulated Wage Growth by Skill Levels
1975 – 1995

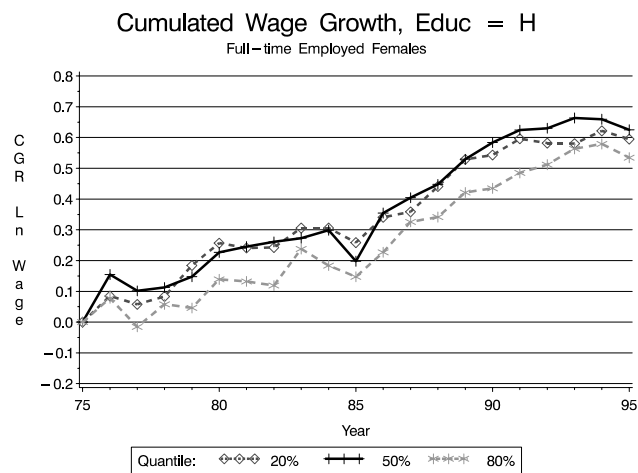
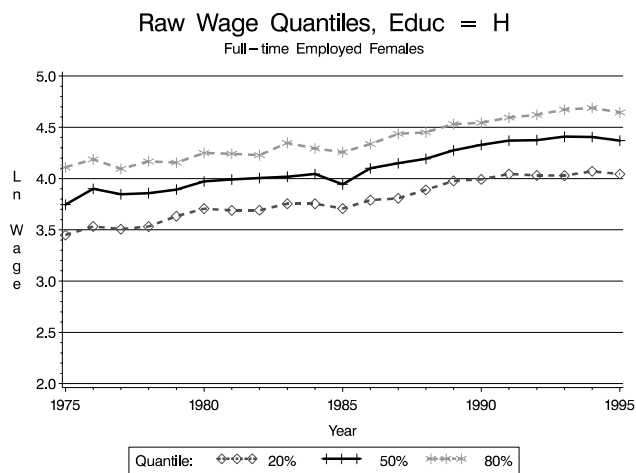
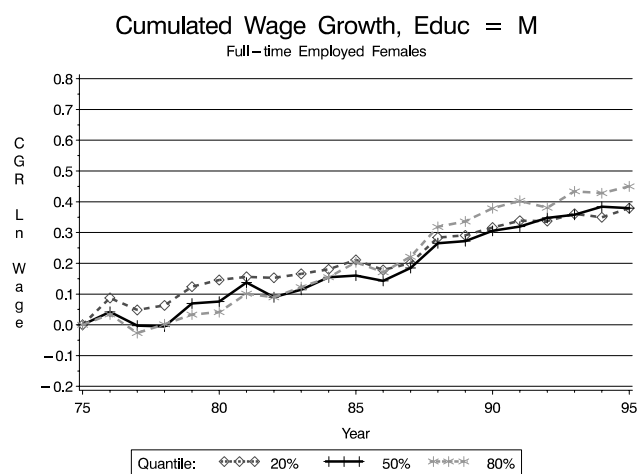
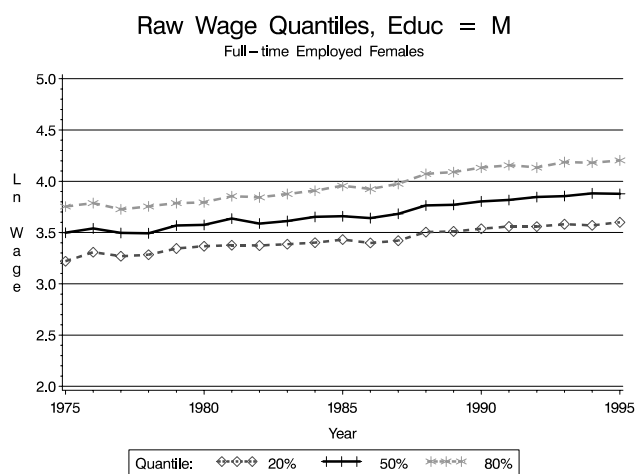
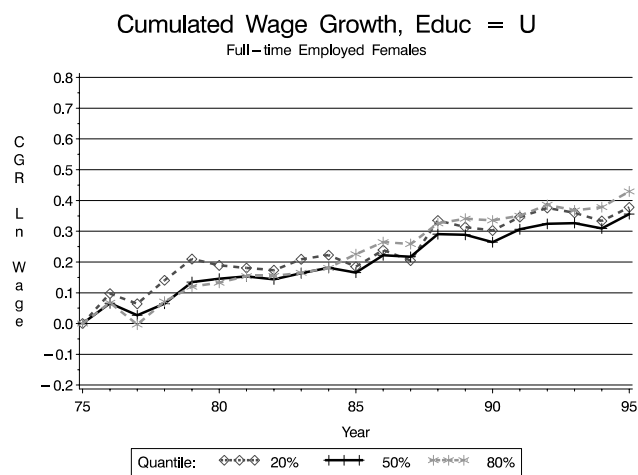
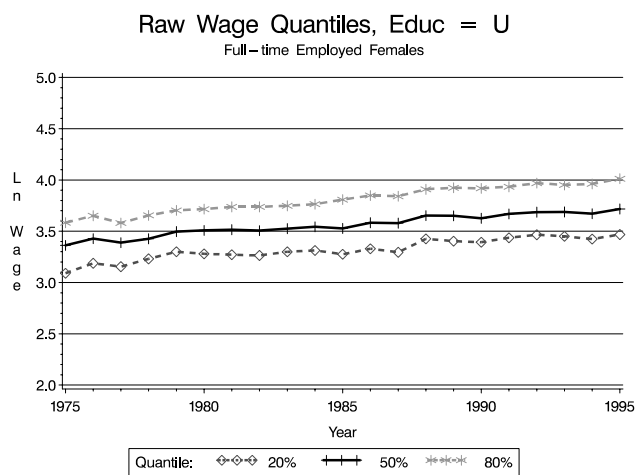


Figure 2 continued: Wage Quantiles and Cumulated Wage Growth by Skill Level
1975 – 1995

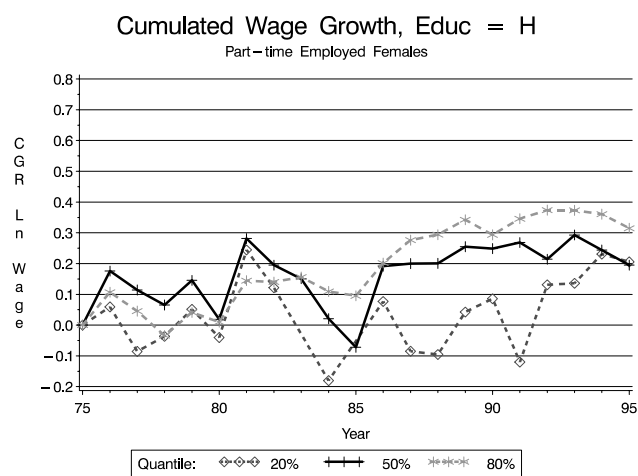
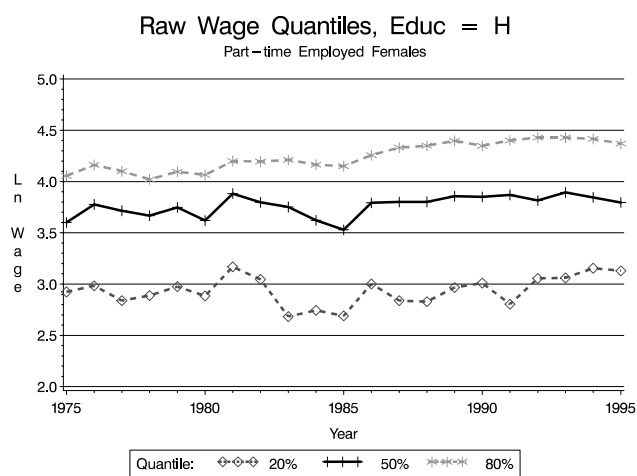
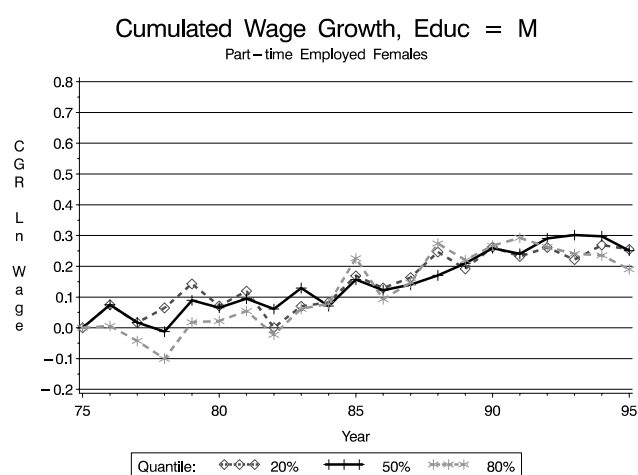
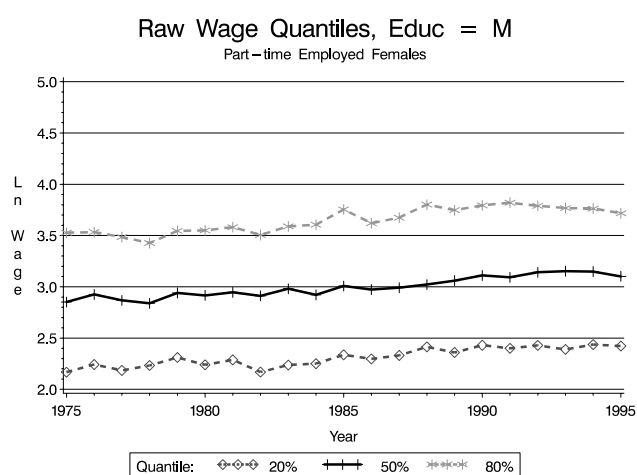
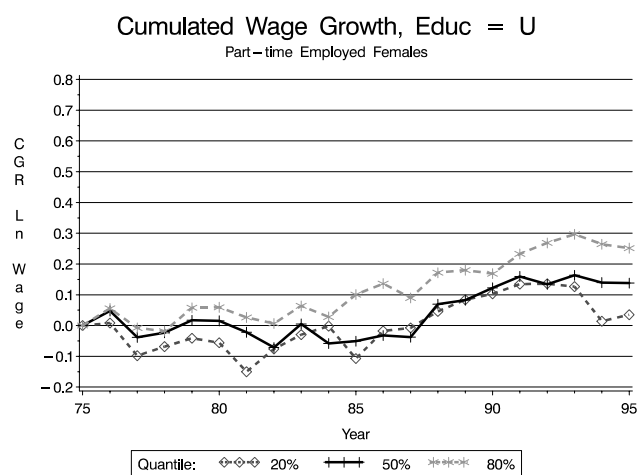
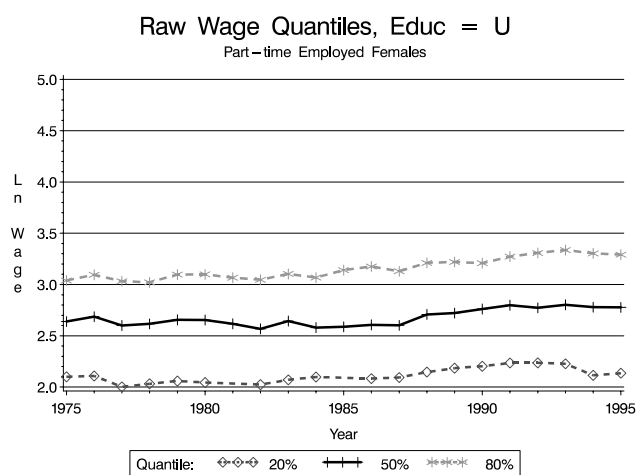
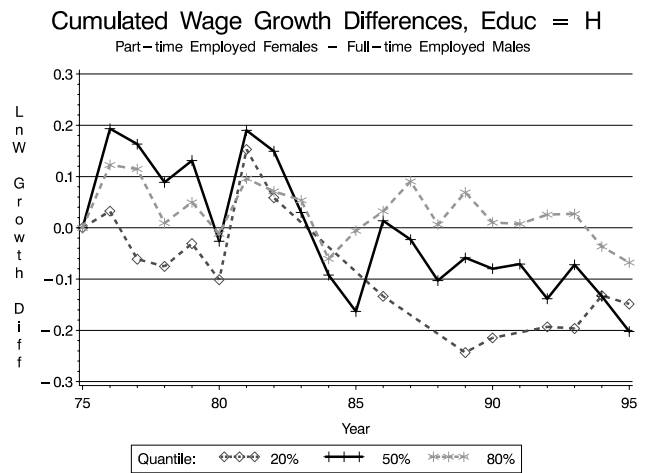
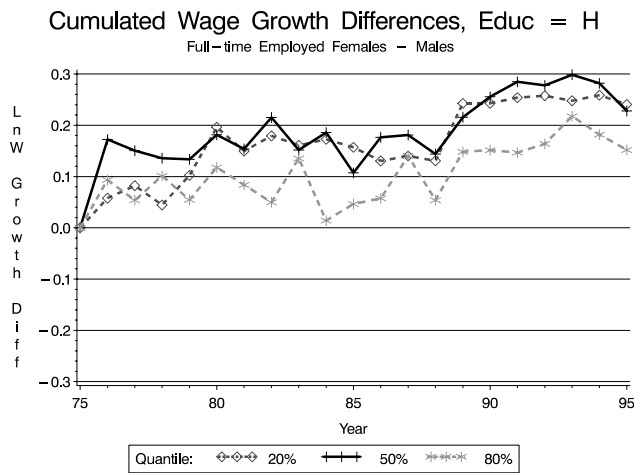
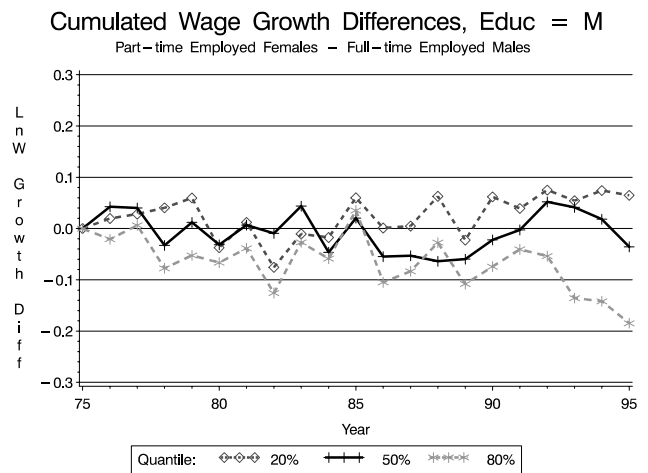
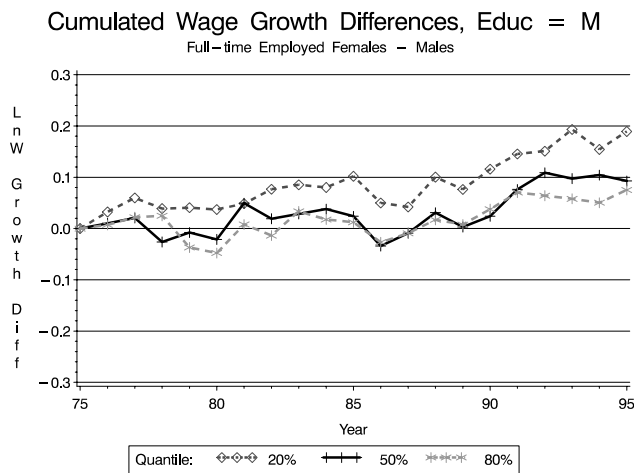
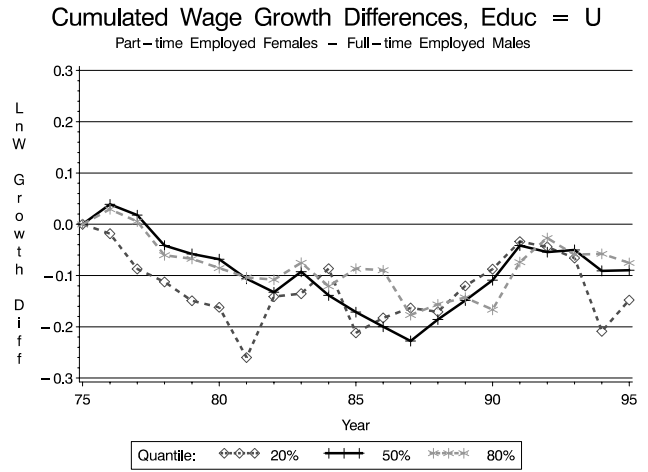
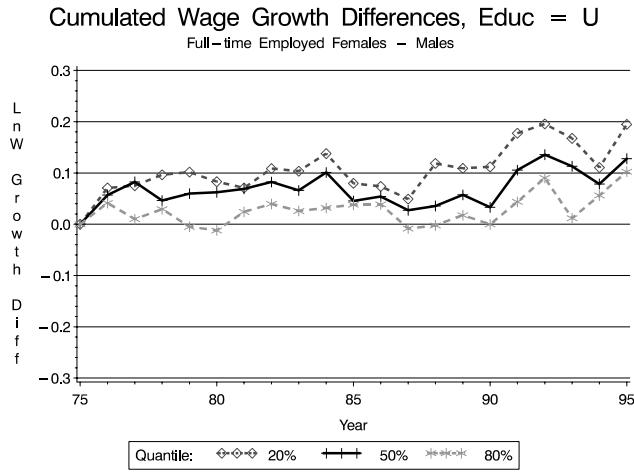
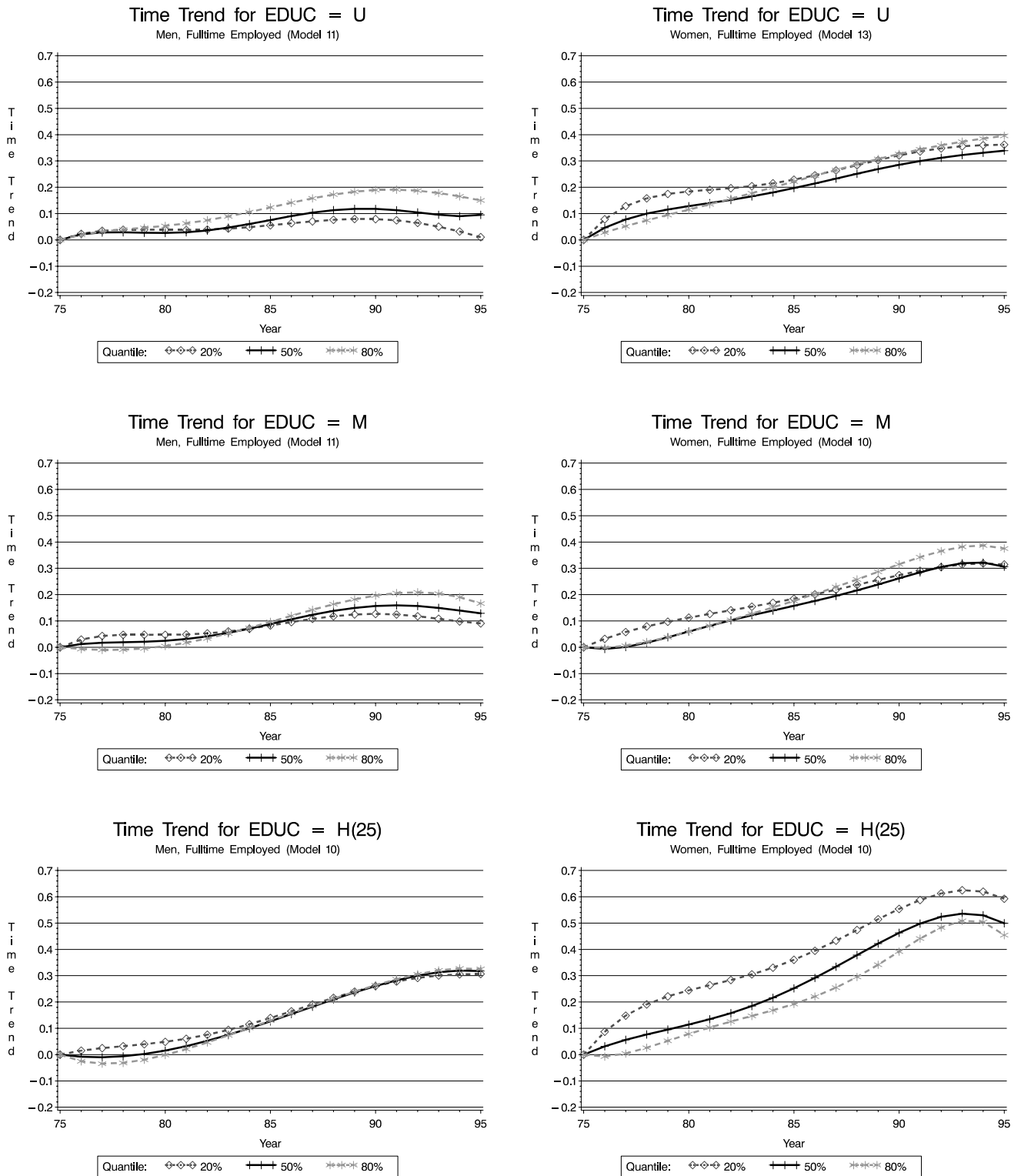


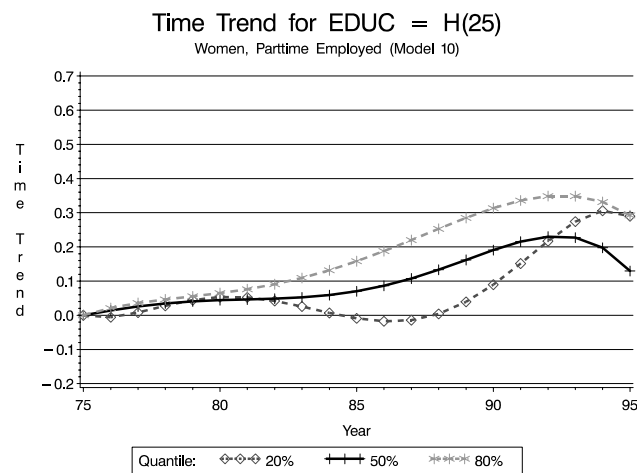
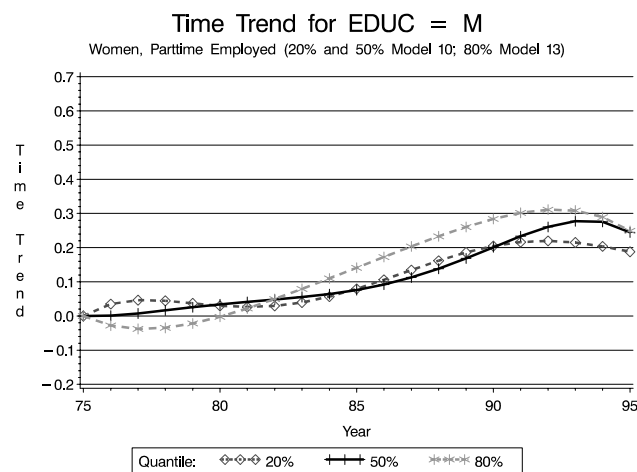
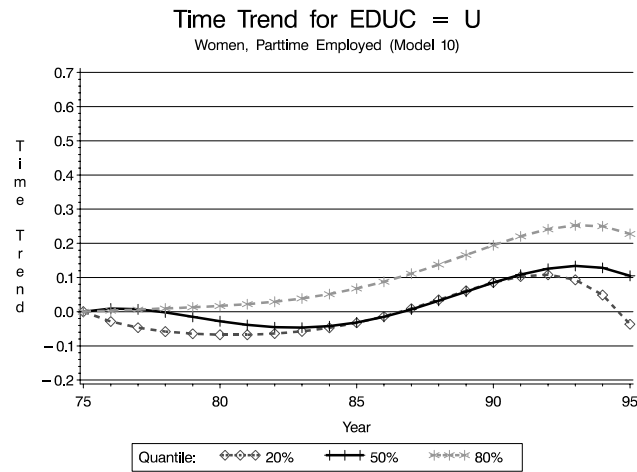
Figure 3: Differences in Cumulated Wage Growth Rates by Skill Level
1975 – 1995



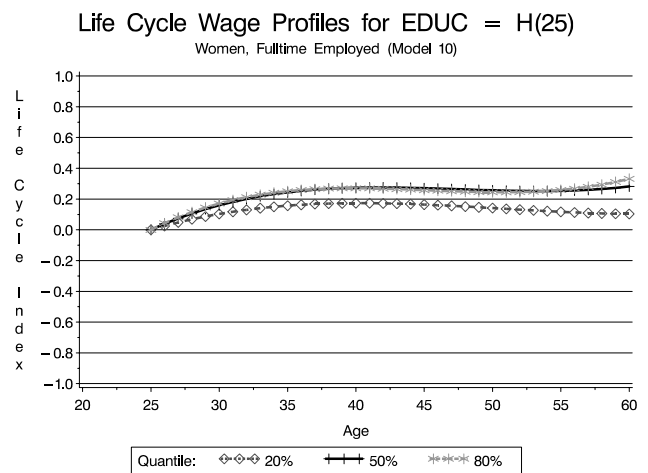
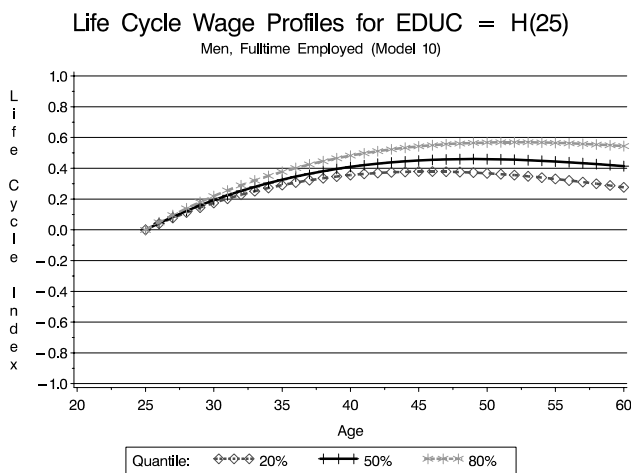
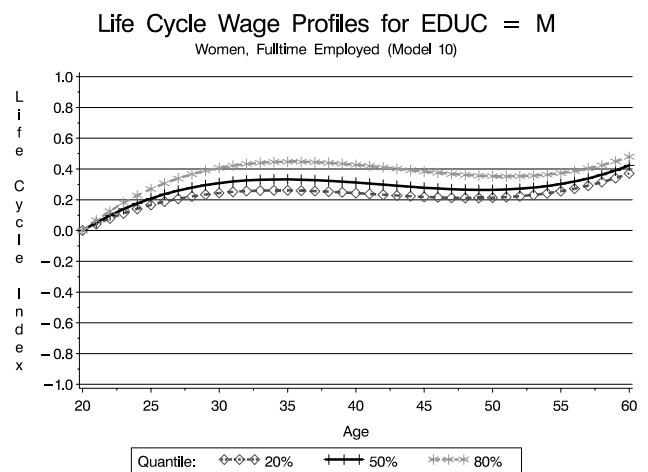
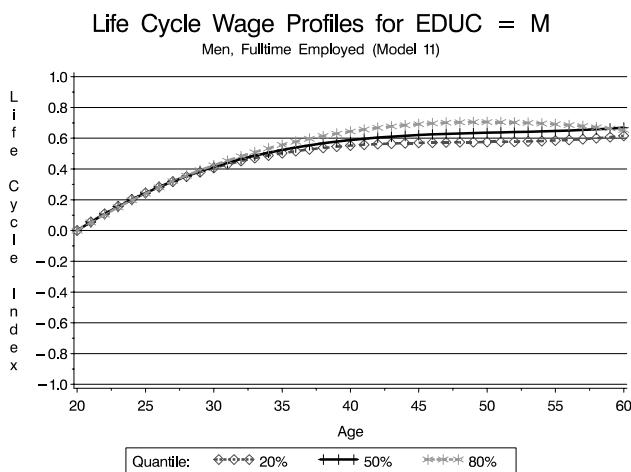
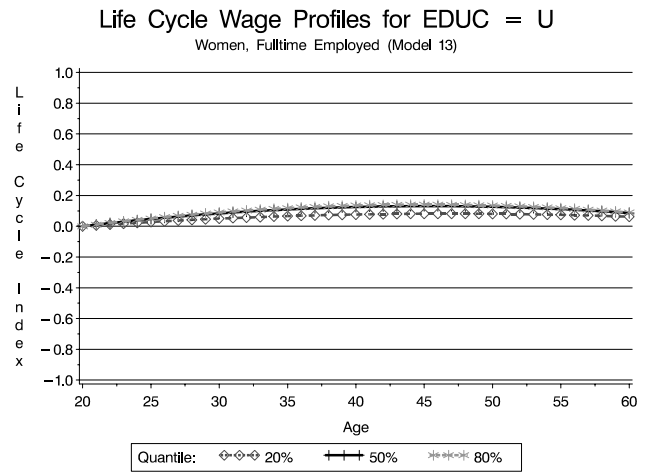
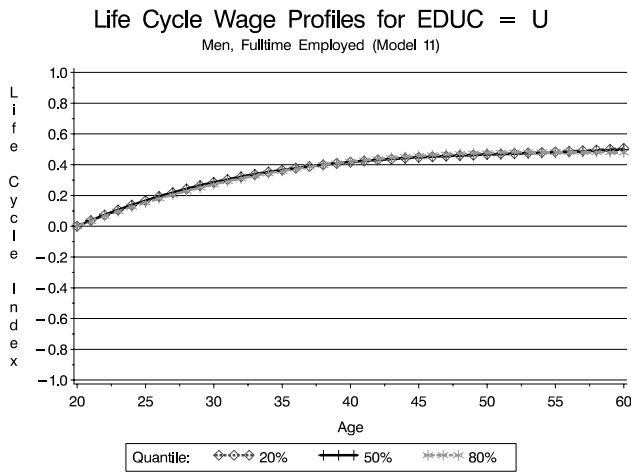
**Figure 4: Time Trends – Full-time Employed Males and Females
1975 – 1995**



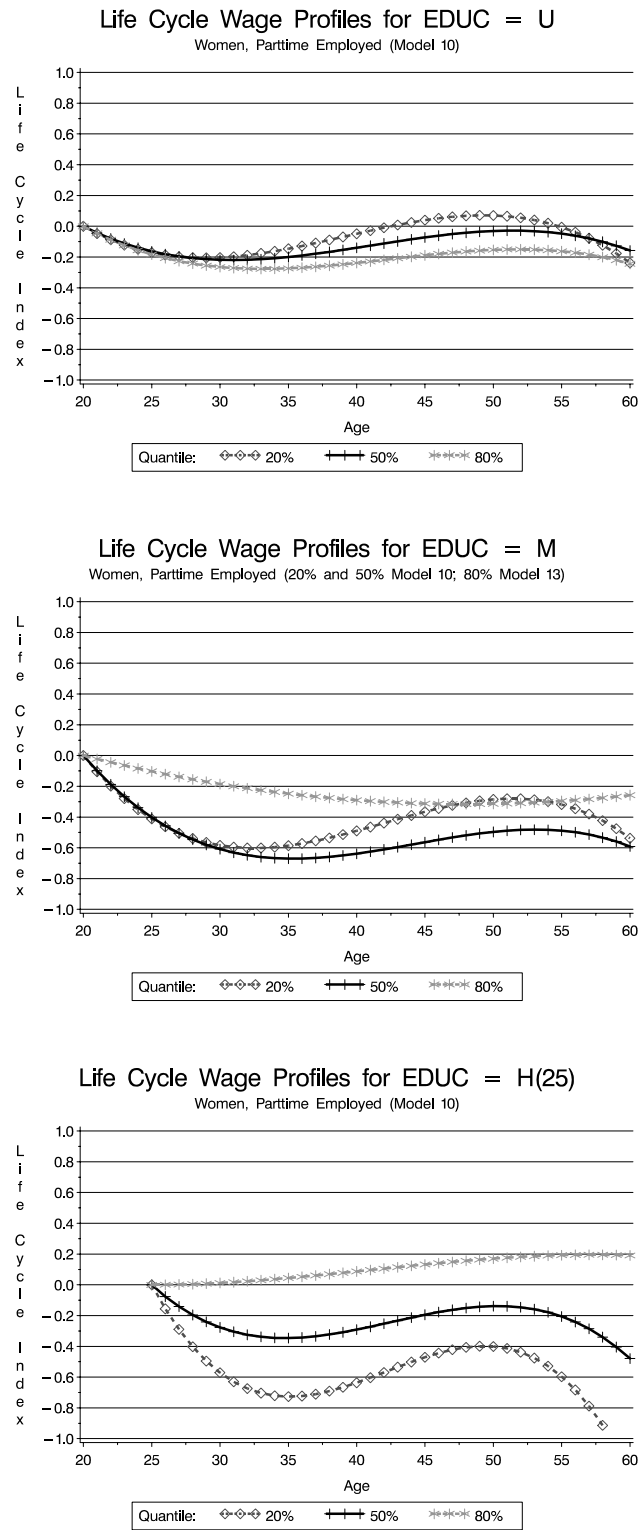
**Figure 5: Time Trends – Part-time Employed Females
1975 – 1995**



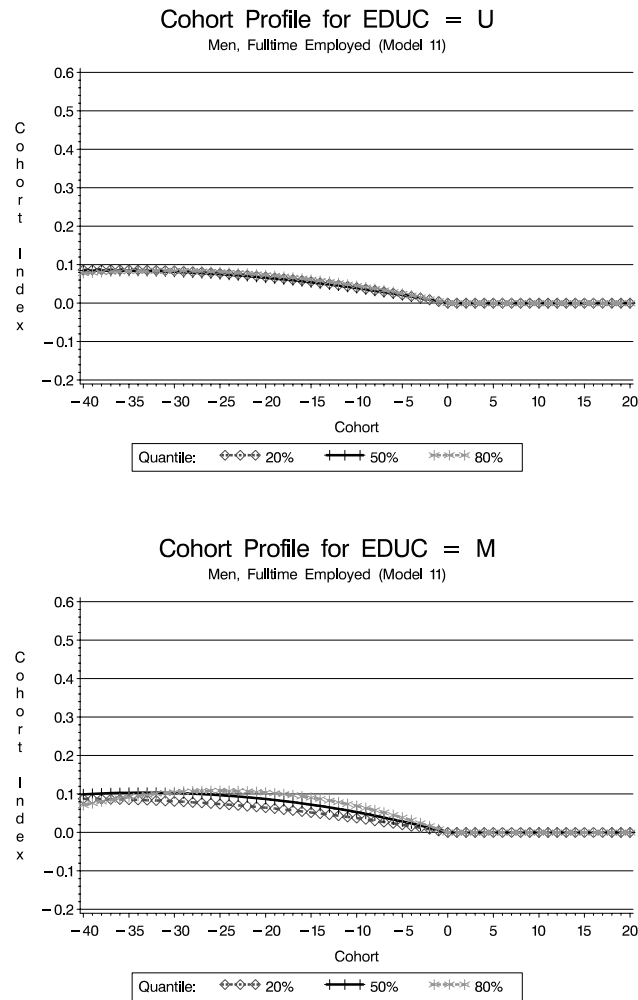
**Figure 6: Life Cycle Profiles – Full-time Employed Males and Females
1975 – 1995**



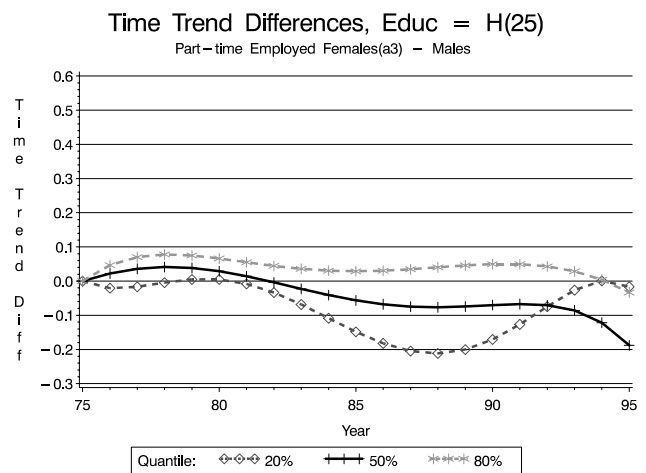
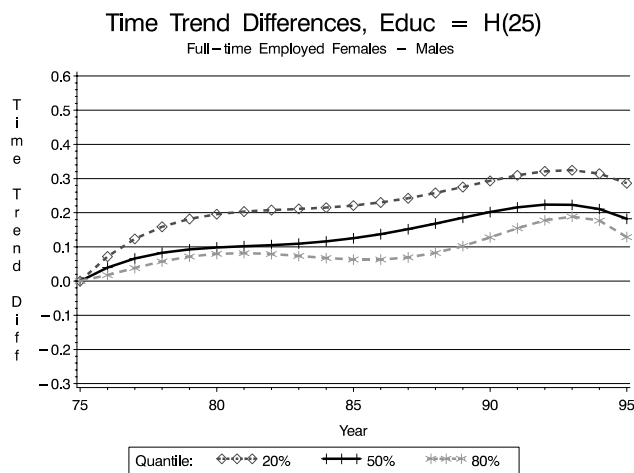
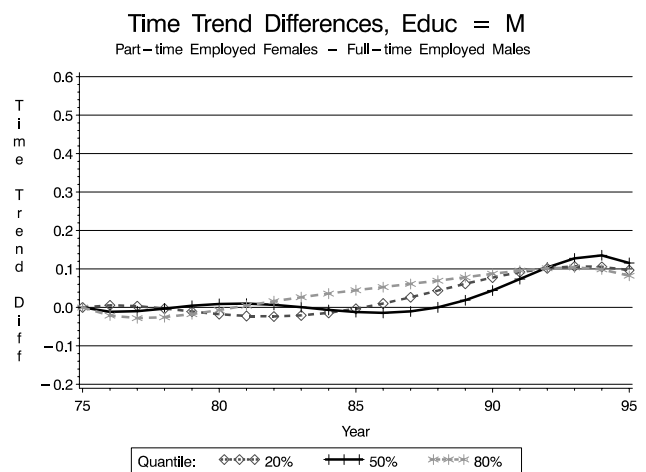
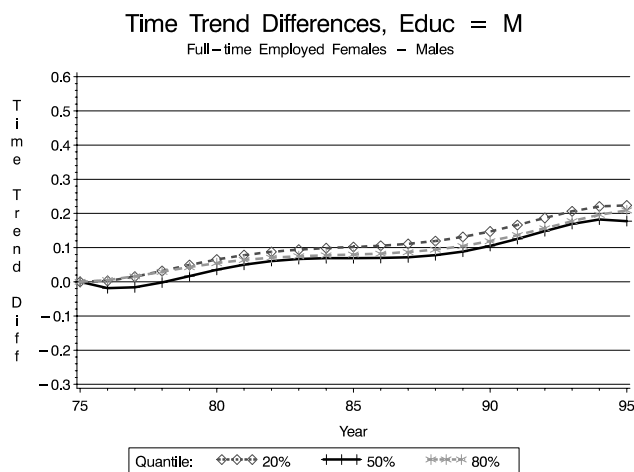
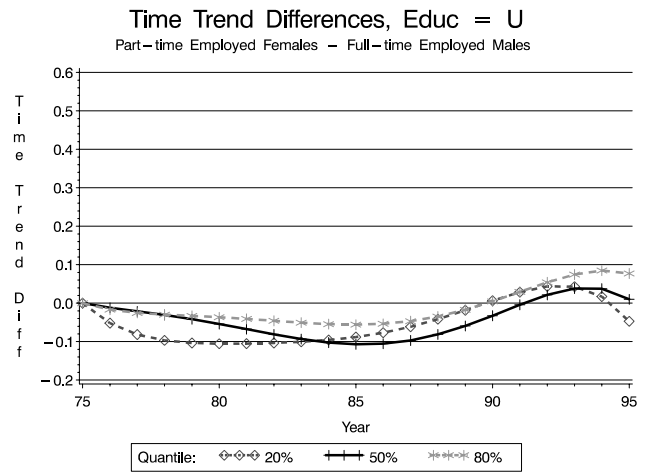
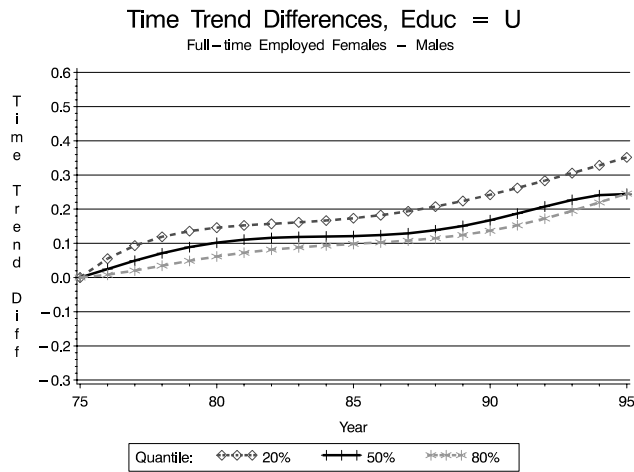
**Figure 7: Life Cycle Profiles – Part-time Employed Females
1975 – 1995**



**Figure 8: Cohort Profiles – Full-time Employed Males
1975 – 1995**



**Figure 9: Gender Differences in Estimated Time Trends by Skill Level
1975 – 1995**



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