12-21-2014

Why rapidly expanding the number of college-trained workers may not lower income inequality: the curious case of Taiwan, 1978-2011

Shao-Hsun Keng
National University of Kaohsiung, Taiwan

Chun-Hung A. Lin
Tamkang University, Taiwan

Peter Orazem
Iowa State University, pfo@iastate.edu

Why rapidly expanding the number of college-trained workers may not lower income inequality: the curious case of Taiwan, 1978-2011

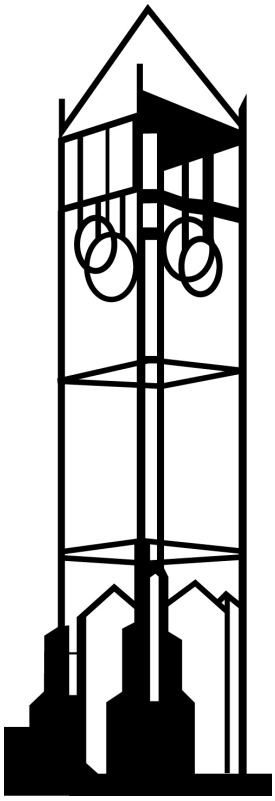
Abstract
Since 1990, Taiwan increased the college share of its labor force from 7% to 28% by converting junior colleges to 4-year colleges. Such a rapid surge in skill supply should suppress college wages and lower income inequality. Instead, inequality rose steadily. The surge of weaker college graduates made them weak substitutes for better trained college graduates, increasing wage inequality within skill groups. The college premium would have been 15% higher had college quality remained unchanged at its 1992 level. The Taiwan case shows that increasing college access alone will not lower income inequality unless college quality is maintained.

Keywords
education, returns to skills, wage inequality, college supply, college quality, Taiwan

Disciplines
Economics

Why rapidly expanding the number of college-trained workers may not lower income inequality: The curious case of Taiwan, 1978-2011

Shao-Hsun Keng, Chun-Hung Lin, Peter Orazem



Working Paper No. 14026
December 2014

IOWA STATE UNIVERSITY
Department of Economics
Ames, Iowa, 50011-1070

Why rapidly expanding the number of college-trained workers may not lower income inequality: The curious case of Taiwan, 1978-2011

Shao-Hsun Keng, National University of Kaohsiung, Taiwan
Chun-Hung Lin, Tamkang University, Taiwan
Peter F. Orazem, Iowa State University, USA

December 2014

Since 1990, Taiwan increased the college share of its labor force from 7% to 28% by converting junior colleges to 4-year colleges. Such a rapid surge in skill supply should suppress college wages and lower income inequality. Instead, inequality rose steadily. The surge of weaker college graduates made them weak substitutes for better trained college graduates, increasing wage inequality within skill groups. The college premium would have been 15% higher had college quality remained unchanged at its 1992 level. The Taiwan case shows that increasing college access alone will not lower income inequality unless college quality is maintained.

I. Introduction

Taiwan's labor market has absorbed a remarkable expansion in the supply of college educated workers over the past two decades. The annual number of college graduates increased five-fold in 20 years: from 56 thousand in 1990 to nearly 300 thousand in 2011. As shown in Figure 1, the surge in college graduates is nearly fully explainable by changes in government policy. Starting in 1990, junior colleges were converted into 4-year colleges and the required pass rate on the college entrance exam was relaxed. These policies greatly increased access to college, generating a substantial shift in the supply of college-educated labor. As a result, the ratio of high school graduates going to colleges in each year rose from 15% to 89%.[1]

Such a rapid change in the college share of the labor market overall and of the cohort of new market entrants in particular would be expected to have large effects on returns to schooling and income inequality in Taiwan. The impact on the distribution of skills in the labor force is shown in Figure 2. Between 1990 and 2011, the share of labor force comprised of 4 year college graduates rose from 7% to 28%. The largest effects should be on the earnings of new market entrants, as the ratio of new college graduates to the number of 22-24 year olds rose from 12% to 73%.[2]

[1] The dropout rate in colleges is less than 2% (MOE, 2014).

[2] This is computed as $\frac{\text{college graduates in year t}}{(\text{population aged 22-24 in year t})/3}$

In contrast to the Taiwan case, a key factor explaining rising wage inequality in many OECD economies has been the slow growth of the supply of college graduates relative to rising trend growth in technology that drives demand for college-educated labor (OECD, 2011). While the college share of the Taiwan labor force was rising at 7.3% per year over the past 15 years, the OECD average growth rate was 3.7%.[3] The average growth rate of the college share in the G-7 was even smaller at 2.8%, and smaller still is the 1.3% growth rate in the U.S. As shown initially by Katz and Murphy (1992) and updated by Goldin and Katz (2008), growth in the relative supply of college graduates in the labor market will tend to lower the returns to college and reduce wage inequality provided the growth in college supply outpaces the growth in relative demand for college graduates. Indeed, college wages fell relative to wages for less educated workers from 1915 to 1960 because the supply of skills outpaced technological expansion. Since 1980, however, relative demand for college graduates has grown faster than relative supply in many of the OECD countries, even though the pace of skill-based technical change slowed since the mid-1990s.[4]

[3] Computed using data from OECD (2012).

[4] A related literature has examined whether there is a common tendency across countries for income inequality to rise or fall as human capital attainment increases. Knight and Sabot (1983) showed that the answer depended on whether the human capital investments are broadly distributed in the population and whether supply of or demand for skills grows faster. De Gregorio and Lee (2002) and Sylwester (2002) found that rising educational attainment or public educational expenditures lowered inequality but Rodríguez-Pose and Tselios (2009) found that increasing tertiary schooling increased inequality in European countries.

The slowing of the growth of skill supply has been most pronounced among the youngest labor cohorts. Card and Lemieux (2001) showed that a relative skill shortage among the youngest cohorts of labor market entrants drove rising returns to young college graduates in the 1990s in Canada, the U.K. and the U.S., even as rates of return stabilized for older college graduates.

If slow growth of the supply of college graduates relative to the pace of technological change favoring skill is at least partially responsible for rising inequality among the OECD economies, the Taiwan case should represent a useful counterexample. With the Taiwan college graduate share of the workforce rising at twice the OECD rate, and the Taiwan college share among young labor market entrants rising even more rapidly, the growth of relative college supply in Taiwan outpaces any estimate of the technology growth rate. More importantly, the college enrollment surges coincide with a presumed reduction in the quality of college graduates which would further depress the Taiwan college premium. Carneiro and Lee (2011) use college enrollment rates across regions of birth in the U.S. to identify the effect of college quality on the wage premium. They find that increases in college enrollment between 1960 and 2000 lowered the average quality of college graduates, leading to a 6 percentage point decline in college premium.

Chen (2013) used data from the Taiwan Manpower Survey to examine the

expansion of post-secondary education on the college premium in Taiwan. Applying Card and Lemieux's (2001) framework, she found that despite the substantial increases in the supply of college graduates, the college premium did not fall. Moreover, her measure of changes in the quality of college graduates, the share of vocational relative to academic high school graduates, did not affect the college wage premium. She concluded that the increase in the relative supply of college graduates was completely absorbed by the rising relative demand for college graduates across all age groups. Her results leave a remaining puzzle: the college premium for older college graduates rose, even as college returns remained steady overall.

Our paper differs from Chen's (2013) in several ways. First, we use data from the Taiwan Survey of Family Income and Expenditure (SFIE), 1978-2011 rather than the Taiwan Manpower Survey. Unlike the Manpower Survey, the SFIE includes commissions, bonuses, stock options, profit and gain sharing, and other forms of performance pay. Performance pay is an increasingly important component of a worker's total compensation (Lazear, 2000; Lemieux *et al.*, 2009; Heywood and Parent, 2009; Pannenberg and Spiess, 2009; Bell and Van Reenen, 2013) in many countries including Taiwan, and is particularly important for college graduates. As we show below, the stable or declining trend in income inequality found by Chen using the Manpower data is completely reversed once performance pay is included

with wage income.[5] This is consistent with the experience in the U.S. that the income inequality among male workers from the 1970 to the early 1990s would have been 21% less if performance pay was not included (Lemieux *et al.*, 2009).

A second difference is that we follow Carneiro and Lee (2011) in measuring quality differences between young and old college workers. Chen's quality measure averages across young and old college graduates which implicitly presume that older and younger college graduates have equal skills.

A third difference is that we use methods employed by Autor, Katz and Kearney (2008) and Lemieux (2009) to construct quality-constant and composition-constant counterfactual paths for wages per unit of human capital and labor market composition. These allow us to illustrate how returns to post-secondary education evolved for older and younger cohorts of college graduates.

This study reaches markedly different conclusions from Chen's regarding the effects of the unprecedented increase in the supply of college graduates in Taiwan on college premium. Our key findings include: (1) there are sharp increases in the returns to college education but these gains are disproportionately earned by older cohorts of college graduates; (2) driving these findings is the fact that the newer college graduates are of lower average quality than older college cohorts and as a

[5] Studies of income inequality using the Manpower Survey which excludes the bonus from compensation include Chan, *et al.* (1999), Chen and Hsu (2001), Cheng (2004), and Chen (2013).

result, young college graduates and graduates who previously were excluded from college are weak substitutes for older college graduates; (3) the return to college would have been 8-15% higher if the quality of young college graduates had remained at their 1992 levels; (4) both wage per unit of human capital and education composition of the labor force contribute to the decline in the relative college premium earned by of young workers after the expanded access to college; and (5) the expansion of college enrollment widens wage inequality both between old and young college graduates, but also within the group of young college graduates due to the increasing variance in college quality.

The next two sections present the stylized facts of schooling outcomes and wage inequality in Taiwan from 1978 to 2006. Section IV shows that a model with imperfect substitution between older and younger college graduates and between high and low quality college graduates can explain the diverging paths of college wage premia for young and old workers. Section V concludes the paper.

II. Background

Taiwan has experienced two waves of expansion in higher education over the past two decades. The first wave started around 1991 as two-year colleges were allowed to change to four-year colleges called Institutes of Science and Technology. As shown in Figure 1, 68 4-year Institutes of Science and Technology had opened by

2000. A second wave of expanded college access began around 1997 when the newly formed 4-year colleges were allowed to convert to Universities of Science and Technology if they had at least three colleges. Over the same period, the minimum acceptable score on the college entrance exam was lowered considerably, and the fraction qualifying for college rose from 35% to 58%. As a result, college enrollments more than doubled. By 2003, there were as many college graduates as there were high school graduates four years earlier. As illustrated in Figure 2, the surge in college enrollments rapidly increased the share of college graduates in the labor force from 7.2% to 28%. The impact on younger cohorts was even more pronounced, as 73% of the population aged 22-24 had a 4-year college degree.

Such a rapid expansion of the supply of college graduates would normally be expected to lower returns to college, reducing wage inequality. A similar rapid expansion of college graduation rates occurred in Korea in the 1970s. Between 1972 and 1989, the college share of the labor force rose from 14% to 25%. Kim and Topel (1995) and Fields and Yoo (2001) found that wage inequality fell rapidly as the college share of the labor market increased. But returns to college actually rose in Taiwan despite the supply surge (Lin and Orazem 2003, 2004). However, workers with less than 10 years in the labor force did experience declining returns to college.[6]

[6] Chen and Hsu (2001) argued that the college expansion in Taiwan led to declining wage inequality. However, their analysis focused only on young males with 10 years or less of work experience. Their

If the slow expansion of the college educated work force is viewed as a main factor in rising college return in the United States, Canada, and the UK (Card and Lemieux,2001; Goldin and Katz, 2008), then the failure of the rapid increase in college supply to depress college premium significantly in Taiwan is a puzzle. A plausible explanation which we explore in this paper is that the expansion of college access generated college graduates who were not of the same quality as graduates of the traditional 4-year universities. If Taiwan employers discount the skills earned at the converted 2-year colleges relative to those of graduates at traditional programs, wage inequality will rise among the new cohorts of college graduates. At the same time, if young and old college graduates are not perfect substitutes, the return to college for older workers will be only partially affected by the surge in college supply.

III. Trends in Three Measures of Wage Inequality in Taiwan

We start by summarizing the stylized facts of the wage structure over the past three decades in Taiwan. We use annual wage income that includes performance pay from the SFIE 1978-2006. The time series ends at 2006, the last year individual data from the SFIE was made publicly available. For what follows in this section, we define college educated workers as those with a college degree or above while our high school educated group includes those with a high school degree. Figure 3

---

study also ignored bonuses which are most important in high skill jobs and excluded omen who represented rapidly growing share of the labor force.

shows the overall and age specific time paths of the college plus wage premium over the past 30 years. The average premium over a high school degree doubled between 1978 and 1992 and then remained fairly stable thereafter. The age-specific time paths show that the overall pattern masks diverging wage experiences for the younger and older college graduates. While younger college workers enjoyed a higher wage premium than older workers throughout the 1980s, as college access increased after 1993, the returns to younger college workers fell from 43% in 1993 to 37%. In contrast, the college plus premium continued to grow for older college graduates, rising from 49% to 70% during the same time period. The negative impact of the rising relative supply of college-educated workers on wage premium is confined to younger workers only, while relative demand for older college-trained workers rose throughout. As shown in Figure 4, the difference in the college plus wage premium between younger (26-35) and older (46-55) workers gets progressively more negative after the early 1990s. The implication is that the wage gap between young and old college-educated workers is growing faster than the wage gap between young and old high-school educated workers.[7]

Additional insights can be garnered by exploring the return to college across different age cohorts during the period of rapidly expanding college access. Figure

[7] $\ln\left(\frac{w^C_{4655}}{w^H_{4655}}\right) - \ln\left(\frac{w^C_{2635}}{w^H_{2635}}\right) = \ln\left(\frac{w^C_{4655}}{w^C_{2635}}\right) - \ln\left(\frac{w^H_{4655}}{w^H_{2635}}\right)$

5A plots the college plus/high school wage gap for five age groups. The youngest workers (solid line, aged 26-30) experienced a rising college plus wage premium until 1993 after which the premium fell. For older cohorts, the college wage premium rose over time with the highest premium in 2003-2006. Moreover, the fastest growing college plus premia were for the ages more distant from the youngest cohorts. The pattern is consistent with both presumptions that the young and old college-educated workers are imperfect substitutes and that the young were receiving poorer college training compared to older college graduates.

The role of cohort-specific supply shocks is further illustrated in Figure 5B. Before the 1990s, the ratio of college plus-to-high school educated workers grew similarly for older and younger cohorts. After the change in college access began, the ratio of college plus to high school educated workers grew much more rapidly for the youngest cohorts. If college-educated workers with different levels of experience are imperfect substitutes, then the sharp increase in college shares for younger workers will depress wages most for the young college graduates but would have less impact, if any, on the wages of older cohorts of college graduates. In fact, the simple correlation between relative supply of and relative wages for college graduates is weekly negative for the youngest cohorts but is strongly positive for the oldest college cohorts. The latter result is consistent with pervasive shifts of relative

demand toward college graduates that are outstripping supply growth, similar to the pattern observed in many of the OECD economies. However, the growth of college supply appears to be outpacing skill-biased technological change for the youngest cohorts.

IV. The Effect of Age-Specific Supplies and School Quality on College/High School Wage Inequality

We adapt the methods used by Card and Lemieux (2001) and Autor, Katz and Kearney (2008) to the Taiwanese labor market. We divide the labor force at any time *t* into two groups, high school educated workers H_t and college educated workers C_t.[8] Each of these education groups is composed of *J* age cohorts within each education group according to:

$$C_t = \left[\sum_j^J (a_j C_{jt}^{\eta})\right]^{1/\eta} \quad (1)$$

$$H_t = \left[\sum_j^J (b_j H_{jt}^{\eta})\right]^{1/\eta} \quad (2)$$

The elasticity of substitution between different age groups (σ_A) is positively related to η, $\infty < \eta \leq 1$, by the relation $\eta = 1 - \frac{1}{\sigma_A}$. C_t and H_t are measured in efficiency units. The parameters a_j and b_j are constant technology parameters that allow productivity to vary across age cohort *j* for high school and college laborers, respectively.

[8] Results are unchanged if we use three groups, high school or less, junior college and Bachelor's degree or more

The rapid growth of the supply of college graduates in Taiwan involved relaxing the passing standards on the college entrance exam and converting junior colleges to four-year colleges, changes that should lower the quality of a portion of the new cohorts of college graduates compared to older cohorts. This suggests that there will be imperfect substitutability between C_{Tjt}, "Traditional" college graduates who would have met the previous entrance requirements and received training of traditional quality; and C_{Njt}, "Nontraditional" graduates who would not have met the previous entrance standards nor received the traditional level of training. As a result, we further modify the efficiency units of a college cohort by:

$$C_{jt} = \left(C_{Tjt}^{v} + C_{Njt}^{v}\right)^{\frac{1}{v}} \tag{3}$$

$$v = 1 - 1/\sigma_{college}$$

The parameter v sets the magnitude of $\sigma_{college}$, the elasticity of substitution between the traditional and nontraditional graduates in a college age cohort.

We do not observe separate wage series for traditional and nontraditional college graduates. We assume that the observed natural log of the college wage for a given cohort, $\log\left(w_{jt}^{C}\right)$ will be related to the wage for the traditional college graduates according to:

$$\log\left(w_{jt}^{C}\right) = \log\left(w_{jt}^{TC}\right) + r log\theta_{jt} \tag{4}$$

where w_{jt}^{TC} is the unobserved wage of traditional college graduates, and $\theta_{jt} \in (0,1]$

is the share of college workers for age group *j* that meet the traditional college standards. Because $log\theta_{jt} < 0$, we would expect *r > 0* so that the average college wage is smaller than the wage paid to the traditional college graduates. As the traditional share of a college cohort *j* falls, the gap between the average college wage and that paid the traditional fraction in the cohort rises, meaning that within cohort inequality will decrease in θ_{jt}. In the limit when $\theta_{jt} = 1$ as is the case with the oldest college graduates, the observed average college wage is equal to the wage paid the traditional college graduates in the cohort and there will be no within group inequality. On the other hand, within group inequality will be increasing for the youngest cohorts of college graduates as the college entrance requirements are relaxed and as more two-year colleges are converted to Bachelor's degree granting institutions.

The aggregate production function is given by the CES form:

$$y_t = \left[\alpha_t C_t^{\rho} + (1-\alpha) H_t^{\rho}\right]^{\frac{1}{\rho}} \quad (5)$$

where $-\infty < \rho \leq 1$ sets the elasticity of substitution σ_{edu} between the two education groups; $\left(\rho = 1 - \frac{1}{\sigma_{edu}}\right)$; and α_t is time varying technology or demographic changes that alter the skill share of production. Using the chain rule, the marginal products of workers from traditional universities and high school in age group *j* at time *t* are given as follows:

$$\frac{\partial q_t}{\partial C_{Tjt}} = \frac{\partial q_t}{\partial C_t}\frac{\partial C_t}{\partial C_{jt}}\frac{\partial C_{jt}}{\partial C_{Tjt}} = \left(a_j \alpha_t q_t^{1-\rho} C_{jt}^{\eta-1} C_t^{\rho-\eta}\right) \times \theta_{jt}^{v-1} \quad (6)$$

$$\frac{\partial q_t}{\partial H_{jt}} = \frac{\partial q_t}{\partial H_t}\frac{\partial H_t}{\partial H_{jt}} = \left[b_j(1-\alpha_t) q_t^{1-\rho} H_{jt}^{\eta-1} H_t^{\rho-\eta}\right] \quad (7)$$

where $C_{Tjt} = \theta_{jt} C_{jt}$. The first-order condition requires that all education cohorts are paid their marginal products. Because we observe w_{jt}^C rather than w_{jt}^{TC}, equation (4) suggests that we add $rlog\theta_{jt}$ to both sides of the first-order condition for traditional college graduates. Imposing these conditions, the relative wage of college to high school graduates in cohort *j* in year *t* becomes:

$$\ln\left(\frac{w_{jt}^C}{w_{jt}^H}\right) = \ln\left(\frac{\alpha_t}{1-\alpha_t}\right) + \ln\left(\frac{a_j}{b_j}\right) - \frac{1}{\sigma_{edu}}\ln\left(\frac{C_t}{H_t}\right) - \frac{1}{\sigma_A}\left[\ln\left(\frac{C_{jt}}{H_{jt}}\right) - \ln\left(\frac{C_t}{H_t}\right)\right]$$
$$-(v-1+r)\ln(\theta_{jt}) \quad (8)$$

Equation (8) can be estimated directly under the assumption that the college and high school educated cohorts represent exogenous supply shifts to the Taiwanese labor market. The first term on the right hand side of Equation (8) captures shifts in relative demand toward or away from skilled labor. Following Autor, Katz, and Kearney (2008), these shifts can be captured by a time trend, the male unemployment rate (a business cycle indicator) and the minimum wage. The $ln\left(\frac{a_j}{b_j}\right)$ term represents the relative productivity of the two education groups in cohort *j* whose effects are controlled through age group dummies. The next two terms allow us to estimate the elasticities of substitution between education groups and between age groups. The last term provides an upper-bound estimate of the substitutability between traditional

and nontraditional college graduates because, with $r>0$, $\frac{1}{1-\upsilon-r} > \frac{1}{1-\upsilon} = \sigma_{college}$.

We use an inverse approximation of θ_{jt}: $\log(P_j)$ the log pass rate on the college entrance exam four years before the cohort graduation date. As the pass rate rises, the average quality of the college cohort should fall, whether because a greater proportion received training at inferior colleges or because entrants to traditional colleges were of lower average quality.[9] There are two important reasons to use the pass rate on the entrance exam rather than the fraction of the college cohort graduating from the traditional colleges. First, the pass rate is the exogenous policy variable that affects college choice while the fraction going to traditional or nontraditional colleges reflects the endogenous response to the changing access to college. Second, the pass rate will alter the distribution of skills of the college graduates regardless of which college they went to. Not only will weak students go to the converted junior colleges, the rosters of the traditional colleges will also be drawn from a pool that includes many previously unqualied exam scores. Therefore, the rising pass rate is a better indicator of the likely declining skill levels of progressive cohorts of college graduates than is the fraction of the cohort graduating from a traditional colleges.

[9] We also used the fraction of Bachelor's degrees from newly converted colleges, getting estimates that were similar in sign and significance. The Bachelor's degree data includes older graduates and so it is harder to tie them to a given age cohort.

IV. Empirical Results

Table 1 reports the estimates of Equation (8). We obtain similar results, whether we use the method suggested by Card and Lemieux (2001) or that used by Autor, Katz and Kearney (2008). The coefficient on $\log\left(\frac{C_{jt}}{H_{jt}}\right)$ implies that a one percent increase in the relative college to high school supply for age group *j* leads to a 0.07 percent decrease in the college-high school wage gap. The implied elasticity of substitution between age groups is 14, which is greater than corresponding estimates of 4 to 6 reported for the U.S. (Card and Lemieux, 2001; Autor, Katz, and Kearney, 2008). We get a similar effect of the aggregate college to high school employment ratio $\log\left(\frac{C_{jt}}{H_{jt}}\right)$ on the college-high school pay gap. A one percent increase in the ratio of college to high school workers depresses the relative wage by 0.07 percent, implying an elasticity of substitution between education groups of 14 which is also 3-4 times larger than that found in the U.S. Two factors potentially are responsible for getting large elasticities of substitution as opposed to those in other papers. First, we do not observe hours worked in SFIE. Labor supply is thus constructed using the number of workers, rather than the number of hours worked. The relative supply of college to high school equivalents are likely to be highly correlated across years unless the composition of educational attainment in the labor force changes significantly. Second, we correct for the quality of college graduates over time

making college and high school groups more homogeneous, which tends to increase the elasticity of substitution within groups.It is apparent that school quality also plays a role in the college premium. A one percent increase in the pass rate on the entrance exam reduces the college-high school pay gap by 0.13 percent. The implied upper-bound of the elasticity of substitution between traditional and nontraditional college graduates is $\frac{1}{1-v-r} = \left(\frac{1}{0.13}\right) = 7.7$. We can correct for the bias by deriving an estimate of *r* in equation (4). We regressed the cohort-specific log college wage $\log\left(w_{jt}^{C}\right)$ on the logarithm of the cohort's college entrance exam pass rate $logP_j$, time and age group dummies. The coefficient on $logP_j$ is -0.36, implying that $r = 0.36$. The implied elasticity of substitution between college workers with different quality is $\frac{1}{1-v} = \left(\frac{1}{0.13+0.36}\right) = 2.04$. The literal implication is that the nontraditional college graduates are relatively weak substitutes for similarly aged graduates from traditional programs.

For robustness, we re-estimated equation (8) excluding junior college graduates who had been included with the high school group. One might be concerned that including the junior college graduates with the high school graduates would artificially increase the measured substitutability between college and high school workers. However, the coefficient estimates barely change when the two-year college workers are excluded.

Skilled-Biased Technical Change is often cited as the main cause for the shift in relative demand favoring skilled labor and the subsequent rising college plus premium in Europe and North America. In Taiwan, we would expect a similar process to be driving relative labor demand toward college-educated workers. Indeed we see that process clearly for the oldest college cohorts in Figures 5A and 5B. The older college graduates experienced progressively higher relative pay compared to their high school educated counterparts. However, at the same time we see declining wage premia for the youngest college educated workers. More recent college graduates are not experiencing the same productivity boost from complementary capital investments, consistent with our hypothesis that the rapid expansion of college enrollment lowered the average quality of young college graduates.

While the nontraditional college graduates are not getting a premium for their schooling, the wages of the traditionally-educated college graduates in their age cohort are only moderately depressed by the large cohort of weak college graduates. Weak substitutability between traditional and nontraditional college graduates means that the surge in college graduates should create a pay gap between weak and strong college graduates in the same graduating class.

Quality-Adjusted College Premium

In this subsection, we examine the extent to which falling quality of college

educated workers accounts for the stagnation of college plus premium after early 1990s. We construct a quality-adjusted time series of the college plus premium by fixing the quality of college-educated worker alternatively at the 1978 and 1992 levels. Since the pass rate of the college entrance exam is used as a proxy for quality, we use the estimates from Equation (8) to predict the quality-adjusted wage gap for each age group. We are particularly interested in younger workers because they are affected the most by the expansion of higher education.

Figure 6 demonstrates how college wage premia were altered by college quality changes since 1978 and Figure 7 shows how college quality changes since 1992 affected the college wage premia. For workers aged 46-55, the unadjusted college plus premia grew until 1987 and then stagnated for 10 years before resuming its growth. The period of stagnating premia for 46-55 year-olds corresponds to a 10 year increase in the college entry pass rate for that cohort 20 years earlier. In contrast, when college quality is held at its 1978 and 1992 levels, the adjusted college plus wage premium rises steadily through the entire period, reflecting steadily increasing demand for skill. In addition, other than the 10-year anomaly attributable to the temporary relaxing of college entry standards in the 1960s, the gaps between the adjusted and unadjusted series are very small. This suggests that the expanded access to higher education did not significantly depress the college premium for older

college educated workers.

The pattern of college wage premia for the younger workers aged 26-35 is very different. The unadjusted series of college wage premia rose steadily until the first graduates under the expanded college supply began to enter the market. When college cohort quality is held at the 1978 level or at its 1992 level, the college wage premia continues to rise until 2002 and levels off thereafter. The diverging pattern of wage premia between the quality adjusted and the quality varying series after the mid 1990s is consistent with progressively declining quality of college educated workers in the younger group. The wage premium would have been 8% higher had college quality stayed at its 1978 level and 15% higher had college quality remained at its 1992 level. The expanded college access appears to affect the wages of younger graduates only, consistent with the earlier findings that young and older college educated workers are not perfect substitutes. As a result, the expansion of college enrollment increases wage inequality between older and younger college-educated workers.

Decomposition of the Wage and Composition Effect

The significant post-1990 decline in the college plus premium of younger workers relative to older ones coincides with the expansion of college education. Hence, it is important from policy point of view to examine the extent to which changes in labor

force composition and relative wages contribute to the decline in the college plus premium among young workers. We use $\log\left(\frac{w^c_{t2635}}{w^h_{t2635}}\right) - \log\left(\frac{w^c_{t4655}}{w^h_{t4655}}\right) = \log\left(\frac{w^c_{t2635}}{w^c_{t4655}}\right) - \log\left(\frac{w^h_{t2635}}{w^h_{t4655}}\right)$ to measure the relative college plus premium of younger workers to the older ones. The second term shows the difference in the relative wages of the young vs. old between workers with a college plus and high school degree. To estimate the contribution of the increase in college enrollment to the decline in the relative college premium of young workers, we construct a counterfactual distribution of wages in the absence of college expansion using the reweighting approach devised by DiNardo, Fortin, and Lemieux (1996) and used by DiNardo and Lemieux (1997), Lemieux (2006), and Autor et. al. (2008). Our counterfactuals fix relative wages at their 1978, 1992 and 2006 levels and allow the composition of the labor force to evolve at historical rates. The reweighting function is calculated by a logit model that includes dummies for educational attainment, potential experience, a quadratic in potential experience, the interaction of potential experience with educational attainment, and the interaction of the pass rate on the college entrance exam with a college dummy variable. Our counterfactuals take into account changes in quality of college-educated workers. The series are shown in Figure 8. The vertical difference between the counterfactual and actual wage series represents the effect of changes in wages on the relative college premium of young workers, holding labor force

composition constant. The changes in values from start to end of the counterfactual series show the effect of changes in labor force composition while holding the wages constant.

The actual series shows that the college premium of young workers was slightly higher than that of older workers until 1992. A wage premium gap favoring older college workers has grown wider ever since. By 2006, the college premium for older workers was 0.34 log points higher than the premium for younger workers.

The counterfactual series show that had relative wages remained at the 1978 level, demographic shifts would have favored young college graduates. Had they stayed at the 1992 level, the young would have only experienced moderately lower premia But demographic shifts that greatly expanded the labor market share of young college graduates cause substantial reductions in the college plus premium for younger workers when relative wages were fixed at their 2006 levels. The timing of the decline coincides with the large influx of college graduates into the labor market.

Table 2 summarizes the changes in the observed and composition-constant relative college premium of young workers. The relative college premium of younger workers declined by 1.5 log points from 1978 to 1992 and by an additional 33.6 log points from 1992 to 2006. Regardless of the year in which we fix the demographic composition, there are large reductions in the college wage premium for the young in

the post 1992 period. The adverse wage effect on the young is largest when the labor force composition is fixed at 2006. Looking down the columns, we find substantial reductions in college premia due to changes in the share of young college graduates in the labor force. Looking across the columns while holding composition of the labor force constant, we also find substantial reductions in the college premia due to declining returns to young college graduates. In sum, both changes in relative wages and changes in labor force composition have contributed to the rising gap in the college premium between young and old workers.

V. Conclusions

This paper is motivated by the rapid increase of college-educated workers resulted from the expansion of higher education beginning in early 1990s. The college plus/ high school wage gaps of young and older workers have moved in the polarizing directions over the past two decades. In particular, the college premiums for younger workers have fallen substantially while the premiums for older workers have risen significantly.

Our model allows for imperfect substitutability between traditional and newly converted college workers. We argue that the divergent trends of the college plus/high school wage gaps between young and older workers can be largely explained by the age-specific relative supplies, falling productivity of young college

graduates, and the continued rise in the demand for skilled labor. As a result, the firms substitute more experienced college-trained workers for their less experienced counterparts, leading to falling college premia for younger college graduates even as college premia are rising for older graduates. Our results consistently show that falling quality of college education due to the relaxation of college access plays an important role in falling returns to young college graduates. The college plus premium would have been 8-15% higher had the quality of young college remained at their 1992 levels.

Our findings differ from Chen's (2013) conclusion that changes in the quality of college graduates did not affect the college wage premium. The increase in the relative supply of college graduates is completely absorbed by the rising relative demand for college graduates across all age groups. The factor driving this discrepancy is that Chen's quality measure averages across young and old college graduates. This implicitly presumes that older and younger college graduates have equal skills, an assumption that proves inconsistent with the data.

The rising relative supply of young college-educated workers as well as their lower average quality have both contributed to the decline in the college wage premium for younger workers. At the same time, skill-biased technical change has increased the college premia earned by older college graduates who were only

educated in the better traditional universities. In addition, younger and older college graduates are imperfect substitutes and so the adverse impacts of rising college-educated labor supply were disproportionately absorbed by the youngest college cohorts. As a result, the rapid increases in college supply in Taiwan increased wage inequality between young and old college graduates and among young college graduates educated in traditional and newly formed four-year universities. As the Taiwan case shows, increasing access to college without maintaining quality can raise rather than lower income inequality in the economy.

References

Acemoglu, Daron, and David Autor. 2011. “Skills, Tasks and Technologies: Implications for Employment and Earnings.” *Handbook of Labor Economics Volume 4, Part B*: 1043-1171.

Autor, David H., Lawrence Katz and Melissa S. Kearney. 2008. “Trends in U.S. Wage Inequality: Revising the Revisionists.” *The Review of Economics and Statistics* 90(2): 300-323.

Cancian, M., and Reed, D. 1999. “The Impact of Wives’ Earnings on Income Inequality: Issues and Estimates.” *Demography*, *36*(2): 173-184.

Card, David and Thomas Lemieux. 2001. “Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis.” *Quarterly Journal of Economics.* 116 (2): 705-746.

Chan, V. L., Chen, L. T., & Hu, S. C. 1999. “Implications of Technology and Education for Wage Dispersion: Evidence from Taiwan.” *Essays in Memory of John CH Fei: The political economy of Taiwan's development into the 21st century*, *2*, 247.

Chen, Uniko. 2013. “The Impact of the Expansion in Post-Secondary Education on the Labor Market in Taiwan.” Ph.D. Dissertation, Department of Economics, University of Michigan.

Chen, Been-Lon and Mei Hsu. 2001, “Time-Series Wage Differential in Taiwan: The Role of International Trade.” *Review of Development Economics* 5(2): 336-54.

Cheng, P. C. 2004. Educational Expansion and Wage Inequality: A Cohort Analysis of Full-Time Male Employees in Taiwan. *Taiwan Economic Review, 32*(2), 233-266.

Daly, M. C., and Valletta, R. G. 2006. “Inequality and Poverty in United States: The Effects of Rising Dispersion of Men's Earnings and Changing Family Behaviour.” *Economica*, *73*(289): 75-98.

De Gregorio, J., & Lee, J. W. 2002. “Education and income inequality: new evidence from cross-country data.” *Review of Income and Wealth*, *48*(3): 395-416.

DiNardo, John, Nicole M. Fortin, and Thomas Lemieux. 1996."Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach." *Econometrica* 64(5): 1001-1044.

Fields, Gary S. and Gyeonjoon Yoo. 2000. "Falling Labor Income Inequality in Korea's Economic Growth: Patterns and Underlying Causes." *Review of Income and Wealth* 46(2): 139-159.

Goldin, Claudia and Lawrence F. Katz. 2008. *The Race Between Education and Technology.* Cambridge, MA: Harvard University Press.

Katz, Lawrence F. andKevin M. Murphy. 1992. "Changes in Relative Wages, 1963–1987: Supply and Demand Factors. *The Quarterly Journal of Economics* 107(1): 35-78.

Kim, Dae-Il and Robert H. Topel. 1995. "Labour Markets and Economic Growth: Lessons from Korea's Industrialization, 1970-1990," in R. B. Freeman and L. F. Katz, eds. *Differences and Changes in Wage Structures* Chicago: University of Chicago Press.

Knight, J. B., and Sabot, R. H. 1983. "Educational expansion and the Kuznets effect." *American Economic Review, 73*(5): 1132-1136.

Lemieux, Thomas. 2006. "Increasing Residual Wage Inequality: Composition Effects, Noisy Data, or Rising Demand for Skill?" *American Economic Review* 96 (3): 461-498.

Lemieux, T., MacLeod, W. B., & Parent, D. 2009. "Performance pay and wage inequality." *The Quarterly Journal of Economics*, *124*(1), 1-49.

Lin, Chun-Hung and Peter F. Orazem. 2003. "Wage Inequality and Returns to Skill in Taiwan, 1978–96." *The Journal of Development Studies* 39(5):89-108.

Lin, Chun-Hung and Peter F. Orazem. 2004. "A Reexamination of the Time Path of Wage Differentials in Taiwan." *Review of Development Economics* 8(2): 295–308.

Ministry of Education, Republic of China. 2014. *Education Statistics of the Republic of China*. Taipei, Taiwan.

Organization for Economic Cooperation and Development. 2011. *Divided We Stand: Why Inequality Keeps Rising.* Paris: OECD.

Organization for Economic Cooperation and Development. 2012. *Education at a Glance: OECD Indicators.* Paris: OECD.

Pencavel, J. 2006. “A Life Cycle Perspective on Changes in Earnings Inequality among Married Men and Women.” *The Review of Economics and Statistics*, *88*(2): 232-242.

Rodríguez-Pose, Andrés, and Vassilis Tselios. 2009. "Education and Income Inequality in the Regions of the European Union." *Journal of Regional Science* 49 (3): 411-437.

Sylwester, K. 2002. “Can education expenditures reduce income inequality?” *Economics of education review*, *21*(1), 43-52.

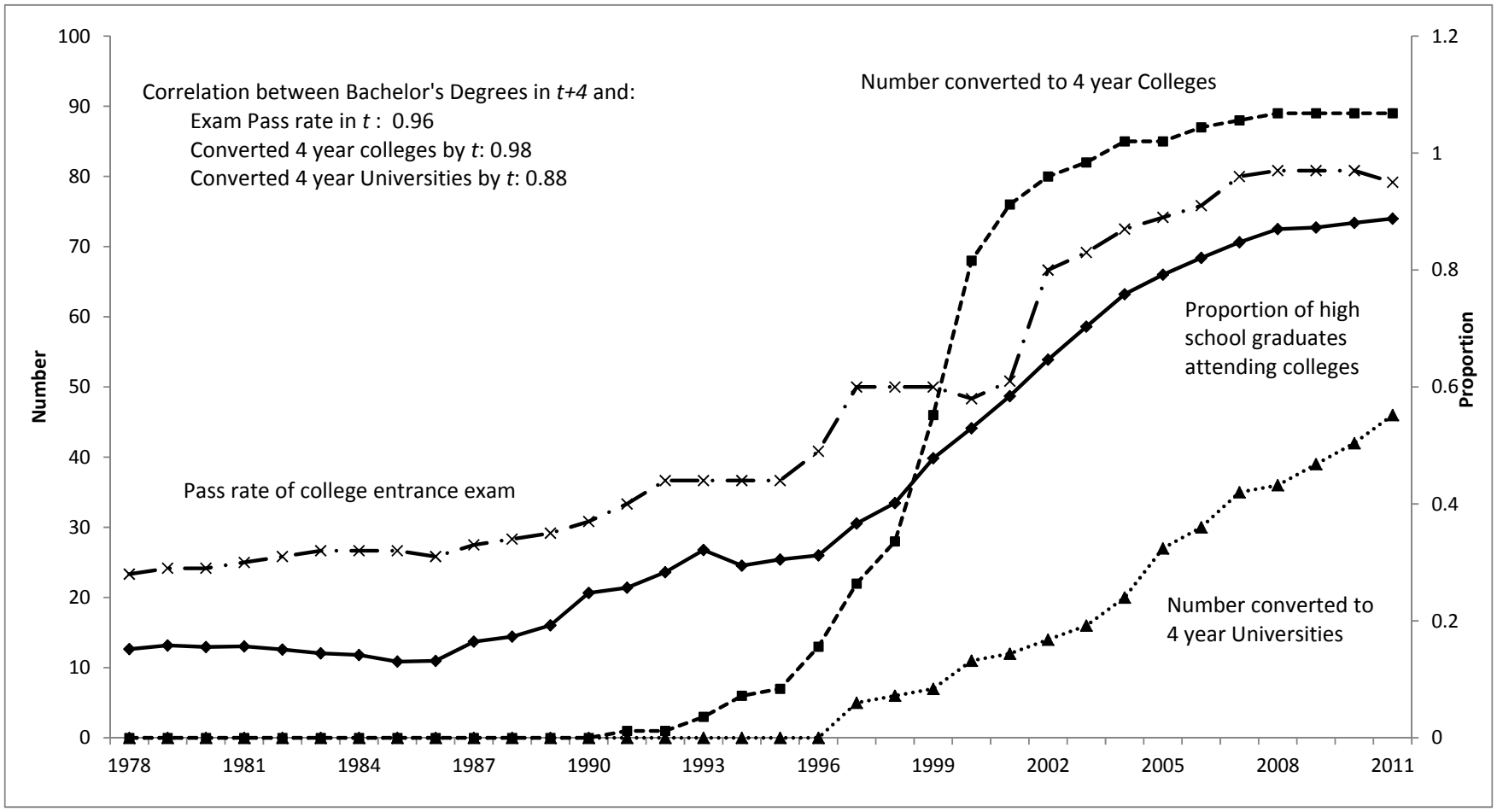


Figure 1: University qualification pass rates, converted junior colleges, and share of high school graduates attending universities in Taiwan, 1978-2011

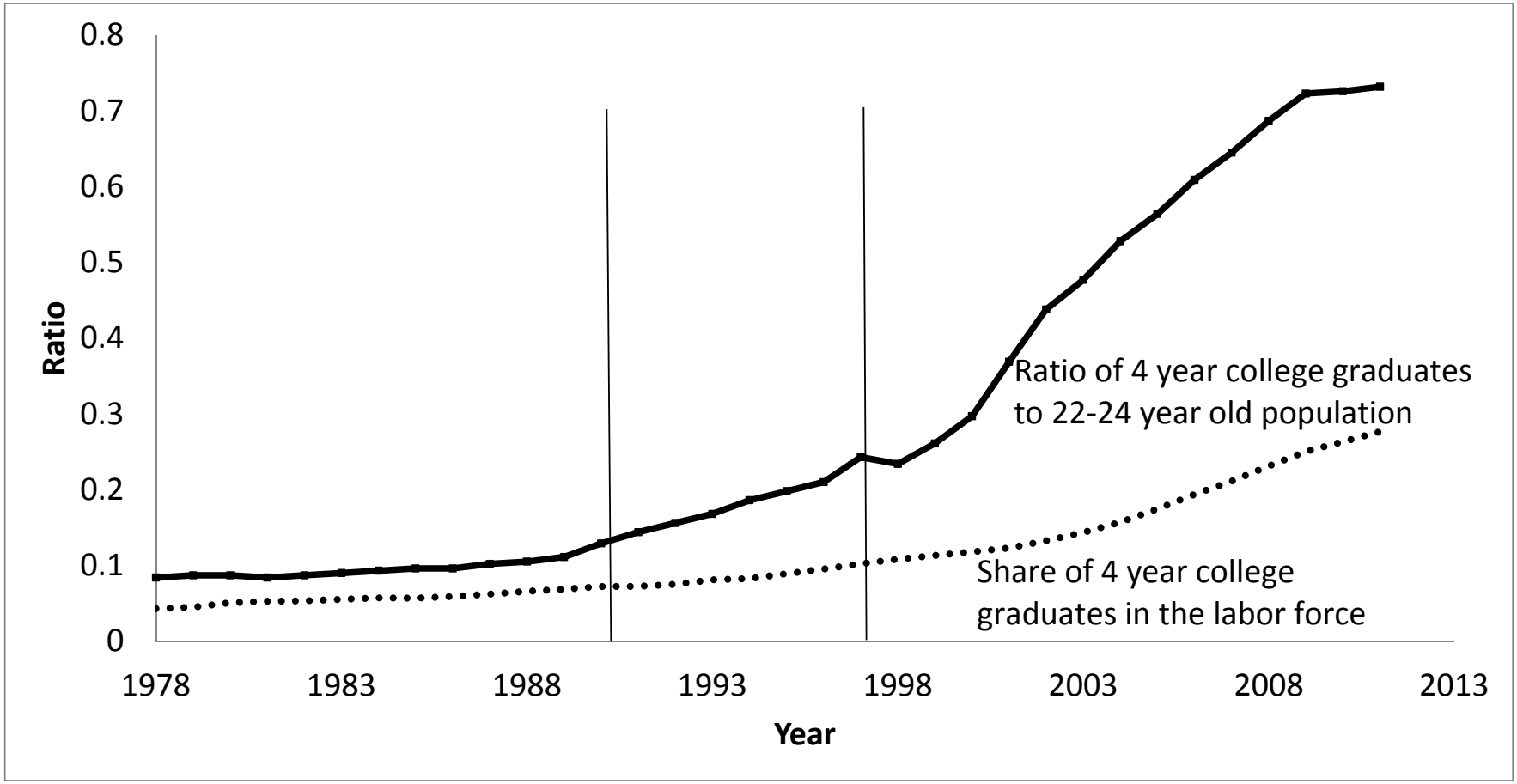


Figure 2: Share of bachelor's degree recipients in the labor force and relative to the youngest cohort in Taiwan, 1978-2011

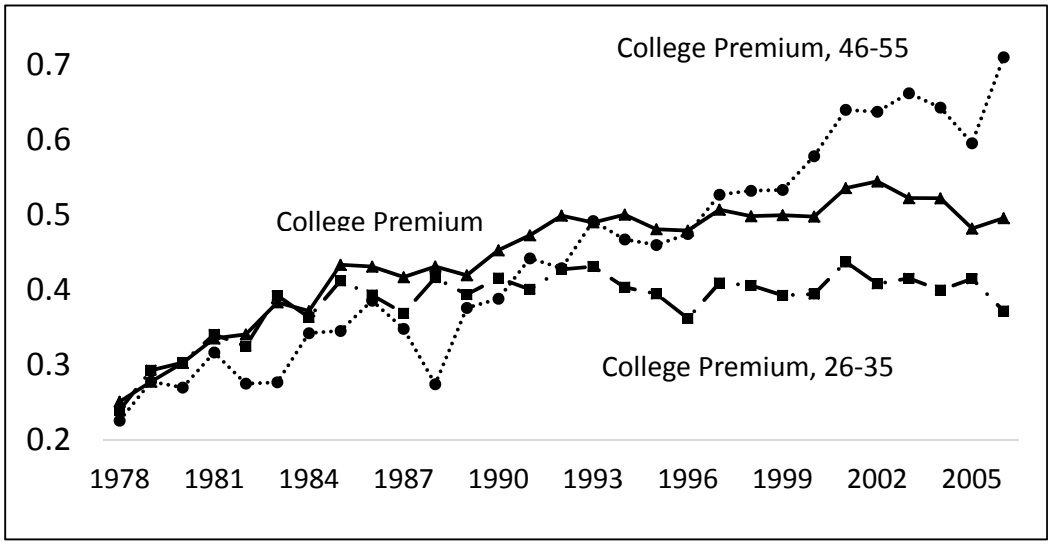


Figure 3: The overall college+ premium and college+ premium by age groups, 1978-2006

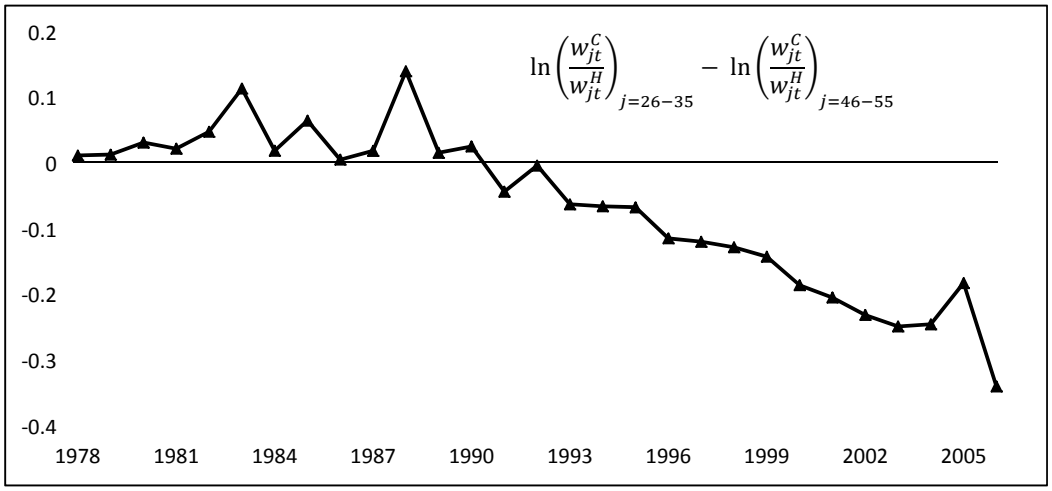


Figure 4: Difference in the college+ premium between young (26-35) and old workers (46-55), 1978-2006

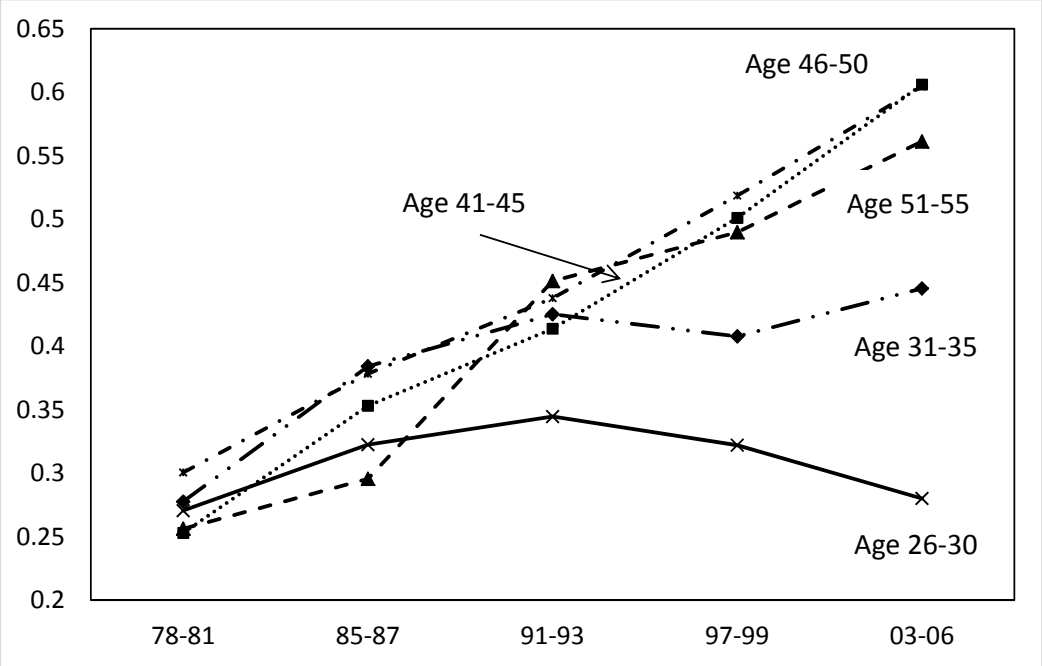


Figure 5A: Trends of college premium by age group, 1978-2006

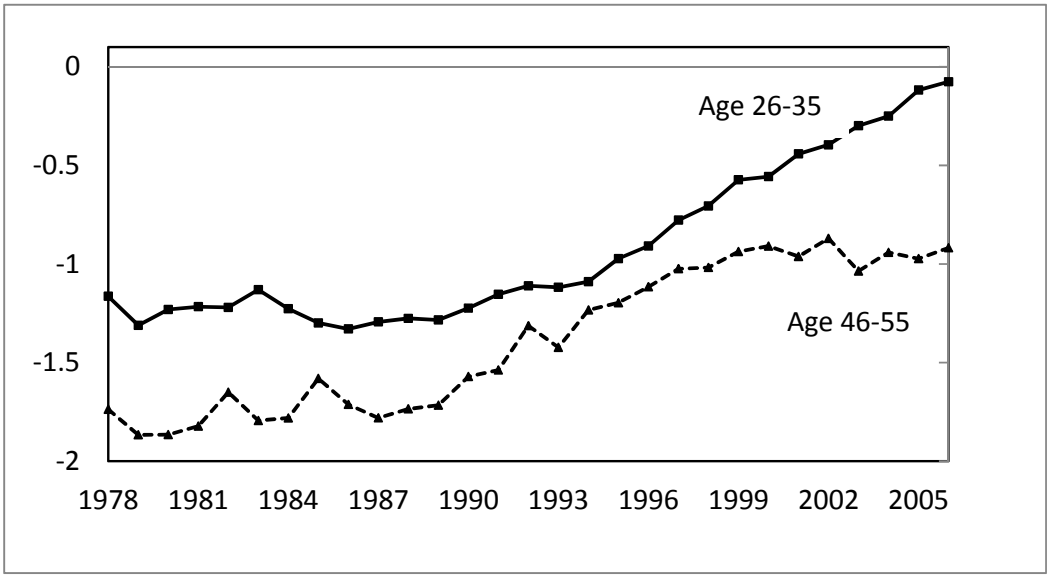


Figure 5B: Relative labor supply of college to high school educated workers by age group, 1978-200

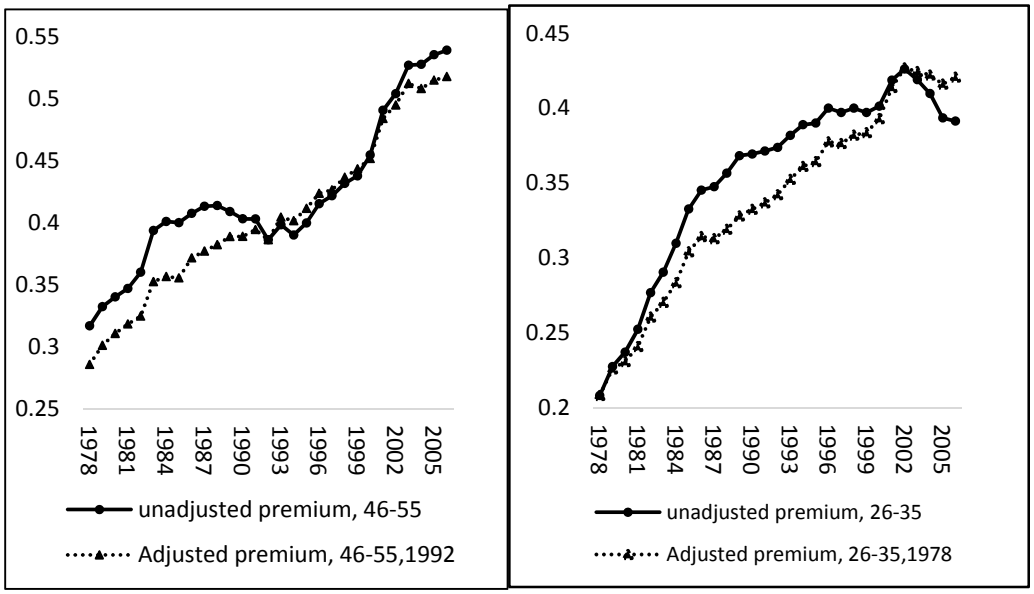


Figure 6: Unadjusted and quality-adjusted college wage premia for young (26-35) and old (46-55) workers. Quality is fixed at its 1978 level.

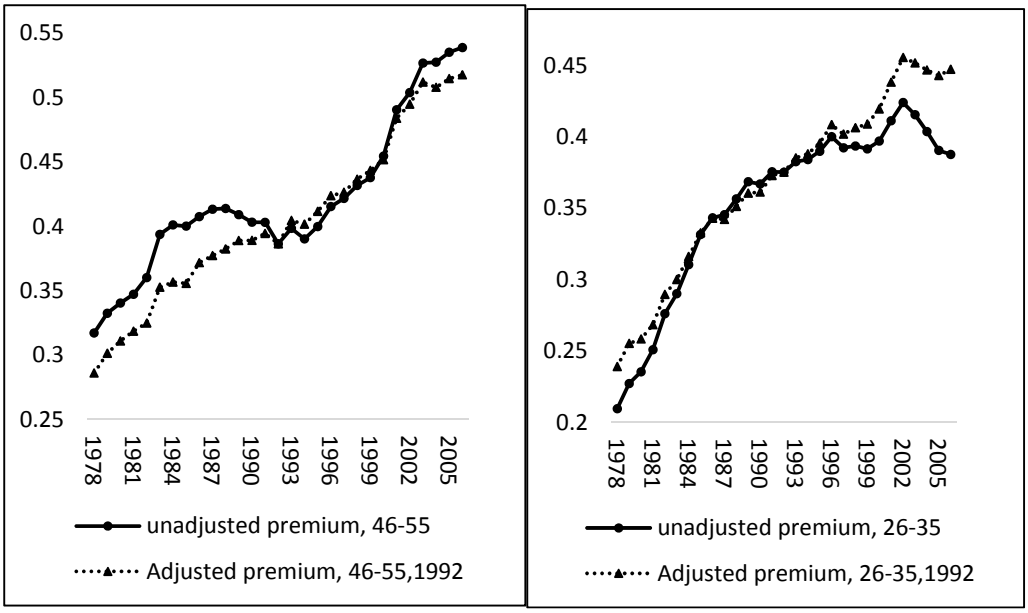


Figure 7: Unadjusted and quality-adjusted college wage premia for young (26-35) and old (46-55) workers. Quality is fixed at its 1992 level.

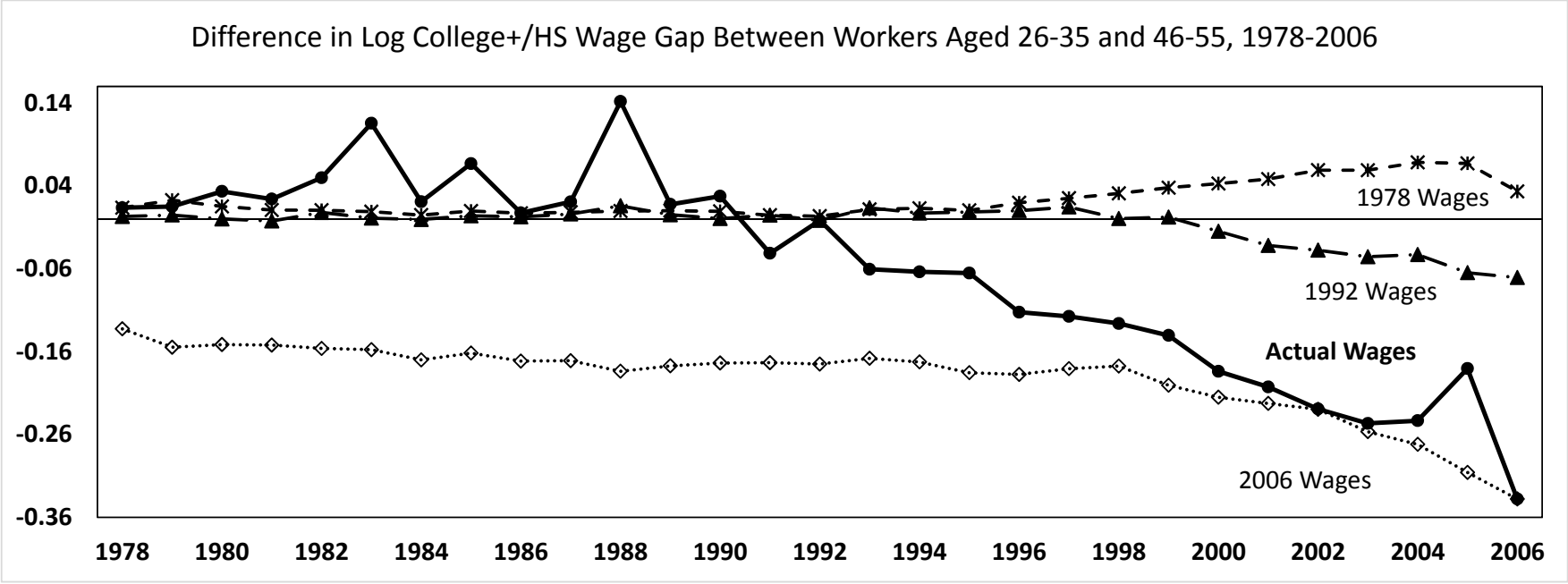


Figure 8: Actual and counterfactual difference in the college premium between younger and older workers: prices fixed at 1978, 1992, and 2006 levels.

Table 1: Estimates of the Weighted Least Square for College /High School Wage Gap: 1978-2006

Variable	Card and Lemieux		Autor, Katz and Kearney		
	First Step	Second Step	College	Cplus/High School	Junior College Excluded
$\log(C_{jt}/H_{jt})$	-0.072 (0.027)***	—	—	—	—
$\log(P_{jt-4})$.	-0.133 (0.031)***	-0.132 (0.032)***	-0.134 (0.032)***	-0.127 (0.032)***	-0.11 (0.034)***
$\log(C_{jt}/H_{jt}) - \log(C_t/H_t)$	—	-0.071 (0.032)***	-0.07 (0.031)***	-0.089 (0.031)***	-0.071 (0.025)***
$\log(C_t/H_t)$	—	-0.075 (0.06)	-0.081 (0.056)	-0.039 (0.06)	-0.055 (0.038)
t	0.001 (0.001)***	0.009 (0.002)***	0.01 (0.002)***	0.01 (0.002)***	0.009 (0.002)***
Age31-35	0.016 (0.035)***	0.016 (0.034)***	0.016 (0.035)***	0.008 (0.036)***	-0.002 (0.035)***
Age36-40	0.083 (0.035)***	0.082 (0.034)***	0.083 (0.034)***	0.085 (0.036)***	0.069 (0.035)***
Age41-45	0.108 (0.035)***	0.11 (0.035)***	0.108 (0.035)***	0.113 (0.036)***	0.097 (0.035)***
Age46-50	0.105 (0.036)***	0.105 (0.036)***	0.105 (0.036)***	0.107 (0.037)***	0.094 (0.037)***
Age51-55	0.085 (0.038)***	0.086 (0.038)***	0.086 (0.038)***	0.086 (0.039)***	0.075 (0.038)***
Age56-60	0.044 (0.04)	0.045 (0.041)	0.044 (0.040)	0.038 (0.04)	0.034 (0.04)
Age61-65	0.005 (0.041)	0.005 (0.041)	0.006 (0.041)	0.0004 (0.042)	-0.001 (0.041)
Unemployment rate	0.011 (0.004)***	0.011 (0.005)***	0.011 (0.005)***	0.012 (0.005)***	0.011 (0.005)***
Minimum wage	-0.003 (0.014)	-0.002 (0.015)	-0.003 (0.015)	-0.007 (0.014)	-0.003 (0.014)
F statistics	49.51	45.49	45.50	63.33	46.4
R^2	0.72	0.71	0.71	0.78	0.72
N	232	232	232	232	232

Note: *** significant at 1% significance level. ** significant at 5% significance level. * significant at 10% significance level.

Table 2: Actual and Composition-Constant Changes in the Relative College Premium of Younger Workers

	1978-1992	1992-2006	1978-2006
Actual	-1.5	-33.6	-35.1
Worker attributes fixed at their 1978 levels	-1.1	-13.6	-14.7
Worker attributes fixed at their 1992 levels	-0.5	-17.3	-17.8
Worker attributes fixed at their 2006 levels	-10.4	-26.7	-37.1

Note: Log points have been multiplied by 100.