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Winning the race against technology

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Abstract

This study examines the importance of the supply factor as a determinant of the college wage premium by comparing the trends of the college wage premium between Japan and the US. The wage differential between college and high-school graduates decreased from 0.35 to 0.34 log points in Japan between 1986 and 2008, while during the same period, it increased from 0.43 to 0.65 log points in the US. This paper demonstrates that the more rapid increase in the number of college graduates in Japan than in the US explains about one-third of these contrasting trends. A simulation indicates that if the supply in the US had followed that in Japan, the return to college would have increased by 0.15 point instead of the actual 0.23 point. The difference in post-war fertility trends largely explains the difference in the supply increase of college graduates between the two countries.

JEL Classification: J23; J31

Keywords: Wage inequality; college wage premium; cohort crowding out; skill-biased technological change

1 Introduction

This study examines the importance of the supply factor as a determinant of the college wage premium by comparing the premiums of Japan and the US. The wage gap between high-school graduates and college graduates changed differently between Japan and the US over the last few decades. The college premium decreased from 0.35 to 0.34 log points in Japan between 1986 and 2008, while during the same period, it increased from 0.43 to 0.65 log points in the US. This paper demonstrates that the supply increase of college-educated workers in Japan, which outpaced that in the US, explains about one-third of the contrasting trends. If the supply growth in the US had been that of Japan, the return to college should have increased by only 0.15 point instead of the actual 0.23 point. We argue that a fertility decline in the 1950s and 1970s in Japan contributes to the more rapid expansion of university education. Lower university tuition and the higher academic achievement of Japanese high-school students additionally explains the difference.

The secular increase of wage inequality in the US attracts much attention from academics, and numerous studies demonstrate that the increase in the return to education is one of the leading proximate causes of rising overall wage inequality. Influential studies point out that both skill-biased technological change (SBTC) and the outsourcing of production processes increase the demand for college graduates relative to high-school graduates as the explanation for the increase of college wage premium.[1] In contrast, Card and Lemieux (2001) downplay the role of the demand growth and emphasize the importance of supply stagnation; the stagnated growth of college graduates in the US, the UK, and Canada increased the return to college education among youth according to them. Fortin (2006) further shows that a faster growth of college graduates in a state suppresses the growth of the college wage premium, exploiting the interstate variation in the growth of college graduates. These two

[1] See Katz and Murphy (1992), Murphy and Welch (1992), Bound and Johnson (1992), Autor et al. (1998), Autor et al. (2008), and Goos and Manning (2007) for support of the SBTC hypothesis. Card and DiNardo (2002) offer a counterargument to the SBTC hypothesis. Katz and Autor (1999) place less emphasis on the effect of international trade as an explanation for wage dispersion. Feenstra and Hanson (2008) dispute this claim by pointing out the importance of trade in intermediate inputs.

studies convincingly demonstrate the importance of supply as a determinant of the college wage premium; their evidence, however, is not yet definitive. For example, all three Anglo-Saxon countries experienced a stagnation of the supply of college graduates in the early 1980s, and this timing overlapped with the timing of skill-biased technological progress that particularly affected younger workers. The overlap of the timings for supply slowdown and demand growth overestimates the role of supply. In contrast, the interstate mobility of college-educated workers underestimates the impact of supply that would be observed in a national economy because of the inter-state mobility of college graduates. Therefore, comparing the wage premiums in two large independent economies with different trends of the supply of college graduates is indispensable to quantify the impact of the supply factor on the college wage premium. Identifying the importance of the supply of college graduates on the college wage premium is important for its implications on higher-education policy; enhancing accessibility to higher education could suppress wage inequality, in addition to promoting productivity growth.

Selecting Japan as a comparison country is attractive for two reasons. First, in contrast to the US, the UK, or Canada, the supply of college graduates among youth has increased secularly in the last two decades. Second, the demand-supply framework well describes wage determination in Japan, because the wages of Japanese workers are determined in decentralized employer-employee bargaining in the absence of a centralized bargaining institution and industrial/craft unions (Koeniger et al. (2007)). Indeed, the results of a subsequent data analysis indicate that the exogenous increase of the college-graduate supply decreases the equilibrium of the college wage premium (See the appendix for a detailed discussion on the institution of wage determination in Japan). The market-based wage determination makes Japan as a nice comparison group to assess the importance of the supply factor in a simple demand-supply framework. Wages are determined through central wage bargaining in many large continental European countries, and thus these countries would not be useful in assessing the simple demand-supply framework (Boeri and van Ours (2013)).

Rigorous empirical studies find a stable wage distribution in Japan has existed for the last three decades.[2] This sharply contrasts with the experience of the US, which is characterized by increased wage dispersion throughout the 1980s and 1990s, as reported by Autor et al. (2008). A leading proximate cause for the difference in the trends in wage inequality across the two countries is their respective different trends in the return to education. In contrast to the increase in the return to education in the US, Noro and Ohtake (2006), Kambayashi et al. (2008) and Yamada and Kawaguchi (2012) point out a stable or declining return to education in the 1990s and the 2000s in Japan. No paper to date, however, structurally explains the different evolutions of the return to education between Japan and the US over the last two decades. This paper demonstrates that the difference in the supply increase of college-educated workers explains one-third of the different evolutions of the return to education between Japan and the US based on a demand-supply framework employed by Card and Lemieux (2001).

An analysis of the Labor Force Survey 1986-2008, which covers both regular and non-regular workers, reveals that Japan's wage inequality was unchanged during the period, except for wage compression at the lower bottom in the late 1980s. We observe a rapid increase in college graduates, whose supply index grows twice as fast as the US index. The more rapid growth of college graduates in Japan than in the US is largely attributable to the difference in fertility trends across two countries. The relative supply of college graduates grew fast among cohorts born in the early 1950s and the 1970s, primarily because their cohort sizes were smaller and suffered less from the cohort crowding out. This makes a sharp contrast to the US, where the post-war baby boom lasting until the 1960s crowded youth out of college education (Bound and Turner (2007)). The exogenous supply trends of college graduates in Japan and the US enable us to identify the demand parameters assuming a constant elasticity of substitution (CES) of production technologies developed by Card and Lemieux (2001). A simulation based on the estimated parameters suggests that the return

[2] Katz and Revenga (1989), Genda (1998), Shinozaki (2002), Ohtake (2005), Noro and Ohtake (2006) and Kambayashi et al. (2008). Lise et al. (2013) reports the increased wage inequality among men in the 2000s.

to college education in the US would have increased only by 0.15 log points, instead of the actual increase of 0.23 log points, if the supply growth had been as rapid as in Japan between 1986 and 2008. The simulated 0.08 point depression of the college premium corresponds to about one-third of the actual divergence of the college premium across two countries, which is 0.24 points. We conclude that the different supply trends explain one-third of the different evolution of the college wage premium. The other two-third is arguably explained by the difference in the speed of skill-biased technological progress.

2 Trends in returns to education: Japan vs. the US

2.1 Data

Previous studies on the Japanese wage distribution are based mostly on the Basic Survey on Wage Structure (BSWS), which collects individual workers' information from payroll records via a random sampling of establishments. The BSWS is an annual establishment survey conducted by the Ministry of Health, Labour and Welfare. All types of workers who are directly employed by establishments are included in the sample, but the educational backgrounds of part-time workers are not recorded. Kambayashi et al. (2008) is an example of a study that is based on the BSWS. Researchers typically exclude part-time workers who work fewer hours than regular workers from the analysis sample, because their educational backgrounds are not available. Critics have pointed out that wage inequality does not show up in these studies, because inequality has increased through the increase of non-standard workers (part-time workers, contingent workers, and workers other than permanent and full-time workers), who comprised more than 1/3 of the labor force as of 2011, according to the Labor Force Survey.

To overcome the limited coverage of the BSWS, this study uses the Labor Force Survey Special Survey (LFS-SS) in addition to BSWS. The LFS is conducted every month on household members aged 15 or older in approximately 40,000 households dwelling in sampled units that cover the complete population.[3] The monthly LFS does not record earnings, but the LFS-SS, which is a supplementary survey to the LFS conducted in February targeting around 40,000 households until 2001, records earnings.[4] Since 2002, the special survey has been integrated into the monthly LFS. The monthly LFS adopts a rotating sampling structure that surveys the same household for two consecutive months, and after a 10-month break, it again surveys the same households for two months. In this 2-10-2 rotating sampling structure, the special survey is conducted in the second month of the second year. Therefore, about 10,000 households answer the special survey form in every month. For this study, we use data between 1986 and 2008. Reflecting a change of sampling design of the LFS, the annual sample size is about 90,000 individuals from 40,000 households between 1986 and 2001 and 240,000 individuals from 120,000 households between 2002 and 2008.

The special survey collects information on household members and each member's age, educational attainment, and labor-force status during the last week of each survey month. The survey records the highest educational attainment in the following four categories: 1: junior-high school, 2: high school, 3: junior college and technical-college, and 4: four-year college and graduate school. The survey also records hours worked in the last week of the survey month and annual labor earnings from all jobs, in ranges.[5] For average annual earnings of each range, we match the average annual earnings for each range calculated from continuous annual earnings, based on the BSWS.[6] Hourly rate of pay is annual earnings divided by hours worked in the last week of the previous month multiplied by 50. The hourly wage is deflated to the 2005 price using the Consumer Price Index. We consider these to be the best available data to describe the secular change of the Japanese wage

[3]Foreign diplomats, and foreign military personnel and their dependents are excluded.

[4]Between 1998 and 2001, the special survey was also conducted in August, but we do not use the sample for this analysis.

[5]The annual income ranges denominated by thousand yen are: 500 or less, 500-990, 1,000-1,490, 1,500-1,990, 2,000-2,990, 3,000-3,990, 4,000-4,990, 5,000-6,990, 7,000-9,900, 10,000-14,900, and 15,000 or above for year 2002.

[6]The BSWS is an annual establishment survey that includes payroll records of more than one million workers. It records monthly earnings in June and bonus payments in the previous year. Annual earnings is monthly earnings in June multiplied by 12, plus the annual bonus payment in the previous year.

distribution and returns to education, considering that the sample coverage is wider than that of the BSWS.

For both LFS and BSWS, the analysis samples are restricted to those ages 25-59; 24 and below are excluded to avoid those who enroll in school, and 60 and above are excluded to avoid those who face mandatory retirement.[7] Self-employed workers are excluded from the wage sample because their income is difficult to measure, but they are included in the supply index. The sample is further restricted to observations with a valid age, educational background, and employment status.

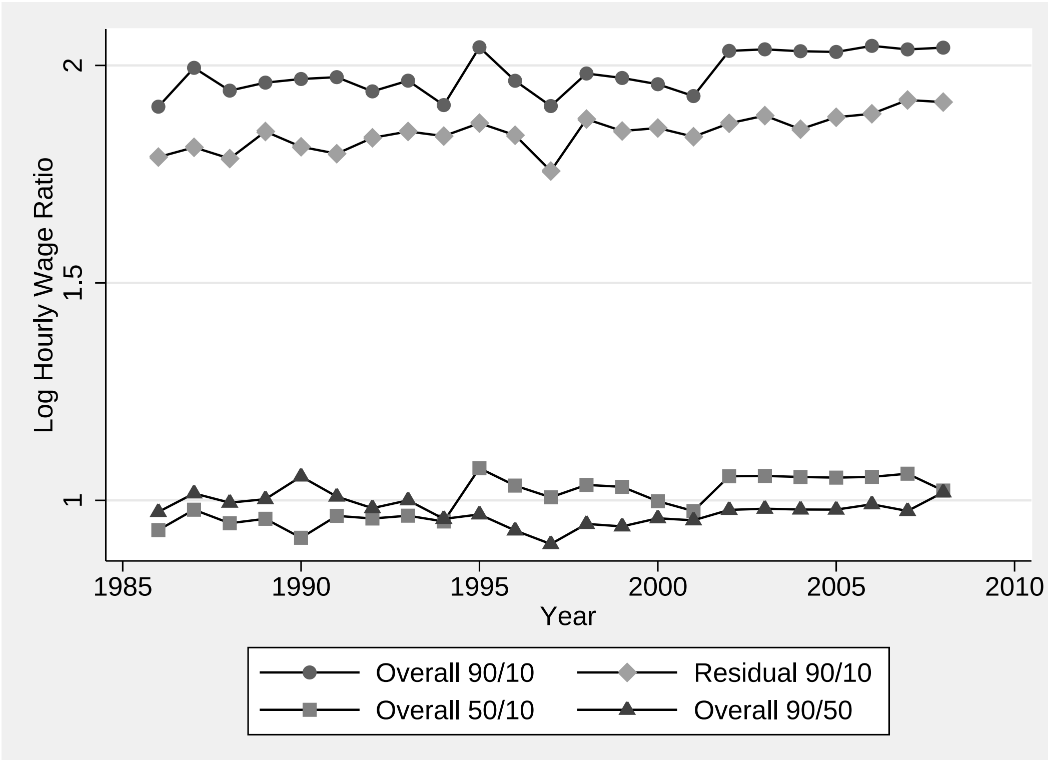
To compare returns to education between Japan and the US, we draw on the Current Population Survey March (CPS-March), 1975-2006. The analysis sample is restricted to ages 25-59. Self-employed workers are excluded from the wage sample but included in the quantity sample. Hourly wage reflects either the reported hourly wage or the one calculated by dividing weekly wage by actual hours worked in the previous week. All nominal wages are deflated to the 2000 price using the personal consumption expenditure deflater.

2.2 Trends in the wage distribution in Japan

Figure 1 displays the evolutions of the 90/10, 90/50, and 50/10 log hourly wage gaps of Japanese male workers. The 90/10 gap stayed around 2.0 between 1986 and 2008. The residual 90/10 log wage gap, adjusted for educational attainment and age, moved in tandem with the unadjusted series. The overall 90/50 and the overall 50/10 were both flat throughout the sample period. The stable wage inequality after the 1990s is corroborated by the wages of permanent regular workers from the establishment-based payroll record of the BSWS as shown in Figure 2. It is worth mentioning that the wage inequality measures based on LFS are larger that those based on BSWS because of measurement errors in hourly wage in LFS. With this caveat in mind, the consistent trends from the two independent surveys

[7] According to the 2008 General Survey on Working Conditions, 94.4 percent of firms set a mandatory retirement age and 85.2 percent of them set it at age 60. In 1986, 52.5 percent of firms set it at 60 and 43.3 percent set it at 59 or below (Clark and Ogawa (1992)). The mandatory retirement age typically does not depend on educational attainment.

Figure 1: Changes of the Wage Distribution, Japan, LFS, All Employed Workers, Male 25-59, 1986-2008.



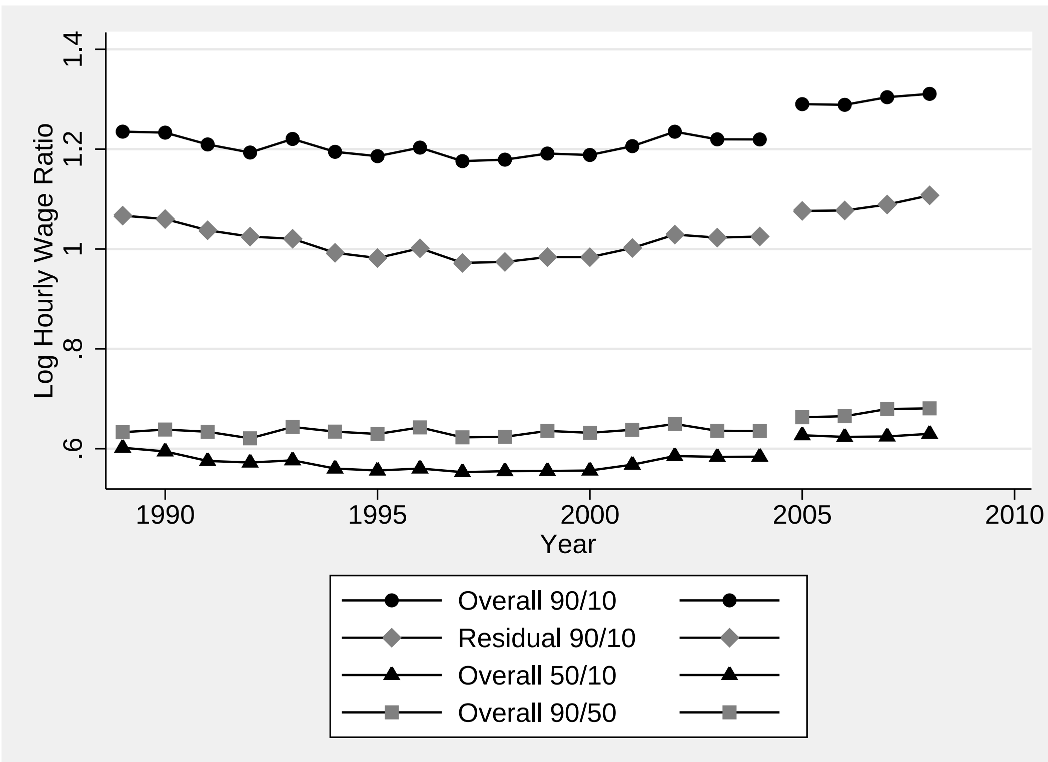
Note: Hourly wage is calculated using annual earnings and annual hours worked in the special survey of the Labor Force Survey. See the appendix for details regarding the construction of the data. Residual wage is calculated from the regression of log wage on education dummy variables, quartic functions of age, whose functional forms are allowed to differ by educational background.

demonstrate that the unchanged wage inequality is not a mere artifact of calculating hourly wage from annual earnings reported in ranges, nor by the limited sample coverage of the BSWS.

The wage inequality measures displayed in Figure 3 show that wage inequality in the US has consistently increased, as pointed out in numerous studies. Focusing on the period after 1986, the period-for which comparable data are available for Japan, the trend of the 90/50 gap makes a sharp contrast to the trend in Japan; the 90/50 wage gap increased from 0.55 to 0.75 between 1986 and 2005 in the US, while it stayed constant around 1.00 in Japan based on LFS and around 0.6 based on BSWS.

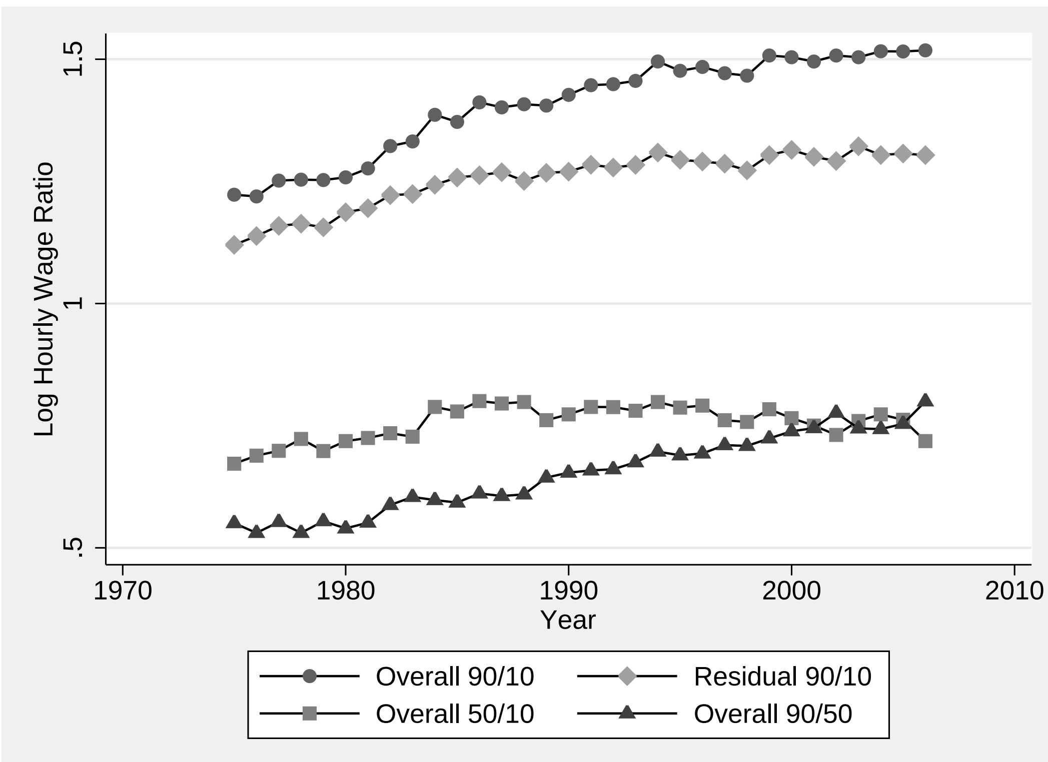
Numerous reasons have been pointed out as causes for rising wage inequality in the

Figure 2: Changes of the Wage Distribution, Japan, BSWS, Full-time Workers, Male 25-59, 1986-2008.



Note: Hourly wage is calculated using monthly wage, annual bonus in the previous year, and monthly hours worked in the Basic Survey of Wage Structure. The suvey design significantly changes in 2005 and numbers are discontinuous at this year. See the appendix for details regarding the construction of the data. Residual wage is calculated from the regression of log wage on education dummy variables, quartic functions of age, whose functional forms are allowed to differ by educational background.

Figure 3: Changes of the Wage Distribution, U.S., All Employed Workers, Male 25-59, 1975-2006.



Note: Hourly wage reflects either the reported hourly wage or the one calculated by dividing weekly wage by actual hours worked in the previous week in Current Population Survey. See the appendix for details regarding the construction of the data. Residual wage is calculated from the regression of log wage on education dummy variables, quartic functions of age, whose functional forms are allowed to differ by educational background.

Table 1: College wage premium as a determinant of wage inequality, Male 25-59, 1986-2008

	(1)	(2)	(3)
Inequality measure	Log(90/10)	Log(90/50)	Log(50/10)
College wage premium in log	0.458	0.808	-0.350
	(0.113)	(0.058)	(0.104)
The US	-0.622	-0.483	-0.139
	(0.031)	(0.016)	(0.028)
Constant	1.843	0.742	1.101
	(0.034)	(0.017)	(0.031)
Observations	42	42	42
R-squared	0.981	0.985	0.925

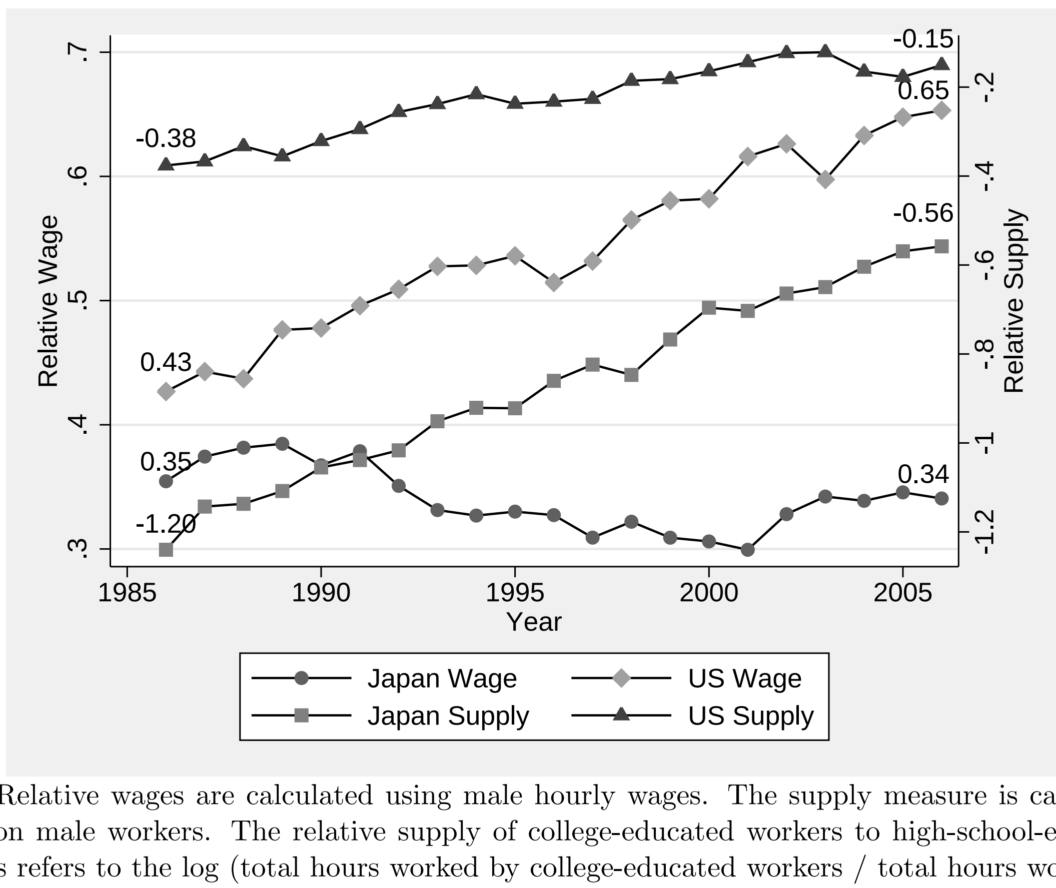
Note. Standard errors are in parentheses. Models are fit by weighted least squares. Weights are inverse standard errors of estimated wage gaps. Age and year fixed effects are included as independent variables.

US, but rising returns to education are pointed out as one of the leading proximate causes (Autor et al. (2008)). To understand the importance of the college wage premium as a determinant of overall wage inequality, we regress the 90/10, 90/50 and 50/10 wage gaps in both countries on the college wage premium and the US dummy variable. Table 1 tabulates the regression results. The estimated coefficients for the college wage premium measured in log are 0.458 for log(90/10) and 0.808 for log(90/50) gaps, implying that the evolution of the college wage premium in the two countries are closely related to the evolution of upper-tail wage inequality. In contrast, the college wage premium is negatively correlated with log(50/10). At the first glance, this result may be surprising but understandable, because the relative fall of wages of high school gradautes compresses the wage gap of high school graduates, who presumably comprise of the median earner, and high school drop outs, who presumably comprises of the 10th percentile earner. The wage compressions in the lower end of wage distributions are reported in both countries (Autor et al. (2008) and Kambayashi et al. (2013)). The result shows that understanding the different evolutions of the return to college education is crucial for understanding the different evolutions of the wage inequality, particualrly that of the upper tail, across two countries.

2.3 Evolution of returns to education: Japan vs. the US

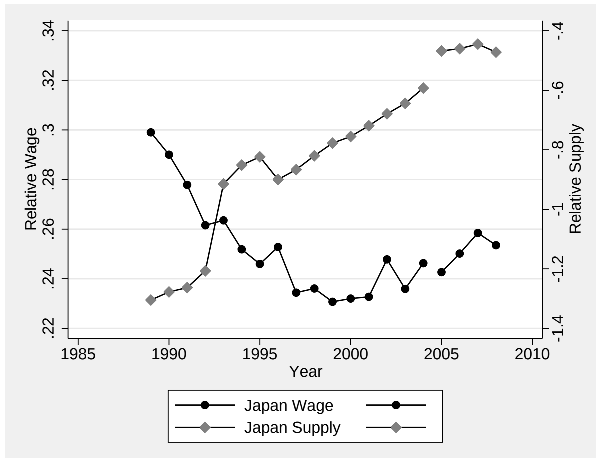
Autor et al. (1998) argue that skill-biased technological progress embodied in computerization increased the demand for educated workers, while Feenstra and Hanson (2008) argue that the increase of trade in intermediate inputs has a similar impact on the demand structure for skills. In addition to these demand-shift explanations, Card and Lemieux (2001) and Autor et al. (2008) emphasize the slow supply increase of college-educated workers as an additional explanation for the increase of the college premium. Given this development of the literature, we focus primarily on returns to education, the college wage premium in particular, to explain the different evolutions of wage inequality between Japan and the US.

Figure 4: Quantity of 4-Year-College-Graduate Workers and College Wage Premium, Male 25-59, 1986-2006, Japan (LFS) and U.S.



Note: Relative wages are calculated using male hourly wages. The supply measure is calculated based on male workers. The relative supply of college-educated workers to high-school-educated workers refers to the log (total hours worked by college-educated workers / total hours worked by high-school-educated workers). Hours worked by junior- or technical-college graduates are prorated to hours worked by college-educated or high-school-educated workers using the average hourly wage rates of the sample period as the weights for prorating.

Figure 5: Quantity of 4-Year-College-Graduate Workers and College Wage Premium, Male 25-59, 1989-2006, Japan (BSWS)



Note: Relative wages are calculated using male hourly wages. The supply measure is calculated based on male workers. The relative supply of college-educated workers to high-school-educated workers refers to the log (total hours worked by college-educated workers / total hours worked by high-school-educated workers). Hours worked by junior- or technical-college graduates are prorated to hours worked by college-educated or high-school-educated workers using the average hourly wage rates of the sample period as the weights for prorating.

Figure 4 illustrates the wage and quantity of college graduates relative to high-school graduates in Japan, based on LFS, and the US between 1986 and 2008. Following the practice by Card and Lemieux (2001), we draw on male workers to calculate a wage index and a quantity index. Details of the calculation of the indexes are provided in the footnote of Figure 4. Throughout the sample period, the relative supply of college graduates is higher in the US than in Japan; however, the growth rate in Japan is twice as high as that in the US. Reflecting the supply growth difference, the college premium increased by about 0.25 log point in the US, while it decreased by 0.05 log point in Japan. Figure 5 confirms the robustness of the results even if we use permanent regular workers in BSWS as the analysis sample. Given the similarity of the results based on LFS and BSWS, the further analysis for Japan only reports the results based on LFS for the sake of saving space. We confirm all the results based on BSWS are similar to the results based on LFS.

Figure 6 tracks the relative supply index, the log of college graduates minus the log of high-school graduates, by age group in Japan. This figure shows that younger workers at any given year are generally more educated than older workers, reflecting the post-war expansion of college education. The evolution of the relative supply is heterogeneous across age groups. The relative supply of college graduates increased by 1.2 points for ages 50-59 between 1986 and 2008, whereas the relative supply for ages 25-29 increased by 0.2 point. The relative supply for ages 40-49 increased until 2000 and stagnated afterward. Similarly, for ages 30-39, it increased until 1993 and stagnated afterward. This complex movement of the relative supply index by age group suggests the need for a cohort-based analysis.

The aggregate trend of the college wage premium may mask heterogeneous trends by age groups that can arise when workers in different age groups within the same education group are imperfectly substitutable, as articulated by Card and Lemieux (2001). Figure 7 displays the college wage premium of each age group. The college wage premium is larger among older age groups, reflecting the fact that the wage-experience profile of college-educated workers is steeper than that of high-school educated workers. In addition, as shown in Figure 7, college-educated workers are scarce among older age groups. The college wage premium evolves differently across age groups. For ages 50-59, it decreased drastically from 0.7 to 0.4 between 1986 and 2008, whereas for ages 25-29, it increased slightly from 0.08 to around 0.18 in the same period. The heterogeneous evolution paths of the college premium implies that workers of different ages with the same educational attainment are imperfectly substitutable in the production process.

It should be noted that the evolution of the college wage premium by age group is inversely related to the evolution of the relative supply of college-educated individuals by age group. For ages 50-59, the college wage premium decreased, while the supply increased. The same is observed for ages 40-49 until 2000. In contrast, for ages 25-29, the college wage premium stayed constant, while the relative supply increased by a smaller amount.

Turning to the US experience, Figure 8 draws the relative supply of college graduates to high-school graduates by age groups. Quite notable is the rapid supply expansion until around 1980 for all age groups: the period characterized as that of "overeducated Americans"

Figure 6: Log College/HS Supply by Age Groups, Japanese Male 25-59, 1986-2008 (LFS).

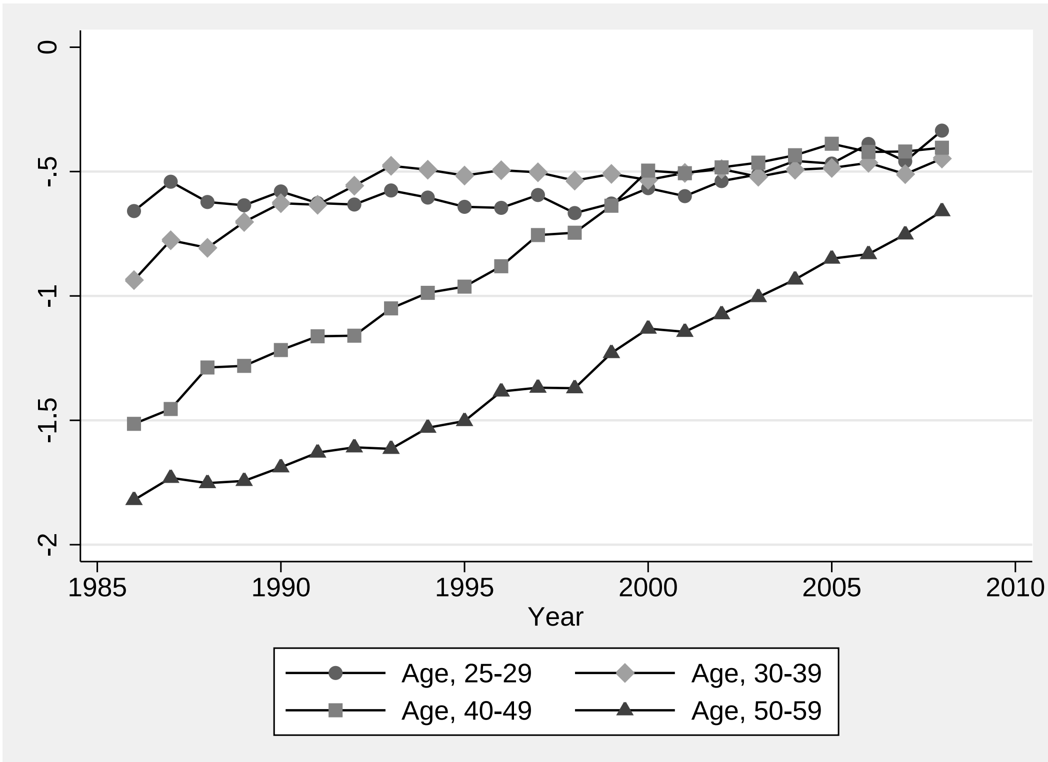


Figure 7: Log College/HS Wage Gap by Age Groups, Japanese Male 25-59, 1986-2008 (LFS).

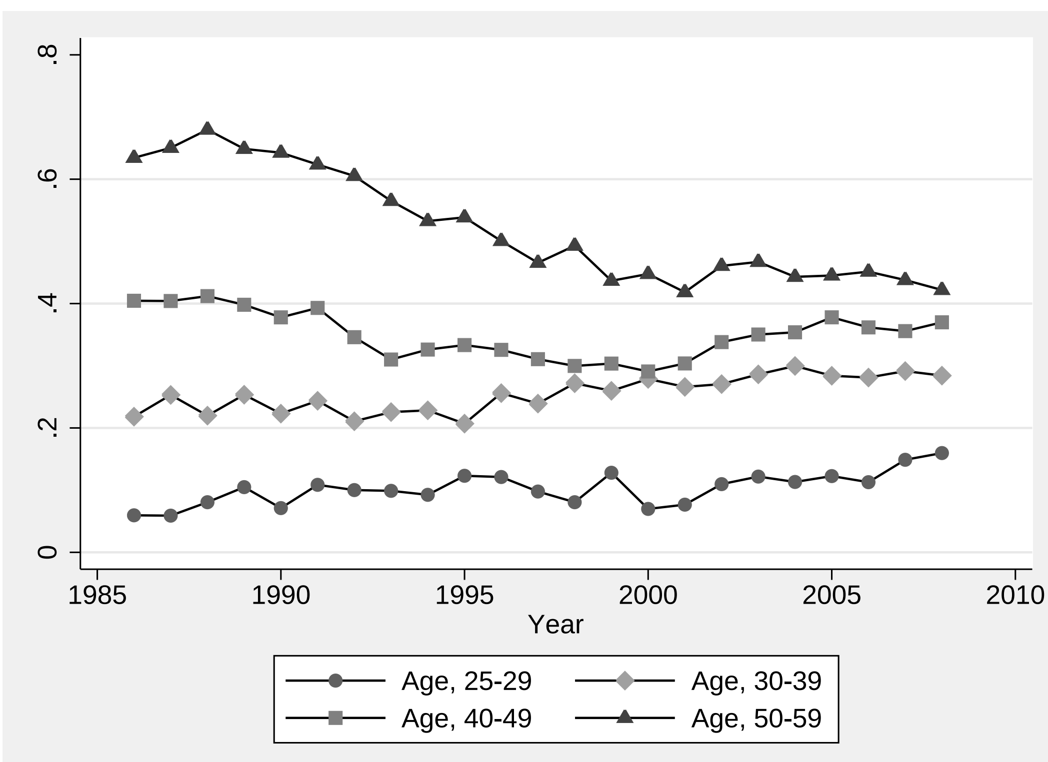


Figure 8: Log College/HS Supply by Age Groups, US Male 25-59, 1975-2006 (March CPS).

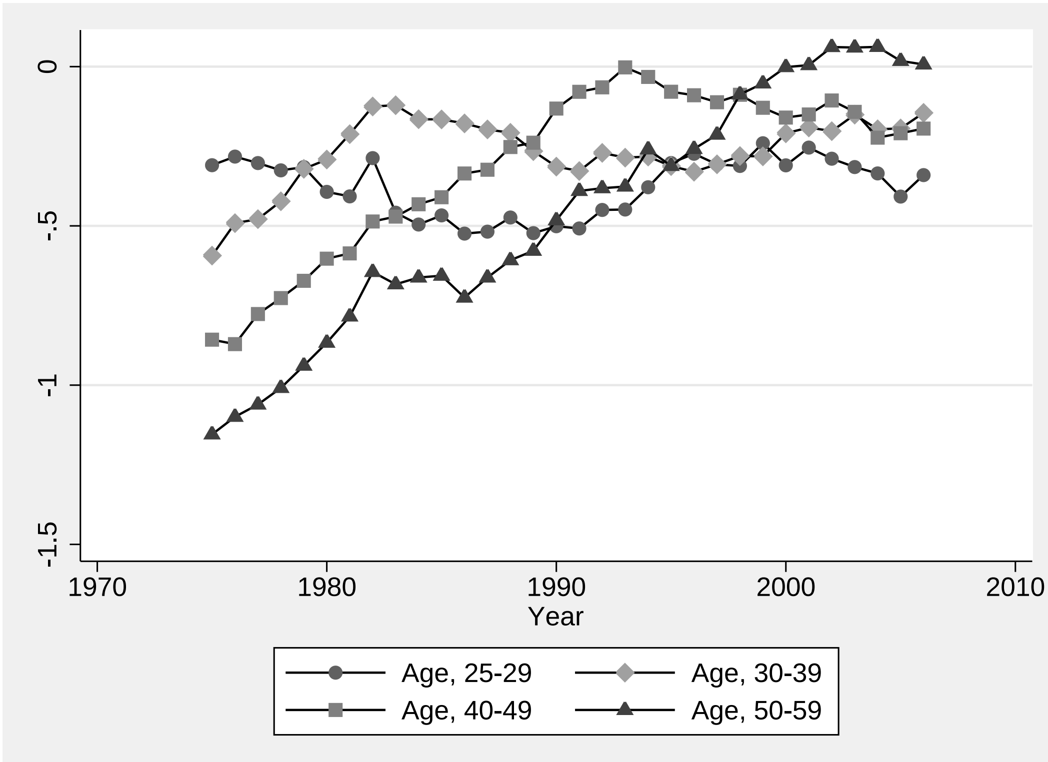
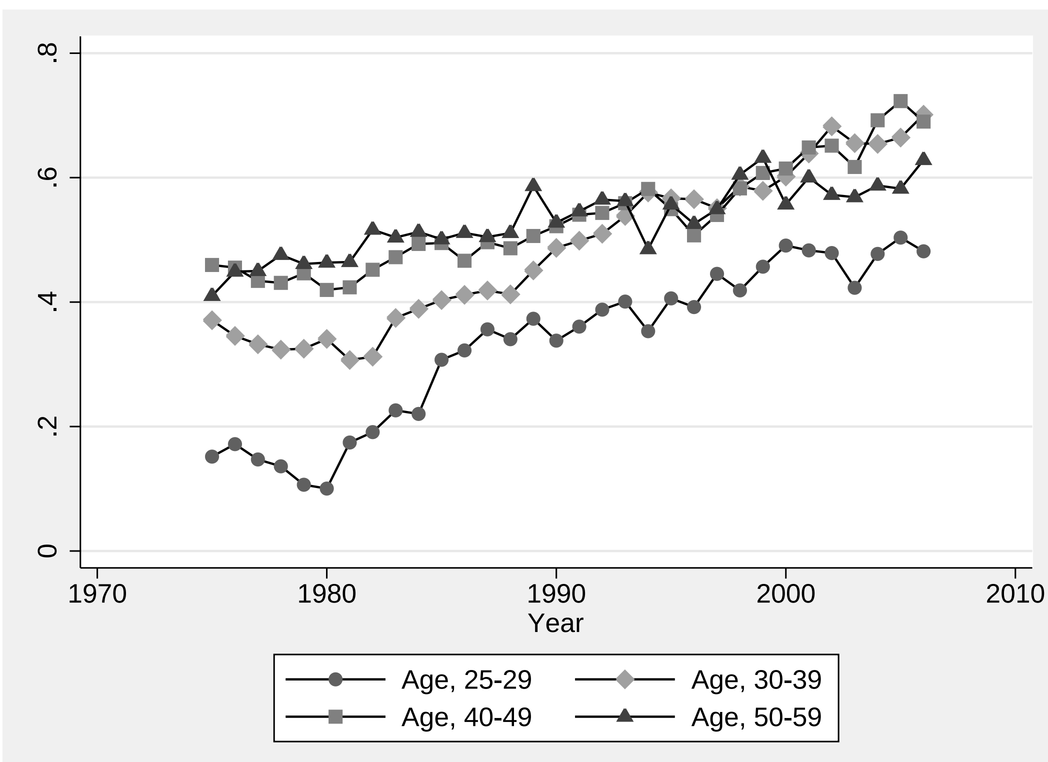


Figure 9: Log College/HS Wage Gap by Age Groups, US Male 25-59, 1975-2006 (March CPS).



by Richard Freeman. Since the late 1970s to 1990, the supply has decreased even among workers aged 25-29. The rapid increase of college-educated workers made younger workers are more educated workers until the 1970s, but it became no more the case after 1980. The relative supply index for each age group peaks out at a different year. The supply index of ages 25-29 peaks around the mid 1970s, that of ages 30-39 peaks around the early 1980s, that of ages 40-49 peaks around the early 1990s, and that of ages 50-59 peaks around the early 2000s. These systematic peaking out patterns indicate that the cohort born in the 1950s reached the peak in terms of college graduation. Later in this paper, we investigate the reason for the peaking out based on a cohort-based analysis.

Figure 9 tracks the college wage premium by age groups in the US. For all age groups, the college wage premium started to increase around 1980, but the degree of the increase was different across age groups; there was a significant increase among younger groups and a slight increase among older groups. The increase of the college wage premium was observed among age groups with a stagnated supply. The trends in the relative wage suggest that workers in different age groups are not perfectly substitutable in the production process and point to the supply factor as an important determinant of the college wage premium.

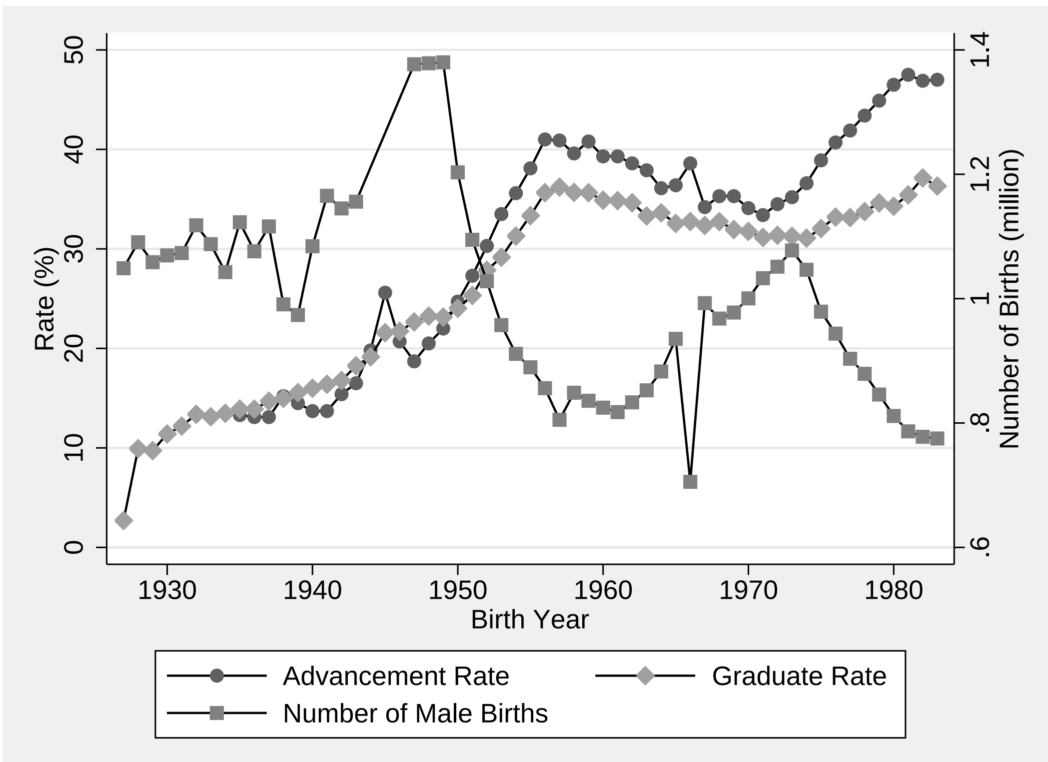
2.4 Post-war increase of college graduates in Japan and the US

The fraction of college-educated workers in Japan increased steadily beginning in 1986, but the degree of increase was not uniform across age groups because college-attendance rates varied across cohort groups. Figure 10 summarizes the four-year-college-advancement rate, which is defined as the number of students that started attending four-year colleges divided by the number of junior-high-school graduates three years before.[8]

The post-war cohort can be divided into four groups in terms of four-year college-attendance behavior. The 1945-1947 cohort is an elite cohort, 1948-1957 is a rapid-expansion

[8] The Japanese educational system consists of six years of primary school, three years of junior-high school, and three years of high school. Completing junior-high school is compulsory. More than 95 percent of junior-high school graduates attended high school after 1990. After graduating from high school, students can choose to advance to a four-year college, a two-year junior college, or an occupational-training school.

Figure 10: Non-monotonic Increase of Post-War 4-Year-College Advancement and Graduation Rates among Males and Cohort Size.



Note: Advancement rate is defined as the number of students who enter a 4-year college divided by the population size of the specific cohort. The advancement rate is calculated based on the Basic School Survey. The graduation rate is based on the fraction of 4-year-college graduates in a specific cohort based on Labor Force Survey, 1986-2008.

cohort, 1958-1971 is a stagnant cohort, and 1972-1983 is a second-expansion cohort. Historically, only around 10 percent of the population went to a four-year college until the 1947-born cohort, but this number rapidly rose to 28 percent by the 1956-born cohort. Then the four-year-college-attendance rate stagnated around 25 percent until the 1971-born cohort, and it soared again to 40 percent until the 1983-born cohort.

These nonlinear trends in college-attendance behavior are closely tracked by the fraction of four-year-college-educated workers by birth cohort based on the LFS special survey. The divergence of the college-attendance rate from the Basic School Survey and the fraction of college graduates partly reflects the increase of the college-dropout rate, which is 9 percent for the 2000 and 2002 entry cohorts.[9]

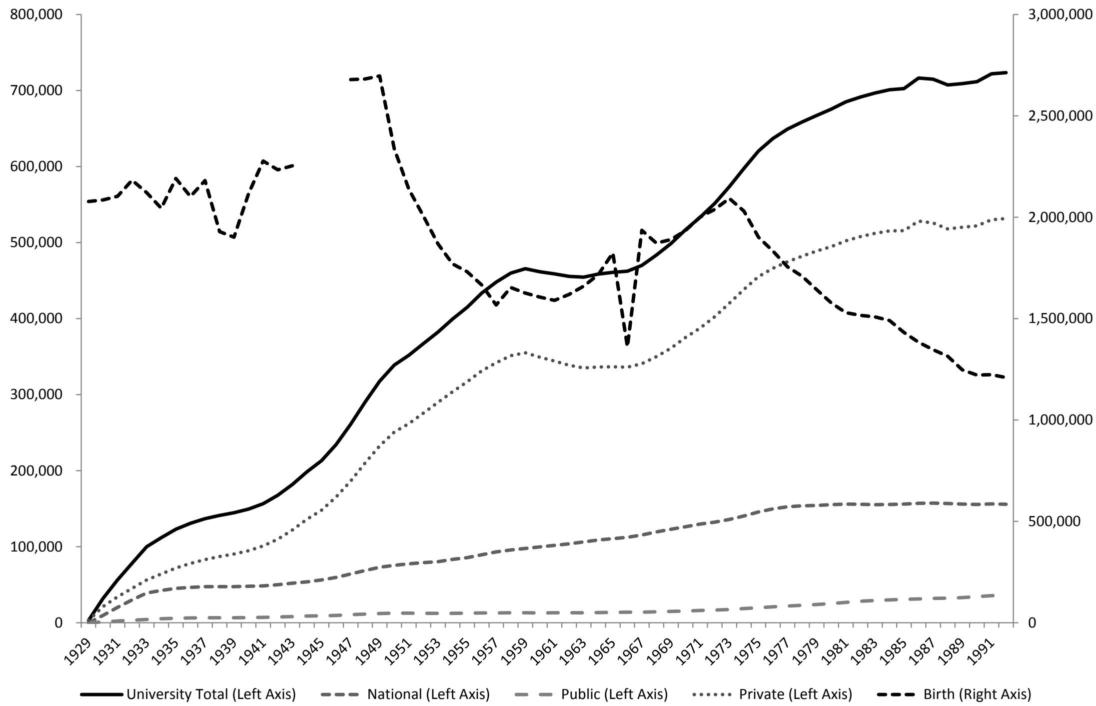
The number of high-school graduates who express interest in proceeding to a four-year college has exceeded the actual number of students who enter a four-year college.[10] Universities typically admit students based on their performance on entrance examinations. Because of this limited capacity of four-year colleges, two factors determine the college-attendance rate after high-school graduation in the post-war period: the size of the four-year-college capacity and the cohort's population size. The size of the four-year-college capacity was strictly regulated by the Ministry of Education until 1991.

Figure 11 displays the size of the four-year college capacity (by types of colleges) and population size by birth-year cohort. The rapid increase of the four-year -college attendance rate of the 1948-1957 cohorts is largely induced by the population size's rapid contraction from 2.7 million to 1.6 million. Hashimoto (1974) attributes the rapid fertility decline to women's educational advancement, in addition to the diffusion of contraceptive methods and the liberalization of abortion laws. In addition, the Ministry of Education expanded the college capacity during the late 1950s and early 1960s to meet the growing demand for high-skilled workers under pressure from politicians and industry leaders, as documented by

[9]Education at a Glance 2008: OECD Indicators, Table A4.1. Tertiary-type A education.

[10]According to the Basic School Survey, about 1.33 million students graduated from high school in March 2000. Among them, 56 percent wanted to attend colleges including 2-year colleges, but 45 percent actually attended college.

Figure 11: Number of Births and Four-Year-College Capacity by Birth Cohort.



Note: Numbers of college students are from the Basic School Survey and numbers of births is from Vital Statistics. Numbers of births between 1944 and 1946 are missing. Numbers of births between 1947 and 1972 do not include Okinawa prefecture because of US occupation. An individual born in year t is assumed to start college after 19 years. Total number of four-year-college students is divided by 4.

Pempel (1973).

The four-year-college advancement rate declined slightly for the 1958-1971 cohort. During this period, the Ministry of Education became reluctant to expand the college capacity because of its limited fiscal ability. In particular, beginning in 1976 (when the 1957-borns were 19 years old), the Ministry cut its subsidies to private universities that accepted more students than the official capacity (Higuchi (1994)). The rise of the left-wing student movement that peaked in 1969 is also pointed out as a reason that the Ministry suppressed the college capacity (Nakata and Mosk (1987)). At the same time, the population size increased for this cohort because the baby boomers born in 1945-47 reached child-bearing age during this time. The college capacity's stagnation until 1991 and the expanding cohort size decreased the college attendance rate for the 1958-1971 cohort.

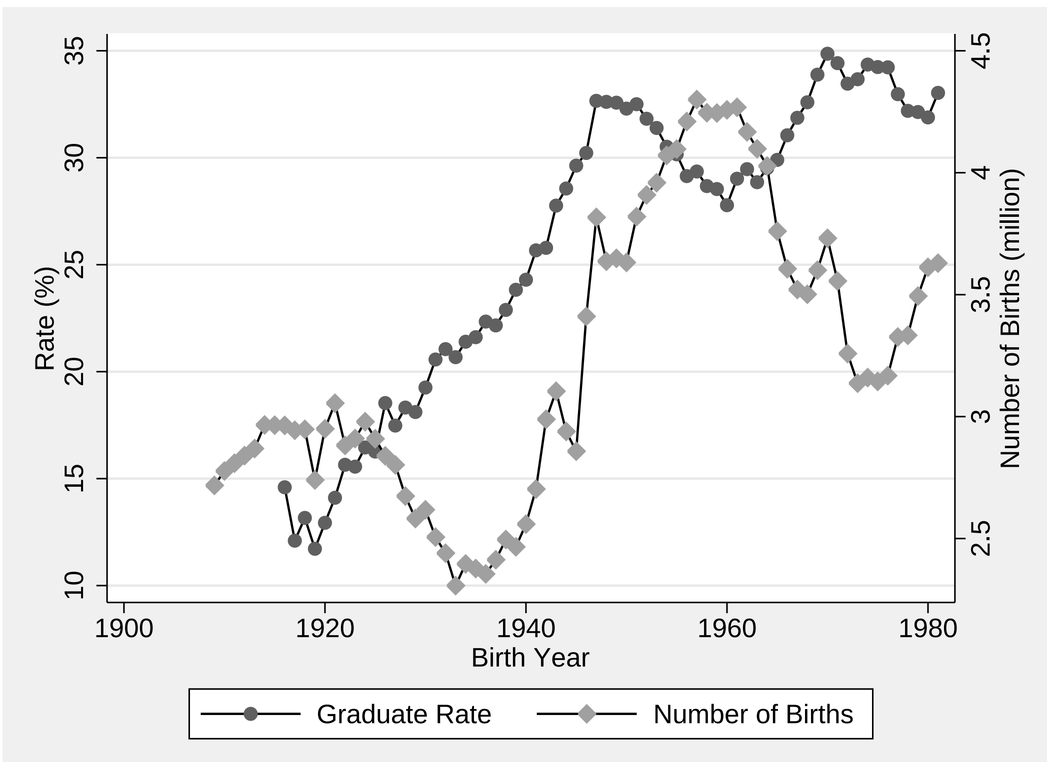
The college-advancement rate increased rapidly from the 1972- to 1983-born cohort. This was partly induced by the deregulation of college standards set by the Ministry in 1991 (when the 1972-born cohort was 19). Around the time of deregulation, the college capacity expanded from 450,000 to 650,000, while the population of 18-year-olds steadily decreased throughout the period, from 2 million to 1.2 million. With these two effects combined, the college-advancement rate increased from 25 to 40 percent between the 1972- and 1983-born cohorts. The fluctuation of the college-advancement rate was created by the cohort population size of 18-year-olds and the Ministry's higher-education policy.

What then explains the stagnated supply growth of young college-educated workers from the late 1970s in the US? Those ages 25-29 in 1980 were born in 1955-1959, and each cohort includes more than 4 million individuals, which is huge compared with the cohorts born before 1955, which included fewer than 3 million individuals for each, as indicated in Figure 12. The rapid population increase of the US post-World War II baby boomers born between 1946 and 1964 outpaced the increase of the college admission capacity and suppressed or even decreased the college-graduation rate among those cohorts.

Bound and Turner (2007) propose the cohort crowding out hypothesis as an explanation for the fluctuation of college-graduation rates by birth cohorts. The hypothesis points out that the supply of college-education service is inelastic in the short run because higher education is heavily subsidized by public funds and the change of college capacity involves a political process. Given the sluggish adjustment of college-admission capacity, an 18 year old belonging to a large population-size cohort is less likely to be admitted to a college. Bound and Turner (2007) demonstrated that the hypothesis stands well with the cross-states variation of cohort-specific college graduation rates.

The cohort-crowding-out hypothesis explains Japanese trends as well. The sharp contrast of fertility trends in Japan and the US during the 1950s, the baby burst in Japan, and the

Figure 12: Non-monotonic Increase of Post War 4 Year College Graduation among US Male (1916-1981) and Cohort Size.



baby boom in the US explain the difference in supply trends of adult college graduates in the 1990s and the 2000s. In a further analysis, we exploit the fluctuation of the college-advancement rate as an exogenous supply shift of college-educated workers.

3 Explaining trends in returns to education

We learned that the supply increase of college graduates was more rapid in Japan than in the US over last two decades. Then, how would the college premium have evolved in the US if the supply increase had been that of Japan? To answer this question, we need to identify the demand shift for college graduates relative to high-school graduates. This section identifies the age-specific demand for college graduates based on the double CES production function proposed by Card and Lemieux (2001). Once the demand for college-graduate relative to high-school-graduate workers is identified, we can simulate the effect of the supply increase on the relative wage. The simulation allows us to form a counter factual college wage premium in the US if the supply increase were that of Japan.

3.1 Demand for college and high-school graduates

We assume that there are many firms in the market and each firm has a technology that is represented by the production function:

$$Q_t = [(\theta_{ct} L_{ct})^{\eta} + (\theta_{ht} L_{ht})^{\eta}]^{\frac{1}{\eta}}, \ \eta \leq 1, \tag{1}$$

where Q_t is the output in year t, L_{ct} is the aggregated labor input of college graduates in year t, and L_{ht} is that of high-school graduates. The parameters θ_{ct} and θ_{ht} represent the efficiency of the college-graduate and high-school-graduate labor forces, respectively. The elasticity of substitution between college graduates and high-school graduates is expressed as $\sigma_e = 1/(1-\eta)$. The SBTC is represented by the increase of θ_{ct}/θ_{ht} if $\sigma_e > 1$ (Katz and Autor (1999)). The production function abstracts away from the capital. The capital does not affect the following discussion as far as it does not affect the ratio of marginal products of college-graduate and high-school-graduate workers. If the capital is not neutral to the ratio of marginal products, then the non-neutrality is captured by the θ_{ct}/θ_{ht}.

The aggregated labor inputs for college graduates and high-school graduates are also presented in CES form:

$$L_{ct} = [\sum_j (\alpha_j L_{cjt}^{\rho})]^{\frac{1}{\rho}} \tag{2}$$

and

$$L_{ht} = [\sum_j (\beta_j L_{hjt}^{\rho})]^{\frac{1}{\rho}}, \tag{3}$$

$\rho \leq 1$, where j is the index for age group. The elasticity of substitution between age groups is $\sigma_a = 1/(1-\rho)$.

We assume that the product price is given as unity. From the firm's profit-maximization condition, we obtain:

$$\frac{w_{cjt}}{w_{hjt}} = (\frac{L_{ct}}{L_{ht}})^{\eta-1}(\frac{\theta_{ct}}{\theta_{ht}})^{\eta}(\frac{L_{cjt}}{L_{hjt}}/\frac{L_{ct}}{L_{ht}})^{\rho-1}\frac{\alpha_j}{\beta_j}. \tag{4}$$

By taking the log, we can derive the estimated equation as follows:

$$\ln(\frac{w_{cjt}}{w_{hjt}}) = (1-\frac{1}{\sigma_e})\ln(\frac{\theta_{ct}}{\theta_{ht}}) + \ln(\frac{\alpha_j}{\beta_j}) - (1/\sigma_e)\ln(\frac{L_{ct}}{L_{ht}}) - (1/\sigma_a)[\ln(\frac{L_{cjt}}{L_{hjt}}) - \ln(\frac{L_{ct}}{L_{ht}})]. \tag{5}$$

When workers of different ages are perfectly substitutable (i.e., $\sigma_a = \infty$), the term $[\ln(\frac{L_{cjt}}{L_{hjt}}) - \ln(\frac{L_{ct}}{L_{ht}})]$ drops. The change in θ_{ct}/θ_{ht} widens the wage gap if four-year-college graduates and high-school graduates are substitutes (i.e., $\sigma_e > 1$), and its effect is large when college graduates and high-school graduates are close substitutes (i.e., σ_e is large). Relative productivity of four-year-college graduates to high-school graduates, α_j/β_j, is constant across age groups if the speed of human-capital accumulation is constant for both groups. Since the equal speed of human-capital accumulation for four-year-college graduates and high-school graduates is inconsistent with actual data, the estimation equation includes age-group dummy variables to allow for difference in the speed of skill accumulation.

As articulated by Card and Lemieux (2001), estimating (5) is not straightforward, because it includes the aggregate labor-supply index ($\frac{L_{ct}}{L_{ht}}$), which depends on parameter values, α_j, β_j, and ρ (or σ_a). This complication is resolved by estimating the model using several steps. Combining terms by the subscripts, the equation (5) can be written as:

$$\ln(\frac{w_{cjt}}{w_{hjt}}) = d_t + d_j - (1/\sigma_a)\ln(\frac{L_{cjt}}{L_{hjt}}), \tag{6}$$

where d_t and d_j are time and age-group dummy variables. From this equation, the elasticity of substitution across age groups, σ_a, is identified, and ρ is consequently recovered.

From the first-order condition of firms' profit maximization, we obtain

$$\ln w_{cjt} + \frac{1}{\sigma_a}\ln L_{cjt} = \ln\{[(\theta_{ct}L_{ct})^\eta + (\theta_{ht}L_{ht})^\eta]^{1/\eta-1}\theta_{ct}^{\eta-1}L_{ct}^{\eta-\rho}\} + \ln(\alpha_j) \tag{7}$$

and

$$\ln w_{hjt} + \frac{1}{\sigma_a}\ln L_{hjt} = \ln\{[(\theta_{ct}L_{ct})^\eta + (\theta_{ht}L_{ht})^\eta]^{1/\eta-1}\theta_{ht}^{\eta-1}L_{ht}^{\eta-\rho}\} + \ln(\beta_j). \tag{8}$$

Because the leading terms of the right-hand side in the above two equations depend only on time, the regressions of left-hand-side variables on year and age-group dummy variables identify the parameters α_j and β_j for each j.

With knowledge of ρ, α_j, and β_j, the aggregate-supply index is calculated and the equation of interest (5) can be estimated. We parameterize the SBTC as $(1-\frac{1}{\sigma_e})\ln(\theta_{ct}/\theta_{ht}) = \gamma\times t$, where t is the linear time trend, assuming that technological progress has a linear time trend. The parameter γ is the reduced-form measure of SBTC if $\sigma_e > 1$.

We assume that the relative numbers of four-year-college graduates to high-school graduates is exogenous. As discussed in the previous section, the relative numbers of college graduates is historically determined by such factors as cohort size and college capacity, which are arguably exogenous to the current college wage premium. However college and high-school graduates could supply their hours elastically responding to their wages. Then the unobserved shock to the college wage premium is positively correlated with the quantity of college graduates relative to high school graduates. This correlation makes the parameter estimates upward biased. To deal with this potential bias, we implement IV estimation using the numbers of college graduate relative to the number of high school graduates as instrumental variables.

3.2 Demand structure in Japan and the US

Table 2 reports the estimation results for the regression to identify the elasticity of substitution across age groups, σ_a, which is (6). Column 1 reports the result for the US. The estimated coefficient -0.205 (s.e. = 0.015) indicates that workers in different age groups are not perfectly substitutable. Therefore, college wage premiums are suppressed for age groups with many college graduates. The implied elasticity of substitution between age groups within the same educational category is around 5, which is close to the estimates of about 5 by Card and Lemieux (2001) but somewhat larger than about 3.5 by Autor et al. (2008). The differences of the analysis sample and the model specification may well explain the different results, as reported in Appendix Table A1. Table 1 Column 2 reports the results for Japan. The estimate -0.176 (s.e. = 0.023) implies an imperfect substitutability across workers in different age groups, and the implied elasticity of substitution is 5.7, which is very close to the 5.8 in Noro and Ohtake (2006), based on the male regular worker sample from the BSWS, 1976-2001.

With the estimate of the elasticity of substitution across age groups, the auxiliary regression models are estimated to identify the age-specific productivity parameters, α_j and β_j. With the estimated values for σ_a, α_j, and β_j, we construct the aggregate relative supply index and estimate the equation (5) to additionally identify the elasticity of substitution between educational groups and the time trend, which presumably captures skill-biased technological change.

Estimation results appear in Table 3. Column 1 reports the estimates for the US. The estimated coefficient for the age-specific relative supply is comparable with the one in Table

Table 2: Age-specific log college/HS relative wage, male 25-59, 4 age groups, 1986-2008 (Japan) 1975-2006 (U.S).

	(1)	(2)
Country	U.S	Japan
Age-specific college/high school	-0.195	-0.178
	(0.016)	(0.023)
Age group F.E.	Yes	Yes
Year F.E.	Yes	Yes
Observations	128	92
R-squared	0.972	0.952

Note: Standard errors are in parentheses. Models are fit by weighted least squares. Weights are inverse standard errors of estimated wage gaps. Age effects and Year effects are included.

1. The estimated coefficient for aggregate supply, -0.200 (s.e. = 0.017), implies that the elasticity of substitution between college and high-school graduates is about 5.00, which is higher than the estimated 2.1 by Card and Lemieux (2001) and 1.53 by Autor et al. (2008). The positive coefficient for the time trend implies that the college wage premium increased by 1.3 percentage points annually if the supply was constant, and this is consistent with the SBTC hypothesis. This estimate is slightly below the 2.0 percentage points found by Card and Lemieux (2001) and the 2.7 percentage points found by Autor et al. (2008). The estimates in this study attribute the increased return to college education more to the slowing supply of college graduates and less to skill-biased technological change. Whether attributing the increased return to a slowing supply increase or skill-biased technological progress depends on the analysis sample, specification or variable definition reflecting multicollinearity between the aggregate supply index and the linear time trend, as reported in Appendix Table A1. After all, determining whether the increased return to college education is caused by an increased demand for them or a decreased supply of them is not easy task. So, we should note a caveat that our estimates may slightly exaggerate the effect of slowed college-supply increase on the increased return to college education.

Column 2 reports the IV estimation results using the numbers of college graduates relative to high school graduates as IVs for the total hours worked by college graduates relative to high school graduates. This IV estimation renders a consistent estimator even when hours worked by college graduates and high school graduates elastically respond to the relative wage shocks. The estimated coefficients virtually do not change from the ones reported in Column 1.

The result in Table 3 Column 3 is for Japan. The estimated coefficient for the age-specific supply is almost identical to the estimate in Table 2. The coefficient for the aggregate supply index, -0.022 (s.e. = 0.043), is imprecisely estimated. The estimate is imprecise because the aggregate supply index of college graduates follows an almost linear trend, as hinted by Figure 4. Even after allowing for imperfect substitutability of workers across different age groups, not much nonlinearity remains. As a result, the aggregate supply index is highly collinear with the linear time trend. Consequently, the coefficient for the linear time trend, -0.001 (s.e. = 0.002), which presumably captures skill-biased technological progress, is imprecisely estimated too. The IV estimation using the numbers of college graduate relative to high school graduates as IVs do not resolve the problem as reported in Column 4. In fact, Noro and Ohtake (2006) face the same identification issue for Japan and Card and Lemieux (2001) for Canada. This fact implies that a low elasticity of substitution between education groups with larger SBTC and high elasticity of substitution with smaller SBTC are observationally equivalent; both cases result in a stable college wage premium. If college graduates and high-school graduates are not substitutable, the increase of college graduate substantially suppresses the college premium but high SBTC increases the college premium. In contrast, if college graduates and high-school graduates are substitutable, the increase of college graduate does not suppress the college wage premium, so that the counteracting SBTC does not need to be small. This argument reveals that attributing the change of the college wage premium to the substitutability between college graduates and high-school graduates and SBTC depends critically on the nonlinear change of aggregate supply of college graduates and the choice of a functional form for SBTC.

The nonlinearity of the aggregate supply index of college graduates in the US helps to precisely estimate the elasticity of substitution between college graduates and high-school graduates and the speed of SBTC. To overcome the difficulty of estimating the demand structure of Japan, we use the US estimate of the speed of SBTC. The problem of simply applying the US estimate to Japan is that the speed of SBTC is likely to be different between Japan and the US. To adjust the difference in the speeds of SBTC between two countries, we exploit the contribution of ICT equipment to the growth of total capital services available in the OECD statistics.[11] The geometric means of annual growth rates between 1986 and 2006 are 1.87 percent for Japan and 2.58 percent for the US. Therefore, the average annual growth rate of ICT capital of Japan had been about 72 percent of the US. SBTC in the US widens the wage gap between college and high-school graduates by 1.6 percent annually, holding all else constant. Considering the slower speed of ITC accumulation in Japan, we guesstimate the impact of SBTC on the wage gap between college and high-school graduates to be 72 percent of that of the US. Column 5 reports the hypothetical situation that the speed of SBTC is 72 percent at the US value, 0.009. While the estimated coefficient for age-specific supply index does not change, the coefficient for the aggregate supply index becomes substantially larger, implying a small elasticity of substitution. The implied aggregate elasticity of substitution between college graduates and high-school graduates becomes smaller than the estimates in the US. The IV estimation does not change the results substantially as reported in Column 6.

Notwithstanding the difficulty in the estimation for Japan, the positive coefficients for the linear time trends for the US and Japan imply that the college wage premium would have increased if the supply of college graduates relative to high-school graduates had been constant between 1986 and 2008. Moreover, the elasticity of substitution between college graduates and high-school graduates is smaller in Japan than in the US, and this implies that the college wage premium would have grown without the rapid supply increase of college graduates relative to high-school graduates in Japan.

[11]URL: http://stats.oecd.org/

Table 3: Age-specific log college/high school relative wage, male 25-59, 4 age groups, 1986-2008 (Japan) 1975-2006 (U.S).

	(1)	(2)	(3)	(4)	(5)	(6)
Country	U.S.	U.S.	Japan	Japan	Japan	Japan
Age specific college/high school	-0.200	-0.200	-0.135	-0.144	-0.119	-0.136
- college/high school	(0.017)	(0.016)	(0.023)	(0.026)	(0.026)	(0.027)
College/high school	-0.146	-0.170	-0.022	0.072	-0.206	-0.222
	(0.043)	(0.050)	(0.043)	(0.256)	(0.014)	(0.015)
Trend	0.013	0.013	-0.001	-0.005	0.009	0.009
	(0.001)	(0.001)	(0.002)	(0.013)	(fixed)	(fixed)
Age group F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Estimation methods	WLS	WIV	WLS	WIV	WLS	WIV
Observations	128	128	92	92	92	92
R-squared	0.959	0.959	0.959	0.956	0.952	0.951

Note: Standard errors are in parentheses. Models are fit by weighted least squares. Weights are inverse standard errors of estimated wage gaps.

3.3 Quantifying the importance of supply on the college wage premium

The estimated demand structure for a college graduate relative to a high-school graduate in the previous section reveals that both economies share reasonably similar technological parameters. The similar demand structure implies that the contrasting trends in the returns to college education in Japan and the US is largely the result of the speed of the supply increase of college graduates between them. To what extent does the difference in supply growth explain the difference in the trends of returns to college education? How would the return to college education in the US have evolved if the supply growth had grown as in Japan? To answer these questions, we simulate a counter-factual college premium in the US, combining US parameter values and Japan's supply index of college graduates. To attain the goal, we combine US parameter values, reported in Table 3 Column 1, and Japan's age-specific supply index to construct the counter factual aggregate supply index for the US. Then the combination of US demand parameter values and the counter-factual supply index renders the age-specific college premium in the US. The simulated average college premium is obtained by the weighted average of the age-specific college premiums, using the number of workers in each age group as weights.

Figure 13 reports the actual and simulated changes of college premiums in the US. The actual US college premium increased by 0.23 log point, from 0.43 in 1986 to 0.65 in 2008. The actual change of the college wage premium is well replicated by the simulated change of college wage premium with US parameters and US supply indexes. The simulated change of the college wage premium with US parameters and Japanese supply indexes, in contrast, indicates that the college wage premium would have increased by only 0.15 log point. The college wage premium diverged by 0.24 log points between Japan and the US between 1986 and 2008. Of the actual 0.24 points divergence, 0.08 points are explained by the difference in supply growth based on the counter-factual simulation for the US. Therefore, about 40 percent of the different evolutions of college premiums in the last two decades is attributable to the difference in the speed of supply growth of college graduates between two countries. The rest should be attributed to the difference in the speed of skill-biased technological progress and other unidentified factors.

Figure 14 displays the simulation results for Japan based on the parameter estimates in Table 3 Column 5, which are obtained by imposing the speed of SBTC a priori. According to the counter-factual simulation (JP with US supply), the equilibrium wage differentials would have increased by 0.13 point, if the supply trend followed that of the US, instead of a 0.01 point decrease. The difference in the supply trends across the two countries explains 0.14 points out of the 0.24 point divergence of the college wage premium between Japan and the US. The counter-factual simulation for Japan indicates that the difference in the supply trends explains about 58 percent of the divergence of the college wage premium between the two countries.

The simulation for the US is the preferable one because the simulation is based on the labor demand function estimates without imposing an exogenous SBTC speed. Therefore, we conclude that the difference in the supply trends of college graduates explains about one-third of the divergence of the returns to college education between Japan and the US; the supply of college graduates plays a crucial role as a determinant of the college wage premium and wage inequality.

4 Stagnated supply in the US and growing supply in Japan: Why?

About one-third of the difference in the evolution of the college wage premium over the last two decades is explained by the difference in the supply growth of college-educated workers between Japan and the US. The aggregate supply index of college-educated workers relative to high-school-educated workers in Japan has grown twice as fast as that in the US (Figure 4). An interesting question is why the trends have been different across two countries. Answering the question responds to Card and Lemieux (2001)'s call for more research: "A key issue for future research is to understand the sources of the slowdown in the intercohort trend in educational attainment that has affected the post-1950 cohorts in all three countries (the US, the UK and Canada)."

A primary answer to the question is that the cohort size among the post-1950 cohorts increased because of the baby boom in the US. As Bound and Turner (2007) argue, the costs of college education are largely public funded, and the resources spent for college education do not respond quickly to the demand for college education. The hysteresis of the education budget for college education and the expansion of cohort size among the post-1950 cohorts in the US make them crowded out from college education. The fertility trend of post-1950 cohorts in Japan makes a sharp contrast to the US trend because of the post-war rapid fertility decline; the cohort size decreased by 40 percent from the 1949 cohort to the 1957 cohort. The contrasting fertility trends between Japan and the US and the relatively fixed college enrollment capacity are the primary reasons for the difference in the supply trends of college-educated workers between two countries.

Figure 13: Counter-Factual Simulation of Return to College Education, the US, if the relative supply in U.S. were equal to that in Japan.

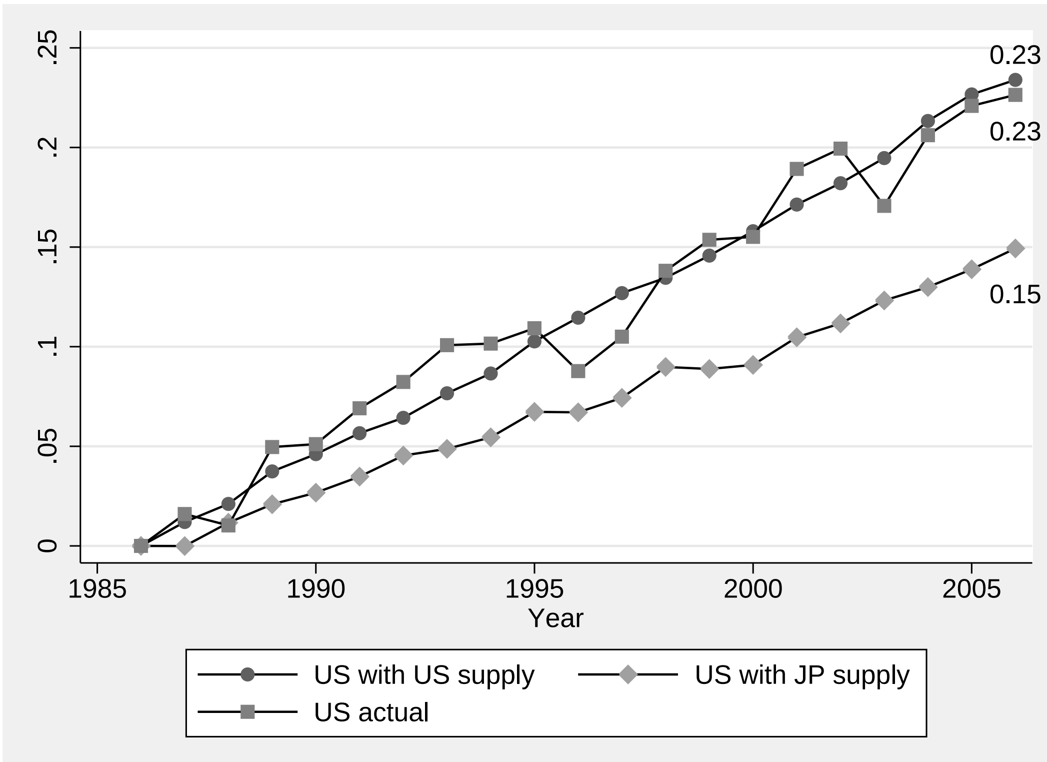
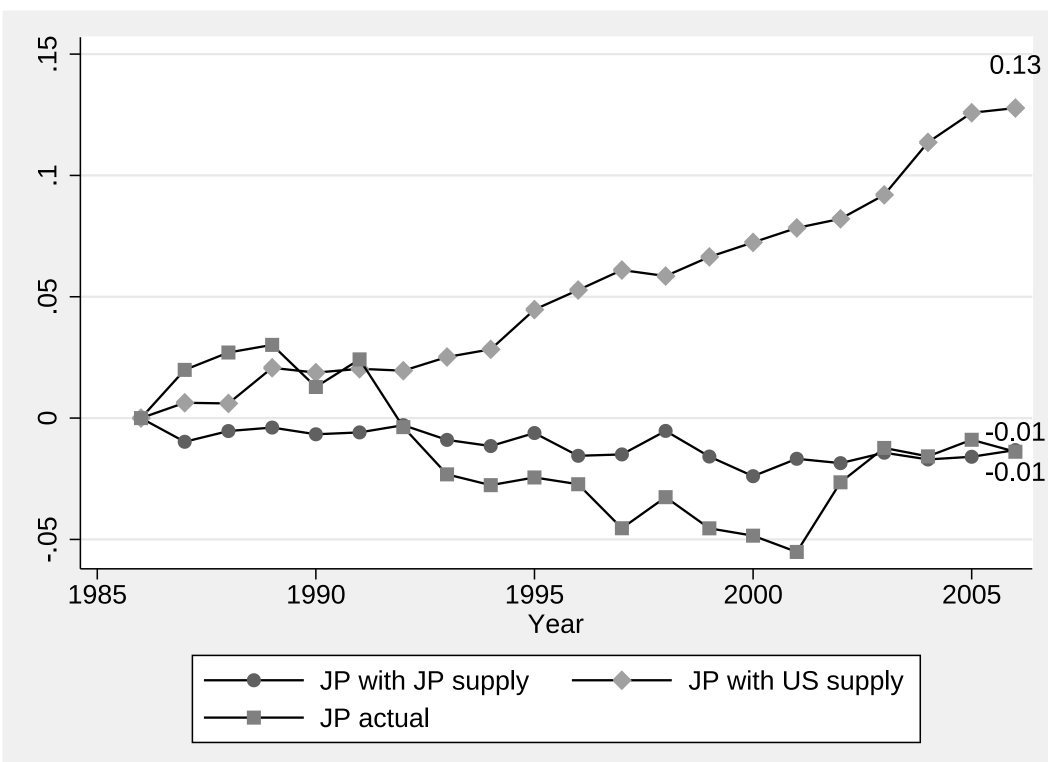


Figure 14: Japan-US Comparison of Return to College Education, Counter-Factual Simulation, Japan, if the relative supply in Japan were equal to that in the US.



Bound et al. (2010) further investigated the reason behind the stagnation of the college-completion rate in the US regardless of the increase in the college-enrollment rate. Comparing the high school classes of 1972 and 1992, the college-completion rate conditional on college attendance dropped from 50.5 percent for the 1972 cohort to 45.9 percent for the 1992 cohort. Two factors, according to them, explain the recent decline of the college-completion rate among college attendees: the quality deterioration of college entrants and the decrease of resources per student.

As the fraction of high-school students who proceed to college increases, the quality of college attendees naturally deteriorates. The deterioration of students' quality explains the one third of the drop in the college-completion rate, according to Bound et al. (2010). The deterioration of the quality of college entrants is a common phenomenon in both Japan and the US, but a higher fraction of high-school graduates proceed to four-year college in the US than in Japan; 67 percent of US males attend a four-year college at age 18, while 57 percent of Japanese males do so between 2005 and 2010 (OECD (2012)). In addition, the increase of unprepared students poses less of a challenge to college education in Japan than in the US, because Japanese high-school students are academically better prepared than US high-school students at the whole range of the test-score distribution. Table 4 tabulates the distribution of international standardized test scores of three subjects in the OECD Programme for International Student Assessment (PISA). The test scores are standardized so that each score has a mean of 500 and a standard deviation of 100. Under a scenario that the better half of high-school graduates enter college, the mathematics score of the marginal student is 534 in Japan and 485 in the US. The academic attainments of marginal students differ by 0.5 standard deviation between Japan and the US. A similar discussion applies to academic achievements in science and language. The better academic achievements of college entrants means that the college entrants in Japan are better prepared for college education than their US counterparts. Moreover, more lenient requirements for college graduation in Japan compared with the US explains the greater increase of college graduates in Japan than in the US. While not well grounded in comparable statistics, plenty of anecdotal evidence suggests that earning credits from college in Japan requires much less effort than in the US (for example, Clark (2012)). The combination of good primary/secondary education and lenient college-credit in Japan partly explains the more rapid growth of college graduates in Japan than in the US.

Table 4: Distribution of PISA test scores in Japan and the US, 2009.

Percentiles	10	20	30	40	50	60	70	80	90
Mathematics									
Japan	415	456	485	511	534	556	581	608	643
The US	373	412	440	463	485	507	533	562	599
Difference	41	44	45	47	48	49	48	47	44
Science									
Japan	412	462	498	527	553	575	597	621	654
The US	377	418	449	475	499	526	553	584	622
Difference	35	44	50	53	54	49	44	38	32
Language									
Japan	391	445	479	507	533	555	578	603	633
The US	376	416	447	474	498	526	553	580	618
Difference	15	29	32	33	35	30	26	23	15

Note: Test scores are normalized to have 500 as the mean and 100 as the standard deviation worldwide. All differences are statistically different from zero at the 1 percent significance level.

Another important difference of college education between Japan and the US is cost; the per-student expenditure of US tertiary education is about twice as high as that of Japan. According to OECD statistics, annual expenditure per student by educational institutions in 2009 is 15,957 in Japan and 29,201 in the US, measured in PPP-equivalent US dollars (OECD (2012)). The cost is shared by public and private expenditures in both countries, and the figures of the burden sharing are similar across the two countries; 35.3 percent is shared by public sources in Japan, and 38.1 percent in the US. With a similar fraction of the expenditures shared by the public, the higher cost of tertiary education in the US directly connects to the higher public expenditure, which often faces political difficulty (Bound and

Turner (2007)). The budget constraints of public money and the concentration of resource allocated to elite colleges contributed to reduced expenditures in mediocre public colleges and community colleges. The reduction of resource allocation to these schools lowers the completion rate of their students (Bound et al. (2010)). The lower per-student expenditure contributed to the improved accessibility of college education in Japan. We should cautiously note, however, that the lower expenditure per student may well reflect the lower quality of college education in Japan.

5 Conclusion

This paper examined the change in Japan's wage distribution between 1986 and 2008 based on micro data from the Labor Force Survey. An examination of the 10th, 50th, and 90th percentiles of the wage distribution reveals that it was stable during the analysis period. If there was any change in the wage distribution, male workers at the lower bottom of the distribution experienced more wage gain in the late 1990s. The stability of the wage distribution found in previous studies (Genda (1998), Shinozaki (2002), Kambayashi et al. (2008) and Yamada and Kawaguchi (2012)) is confirmed based on the Labor Force Survey, which covers not only full-time regular workers, but also part-time or non-regular workers.

We explained this unchanged wage inequality based on a simple demand and supply framework, focusing on stable returns to education. We first noted that the non-monotonic increase of the college-advancement rate in Japan was caused mostly by a rapid fertility decline during the 1950s and 1970s and the government's higher-education policy that deregulated college openings in 1992. An estimation of technology parameters based on the double CES production function, which allows for imperfect substitutability between education groups and age groups within an education group, revealed that four-year-college graduates and high-school graduates were imperfect substitutes and that workers belonging to different age groups in an education group were also imperfect substitutes. While we obtain only imprecise estimates for Japan, the estimation results suggest that the college wage premium would have increased if the relative supply had been constant. This implies that Japan experienced a demand shift in favor of four-year-college graduates relative to high-school graduates.

Based on the Current Population Survey, we obtained the supply series of college graduates relative to high-school graduates in the US and estimated identical models to obtain the parameter values for the demand structure of the US economy. Using the model parameters of the US and the supply series of Japan, we simulated the trend of the college wage premium in the US as if the supply of college graduates had grown as fast as in Japan. If the supply of college graduates had grown as in Japan, the college wage premium would have increased by only 0.15 log point between 1986 and 2008, while the actual wage premium would have increased by 0.23 log point.

The college wage premium in Japan decreased by 0.01 log point between 1986 and 2008, whereas that in the US increased by 0.23 log point during the same period. Of the 0.24 log-point difference in the trends between Japan and the US, 0.08 log points can be explain by the different speeds of the supply growth of college graduates. Therefore, the difference in the supply trends of college graduates explains one-third of the difference in the evolution of the college wage premium. The stable college premium of Japan thus is partly the result of a more rapid increase of college-educated workers than in the US. The analysis in this paper demonstrates the crucial role of higher education policy as a significant determinant of a nation's wage inequality.

The results help us predict the inequality trends in Japan for the near future. The cohorts born in the 1950s that experienced a rapid increase of college education in Japan are about to retire from the labor market as they reach age 65. The college premium is predicted to raise among elder workers over age 50 in the near future, because the supply of college-educated workers stagnated among workers who were born in the 1960s.

The difference in the post-war fertility trends between Japan and the US is the primary reason for the difference in the growth of college graduates. In addition to fertility, two other factors characterizing Japan explain the more rapid growth of college graduation rate: higher academic achievement of high-school students and lower cost of college education. Japanese high-school graduates are more prepared for college education. The lower cost of Japan enables the expansion of college capacity, while the lower cost may well mirror inferior quality of college education in Japan as suggested by the lower college wage premium regardless of the smaller fraction of college graduates in the labor force. Better qualified high-school graduates and the lower college wage premium in Japan than in the US articulates the difference in the educational challenges the two economies face: the betterment of primary and secondary education in the US and the betterment of college education in Japan.

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Appendix: Institutions on Japanese wage determination

A presumption of this paper is that wages in Japan and the US are determined thorough market mechanisms rather than wage-setting institutions. Japan is known to have a more well-developed internal labor market. The wage determination of internal labor markets could deviate from the market based wage determination. Important is the fraction of workers who are potentially covered by the practices and whether the practices are determined independent of labor-market forces. So-called Japanese employment practices, characterized by long-term employment, steep tenure-wage profile, coverage by company-based labor unions, applies to workers working for large and stable companies. The potential coverage of total workers by Japanese employment practices is quantitatively limited. According to the Employment Status Survey 2007, among about 53.6 million employees in the private sector, about 10.8 million work for companies hiring 1,000 employees or more. These figures imply that about 20 percent of workers in the private sector works for companies with 1,000 or more employees. Ono (2010) reports that the fraction of workers who work under informal long-term contracts is no more than 20 percent. Moreover, recent studies report that the long-term stagnation of the Japanese economy decreases the importance of Japanese employment practices, as evidenced by the increase of non-regular workers, the decreasing average tenure of workers, and the flattening age-wage profile (Hirokatsu et al. (ming), Kawaguchi and Ueno (2013) and Hamaaki et al. (2012)). Case studies also report that many large companies replace the ability-based pay system (*Shokuno kyu*) with a function based pay system (*Yakuwari kyu*) and that the wage-system reform brings wages closer to the value of marginal products (Ishida (2006)). The change of Japanese employment practices reflects that fact the practices are determined within market constraints. The distinction between legally binding institutions and informal practices is critically important.

Furthermore, the coordination of company-based wage bargaining called *Shunto* and the high fraction of bonus payment as part of the total compensation are claimed to accelerate the speed of the wage adjustment to productivity shock even faster than that of the US. The

Shunto (Spring Offensive) consists of the coordination of wage bargaining by individual labor unions and management. The contract period is one year, which is shorter than the typical contract in the US. Synchronized bargaining prevents a sluggish wage adjustment caused by unions' failure to coordinate. Ito (1992) pointed out that "[t]his annual synchronized contract negotiation makes wage adjustment more flexible in Japan than in other countries." Hashimoto (1979) explains the bonus payment as the mechanism to share the return to firm-specific human capital between a firm and a worker. The sharing aspect of bonus payment makes it more procyclical than the base monthly payment. Therefore, we have good reason to expect that a simple demand-supply framework works well to account for the movements of returns to college education in the last two decades.

Appendix: Data construction

Japan

Data source: 1986-1998, labor force special survey February survey, 40 thousand households; 1999-2001, labor force special survey February survey, 40 thousand households, August survey including 30 thousand household is not utilized; 2002-2008, labor force survey special survey form (form distributed in the second wave of the second year), 10 thousand households.

Sample construction: The sample consists of male aged between 25 and 59 who mainly work. Age categories are 25-29, 30-39, 40-49 and 50-59. Education categories are 1. high school graduate or below, 2. technical college/junior college graduate and 3. four year college graduate or above.

Hourly wage: Annual earnings is recorded in range in labor force survey. Based on basic survey of wage structure, we calculate the average wage for each annual earnings range in labor force survey. Annual earnings in the basic survey of wage structure is defined as cash earnings in June times 12 plus annual bonus amount in the previous year. Annual hours worked is calculated as hours worked in the previous week times 50. Hourly wage is calculated as annual earnings divided by annual hours worked. Hourly rate of pay is deflated to 2005 price using consumer price index. Self-employed workers are not included in the hourly wage calculation.

Relative wage index: Log hourly is regressed on quartic function of age, college graduate dummy, junior and technical college graduate dummy, the interaction terms of education dummy variables and age function, and prefecture dummy variables by year. Obtain predicted wage for each year, education and age categories. To obtain the predicted wage for age categories, we use 27, 35, 45 and 55. From the predicted wage, the relative wage of college graduate to high school graduate is calculated for each year and age categories.

Relative supply index: Aggregate supply for high school graduate and college graduate are defined as the hours worked in the previous week times the numbers of workers. The supply of technical and junior college graduates are prorated to high school graduates and college graduates based on their hourly wage. The fraction (technical/junior college graduates' hourly wage - high school graduates' hourly wage)/(college graduates' hourly wage - high school graduates' hourly wage) is allocated to high school graduates and the rest is allocated to college graduates. From the constructed aggregate supply indexes, the relative supply index is calculated for each year and age categories. Self-employed workers are included in the aggregate supply index calculation.

The United States

Data source: 1975-2006 March current population survey downloaded from David Autor's data archive.

Sample construction: The sample consists of male aged between 25-59 who work excluding the workers whose wages are imputed. Workers with hourly wage below 1.675 dollar in 1982 dollar are excluded. Age categories are 25-29, 30-39, 40-49, and 50-59. Education categories are 1. high school graduate or below, 2. technical college/junior college graduate and 3. four year college graduate or above.

Hourly wage: Use hourly wage is calculated in the constructed data set. Hourly wage is deflated to 2000 price using chai-weighted price deflater for personal consumption expenditure.

Relative wage index: Log hourly is regressed on quartic function of age, college graduate dummy, junior and technical college graduate dummy, the interaction terms of education dummy variables and age function, and four regional dummy variables and black dummy by year. Obtain predicted wage for each year, education and age categories. To obtain the predicted wage for age categories, we use 27, 35, 45 and 55. From the predicted wage, the relative wage of college graduate to high school graduate is calculated for each year and age categories.

Relative supply index: Aggregate supply for high school graduate and college graduate are defined as the hours worked in the previous week times the numbers of workers. The supply of technical and junior college graduates are prorated to high school graduates and college graduates based on their hourly wage. The fraction (technical/junior college graduates' hourly wage - high school graduates' hourly wage)/(college graduates' hourly wage - high school graduates' hourly wage) is allocated to high school graduates and the rest is allocated to college graduates. From the constructed aggregate supply indexes, the relative supply index is calculated for each year and age categories. Self-employed workers are included in the aggregate supply index calculation.

Appendix: Previous estimates of the demand structure

Appendix Table A1. Estimates using alternative specifications and data

	(1)	(2)	(3)	(4)
Year	1963-2006	1963-2006	1963-2006	1963-2006
Sex	Male	Male Female	Male	Male Female
Group	Age	Age	Experience	Experience
Age-Specific Supply - Aggregate Supply	-0.212	-0.236	-0.176	-0.270
	(0.014)	(0.016)	(0.021)	(0.026)
Aggregate Supply	-0.308	-0.375	-0.493	-0.538
	(0.016)	(0.017)	(0.068)	(0.073)
Trend	0.015	0.018	0.028	0.025
	(0.000)	(0.001)	(0.004)	(0.004)
Age group F.E.	Yes	Yes	Yes	Yes
Trend squared	No	No	Yes	Yes
Observations	176	176	176	176
R-squared	0.956	0.961	0.9	0.881