

Explaining the Decline in High Skill Employment in the 2000s in the

US

Job Market Paper

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Abstract

A slowdown in the growth of the level of employment in high-skill occupations in the United States has resulted in a slight decrease in the share of the working population employed in high skill occupations beginning around the year 2000. This paper shows that this decrease is mainly driven by demographic changes associated with the exit from the high skill employment of the first baby boom generation, which had a high rate of employment in high skill occupations. It then provides evidence that suggests that the slowdown of high-skill employment is not caused by a negative demand shock. The finding suggests that the US economy has experienced a negative skill supply shock and that the slowdown in the share of individuals employed in high-skill occupations will continue further.

KEYWORDS: college premium, earnings inequality, occupations, returns to schooling, skill biased technical change, skill premium, labor force and employment, retirement.

JEL: J20, J21, J23, J24, J26, J30, J31, O33

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1 Introduction

A large literature in economics has documented the growth in employment for occupations involving a high degree of cognitive skills, named hereafter high skill occupations and the associated disappearance of occupations intensive in routine tasks, typically referred to as middle-skill occupations (Katz and Murphy (1992), Acemoglu (2002), Autor and Murnane (2003), Autor and Dorn (2013), Autor and Kearney (2006), Goos and Manning (2007))¹. The share of men between 25 and 55 years employed in high skill occupations had grown at an approximately constant rate since the 1970s. However, beginning around the year 2000, this share started to decline ².

In this paper I provide an explanation for the slowdown in the level and the slight decrease in the share of working individuals employed in high skill occupations between the year 2000 and the year 2007. I limit the analysis up to 2007 to abstract from changes in employment associated with the economic recession of 2008 and 2009. The main focus of the paper is on men, in order to abstract from life cycle differences in the labor supply of men and women.³ Figure 1 shows for males 25-55, the trends in levels of employment and both the share of individuals employed in high skill occupations and the share of *total hours worked* employed in high skill occupations between 1970 and 2007.⁴ The upper panel of Figure 1 also shows the trend that would have been observed in the absence of a post 2000 slowdown. The difference between the two lines represents about one million workers.

This paper provides evidence that an important source of the slowdown shown in these graphs is a change in the composition of the workforce in the United States. Previous work has documented a

¹This same literature has noticed a slight expansion in employment of jobs that require the least amount of skill, which are also associated with low wages. This has led numerous researchers to consider this period as one of polarization, with increases in employment and real wages at both ends of the skill distribution.

²The Appendix contains a detailed list of occupations

³When I include both men and women in the analysis I find a less pronounced slowdown in the proportion of individuals working in this type of occupations.

⁴Appendix Figure 1 shows the combined male and female share of total hours worked employed in high skill occupations.

slowdown in the proportion of men and women obtaining a college degree or a graduate degree for cohorts born after the second World War ((Card and Lemieux, 2000)). The present study complements the previous literature in three ways. First, I document that the slowdown in the trend of accumulation of higher education coincided with a slowdown in the share of the population working in high skill occupations. Specifically, for cohorts born between 1920 and 1945, the share of workers going to high skill occupations had been growing at an approximately constant rate. However, starting with the post World War II (WWII) cohorts there was a decline in the proportion going into high skill occupations. This proportion remained about constant for cohorts born in the 1950s and early 1960s. Second, I document that there is an age gradient associated with employment in high skill occupations: as cohorts age, a higher proportion of each cohort ends up working in this type of occupations, followed by a sharp transition out of high skill occupations as cohorts enter their fifties.⁵ These two facts suggest the exit from high skill occupations of the highly skilled cohorts born in the late 1940s has contributed to the stagnation in high skill employment previously mentioned.

Indeed, a simple decomposition of high skill employment into cohort, age, and time effects suggests that if cohorts born in the 1950s and 1960s had entered high skill occupation at a higher rate than older cohorts, the share of the labor force in high skill occupations would have increased more and would not have stopped increasing after the year 2000.

Third, using standard assumptions that relate skill supplies and relative wages ((Card and Lemieux, 2001), Autor et al. (2008)), I show that the implied relative demand for high skill workers has continued increasing during the 2000s⁶. Using a production function that takes as inputs high skilled workers and workers in other occupations and that allows workers of different age groups to be imperfect

⁵This is consistent with evidence on age-related career progression

⁶Notice that this differs from the demand for workers in high skilled occupations

substitutes. This allows me to recover the degree of substitutability across workers of different age groups. I find that, within high skill occupations, there is a high degree of substitutability across workers of different age groups. This suggests that the exit from high skill occupations of old highly skilled cohorts will increase the wage premium younger workers employed in high skill occupations are able to command over workers in other sets of occupations. Since higher education increases the probability of entering this type of occupations, this provides an incentive for younger workers to accumulate more human capital.⁷

This paper contributes to the literature on by documenting a slowdown in entry into high skill occupations starting with post WW2 cohorts and exploring its potential consequences for inequality. The next section provides an overview of trends in the data. Section 3 explains the decomposition and presents results from simple counterfactual exercises. Section 4 considers the exit from high skill occupations of relatively older cohorts. Section 5 explains the link between education and high skill employment and, using standard structural assumptions, presents estimates of the implied elasticity of substitution across age groups and estimates of the implied trend for the relative demand for high skill workers. Section 6 discusses implications for policy and its connection to the literature on polarization. Section 7 concludes and presents avenues for future research.

2 Trends in the data

In this section I present a descriptive overview of trends in employment in high skill occupations. In the first subsection I discuss high skill occupations' **relevance**. In the second subsection, I describe the data. In the third subsection I present the trends in the data that motivate the empirical analysis.

⁷Notice that this hinges upon the assumption that the unobservable characteristics of younger high school graduates has remained relatively unchanged. (Altonji et al., 2012) suggest this is a strong assumption.

2.1 Overview

This paper uses 3 main sources of data. In Sections III, IV and V, I use 5 percent samples of the U.S. censuses from the 1970, 1980, 1990, and 2000 Integrated Public Use Microdata Series (IPUMS) (Ruggles et al. (2010)) and annual data from the American Community Survey for the years 2000-2010. I also use data from the May/Org rotation groups of the Current Population Survey (CPS). These data provide individual level information on economic and demographic characteristics, employment, and occupation. The analysis in all sections of the paper is restricted to non-institutionalized individuals between 25 and 65 years of age. The data are used to construct estimates of educational attainment, employment, and wages. Further details about the data and the construction of variables of interest are provided in Appendix A.

A central feature of the analysis is the definition of occupations. I follow the standard in the literature (Autor and Murnane, 2003) and convert all occupations to the 1990 classification. Appendix A provides a detailed discussion of the definition and construction of occupations.

2.2 Trends in the Data

2.2.1 Employment Levels

Although the level of employment in high skill occupations increased continually during the 1970s, 1980s and 1990s, the aggregate pattern masks important differences across age groups and cohorts in the labor market. Figure 3A shows the average number of workers employed in high skill occupations for cohorts born five years around each of the labeled Birth Years at different points in their lives. For example, the 1930 Birth Year cohort includes those born between 1928 and 1932. The figure reveals three important features of the data. First, there is a very marked increase in the level of employment in high skill occupations for cohorts born around 1950 relative to cohorts born around 1940. There is

a strong slowdown in the number of individuals entering high skill occupations between cohorts born around 1950 and 1960 and this slowdown persists for successive cohorts. Second, as individuals age, a higher number of members of a given cohort are employed in high skill occupations. In the figure, this increase is more pronounced between ages 30 and 40. Third, between ages 50 and 60 a large number of members of each cohort are no longer employed in high skill occupations⁸. The figure confirms the presence of a large expansion and subsequent stabilization of employment in high skill occupations for cohorts born between the early and late 1940s and a concave age profile in employment in high skill occupations.

Abstracting from the age profile for a moment helps understand the force behind the slowdown in the growth of employment in high skill occupations seen in the 2000s. Consider first the cohort born in 1930. Assuming for simplicity that all individuals belonging to such cohort exit high skill employment between 50 and 60 years old, the number of individuals from such cohort leaving the labor market between 1980 and 1990 would be lower than the number of individuals born around 1960, who would be entering high skill employment in 1990. In such a scenario, the level of employment in high skill occupations would have undoubtedly increased between 1980 and 1990. Similarly, the entry into high skill employment of the 1970 cohort would more than compensate for the exit of the 1940 cohort. However, the number of individuals belonging to the 1980 cohort entering the high skill employment in 2007 is lower than the large number of individuals belonging to the 1950 cohort exiting high skill employment between 2000 and 2007.

There are two ingredients that generate the disproportionate expansion and subsequent stabilization of employment in high skill occupations. First, cohorts born in the late 1940s and 1950s were disproportionately large relative to previous cohorts⁹ These are typically called baby-boom cohorts.

⁸Appendix Figure 3 plots the age profiles for all cohorts in the data.

⁹Appendix Figure 2 shows the number of individuals born in different cohorts in the year 2000. There is a clear increase in cohort size starting with cohorts born in 1946 up to cohorts born in 1964.

Second, starting with the baby-boom cohorts, the share of individuals entering high skill occupations stopped growing. Figure 3B shows that, as a share of total employment, high skill employment increased for cohorts born before 1950 at every point in their lifetime. It also shows that this share experienced a slight decrease for baby boom cohorts and a slight recovery for cohorts born around 1970.

Whereas Figure 3A showed an increase in the number of individuals employed in high skill occupations between 30 and 50 years, Figure 3B shows that, as cohorts age, high skill occupations represent a higher proportion of employment. Notice that this is generated in part by the increasing number of individuals who gain access to high skill employment and partially by exit from the labor market of individuals employed in other occupations. Thus, the high skill level of employment stops growing between 40 and 50 years old but the share of employment corresponding to high skill occupations continues increasing. This is consistent with individuals in other occupations exiting the labor force earlier¹⁰.

Taken as a whole, Figures 3A and 3B suggest that the reversal in high skill employment in the 2000s is connected to the changes in high skill employment brought about with the exit from the labor market of the baby boom cohort. In order to show more formally the effect of changes in the composition of the labor force on high skill employment, in the next section I use a simple decomposition that allows me to perform some counterfactuals that highlight the importance of the slowdown in entry into high skill occupations associated with the baby boom cohort.

¹⁰Individuals in middle and low skill occupations tend to exit the labor force earlier than individuals employed in high skill occupations

3 Decomposition

To understand how demographic changes have impacted the occupational distribution in the data, we would like to compare two otherwise identical economies that differed in their demographic composition. A simple comparison of these two economies' occupational composition would suffice to understand how demographics affect the occupational distribution in the data. In the absence of this source of variation in the data, in this section I illustrate the consequences of changes in the demographic composition of the labor force by decomposing the share of employment of individuals of different age groups at different points in time as a function of their age and the cohort they belong to. In the first subsection I briefly discuss the decomposition. In the second subsection I discuss the results.

Consistent with the patterns presented in the previous section, suppose that the share of individuals in age group a at time t working in high skill occupations is given by:

$$S_{it} = a_i + c_{t-i} + e_{it}$$

where i is an index for age, t is an index for time, and $t - i$ indexes cohorts. This specification imposes that as individuals age, a larger fraction ends up working in high skill occupations, which is consistent with career progression motives. The second term, c_{t-i} , captures the remaining cohort specific variation in the data.

Panels A and B of Figure 4 show the estimated age and cohort effects.¹¹ The figure shows a concave age profile in high skill employment. Relative to individuals in their early twenties, the share of individuals

¹¹A similar specification that exploits only within-industry variation:

$$S_{ijt} = a_i + c_{t-i} + d_j + e_{ijt}$$

generates similar coefficients (Appendix)

going into high skill occupations increases by 10 percentage points by the time they reach 40 years old. Between 50 and 60 years old there is a very steep decline in the fraction of individuals still working in high skill occupations. Panel B of Figure 4 displays the estimated cohort effects. As can be seen, for individuals born between 1925 and 1945, a higher share of each successive cohort entering the labor market has worked in high skill jobs throughout their lives. There was a strong reversal starting with cohorts born in the second half of the century. There has been a slow increase in high skill employment for cohorts born in the 1970s.

The upper panel of Figure 5A shows the predicted values obtained using the estimated coefficients from this decomposition along with the predicted values under a counterfactual scenario in which post WW2 cohorts had entered high skill occupations at an increasing rate¹². The figure reveals several facts. First, consistent with the graphical evidence presented in the previous section, this simple decomposition captures the trends in the data, as revealed by the predicted values displayed in the graph. Second, the figure suggests that, if post World War II cohorts had continued entering high skill employment as previous cohorts did, employment in high skill occupations would have displayed a less significant slowdown between 2000 and 2007.

This section has shown that the reversal in high skill employment observed in the data appears to be mainly driven by the exit from high skill employment of the first baby boom cohorts. This suggestive evidence is not conclusive. Thus, in the next sections I first provide complementary evidence that suggests that the cohorts exiting high skill employment in the 2000s have not been subject to negative demand shocks and then I make use of structural assumptions relating relative wages and relative quantities to confirm that the slowdown in the high skill employment share cannot be a consequence of negative changes in the demand for skill.

¹²I assume the share continues increasing at its pre-1945 cohort trend

4 Exit from High Skill Occupations

In the previous section I provided evidence that suggests that the slowdown in the growth of employment in high skill occupations and the decline in the share of the population working in high skill occupations is strongly related to the exit of relatively older cohorts from high skill occupations. In this section I provide evidence that suggests that a negative demand shock affecting individuals working in high skill occupations around the year 2000 cannot play a big role in these individuals' exit from employment in high skill occupations. This exercise does not require me to impose any assumptions on the selection of individuals still employed in high skill occupations.

4.1 Exit Rates from Census Data

From Census and ACS data I know the number of individuals belonging to each cohort that work in high skill occupations. Thus, I can also calculate the cohort-specific proportion of individuals leaving high skill occupations between two given dates. Then I can take the difference in this measure for consecutive cohorts. To fix ideas, consider the cohort of individuals born in 1947. These were 53 years old in 1990 and 63 years old in 2000. I calculate the proportion of those employed in high skill occupations in 1990 who are no longer employed in high skill occupations in 2000. I obtain (equation for exit rate 1947). Similarly, for each cohort c I can obtain this measure between time periods t and

$$t + 1 : \text{ExitRate}_{c,t:t+1} = \frac{HS_{c,t} - HS_{c,t+1}}{HS_{c,t}}$$

Now consider the cohort of individuals born in 1937. These were 53 years old in 1980 and 63 in 1990. If labor supply has remained stable across these two dates, exit rates between 53 and 63 years old should be similar for these two cohorts unless these were exposed to differential demand shocks. Figure 5A plots the implied exit rates for different cohorts between different ages. First, notice that the

figure mirrors the age profile of employment in high skill occupations discussed in Section (Profiles): the share of individuals no longer working in high skill occupations between two Census years (i) starts increasing as individuals approach their mid fifties and (ii) continues rising smoothly with age. Second, the figure shows the *implied* exit rate from high skill employment: in order to make the exit rates from high skill employment between 1980-1990, 1990-2000 and 2000-2007 comparable I assume that the 2000-2007 exit rate represents 70% of the implied exit rate 2000-2010. Third, the differences in exit rates across the three time periods considered are not increasing. This suggests that negative demand differentially affecting high skill workers in the 2000s cannot play a big role in explaining exit from high skill occupations.

Table I confirms the visual impression conveyed by Figure 5. It shows the within age-group average difference in exit rates between years from 1980 to 2007. Between 1980 and 1990 exit rates from high skill occupations for individuals 50-65 years old were essentially constant. Following a 1% increase in exit rates from high skill employment between 1990 and 2000, there was a 4% decrease in high skill employment exit rates between 2000 and 2007. Hence, there is no evidence of a negative demand shock that would reduce employment for highly skilled individuals in the 2000s.

5 What explains the decline in High Skill Employment starting with the Baby Boom Cohort?

In Section 3 I provided evidence that suggests that the decline in high skill employment is a consequence of the exit from high skill occupations starting with the first baby boom cohorts. In Section 4 I provided evidence that suggests that, relative to older generations, these cohorts were not subject to

stronger negative demand shocks as they approached retirement. Moreover, the evidence provided so far suggests that the decline in high skill employment is strongly related to the fact that the share of individuals employed in high skill occupations stopped growing precisely for generations born in the late 1940s and 1950s.

Why did baby boomers stop going into high skill occupations at higher rates than previous cohorts? In this section I provide evidence that suggests that a slowdown in educational attainment characteristic of the baby boom generation represented a negative skill supply shock to the economy that in turn reduced employment growth in high skill occupations. I first show that there is a strong positive relation between a cohort's higher education rate and the share of that cohort that is employed in high skill occupations. I then present evidence that suggests that this negative skill supply shock contributed to increase the wage premium workers in high skill occupations received relative to workers employed in other occupations.

5.1 Educational Attainment, Employment in High Skill Occupations, and Wage Differentials

For all the years considered in this study, there is a strong association between a cohort's educational attainment and its share working in high skill occupations.

The cross sectional correlation of a cohort's share of individuals with more than four years of education and the share working in high skill occupations is 95%; a 10 percent increase in a cohort's share of individuals with more than 4 years of education is associated with a 9 percent increase in that cohort's share of individuals working in high skill occupations. Figure 6 shows that there was a strong reversal in the share of workers with a college degree or more education for cohorts born in the second half of the century.

This suggests that the reversal in educational attainment of post WWII cohorts reduced the supply of skill available to work in high skill occupations. In the next subsection I discuss the implications in terms of wages of this negative skill supply shock.

Did the slowdown in educational attainment contribute to increase wages in high skill occupations? The extent to which a slowdown in educational attainment increases different cohorts' wages depends on the elasticity of substitution across age groups. If different age groups with the same level of education are perfectly substitutable, a slowdown in the educational attainment of cohorts just entering the labor force should increase the relative wage of those with a higher level of education. If different age groups are far from perfect substitutes in production, age groups for which the relative supply of educated individuals decreases the most will experience larger increases in relative wages. If a slowdown in educational attainment constitutes a negative shock to the supply of skill available to work in high skill occupations, the wage of workers in high skill occupations will also increase relative to the wage of workers in other less skill-intensive occupations. How this increase in wages is distributed across different age groups will also depend on the degree of substitutability across different age groups in high skill jobs.

Following (Card and Lemieux, 2001) I decompose the log wage difference between groups with different levels of skill into age effects, time effects, and post WWII cohort effects. Age effects capture the increase in the wage differential between skilled and unskilled individuals coming from returns to experience. Time effects capture time-varying increases and decreases in the relative aggregate demand and supply of skill. Cohort effects capture cohort specific premia. Under perfect substitutability across age groups, a cohort-specific increase in the relative supply of skill in a specific year will increase the wage premia of all age groups in the market in that year. Year effects will absorb this demand shock and cohort effects will be equal to zero. Under imperfect substitutability across age groups, a cohort-

specific increase in relative skill supply will disproportionately increase the wage premium experienced by that cohort, absorbed by a cohort effect. Table II shows the results of such a decomposition for several skill groups. I first show the College-High School log wage difference. The year effects show that after a dip in 1980, the aggregate returns to college have been increasing over time, consistent with both an acceleration of demand for skill and a deceleration in the average level of education since that year. Cohort specific effects of post WWII cohorts are also increasing over time. This is inconsistent with perfect substitutability across age groups with the same level of schooling, and confirms Card and Lemieux's (2001)* observation that the slowdown in educational attainment of the 1950-1970 cohorts has also been a key component in the increase in inequality after 1980. Column II shows that the returns to post-graduate education have increased at a faster pace than the returns to college, and the increasing cohort effects also suggest the presence of imperfect substitutability across age groups. Columns III shows the log wage difference between workers employed in high skill occupations and those employed in middle or low skill occupations. Columns IV and V show this difference separately for workers with college and those with more than college. Column III shows a pronounced increase in the wage difference between workers in high skill occupations and those in other sets of occupations. The time effects in Columns IV and V suggest that this increase is fundamentally driven by high skill workers with more than four years of education, whose relative supply contracted the most. However, for both college workers and post-graduate workers the wage differential has increased the most in the 2000s. This can be a consequence of a post-2000 increase in the demand for skill or from a post-2000 contraction in the supply of skill. Although the cohort effects in Columns IV and V are somewhat increasing for post WWII cohorts, they are estimated very imprecisely. The lack of strong cohort effects could be a consequence of a higher degree of substitutability across different age groups among the highest educated skilled workers as compared to college workers. In order to make progress in

disentangling supply from demand, in the next subsection we make some functional form assumptions.

Implied Relative Demand for Skill

Under certain assumptions regarding the underlying production function of the economy, we can use information about wages and relative supplies of work to obtain estimates of the implied demand for high skilled workers relative to middle and low skilled workers. Building on (Card and Lemieux, 2001), we can assume that production of a single final good is CES and depends on high skilled labor HS_t , non-high skill labor NHS_t ¹³, and the productivity of each of these two groups (θ_{HS_t} and θ_{NHS_t} , respectively). We can also assume that total high skilled and total non-high skilled labor are themselves CES aggregates of age-specific high skilled and non-high skilled labor. Thus, the production function can be written as follows: $y_t = (\theta_{HS_t}HS_t^\rho + \theta_{NHS_t}NHS_t^\rho)^{1/\rho}$, where $HS_t = (\sum_a (h_a HS_{at}^\eta))^{1/\eta}$, and $NHS_t = (\sum_a (n_a NHS_{at}^\eta))^{1/\eta}$. If we assume both types of workers are paid their marginal product, the log wage ratio between the two types of workers can be written as a function of the overall relative productivity ($\theta_{HS_t}/\theta_{NHS_t}$), the age-specific relative productivity (h_a/nh_a), the age specific relative supply (HS_{at}/NHS_{at}), the aggregate relative supply (HS_t/NHS_t) and both the elasticity of substitution across age groups ($\sigma_a = 1 - 1/\eta$) and the elasticity of substitution across skill groups ($\sigma_s = 1 - 1/\rho$):

$$\log\left(\frac{w_{HS_{at}}}{w_{NHS_{at}}}\right) = \log\left(\frac{\theta_{HS_t}}{\theta_{NHS_t}}\right) + \log\left(\frac{h_a}{nh_a}\right) - \left(\frac{1}{\sigma_s}\right)\log\left(\frac{HS_t}{NHS_t}\right) - \left(\frac{1}{\sigma_a}\right)\left[\log\left(\frac{HS_{at}}{NHS_{at}}\right) - \log\left(\frac{HS_t}{NHS_t}\right)\right]$$

Provided data on relative wages and relative supplies of different skill groups we can obtain estimates for σ_a ¹⁴, h_a , nh_a and construct estimates for HS_t and NHS_t . With these estimates in hand, and information on relative supplies, we can obtain the implied values for $\log(\theta_{HS_t}/\theta_{NHS_t})$ for different

¹³In the polarization literature, non-high skill labor is itself composed of two different types of labor inputs: middle skill labor and low skill labor

¹⁴Specifically, in a regression of the log wage ratio on time effects, age effects and age-specific relative supplies, $\log(\theta_{HS_t}/\theta_{NHS_t})$ and $[-(1/\sigma_s) + (1/\sigma_a)]\log(HS_t/NHS_t)$ will be absorbed by the time effects, and $\log(h_a/nh_a)$ will be absorbed by the age effects. Thus, the coefficient on $\log(HS_t/NHS_t)$ will provide an estimate of $1/\sigma_a$

values of σ_s .

OLS and IV estimates

In order to obtain consistent estimates of the elasticity of substitution across age groups and skill levels we need exogenous variation in the relative supplies of high skill workers and workers in other sets of occupations. I first report estimates that assume the relative employment in high skill and other occupations to be exogenously given. Since this very strong assumption is not likely to be tenable I supplement these estimates with estimates obtained by instrumenting a cohort-specific supply of workers in high skill occupations and other sets of occupations with cohort-specific educational attainment. This strategy is motivated by two facts. First, there is a strong relationship between a cohort's educational attainment and the share of workers belonging to that cohort employed in high skill occupations. Second, the educational attainment of a given cohort is approximately fixed after individuals in that cohort turn around 30 years old¹⁵. If the average educational attainment of a given cohort does not increase as a consequence of increases in the wages of more highly educated individuals relative to less educated individuals, using educational attainment of a cohort as an instrument for the share of that cohort working in high skill occupations seems valid¹⁶.

Table III shows results from regressions of log wage differentials on time effects, age effects, and log relative supplies, for different groups of interest¹⁷. In general, the results indicate relatively high elasticities of substitution across different age groups. When we compare college graduates to high school graduates, the implied elasticity of substitution is close to 10. A comparison of individuals with

¹⁵This can be a consequence of large perceived opportunity costs associated with acquiring further education once an individual has entered the labor force and accumulated some experience

¹⁶Katz and Murphy (1992) and numerous studies thereafter assume relative supplies of education to be fixed to study the evolution of the college to high-school wage gap

¹⁷Age effects are not shown

more than 4 years of college with individuals with just high school implies an overall high degree of substitutability between young and old highly educated individuals.

The higher degree of substitutability between young and old workers obtained when we compare highly educated high skill workers to non-high skill workers than that obtained when we compare college graduates in high skill education relative to non-high skill workers reveals that assuming the same elasticity of substitution across age groups for all types of work is a strong assumption rejected by the data. Maintaining the assumption that factors are paid their marginal product, we can use expressions for each factor's marginal product to obtain separate estimates of the elasticity of substitution for different skill groups¹⁸

Table IV displays separate estimates of the elasticity of substitution across age groups for several skill groups. Columns four and six suggest that the elasticity of substitution across age groups is lower for High Skill Workers with College than it is for Graduate High Skill Workers. The relative supply of High Skill Workers to workers in other occupations can respond to changes in relative wages so the obtained estimates might be biased. Under the assumption that a cohort's relative supply of different groups of education is approximately constant along the life-cycle, we can instrument college high skill employment with the number of college graduates, post-college high skill employment with the number of post-college graduates and employment in other types of occupations with the stock of individuals with some college, high school graduates and high school dropouts. The estimates shown in Columns 5 and 7 follow this strategy. The estimates are similar to those obtained via OLS and confirm that the elasticity of substitution across age groups is about 5 for High Skill Workers with College and about

¹⁸Allowing for skill-specific age-elasticities of substitution, the marginal product of high skill workers is given by:

$$\log(w_{HSat}) = \log(\theta_{HS_t}) + \log(h_a) - (1/\sigma_s)\log(HS_t) - (1/\sigma_{aH})[\log(HS_{at}) - \log(HS_t)]$$

A similar expression holds for non-high skill workers. The difference between the two can be expressed as

$$\log(w_{HSat}) - \log(w_{NHSat}) = d_t + d_a - (1/\sigma_{aH})[\log(HS_{at})] + (1/\sigma_{aNH})[\log(NHS_{at})]$$

where the first two terms absorb time-specific and age-specific variables, respectively.

10 for Graduate High Skill Workers. The relatively high estimated elasticity of substitution across age groups for high skill workers with a graduate degree has an important implication: if the relative demand for skill does not decrease in the following years, the return to post-graduate education is likely to increase for *all* workers, as a consequence of the retirement from the labor force of the most educated cohorts. The return to college is likely to increase as well, especially for middle-age and older workers.

Under the assumption of a linear Trend in Demand, Table V provides estimates of the Relative Demand for High Skill Workers, the elasticity of substitution across skill groups, and skill-specific estimates of the elasticity of substitution across age groups.¹⁹ The estimates for the elasticities of substitution across age groups are in line with those of Table IV.

Non-parametric estimate of the Relative Demand for Skill

The previous estimates assume a linear trend for the relative demand for skill. This is a restrictive assumption. In principle, the relative demand for skill could have substantially increased up to 2000 and stagnated afterward. In order to obtain a flexible estimate of the implied trend for the relative demand for skill I can choose specific values for the elasticity of substitution across skill groups (σ_s) and, recover the implied trend for the relative demand for skill ($\log(\theta_{HS_t}/\theta_{NHS_t})$). Figure 7 shows the implied estimates for this trend when we compare college graduates in high skill occupations and post-college graduates in high skill occupations, respectively. The figure shows that the implied relative demand for skill has continued increasing during the 2000s, although it has increased substantially more for individuals with more than 4 years of higher education.

In the next section I discuss some implications of these results.

¹⁹These estimates come from the following specification:

$$\log(w_{HS_{at}}/w_{NHS_{at}}) = \log(\theta_{HS_t}/\theta_{NHS_t}) + \log(h_a/nh_a) - (1/\sigma_s)[\log(HS_t/NHS_t)] - (1/\sigma_{aH})[\log(HS_{at}/HS_t)] + (1/\sigma_{aNH})[\log(NHS_{at}/NHS_t)]$$

6 Implications

6.1 Education

In previous sections I provided evidence that suggests that the slowdown in employment of individuals in high skill occupations has been a consequence of the slowdown in the rates of entry into this type of jobs characteristic of generations born since the late 1940s. I have also argued that the relative wage of younger individuals working in high skill occupations has increased partially in response to this slowdown.

If the late baby boomers start exiting high skill employment in the next few years, the wage premium workers in high skill occupations command over workers in other occupations is likely to increase for both young and older workers. Since there is a strong relationship between This provides additional incentives for young individuals at the margin between continuing studying or not, to continue acquiring education.

6.2 Polarization

An important hypothesis put forward in the literature on polarization (Acemoglu and Autor, 2010), (Autor and Dorn, 2013) argues that increases in employment and wages at both the high and the low end (but not the middle) of the wage distribution starting in 1980 is consistent with a special type of technological change that complements highly skilled workers, substitutes middle skilled workers whose jobs can be replaced with capital, and neither complements nor substitutes workers at the bottom of the skill distribution, who typically work in service occupations that require assisting others and are difficult to codify.

Figure 8 reproduces a graph from Acemoglu and Autor (2010) for men that shows the 1980-1990, 1990-2000 and 2000-2008 change in the share of total employment corresponding to each of 326 occupations

in 1980. Occupations are ranked according to the mean wage for individuals in that occupation in 1980. Panel B shows these changes for men. As we can see, the contraction of middle skill employment is evident in all decades. However changes at the top and the bottom do not follow a consistent pattern: whereas employment in high skill occupations expands between 1980 and 2000, its share of total employment stops growing in the last decade. Conversely, low skill service occupations seem to only start expanding beginning in the 1990s. Given that high skill employment does not expand in the 2000s and that middle skill employment keeps contracting in the last decade, the share of total employment low skill occupations represent greatly expands in the last decade.

The stagnation in both educational attainment and employment in high skill occupations documented in this paper offers a plausible explanation for this pattern. A more thorough analysis is needed to obtain conclusive evidence in this respect.

7 Concluding Comments

In this paper I have provided evidence that suggests that an important determinant of the reversal in the growth of employment in high skill occupations since the year 2000 is a change in the composition of the US skill distribution. Using some standard structural assumptions I provide evidence that suggests that the return to higher education is likely to continue increasing as cohorts of highly skilled workers are exiting the labor force. Other industrialized countries have experienced demographic shifts similar to those of the United States. An immediate step for research is to extend the present analysis for these countries to better understand the links between demographic changes, educational attainment, and occupational structure. Since some of these countries have large longitudinal publicly available datasets, an immediate direction for future work is to follow individuals from different cohorts to better understand the entry and exit from high skill occupations of workers at different points in the

lifecycle.

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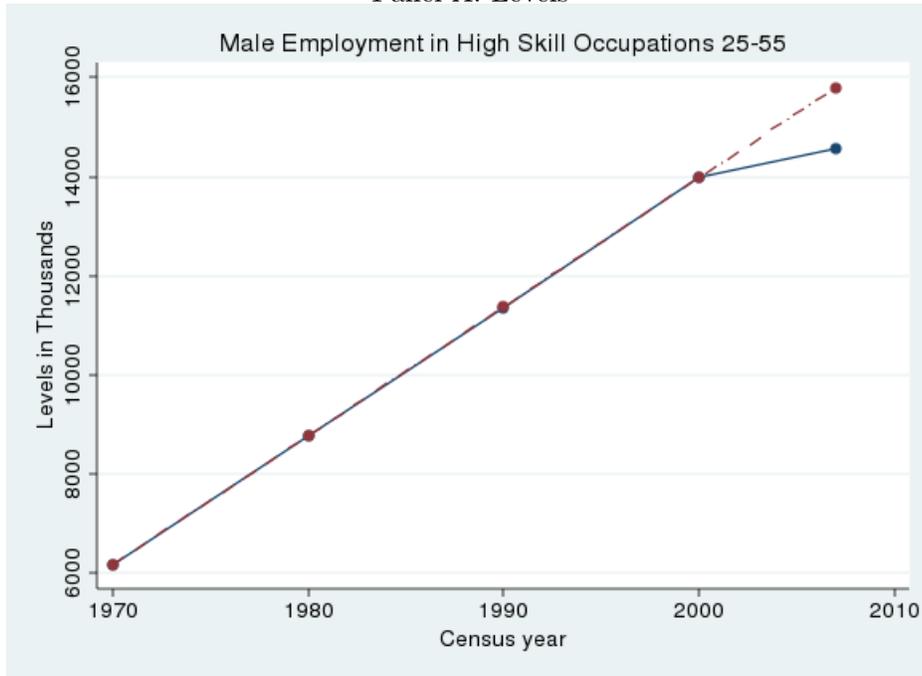
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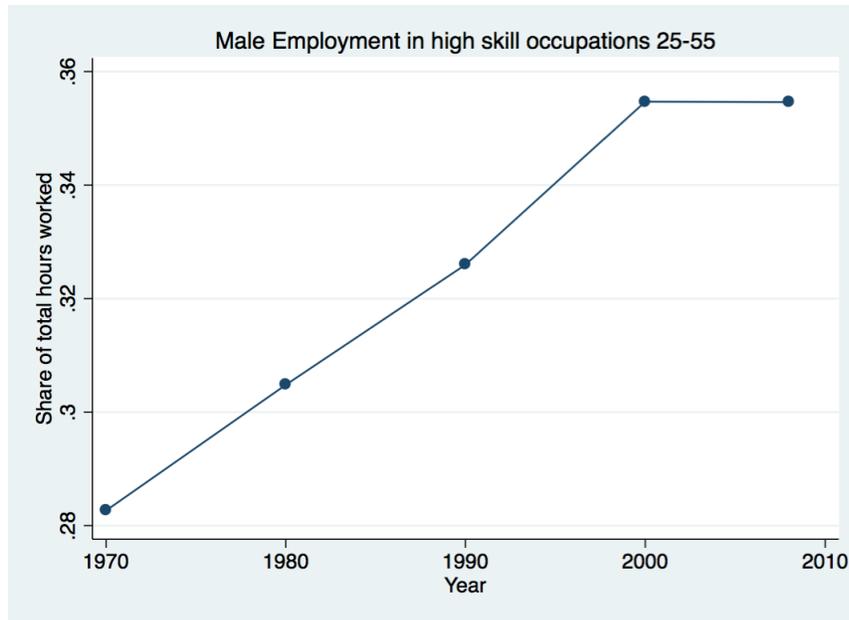
Figure 1: Aggregate Employment in High Skill Occupations

Panel A: Levels



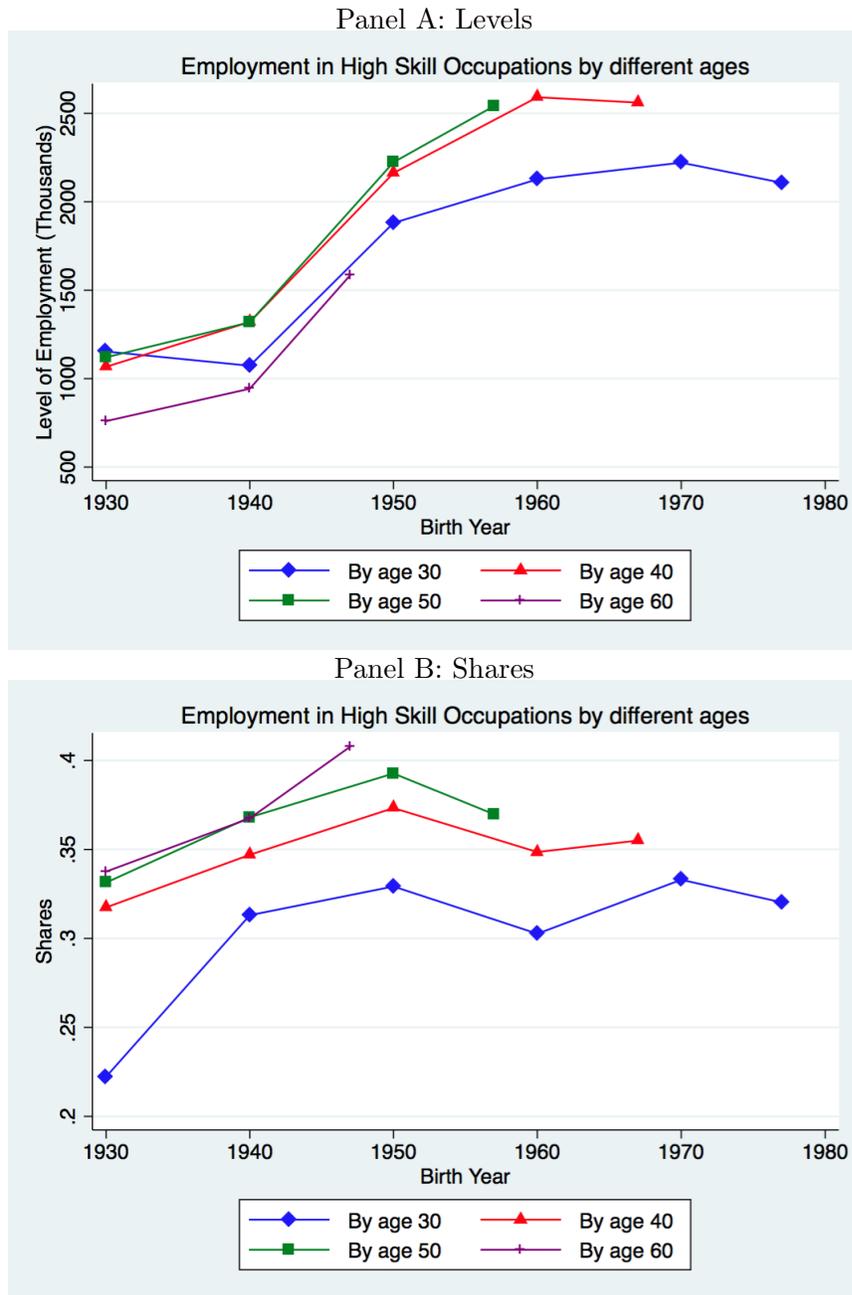
Panel B: Shares





Notes: The upper panel of the figure plots the number of individuals working in high skill occupations. The medium and lower panels plot, respectively, the share of individuals whose main job is at a high skill occupation, and the share of hours worked in high skill occupations.

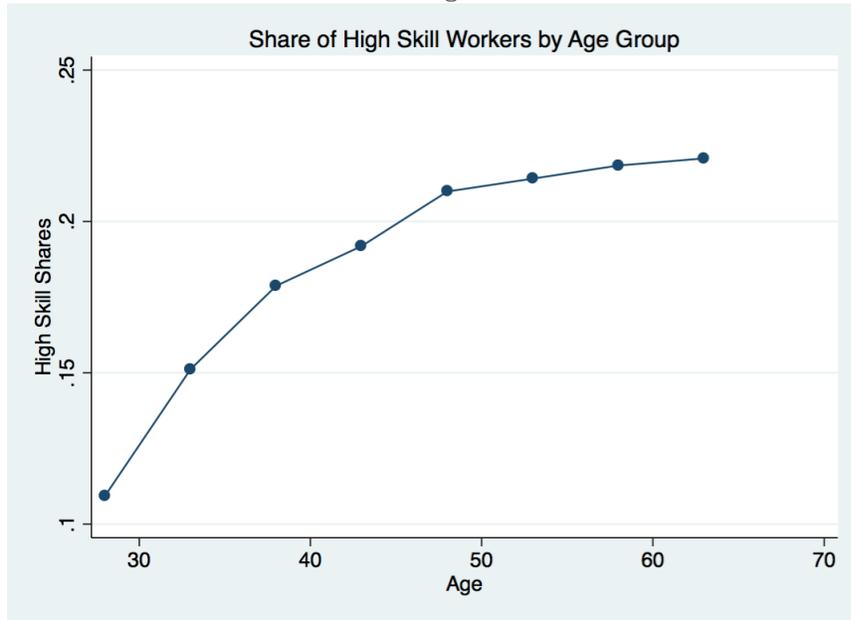
Figure 2: Employment for different cohorts



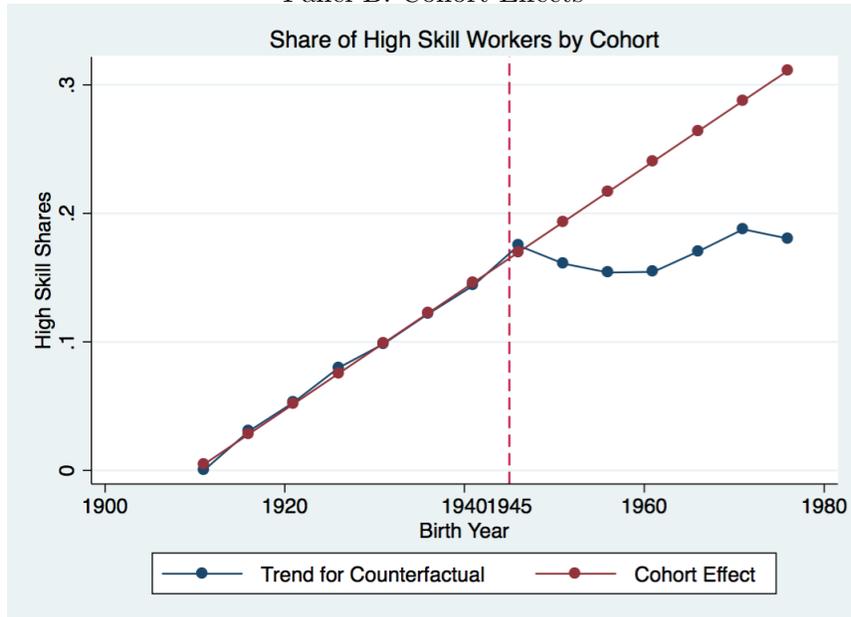
Notes: Panel A displays the estimated average number of workers employed in high skill occupations for cohorts born around 1930, 1940, 1950, 1960, 1970 and 1980. For example, cohorts born around 1930 include those born between 1928 and 1932. Panel B displays the estimated average proportion of workers employed in high skill occupations for these same representative cohorts.

Figure 3: Estimates from Decomposition: Shares

Panel A: Age Profile

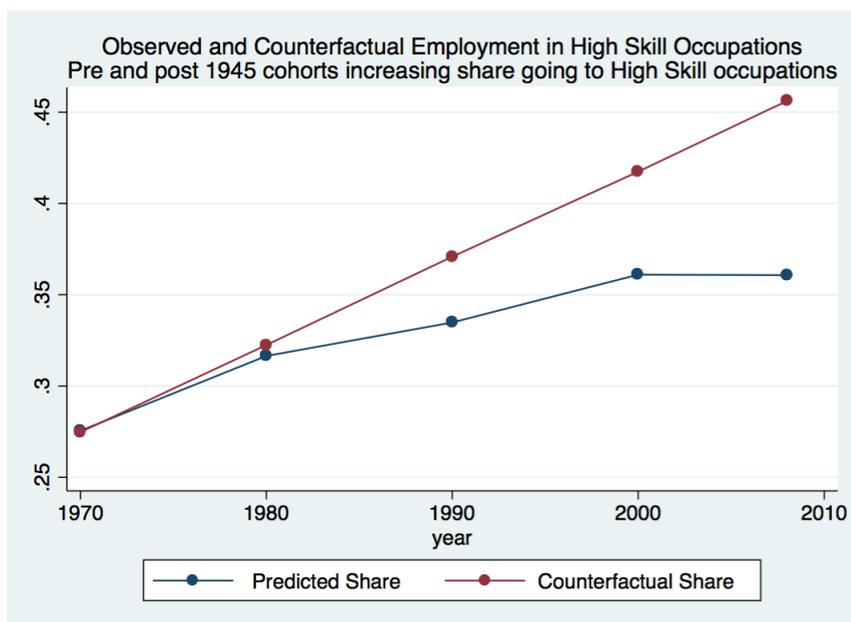


Panel B: Cohort Effects



Note: Decomposing a cohort's share of workers in high skill occupations into age, cohort, and time effects generates the displayed coefficients in panels A, B, and C, respectively.

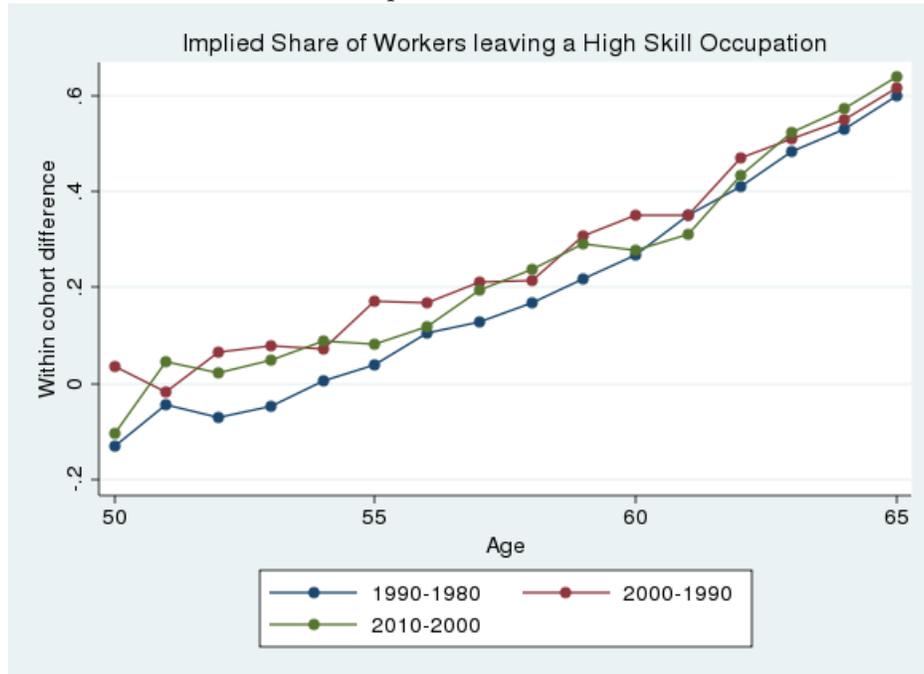
Figure 4: Decomposition Counterfactual Shares



Note: This figure displays the estimated share of workers in high skill occupations along with the counterfactual share of workers in high skill occupations if post WW2 cohorts had entered high skill occupations at increasing rates.

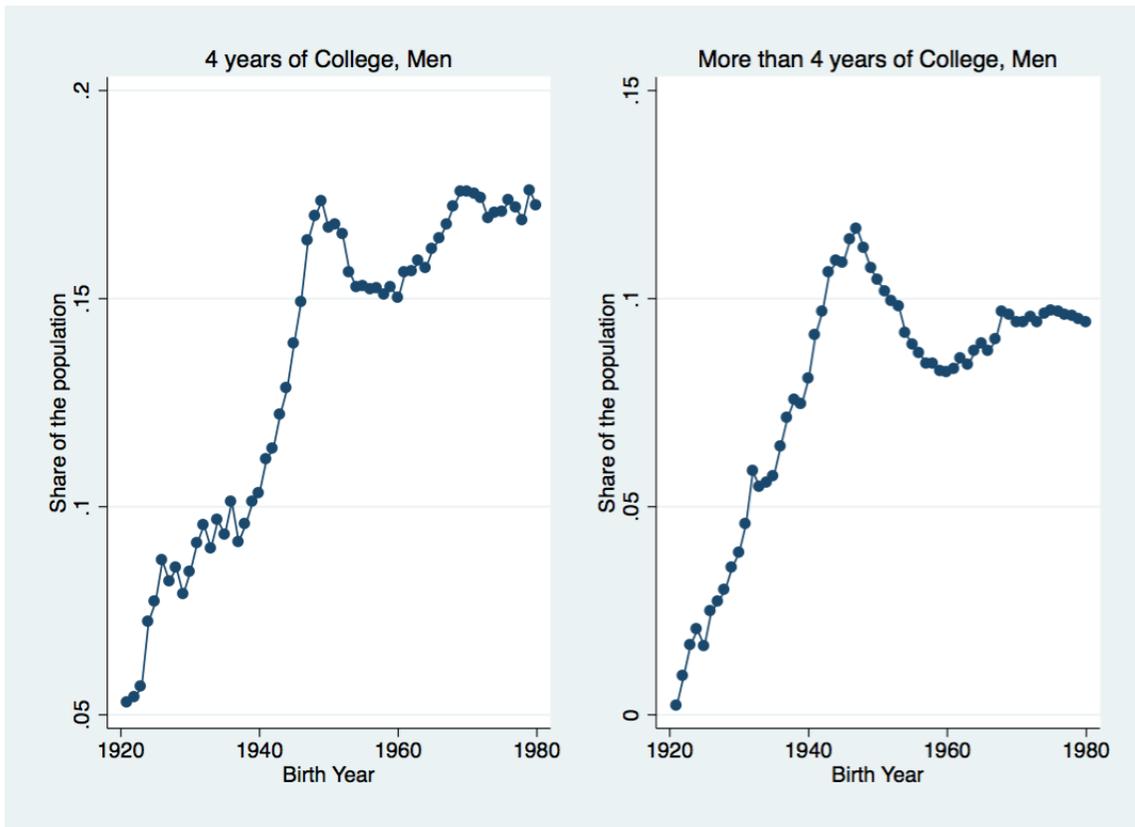
Figure 5: Exit from High Skill Employment

Implied Exit Rates



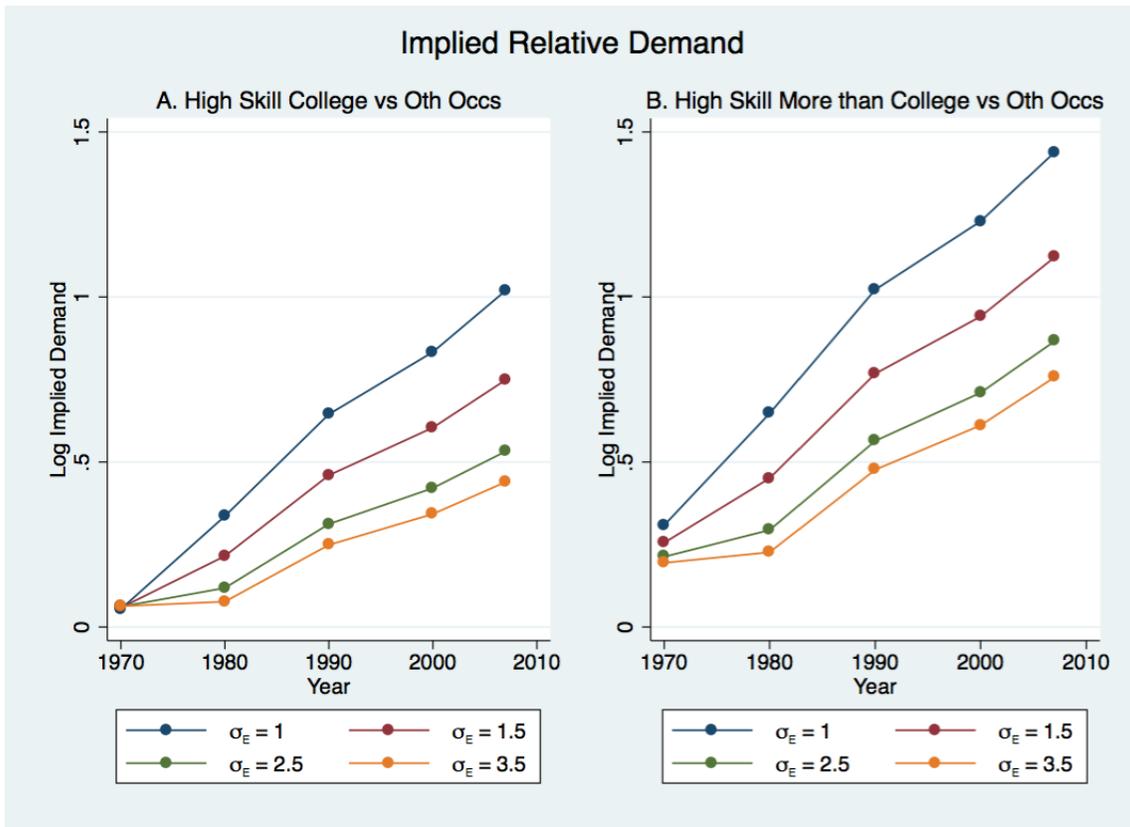
Note: This figure uses Census and ACS data to display the implied exit rates from high skill employment for older workers.

Figure 6: Educational Attainment, Men



Note: This figure presents estimated cohort effects from a regression of the share of the population with a college degree (left panel) and more than 4 years of college (right panel) on age and birth cohort indicator variables. using CPS MORG data from 1973 to 2009.

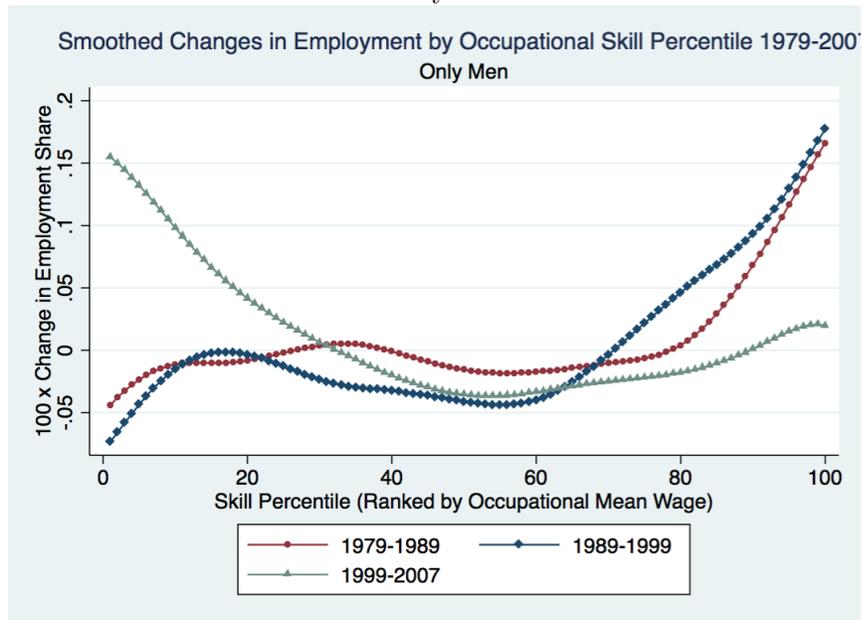
Figure 7: Implied Relative Demand



Note: This figure shows the implied nonparametric relative demand trend for workers in high skill occupations relative to workers in other sets occupations. Panel A focuses on workers with a college degree working in high skill occupations. Panel B focuses on post-college workers working in high skill occupations.

Figure 8: Polarization

Polarization by Decade Men



Note: This figure reproduces Figure 10 in (Acemoglu and Autor, 2010) for men. Using data from the Census and the ACS, it shows that employment growth in high skill occupations has been stagnant during the 2000s.

Table I

Exit Rates from High Skill Occupations: Men

	(1)	(2)	(3)
	All	College or More	High School Graduates
Implied 1980-1990	-0.00622 (0.0115)	0.0568*** (0.0129)	-0.0270* (0.0156)
Implied 1990-2000	0.0121 (0.0115)	0.00656 (0.0129)	0.0423*** (0.0156)
Implied 2000-2010	-0.0448*** (0.0115)	-0.0215 (0.0129)	-0.0681*** (0.0156)
Observations	48	48	48
R-squared	0.268	0.396	0.396

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Using Census data, this table shows average implied exit rates from high skill occupations for men.

Table II

Wage Decompositions by Age and Year into Age, Time, and Cohort Effects

	(1)	(2)	(3)	(4)	(5)
Wage differences	Col-HSC	Grad-HSC	HSK-OthOcc	HSKCol-OthOcc	HSKGrad-OthOcc
Year Effects					
1960	0.180*** (0.0105)	0.0717*** (0.0123)	0.148*** (0.0121)	0.280*** (0.0160)	0.133*** (0.0160)
1970	0.247*** (0.0105)	0.224*** (0.0123)	0.184*** (0.0121)	0.330*** (0.0160)	0.277*** (0.0160)
1980	0.174*** (0.0108)	0.135*** (0.0127)	0.149*** (0.0125)	0.234*** (0.0166)	0.185*** (0.0165)
1990	0.283*** (0.0117)	0.316*** (0.0138)	0.258*** (0.0136)	0.309*** (0.0179)	0.321*** (0.0179)
2000	0.321*** (0.0134)	0.398*** (0.0158)	0.312*** (0.0155)	0.346*** (0.0205)	0.391*** (0.0205)
2007	0.367*** (0.0145)	0.510*** (0.0171)	0.397*** (0.0168)	0.404*** (0.0223)	0.507*** (0.0222)
Cohort Effects					
1944-1948	-0.0589*** (0.0124)	0.000759 (0.0147)	-0.00778 (0.0144)	-0.0722*** (0.0191)	-0.0257 (0.0191)
1949-1953	-0.0393*** (0.0119)	0.0118 (0.0140)	-0.0197 (0.0138)	-0.0474** (0.0182)	-0.0287 (0.0182)
1954-1958	-0.00494 (0.0152)	0.0508*** (0.0180)	-0.0134 (0.0177)	-0.0112 (0.0234)	0.0271 (0.0233)
1959-1963	0.0567*** (0.0144)	0.0775*** (0.0170)	0.00502 (0.0167)	0.0484** (0.0221)	0.0513** (0.0220)
1964-1968	0.0437** (0.0192)	0.0933*** (0.0226)	0.00231 (0.0222)	0.0350 (0.0294)	0.0806** (0.0293)
1969-1973	0.0679*** (0.0179)	0.0804*** (0.0211)	0.0154 (0.0208)	0.0689** (0.0274)	0.0852*** (0.0274)
1974-1978	0.0556** (0.0260)	0.0579* (0.0307)	0.0251 (0.0302)	0.0797* (0.0399)	0.0518 (0.0398)
Observations	54	54	54	54	54

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: All columns display differences in log wages for males. Column 1 reports the difference between those with exactly 4 years of college and those with exactly high school. Column 2 reports the difference between those with more than 4 years of college and those with only high school. Column 3 shows the difference between those working in high

skill occupations and those in other occupations. Columns 4 shows the same difference for those with College and those with more than college.

Table III

Relative Supplies and Elasticity of Substitution Across Age Groups

	(1)	(2)	(3)	(4)	(5)	(6)
	Col/Hsc	ColE/HscE	Gr/Hsc	Hsk/Oth	HskC/Oth	HskG/Oth
1970	0.0831*** (0.0181)	0.0477** (0.0184)	0.132*** (0.0180)	0.00434 (0.0113)	0.0539** (0.0229)	0.124*** (0.0180)
1980	0.0683*** (0.0252)	0.00738 (0.0203)	0.119*** (0.0199)	-0.0297** (0.0128)	-0.0126 (0.0260)	0.0973*** (0.0204)
1990	0.194*** (0.0308)	0.120*** (0.0245)	0.320*** (0.0240)	0.0486*** (0.0151)	0.0579* (0.0307)	0.246*** (0.0241)
2000	0.258*** (0.0339)	0.181*** (0.0287)	0.411*** (0.0281)	0.106*** (0.0179)	0.128*** (0.0365)	0.334*** (0.0287)
2007	0.312*** (0.0359)	0.238*** (0.0332)	0.540*** (0.0325)	0.195*** (0.0184)	0.204*** (0.0376)	0.466*** (0.0295)
log(Col/Hsc)	-0.0953*** (0.0235)					
log(ColEq/HscEq)		-0.0682* (0.0342)				
log(Grad/Hsc)			-0.00778 (0.0335)			
log(Hsk/Oth)				0.0192 (0.0240)		
log(HskC/Oth)					-0.192*** (0.0490)	
log(HscG/Oth)						-0.0733* (0.0384)
Constant	0.0297 (0.0416)	0.114*** (0.0407)	-0.0248 (0.0398)	0.215*** (0.0369)	0.0468 (0.0751)	-0.0175 (0.0589)
Observations	54	54	54	54	54	54

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The first column of the Table compares college graduates with exactly four years of college to high school graduates. Column 2 compares individuals with more than 4 years of college to high school graduates. Column 3 compares college equivalents to high school equivalents²⁰. Column 4 compares individuals in high skill occupations to

²⁰The total number of college equivalents equals all individuals with 4 years of college plus individuals with more than 4 years of college weighted by their wage relative to college graduates plus a share of individuals with some college proportional to their wage relative to college graduates. The total number of high school equivalents is given by all high school graduates plus all high school dropouts weighted by their wage relative to high school graduates, plus a share of

individuals in other occupations. Column 5 compares individuals with 4 years of college degree in high skill occupations to individuals in other occupations. Finally, Column 6 compares individuals with more than 4 years of education to individuals in other occupations.

individuals with some college proportional to their wage relative to high school graduates

Table IV

Relative Supplies and Elasticity of Substitution Across Age Groups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Col-Hsc	Grd-Hsc	Hsk-Nhsk	HskCol-Nhsk	2SLSHskCol-Nhsk	HskGrd-Nhsk	2SLSHskGrd-Nhsk
High School Supply	0.105*** (0.0288)	0.0565*** (0.0145)					
College Supply	-0.0985*** (0.0309)						
Graduate Supply		-0.0596*** (0.0170)					
Non-High Skill Supply			-0.0115 (0.0327)	0.179*** (0.0370)	0.209*** (0.0325)	0.0727*** (0.0129)	0.0734*** (0.0108)
High Skill Supply			0.0231 (0.0358)				
Col High Skill Supply				-0.193*** (0.0448)	-0.231*** (0.0393)		
Grad High Skill Supply						-0.0823*** (0.0166)	-0.0832*** (0.0140)
Observations	48	48	48	48	48	48	48

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Column 1 shows the estimated effects of Log College Supply and Log High School Supply on College and High School Log Wages. These provide estimates of one over the elasticity of substitution across age groups for these two. Column 2 compares individuals with more than 4 years of college to high school graduates. Column 3 Compares High Skill Workers to Non-High Skill Workers. Column 4 compares Graduate High Skill Workers to Non-High Skill Workers. Column 5 shows 2SLS estimates for the model in Column 4. Log Supplies of High Skill College Graduates and Non-High Skill Workers are instrumented with Log Supplies of College Workers and Individuals with less than College. Column 6 compares Post-College High Skill Workers to Non-High Skill Workers. Column 7 shows 2SLS estimates for the model in Column 6. Log Supplies of High Skill Post-College Graduates and Non-High Skill Workers are instrumented with Log Supplies of Post-College Workers and Individuals with less than College.

Table V

Implied Demand Trend	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Col-Hsc	Grd-Hsc	Hsk-Nhsk	HskCol-Nhsk	HskCol-Nhsk	HskGrd-Nhsk	HskGrd-Nhsk
Linear Trend	0.0112*** (0.00200)	0.0223*** (0.00146)	0.0135*** (0.00173)	0.0136*** (0.00198)	0.0152*** (0.00179)	0.0144*** (0.00156)	0.0150*** (0.00136)
Agg Rel Supply	-0.378*** (0.104)	-0.611*** (0.0681)	-0.642*** (0.128)	-0.463*** (0.0814)	-0.524*** (0.0738)	-0.243*** (0.0540)	-0.266*** (0.0471)
Rel Supply High Sch	0.00203 (0.0524)	0.0444 (0.0404)					
Rel Supply College	-0.0877* (0.0491)						
Rel Supply Grad		-0.0570** (0.0252)					
Rel Supply Non-High Skill			-0.0544 (0.0569)	0.135** (0.0640)	0.184*** (0.0584)	0.0458 (0.0613)	0.0421 (0.0534)
Rel Supply High Skill			-0.00414 (0.0603)				
Rel Supply High Skill Col				-0.202*** (0.0594)	-0.277*** (0.0555)		
Rel Supply High Skill Grad						-0.0862** (0.0352)	-0.0948*** (0.0306)
Observations	48	48	48	48	48	48	48

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: See Notes to Table IV for Column Information. The Linear Trend is a measure of Relative Demand. In Column 1 Agg Rel Supply equals the log total number of College Graduates minus the log total number of high school graduates. Rel Supply College equals the log College Graduates in age group α minus the total number of College Graduates. Other variables are defined analogously.

Appendices

Data Construction

Employment

I compute data on both the number and proportion of individuals employed and hours worked by these individuals. To achieve the latter I weight each individual observation by the number of hours that individual works each week times the number of weeks worked by the individual.

Wages

Wages are constructed as wage and salary income divided by usual hours of work times number of weeks worked. Usual hours of work is not available for the years 1960 and 1970. Instead hours worked last week is reported in intervals 1-14, 15-29, 30-34, 35-39, 40, 41-48, 49-59, 60+. Since both hours worked last week and usual hours worked are available for 1980 and 1990, I take the median number of usual hours worked for individuals belonging to each interval for both 1980 and 1990. I take the average of these two and input it as usual hours worked for individuals in 1960 and 1970 in each corresponding interval. The results for average number of hours worked for 1960 and 1970 are very similar to those for 1980, 1990, 2000 and 2007. The number of weeks worked is imputed analogously.

Occupations

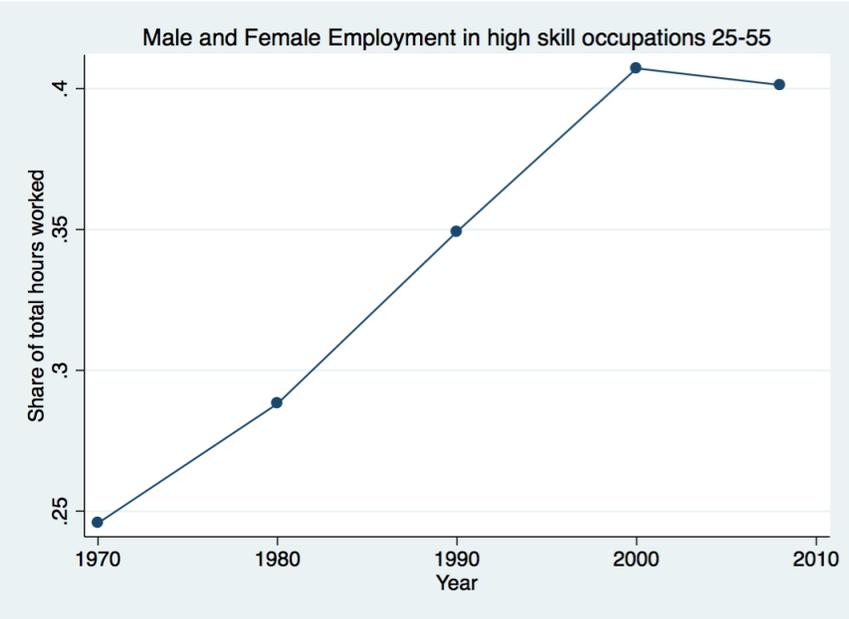
The definition of occupations employed in the paper is based on the 1990 Census Bureau classification of occupations. A detailed discussion of this classification is provided in Meyer and Osborne (2005). High Skill Occupations are composed by Managerial, Professional and Technical Occupations. Examples of these occupations are Managers, Scientists, and Laboratory Technicians, respectively.

Medium Skill Occupations include (i) Sales and Administrative Support Occupations such as Clerks and Sales Representatives, (ii) Precision Production, Craft and Repair Occupations, such as Mechanics and Repairers and (iii) Operators, Fabricators and Laborers.

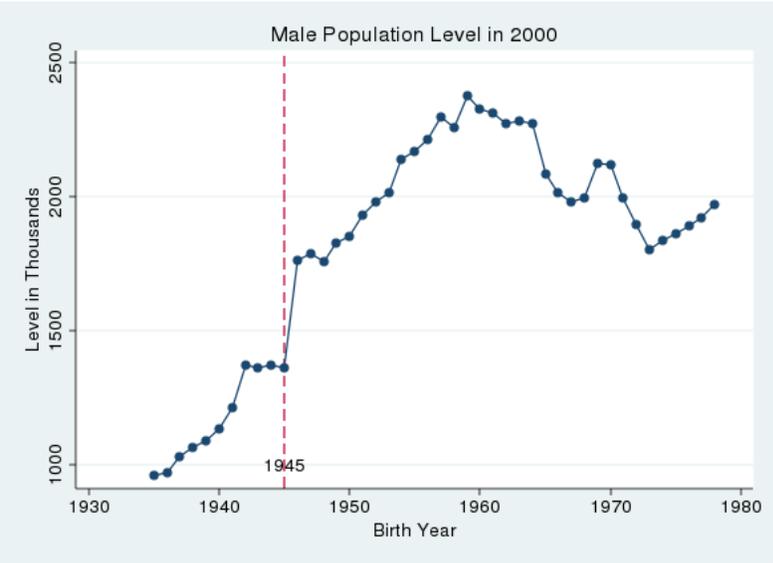
Low skill Occupations include Service Occupations. These include Private Household Occupations, Food Preparation, Cleaning, etc.

High Skill Occupations typically require a higher degree of instruction and are thought to complement recent technological advances in computing power (Autor and Murnane, 2003). Medium Skill Occupations are assumed to be increasingly replaced by technological advances and/or offshored. Low Skill Occupations are typically assumed not to complement nor substitute technological progress and are less susceptible to be offshored.

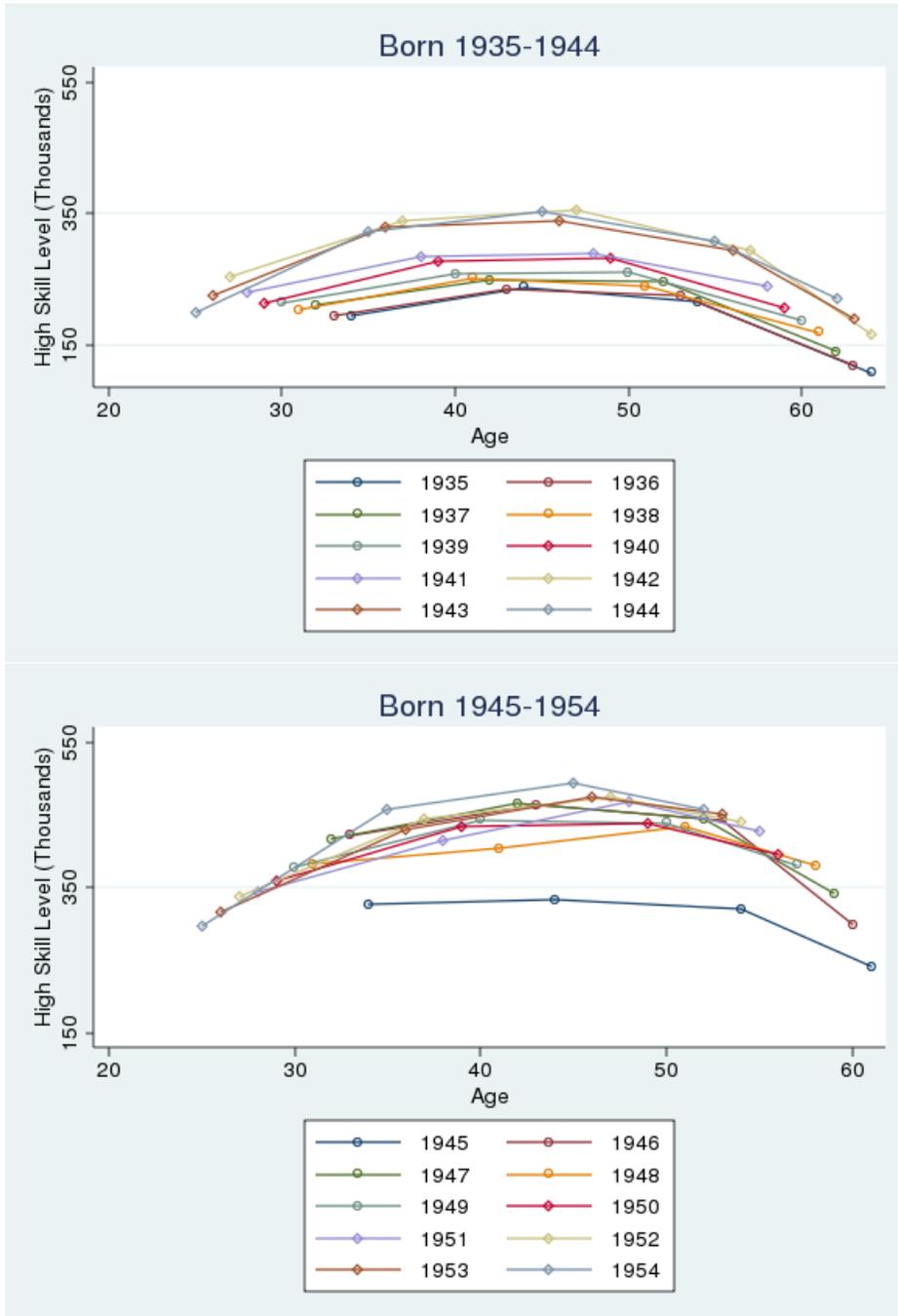
Appendix Figure 1: Employment in High Skill Occupations, Men and Women

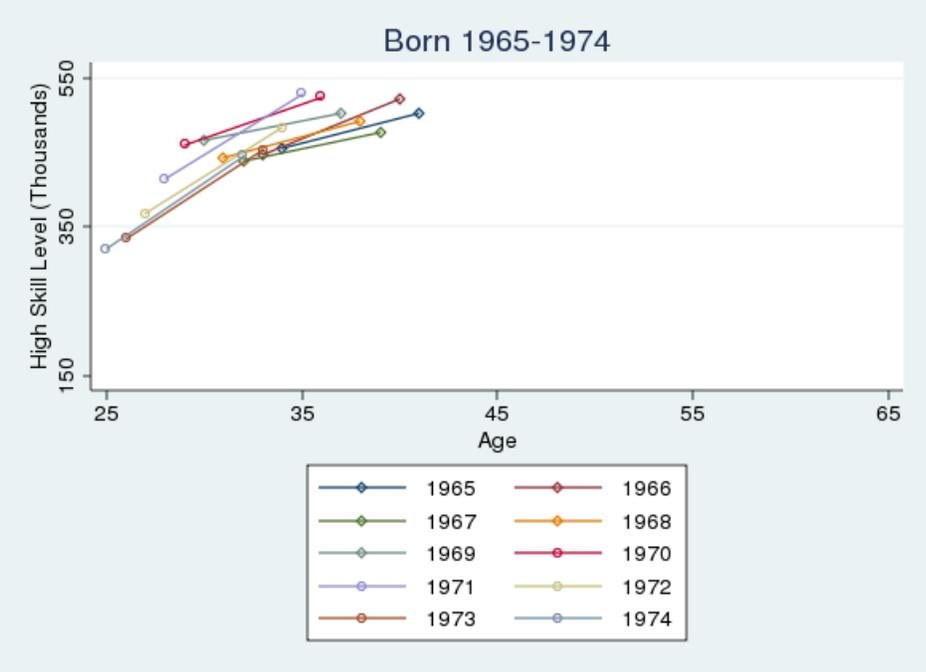
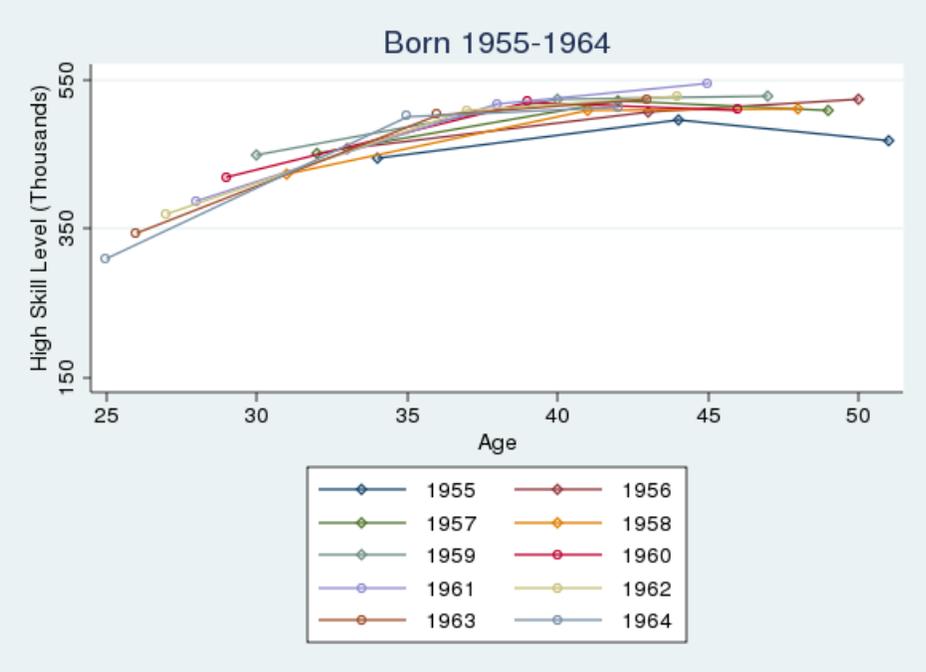


Appendix Figure 2: Cohort Size

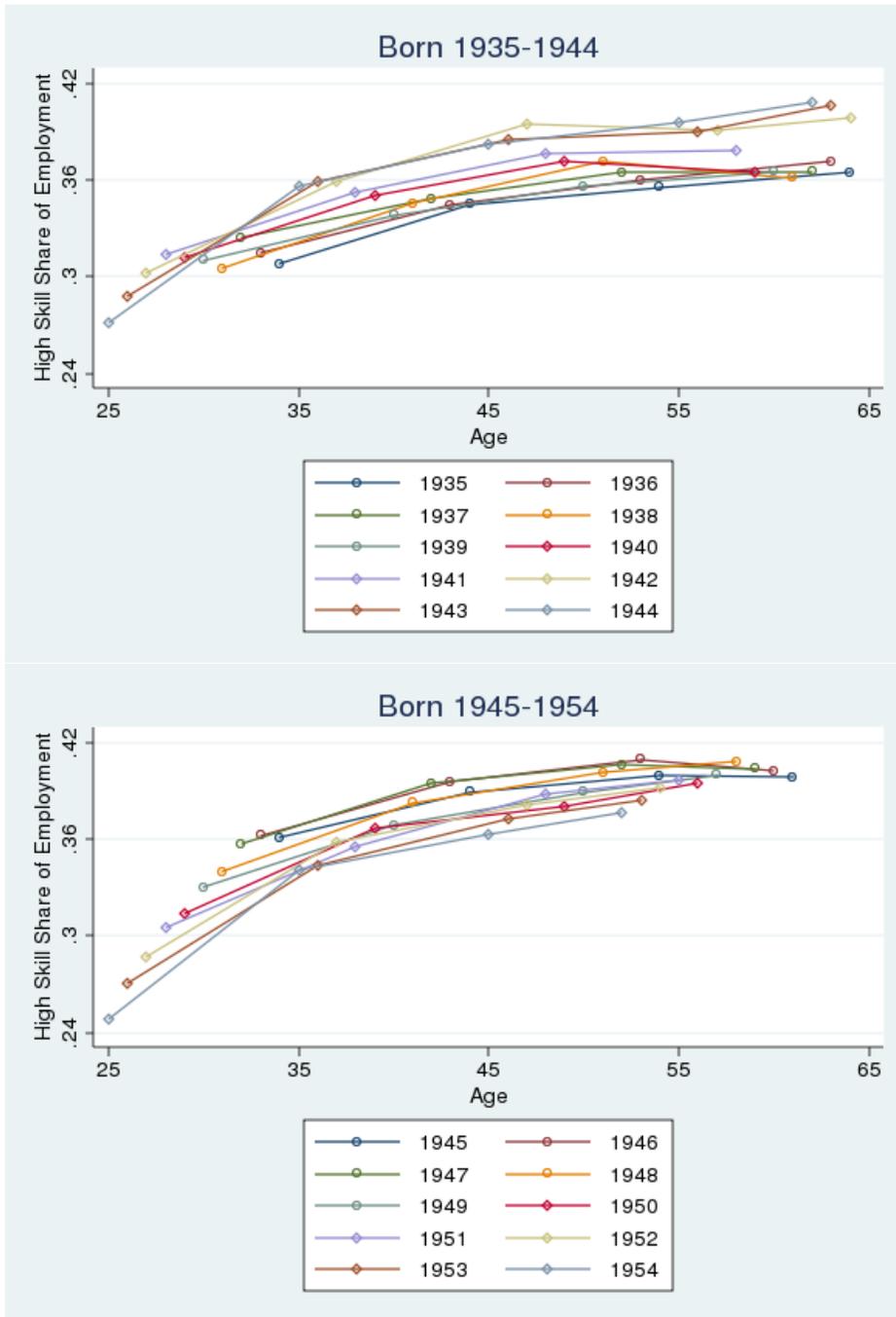


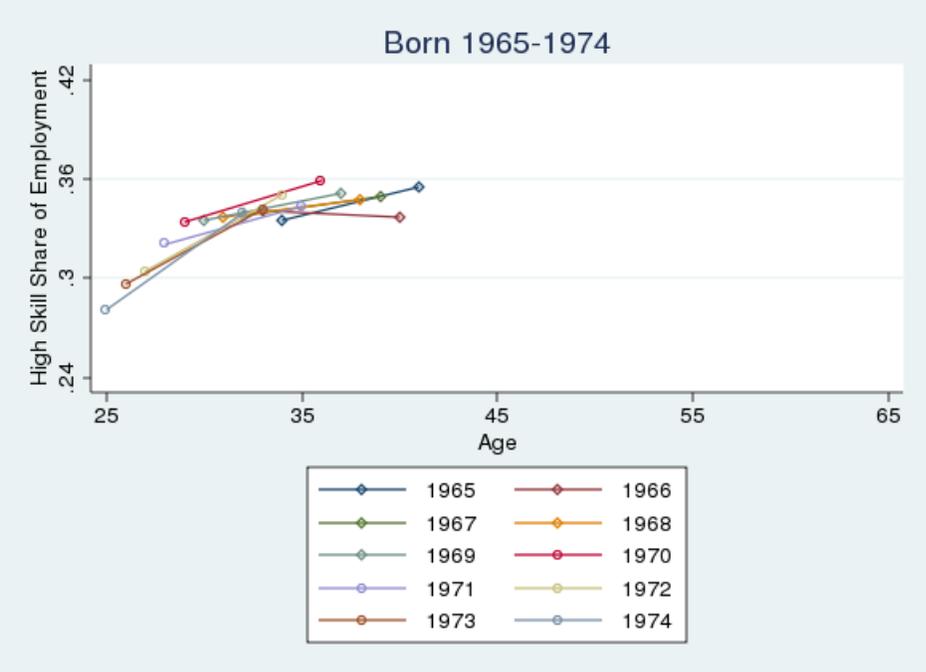
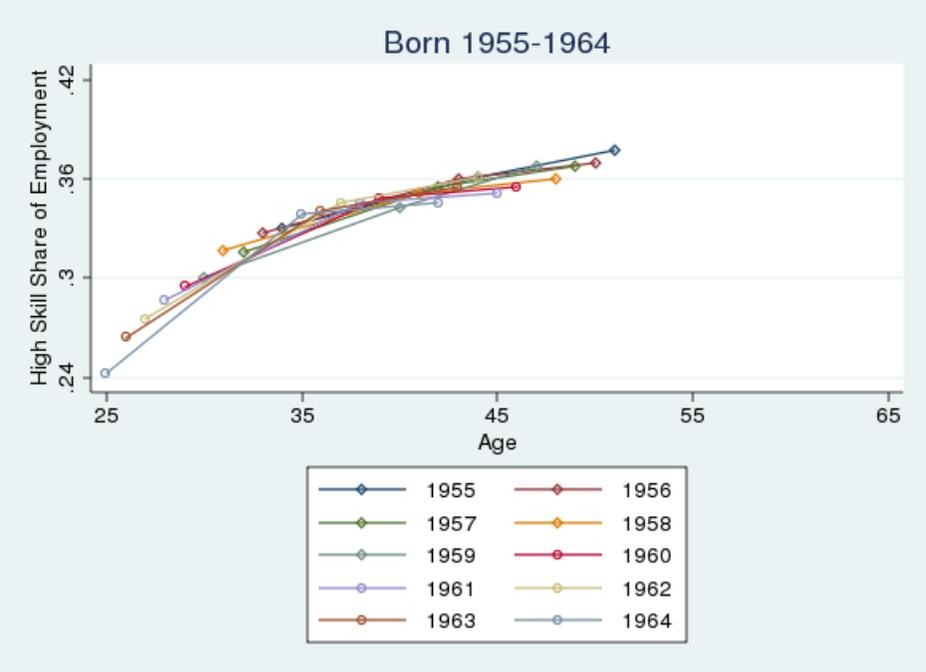
Appendix Figure 3: Cohort Profiles
Levels





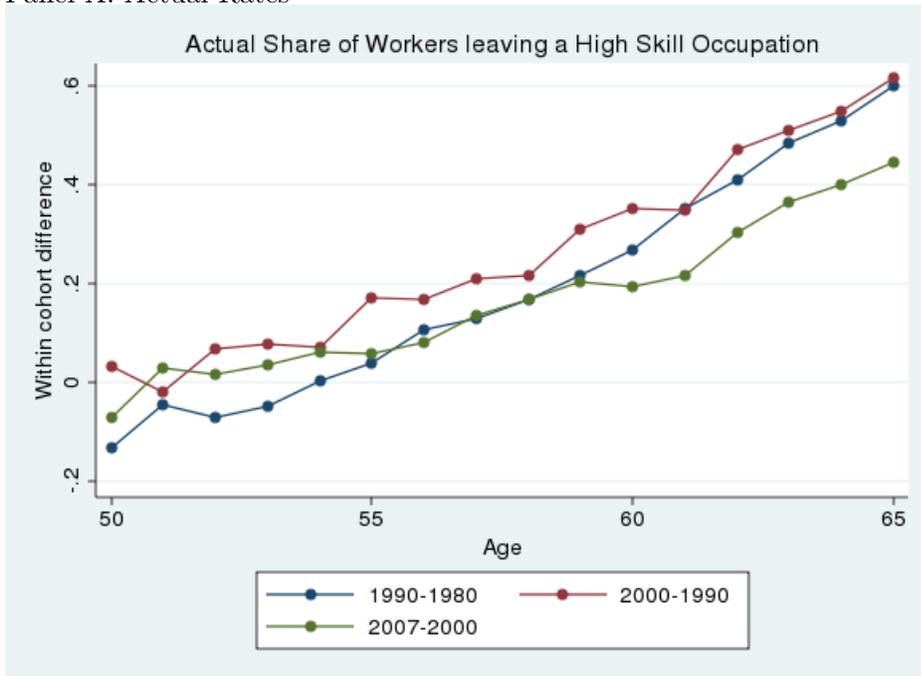
Shares



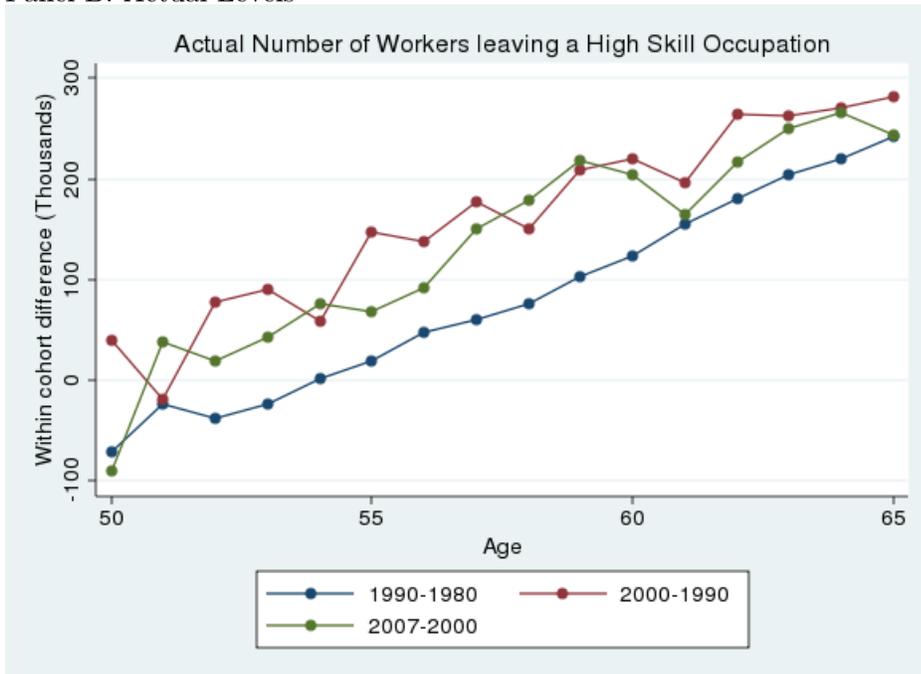


Appendix Figure 4: Exit from High Skill Occupations

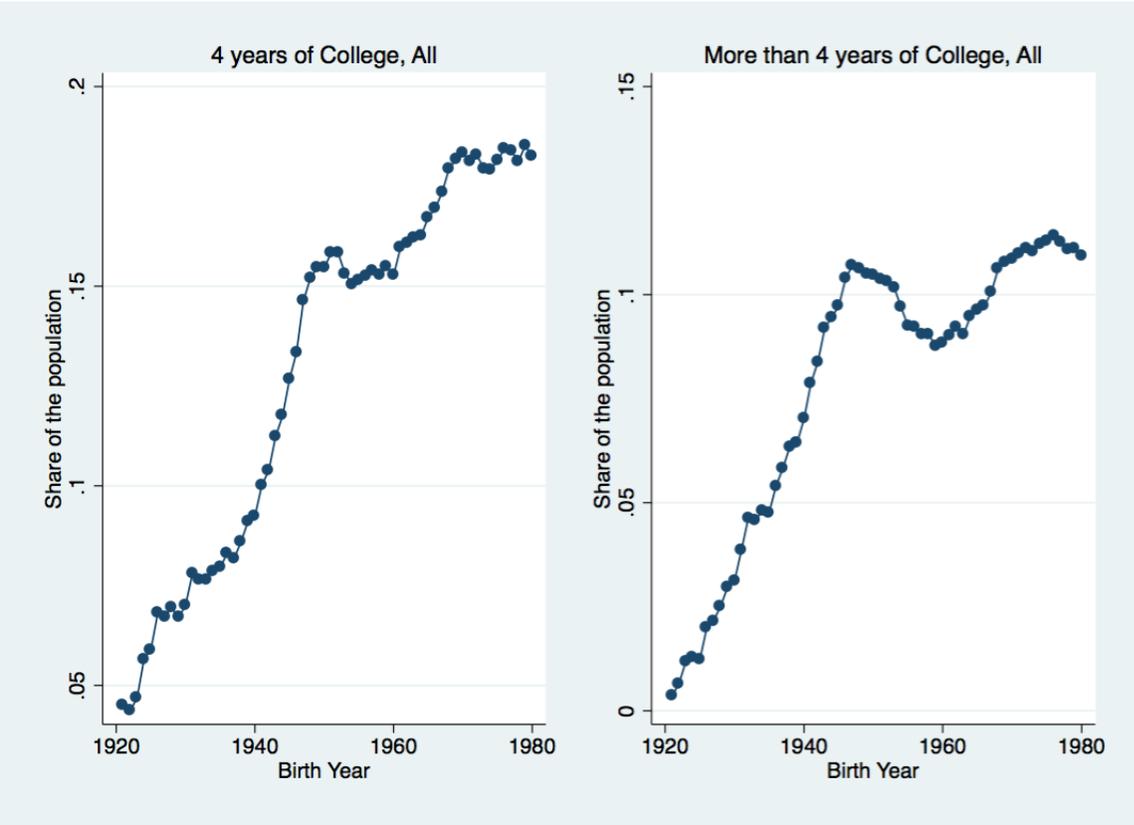
Panel A: Actual Rates



Panel B: Actual Levels



Appendix Figure 5: Educational Attainment, Men and Women



Appendix Figure 6: Within Industry Cohort Effects



Notes: This figure displays the cohort effects estimated when I exploit within-industry variation across different cohorts in the share entering high skill occupations.

Appendix Table I: Relative Supplies and Elasticity of Substitution Across Age Groups Men and Women

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Col-Hsc	Grd-Hsc	Hsk-Nhsk	HskCol-Nhsk	HskCol-Nhsk	HskGrd-Nhsk	HskGrd-Nhsk
High School Supply	-0.0235 (0.0266)	-0.00801 (0.0203)					
College Supply	-0.0876*** (0.0238)						
Graduate Supply		-0.0410*** (0.0149)					
Non High Skill Supply			-0.0624 (0.0428)	0.113 (0.0695)	0.140** (0.0592)	-0.0117 (0.0267)	-0.0117 (0.0221)
High Skill Supply			-0.0519 (0.0366)				
Col High Skill Supply				-0.207*** (0.0550)	-0.231*** (0.0472)		
IGrad High Skill Supply						-0.0986*** (0.0174)	-0.0984*** (0.0144)
Observations	48	48	48	48	48	48	48

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Appendix Table II: Implied Demand Trend Men and Women

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Col-Hsc	Grd-Hsc	Hsk-Nhsk	HskCol-Nhsk	HskCol-Nhsk	HskGrd-Nhsk	HskGrd-Nhsk
Linear trend	0.00771*** (0.00129)	0.0179*** (0.00204)	0.0148*** (0.00222)	0.00768*** (0.00274)	0.00997*** (0.00253)	0.00682*** (0.00200)	0.00737*** (0.00175)
Agg Rel Supply	-0.201*** (0.0547)	-0.370*** (0.0716)	-0.602*** (0.120)	-0.227** (0.101)	-0.310*** (0.0932)	-0.0486 (0.0580)	-0.0647 (0.0505)
Rel Supply High Sch	-0.0286 (0.0295)	0.00207 (0.0312)					
Rel Supply College	-0.0866*** (0.0254)						
Rel Supply Grad		-0.0483** (0.0230)					
Rel Supply Non-High Skill			-0.0626 (0.0563)	0.0967 (0.0905)	0.208** (0.0870)	0.00591 (0.0535)	0.00685 (0.0465)
Rel Supply High Skill			-0.0476 (0.0482)				
Rel Supply High Skill Col				-0.180** (0.0712)	-0.283*** (0.0698)		
Rel Supply High Skill Grad						-0.0891** (0.0351)	-0.0990*** (0.0305)
Observations	48	48	48	48	48	48	48

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Notes: See Notes to Table IV for Column Information. The Linear Trend is a measure of Relative Demand. In Column 1 Agg Rel Supply equals the log total number of College Graduates minus the log total number of high school graduates. Rel Supply College equals the log College Graduates in age group α minus the total number of College Graduates. Other variables are defined analogously.