

Essays on the Returns to Higher Education

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ABSTRACT

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This dissertation examines social and private returns to higher education, which have important implications for development and public finance. Despite their importance, reliable empirical evidence on the returns to higher education is scarce due to the endogeneity in higher education at individual and aggregate levels. This dissertation exploits quasi-experiments to explore the causal effect of higher education on various outcomes.

The first chapter, “Does Human Capital Spillover Beyond Plant Boundaries?: Evidence from Korea” explores a social return to human capital by examining the magnitude of human capital externalities on plant productivity. Human capital externalities exist if plants in a region with a high level of human capital can produce more—given similar inputs—than plants in a region with less human capital. This is difficult to ascertain because human capital levels are endogenous. To address this issue, this paper exploits an educational reform which exogenously increased cross-region differences in the supply of college graduates starting in the mid 1980s. Using annually collected plant level data, I explore the effect of changes in human capital levels induced by this reform on plant productivity. My results suggest that externalities are limited. I find a correlation between the level of human capital and plant productivity which is similar to that observed in the U.S. However, after using an instrumental variable, the effect of the overall level of human capital on

productivity decreases and becomes statistically insignificant.

The second chapter "The Impact of College Education on Labor Market and Non-pecuniary Outcomes"(with Hyelim Son) exploits an education reform in Korea—which discretely increased freshmen enrollment in 1981—to examine the private returns produced by college education. Due to the compulsory school entrance law in Korea, the cohorts that were born after 1962 were more likely to enter college in 1981 or after. Thus, the cohorts born after 1962, had a higher chance of having college education than the cohorts born before. We exploit this idea and adopt a regression discontinuity design to compare the fraction of individuals with some college education and the average wage for cohorts born close to 1962. Our result suggests that college education has a substantial positive effect on labor market outcomes such as wages and employment. In addition, we find that college education affects saving, smoking and transfer behavior.

The third and final chapter of my dissertation, "The Effect of Higher Education on the Careers of Workers", examines the effect of college education on individuals' subsequent careers. As documented by recent literature, college graduation plays a direct role in revealing an individual's ability to labor market. Thus, the ability of college graduates is more directly observed than the ability of high school graduates in the labor market. I examine whether this difference in ability revelation between college and high school graduates has an implication on their career after they enter the job market. I build a model that yields testable implications regarding the effect of college education on ability revealing activity, given the role of college education in ability revelation. Using the NLSY79 data, I empirically confirm the prediction of the model. In particular, I find that high ability high school graduates more actively engage in ability revealing activities than high ability college graduates. Overall, the results coincide with the predictions of the model,

implying that the difference in ability revelation has a large implication on understanding different careers of high school and college graduates.

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To my parents

Chapter 1

Does Human Capital Spillover Beyond Plant Boundaries?: Evidence from Korea

1.1 Introduction

Whether human capital externalities raise productivity is of interest to economists and policymakers, because this issue has substantial implications regarding government subsidies for education and economic growth (Lucas, 1988).¹ However,

¹A substantial body of theoretical literature suggests possible mechanisms behind human capital externalities. Some papers propose spillovers through personal interactions. This idea at least goes back to Marshall (1890) and is more recently suggested by Arrow (1962) and Romer (1986). According to this view, geographical proximity between employees is an important condition for human capital spillovers, as the exchange of ideas through personal interaction is assumed to be decreasing with distance. This view on the mechanism of human capital spillovers, has been used to argue for the importance of cities as engines of economic growth (Jacobs, 1970). More recently, Niehaus (2012) argues that the increase in education levels will lead to knowledge spillovers by increasing workers' ability to learn skills from other workers. Alternatively, Acemoglu (1996) proposes that the increase in human capital could have a positive external effect on productivity without involving technology when there is a costly search between workers and firms. This type of human capital externality does not necessarily involve knowledge spillovers.

there is no consensus on the empirical magnitude of human capital externalities. In particular, there is no agreement on whether they are large enough to help explain cross-regional differences in growth rates, or to justify subsidies for education.² For instance, Rauch (1993) and Moretti (2004a) find positive and sizable human capital externalities on productivity, whereas Acemoglu and Angrist (2000) and Rudd (2000) find little evidence that these externalities are significant in practice.³

In part, these conflicting results may reflect that the literature has struggled to deal with endogeneity. In particular, reliable evidence on the magnitude of human capital externalities is scarce due to several empirical challenges. First, the level of human capital in a given region is usually endogenous since it is likely to be correlated with unobserved characteristics that affect productivity in the region. Additionally, changes in human capital levels are in most cases gradual; and thus, sufficient variation for reliable estimation is hard to find. This matter exacerbates endogeneity concerns when the literature uses within region variation, since even a small amount of endogeneity could bias results by a considerable amount.

In this paper, I provide new evidence on the magnitude of human capital externalities on plant productivity. That is, I examine whether a given plant's productivity is affected by the human capital level of other plants in nearby locations. In particular, I closely follow the methodology of Moretti (2004c) but use a new instrument for human capital levels, one based on arguably exogenous variation in the supply of college graduates across regions induced by the July 30 Education

²Other types of social return to human capital documented by the literature include, effects on non-economic outcomes such as citizenship (Dee, 2004; Milligan, Moretti, & Oreopoulos, 2004), health of one's children (Currie & Moretti, 2003) and criminal activity (Lochner & Moretti, 2004).

³Several papers document the positive relation between productivity and average years of schooling using cross-country data (de la Fuente & Domenech, 2001). However, cross-country evidence is unlikely to reveal the magnitude of human capital externalities since average levels of human capital are likely correlated with characteristics that can affect productivity (e.g. social infrastructure) (Hall & Jones, 1999).

Reform in Korea.

Specifically, in 1980, the Korean government implemented an education reform that resulted in a large and discrete increase in the number of students entering college in 1981. Between 1979 and 1981, the number of freshmen increased from 98,000 to 190,000. College-specific increases in freshmen enrollment were mechanically determined based on the enrollment prior to the reform. In particular, for every college, freshmen enrollment in 1981 was generally *proportional* to freshmen enrollment in 1979. Thus, cross-college differences in enrollment increased discretely as the colleges which had a large freshmen enrollment in 1979 experienced larger absolute increases in enrollment as a result of the reform. Similarly, regions with larger initial freshmen enrollment-levels experienced larger increases in enrollment. This discrete increase in cross-region variation in college enrollment resulted in an increase in the cross-region variation in the supply of college graduates starting in the mid 1980s. Due to this fact, there were rapid increases in the proportion of workers with college degrees in each region starting in the mid 1980s, and there was a sizable variation in the change in this proportion across regions as well.

I construct an instrumental variable which extracts the portion of the region-specific change in the level of human capital predicted by this exogenous reform. That is, I rely on the fact that the reform had a larger impact on regions with higher initial enrollments. My broad approach is closely related to Moretti (2004a) who uses the presence of land grant colleges as an instrument for the human capital level in a given region. However, while Moretti (2004a) uses cross-sectional variation, I exploit the arguably exogenous *increase* in college enrollment to instrument for region-specific *increases* in the level of human capital. I provide further evidence on the potential exogeneity of this change in human capital by showing that

it is positively correlated with the initial freshmen enrollment levels only after the impact of the reform. This evidence helps to address concerns, for example that the impact of the reform was correlated with pre-trends, or that the reform simply amplified developing differences in the trends of human capital levels across regions.

I implement this idea using the 1982-1996 data from the Mining and Manufacturing Survey which is collected by Statistics Korea. The data provide detailed information on output, labor and capital, and other plant-specific characteristics such as ownership type, age, industry and location. In particular, by estimating a production function at the plant level, I examine whether region-specific increases in the share of college graduates had a positive effect on plant productivity after controlling for plant-specific inputs and characteristics.

Overall, I find little evidence of human capital spillovers beyond plant boundaries—after controlling for plants' own level of human capital, the proportion of workers who are college graduates in a given region does not have a meaningful effect on plant productivity. The magnitude of the simple correlation between the regional level of human capital and plant productivity is similar to that observed using plant level data in the U.S. In particular, pooled regressions suggest that a one percentage point increase in the proportion of workers who are college graduates is associated with a 0.7 percentage increase in productivity. However, after instrumenting for the human capital level, the effect decreases and becomes statistically insignificant. The results from the instrumental variable analysis show that there is a positive bias in the correlation between the level of human capital and productivity. Overall, the findings are consistent with recent work by Huber (2012) which questions the presence of human capital spillovers beyond establishment boundaries. In particular, by surveying workers in the R&D complex in England,

he finds that the workers have limited interactions with the workers outside their establishment; internal resources are sufficient and preferable for innovation.

To my knowledge mine is one of few papers to examine human capital externalities using plant level data while addressing the endogeneity of regional human capital. Previous research on human capital externalities mainly uses wages as an outcome variable (Acemoglu & Angrist, 2000; Moretti, 2004a; Iranzo & Peri, 2009).⁴ The idea that if human capital externalities exist, workers in a region with a higher level of human capital will be more productive and thus they will earn higher wages, forms the basis for the papers in question. However, as Moretti (2004a) and Ciccone and Peri (2006) discuss, interpreting the results is complicated due to the imperfect substitution between skilled and unskilled workers. This difficulty along, with the downward sloping demand for the human capital, could yield a positive relation between the level of human capital and average wages even in the absence of externalities. Thus, the literature often fails to provide conclusive evidence on the magnitude of externalities. Moretti (2004c) is one of few exceptions as using plant level output allows results to have a more direct bearing on the magnitude of human capital externalities. In contrast to my findings in Korea, Moretti (2004c) finds sizable human capital spillovers beyond plant boundaries in the manufacturing sector in the U.S.

My paper also contributes to the literature on the subject by examining possible externalities resulting from college education, which could be different from externalities from K-12 education (Iranzo & Peri, 2009). Finally, this paper adds to the literature by exploring the effect of human capital externalities in the context of a developing country. Particularly, despite the widespread belief regarding the importance of human capital externalities on plant productivity in the growth of

⁴Lange and Topel (2006) and Moretti (2004b) provide a good summary of the literature which uses wage data to document the social returns of education.

South Korea—e.g. Lucas (1988, 1993)—little is known about their empirical magnitude in South Korea. My results suggest the human capital spillovers beyond establishment boundaries might not have been a crucial factor in Korea's growth during the 1980s and 1990s.

The rest of this paper is organized into the following sections. Section 2 introduces the institutional background and Section 3 describes the data set. Section 4 presents the identification strategy. Section 5 presents results and a series of robustness checks. The last section discusses the conclusion.

1.2 Institutional Background

Korea offers a unique institutional setting for this type of study in that the central government controls the supply of college graduates by setting the freshmen quota, or entrance quota, for *both* private and public colleges.⁵ The freshmen quota was strictly enforced during 1970s and 1980s as colleges faced severe penalties for admitting freshmen beyond the assigned quota, such as the loss of government funding and a decrease in their quota for the following years.⁶ Moreover, the government also controlled the number of colleges by granting permission for the establishment of new institutions. The number of colleges was more or less stable across regions during the period of interest.⁷ In short, this setting was quite different from countries such as the U.S. in which college enrollment is not set in central-

⁵The government decided not only the freshmen quota but also the admission guidelines for *both* private and public colleges.

⁶The government allowed only a small number of disadvantaged students to be accepted over the freshmen quota. Further, the government provided an incentive for colleges to keep the actual enrollment lower than the freshmen quota. For instance, the government increased the subsidy for colleges if the actual enrollment for a given college was lower than the freshmen quota set by the government.

⁷The government eventually relaxed the regulations for establishing new colleges in 1996.

ized manner. Because of way that the college enrollment was determined in Korea, the supply of college education was less likely to be responsive to time-varying region-specific characteristics.

Until 1980, the government only allowed a gradual increase in the freshmen quota despite a large increase in the demand for college education in 1970s. As a result, the number of ‘repeat applicants’, who were forced to apply to colleges for more than one year to receive higher education, accumulated as the quota was not sufficient to accommodate all of the students who wanted to enter college.

However, in 1981 the freshmen quota discretely jumped due to an unexpected education reform announced on July 30, 1980 (Choi, 1996).⁸ The main purposes of the reform were: i) to increase the probability that students from disadvantaged backgrounds would receive college education, and ii) to reduce the number of ‘repeat applicants’. The major component of the reform was a discrete increase in the freshmen quota to accommodate more students.⁹ Figure 1.1 describes the reform’s mandated increase in the freshmen quota and corresponding increase in the freshmen enrollment in 1981. It is clear that this large increase was a onetime event, as the freshmen quota was stable during the 1980s after the initial increase in 1981.

Importantly, the central government forced each and every college to increase the freshmen quota in essentially the same way. That is, the magnitude of increase was not endogenously adapted to each college to accommodate region-specific demand for higher education. In particular, the implementation of the increase in the freshmen quota was more or less mechanical—in general, the government set

⁸President Park Chung-hee, who was in office for over 15 years, was assassinated by his body guard on October 26, 1979. After the assassination, the military junta lead by General Chun Doo-hwan, gained control after a series of coups. Many people hoped a democratic government would be established after the assassination, and, as a result, this military junta was not popular. To gain popularity, the junta announced the education reform on July 30, 1980.

⁹Other components include prohibiting private tutoring, and abolishing college-specific entrance exams.

the freshmen quota in 1981 for each college proportionally to the freshmen quota of previous years. Thus, the colleges which happened to have a large freshmen quota in 1979 experienced larger absolute increases by 1981. Figure 1.2 plots the freshmen quota for each college in 1979 and 1981 along with a 45 degree line. This figure shows that the relation between the freshmen quota in 1981 and in 1979 is linear, suggesting that the freshmen quota in 1979 primarily determined the increase. The figure also shows that the absolute differences in enrollment increase, the gap between the 45 degree line and the freshmen quota in 1981, increase as the initial freshmen quota increases.

Since the reform was consistently applied to each college, the relationship between the freshmen quota in 1979 and in 1981 in each region is similar. Figure 1.3 describes the correlation between the freshmen quota in 1979 and in 1981 in each region along with the 45 degree line. By comparing the freshmen quota in 1981 with the 45 degree line, one can see that regions which happened to have higher freshmen enrollment in 1979 experienced larger absolute increases by 1981. Thus, the reform exogenously increased the difference in the supply of college graduates in each region after the mid-1980s. Furthermore, this figure confirms that the freshmen quota in 1981 in each region was indeed mostly determined by the proportional increase in the freshmen quota in 1979—the relation between the quotas in 1979 and in 1981 is linear. The figure thus provides evidence against the claim that the increase in the freshmen quota in 1981 was endogenously determined by the government. In fact, Chun Doo-Hwan, the head of the military junta, did not favor his hometown regions—Gyeongbuk and Daegu—by increasing their quotas more than in other regions.

As a result of these changes in the supply of college slots across regions, there is a substantial cross-regional variation in the change in the proportion of the la-

bor force composed of college graduates. To see this variation, suppose that there are two regions: A and B where each region has 1000 people entering the workforce each year. Assume that the initial freshmen enrollments—which could be endogenous—in region A and region B are 200 and 100, respectively. If there is no inter-regional mobility, in the long run the proportion of college graduates in the workforce in region A and region B would be 0.2 and 0.1, respectively.¹⁰ Now, suppose that the government imposed a reform that forces each college to increase its enrollment by 100%. Then, the college enrollment in region A and region B will increase to 400 and 200, respectively. As a result of the reform the proportion of college graduates in the workforce in each region will increase to 0.4 and 0.2. This example demonstrates that the region with a larger freshmen quota would have experienced a larger increase in the share of workers with college degrees due to the reform.

The usefulness of the reform as a quasi-experiment, therefore, depends on whether the changes in human capital levels across regions were indeed induced by the reform. I provide additional evidence on this issue by showing that the trend in the share of college graduates in each region is positively correlated with the freshmen quota—which determined the size of the impact of the reform—only after the reform. Since the reform increased the existing difference in the freshmen quota across regions discretely, the regions with a relatively large freshmen quota are expected to experience a larger increase in the supply of college graduates, and thus a larger increase in share of workers who are college graduates.¹¹ If the change in the level of human capital was truly the result of the reform, the proportion of college graduates among workers in the regions which had a larger number of freshmen

¹⁰The analysis assumes 100% graduation rates.

¹¹As a result of the mandatory military service in Korea which usually last 2-3 years, students who entered college in 1981 entered the job market between 1986 and 1988.

in 1979 should have increased more than in other regions *only* after the mid-1980s. Otherwise, the variation in the increase in the share of college graduates could simply reflect unobserved underlying trends and/or region-specific shocks.

Figure 1.4 illustrates the correlation between the size of the initial freshmen quota—measured by the freshmen quota in 1979 divided by the number of total employees in each region—and the trend in the proportion of college graduates prior to the reform, which is measured by the change in proportion of white-collar workers between 1982 and 1986. There is little correlation between the pre-trend and the size of the freshmen quota in 1979—the correlation is 0.008. This correlation implies that the regions which had a larger freshmen quota in 1979 did not experience larger increases in human capital prior to the impact of the reform, that is, prior to the exogenous increase in the supply of college graduates induced by the reform.

Figure 1.5 describes the correlation between the size of the initial freshmen quota and the change in the level of human capital after the mid 1980s—measured by the change in the proportion of the college educated labor force between 1988 and 1992. The figure confirms that higher initial freshmen quotas are correlated with a greater increase in the proportion of workers with college degrees after the reform—the correlation is 0.6118. Moreover, figures 1.4 and 1.5 confirm large cross-region variation in the change of the share of college graduates after the mid 1980s. The change in share of college graduates among workers prior to the reform in each region—described in y-axis of Figure 1.4—varies from -0.002 to 0.033 with the standard deviation 0.0096. The change in the share of college graduates after the impact, however, varies from 0.034 to 0.0963 with the standard deviation equal to 0.017.

Overall, these findings support the argument that the change in the proportion

of college graduates across regions was driven by the education reform, and that the variation in the impact of the policy across regions was driven by the predetermined characteristics of each region.

1.3 Data

To examine human capital externalities on plant productivity, I use the Mining and Manufacturing Survey provided by Statistics Korea. Statistics Korea has been collecting these data since 1968, but the micro data are only available starting in 1982. Also, since the manufacturing sector of Korea was heavily affected by the Asian financial crisis in 1997, I only use data prior to 1997. These data have been collected annually from mining and manufacturing plants which have five or more workers. The survey contains detailed information about individual plants such as industry classification, output, production cost, location, and tangible assets including capital. The data also contain information on the total number of employees and the number of white-collar (non-production) employees. However, like most plant level data, there is no information on the educational attainment level of workers. Thus, I proxy the change in the proportion of college graduates by the change in the proportion of white-collar workers.

To explore the validity of this proxy, I use the Basic Wage Structure Survey. These data have been collected by the Ministry of Employment and Labor of Korea and are designed to represent the wages of workers in establishments which hire more than 10 employees. The survey collects data from individual workers from a sample of establishments representing each sector. The data contain information on wages, education, occupation and industry.¹² Using these data, I show that the

¹²Unfortunately, the data do not have location identifier for the establishment, thus I cannot use these data for the main analysis.

trend of the proportion of workers with college degrees coincides with the trend of proportion of white-collar workers. Also, I provide evidence that the increase in the proportion of college graduates actually induced the increase in the proportion of white-collar workers.

Figure 1.6 displays the share of college graduates and white-collar among workers in the manufacturing sector using the Basic Wage Structure Survey and Mining and Manufacturing Survey. The time trend for white-collar workers tracks the trend of college graduates closely; both trends shows little increase until the mid-1980s and then start rising steeply after 1987. I provide an additional justification for using white-collar workers as a proxy for workers with college degrees by separately plotting the proportion of college graduates and white collar workers for a young cohort—workers aged between 25 and 29—and an older cohort aged between 40 and 44. Since the policy increased the supply of college graduates beginning in the mid-1980s, one expects the increase in the proportion of college graduates only among the young cohorts—only the cohort affected by the policy would experience the increase in the proportion of workers with a college education. Thus, if the proportion of white-collar workers is indeed a good proxy for the proportion of workers with college degrees, the proportion of white-collar workers should increase only among young cohorts starting in the mid-1980s. Figure 1.7 illustrates the share of college graduates and white-collar among workers separately for the younger and older cohorts of workers. The information in this figure confirms the prediction, as proportions of both college graduates and white-collar workers among the young cohorts increase rapidly after mid 1980 whereas both proportions among the older cohorts shows little if any change during the 1980s until the early 1990s. This information implies that, during this period, the increase in the proportion of white-collar workers was driven by the increased availability

of college graduates.

Finally, Figure 1.8 provides the time trend for the proportion of workers who have a high school diploma as their highest degree. The figure shows a considerable increase in the share of workers with high school education prior to the mid-1980s. Thus, one can verify that the trend of white-collar workers does not coincide with the trend of the high school graduates. Overall, the evidence shows that the increase in workers with college degrees caused the increase in the proportion of non-production workers in this period. Thus, hereafter I use the changes in the proportion of white-collar worker as a proxy for the proportion of college graduates without further distinction.

In my main analysis, in order to compare my study with previous work using plant level data, I focus on the manufacturing sector. Additionally, I omit years when the Mining and Manufacturing Survey was conducted as part of the Industrial Census—1983, 1988 and 1993—since variable definitions and the samples in those years are not consistent with other years.

Table 1 provides summary statistics. The first two columns contain the mean and the standard deviation during the period prior to the impact of the reform and columns (3) and (4) describe the mean and the standard deviation of the variables after the impact of the reform. All monetary values are in 1990 Korean Won. One can verify that both the value of the output and the value-added of individual plants increased rapidly during this period. The average output increased about 50 percent between the two periods from a base of 2.5 billion Won (1USD is about 1,000 Won). The average value added of each plant also increased by a large amount: about 100 percent.¹³ Moreover, the average capital stock also increased rapidly during the period of interest. The average capital stock of each plant was

¹³The value added of each plant is defined as the value of output less the cost of production which includes cost of materials and electricity.

around 723 million Won during the years 1982-1986, whereas it was about 1.4 billion Won during the years 1987-1996.

More importantly, the average proportion of white-collar workers increased by a considerable amount. In particular, the average proportion of white-collar workers within a plant increased by around 25 percent, or about five percentage points, after the reform went into effect. Moreover, the increase in the proportion white-collar workers did not differ significantly across differently sized plants. The proportion of white-collar workers was about 20 percent prior to the impact of the reform for all plant sizes, and about 25 percent after 1987, regardless of plant size. Consistent with the increase in the proportion of white-collar workers in individual plant, the average proportion of white-collar workers in a given region also increased by a similar amount after the mid-1980s. The average payment to workers increased during this period as the total payment to workers increased by a substantial amount despite the decrease in the number of employees. The average age of an individual plant and the building area used by each plant were both stable during the years 1982-1996. Overall, the summary statistics show that many plant level characteristics—with a few exceptions—significantly changed with the policy.

1.4 Research Design and Empirical Specification

In this section, I provide detailed information on how I use this annually collected data to examine human capital spillovers beyond plant boundaries.

The existence of human capital externalities implies that plants located in regions with higher levels of human capital will be more productive. Thus, one can assess the magnitude of such externalities by examining the relation between the level of human capital and plant productivity in each region. However, empirically

estimating externalities is challenging because the change in the level of human capital is endogenous in most cases. That is, unobserved factors affecting regional plant productivity can also have a positive effect on the overall level of human capital. For instance, the establishment of a “million dollar plant” can have a positive effect on the productivity of existing plants and also attract workers with higher human capital (Greenstone, Hornbeck, & Moretti, 2010). In this case, a positive relation between the level of human capital in a given region and its average plant productivity could exist even in the absence of human capital externalities. In other words, a positive correlation between the level of human capital and average plant productivity does not necessarily imply the existence of human capital externalities.

In the remainder of this section, I describe the endogeneity issue in detail using an empirical strategy adopted from Moretti (2004c). I also explain how the empirical setting in this paper helps mitigate some associated concerns.

I assume a Cobb-Douglas production function;

$$Y_{ijrt} = A_{ijrt} B_{ijrt}^{\alpha_b} W_{ijrt}^{\alpha_w} K_{ijrt}^{\beta} \quad (1.1)$$

where Y_{ijrt} is output of the plant i , in industry j , in region r , at year t . B_{ijrt} , W_{ijrt} and K_{ijrt} denote inputs: blue-collar workers, white collar-workers, and capital, respectively. Total factor productivity is represented by A_{ijrt} . If plant productivity depends on the regional level of human capital, then, $\ln A_{ijrt}$ can be expressed as follows:

$$\ln A_{ijrt} = \gamma H_{rt} + \epsilon_j + \epsilon_r + \epsilon_t + \epsilon_{rt} + \epsilon_{ijrt} \quad (1.2)$$

where H_{rt} is the proportion of workers who are college graduates, which measures

the level of human capital in a given region. The coefficient of H_{rt} , γ , indicates the effect of regional human capital on productivity. Thus, the magnitude of human capital externalities on total factor productivity will depend on the size and significance of γ .

After taking logs of the production function (1.1) and substituting for $\ln A_{ijct}$, (1.1) can be rewritten as;

$$y_{ijrt} = \gamma H_{rt} + \alpha_b b_{ijrt} + \alpha_w w_{ijrt} + \beta k_{ijrt} + \mathbf{X}'_{ijrt} \Phi + d_j + d_r + d_t + \epsilon_{rt} + \epsilon_{ijrt} \quad (1.3)$$

where y_{ijrt} is log of the value added of the plant. b_{ijrt} and w_{ijrt} are the log of labor input of white-collar and blue-collar workers, respectively. k_{ijrt} denotes the log capital stock. One advantage of using repeated cross section data is that one can control for year and region fixed effects.¹⁴ d_j , d_r and d_t are industry fixed effects, region fixed effects, and year fixed effects, respectively. In addition to fixed effects, I also control for the basic characteristics of plant i , \mathbf{X}_{ijrt} , such as age of plant, the type of ownership and area of the plant's building, which can affect the productivity of the plant.

The main source of endogeneity arises if time-varying region-specific shocks, ϵ_{rt} , are positively correlated with the change in the share of college graduates, H_{rt} . Moreover, since the change in the level of human capital is gradual in most cases, the endogeneity issue can be exacerbated by controlling for region fixed effects. In other words, since there will be only a small amount of variation left in H_{rt} after controlling for region fixed effects, even a small correlation between H_{rt} and ϵ_{rt} could bias estimates by a large amount.

As stated, I address these challenges by using the policy change that induced a

¹⁴The survey does contain the plant id. Unfortunately, the id is not assigned consistently across the year, thus one cannot control for the plant fixed effects.

sharp increase in the supply of college graduates starting in the mid-1980s (see Section 2). This raises the probability that there will be a sufficient amount of within region variation in the level of human capital to estimate γ reliably. In other words, even after controlling for region fixed effects, the variation left in H_{rt} should be sufficient to estimate γ . Furthermore, there is a sizable amount of variation in the increase in the proportion of workers who are college graduates across regions. Importantly, since this cross-regional variation was arguably induced by the exogenous reform, the variation in H_{rt} during this period is unlikely to be correlated with the region-specific time shock ϵ_{rt} . Moreover, since the magnitude of impact of the reform was largely determined by the predetermined characteristics of each region—freshmen quota in 1979—controlling for region fixed effects will help address the endogeneity in the change in level of human capital.¹⁵

However, Figure 1.5 also provides some evidence of the endogenous sorting of human capital, as there are regions which experienced distinctly smaller increases in human capital compared to the size of their initial freshmen quota. These regions include Jeonbuk and Jeonnam, which rose up against the military junta, and as a result their development was impeded during the 1980s. Another region is Gangwon, where the economy heavily depended on coal mining; the demand for coal fell sharply and the region declined rapidly during the period. Since the deviation in the increase in the level of human capital from the share of the freshmen quota is non-random, the result from longitudinal specification which controls for the region fixed effects would still be biased.

Thus, to further address this concern, I instrument the change in the proportion

¹⁵One shortcoming from using the discrete increase in the supply of college graduates is that the quality of white-collar workers might have decreased due to the policy. In particular, the average quality of white-collar workers might have decreased more in the regions which experienced a larger increase of white-collar workers. If this is the case, the effect of the proportion of white-collar worker on productivity would underestimate the effect of regional human capital on productivity.

of college graduates by exploiting the exogenous timing and the size of the positive supply shock in college graduates induced by the reform. My approach is to use only the change in the level of human capital predicted by the exogenous education reform. In particular, I instrument the change in the level of human capital using the freshmen quota prior to the reform, which determined the size of the impact, interacted with a dummy variable indicating the post-period. Formally, the first stage is as follows;

$$H_{rt} = \text{POST} * \text{PropFresh79}_{rt} + \theta_b b_{ijrt} + \theta_w w_{ijrt} + \kappa k_{ijrt} + \mathbf{X}'_{ijrt} \Pi + d_j + d_r + d_t + \epsilon_{rt} + \epsilon_{ijrt} \quad (1.4)$$

where H_{rt} is proportion of the college graduates and the POST is a dummy variable that takes a value of one after 1986. The relative size of the freshmen quota in 1979, PropFresh79_{rt} , is defined as follows:

$$\text{PropFresh79}_{rt} = \frac{fq1979_r}{emp_{rt}} \quad (1.5)$$

where $fq1979_r$ indicates the freshmen quota in 1979 in each region and the emp_{rt} is the total number of employees in the region, r at time t .

The second stage of the IV regression uses the predicted value of the proportion of college graduates from the first stage, \hat{H}_{rt} , and estimates the following equation.

$$y_{ijrt} = \gamma \hat{H}_{rt} + \alpha_b b_{ijrt} + \alpha_w w_{ijrt} + \beta k_{ijrt} + \mathbf{X}'_{ijrt} \Phi + d_j + d_r + d_t + \epsilon_{rt} + \epsilon_{ijrt} \quad (1.6)$$

Again, the coefficient of interest is γ . Ideally, \hat{H}_{rt} is a function of variables that are not correlated with ϵ_{rt} and γ will not suffer from endogeneity bias and thus will address the bias associated with OLS estimates.

1.5 Results

In this section I provide the estimation results. I begin by documenting results from a ‘pooled regression’ specification which omits the region fixed effects from equation (1.3). Thus, the results from this specification describe the correlation between the proportion of college graduates among workers in a given region and plant productivity.

Table 2 documents the pooled regression results for various specifications. All specifications control for the capital stock, labor input by the type of worker and year fixed effects. Moreover, to control for time-varying region-specific productivity shocks, I also control for the log of capital stock per worker in each region. Labor inputs are measured by the number of employees, and the capital stock is measured as the monetary value of assets excluding the value of land. Columns (2)-(4) control for additional characteristics of plants, such as age, type of ownership, and industry at the 2 digit level. Column (3) also controls for year \times industry dummies, and Column (4) allows the technology to differ across industries by allowing the coefficients of labor inputs and the capital stock to vary across industries defined at the 2 digit level. The results exhibit a positive correlation between the level of human capital and plant productivity; this coincides with cross-sectional results in the U.S. as documented by Rauch (1993) and Moretti (2004c). The coefficient is consistently sizable and statistically significant across specifications. In particular, a percentage point increase in the proportion of white-collar workers in a given region—which is used as a proxy for the share of college graduates—is associated with a 0.75 percent increase in plant productivity. Although the definition of the variables is not exactly the same as in Moretti (2004c), the magnitude of the correlation between the share of workers with a college degree and plant produc-

tivity is similar.¹⁶ Overall, the results from Table 2 show that a positive correlation between plant productivity and level of human capital exist in Korea. In the remainder of this section, I show that the magnitude of the coefficient decreases as I further address the endogeneity by exploring the implementation of the reform.

Table 3 reports on a longitudinal specification which controls for region-specific dummies as well as year fixed effects. Again, all specifications control for the labor input of each type of worker, capital stock, area of the building used by plants, and the log of capital stock per worker in each region. The additional controls and specifications used in each column are the same as in Table 2. Since the change in the proportion of college graduates in this period is mostly caused by the reform, the region fixed effects will address a substantial portion of the endogeneity in the change in proportion of college graduates.

As expected, the magnitude of the main coefficient decreases, compared to the baseline pooled regression result. The size of the coefficients vary from 0.3 to 0.4 which is about half the magnitude of the simple correlation between the level of human capital and productivity. However, the point estimate of the main coefficient in columns (1) and (2) is still somewhat sizable and statistically different from zero. Since this specification cannot completely rule out endogeneity, I further address the issue by using my instrumental variable.

Table 4 conveys the result for the IV regression and the corresponding reduced form result. Columns (1) and (2) report the first stage, and Columns (3) and (4) report the second stage. Additionally, Columns (2) and (4) control for the individual characteristics of plants. The first stage of both specifications is strong as the coefficient of the interaction term is statistically significant at 1%. Moreover the F-statistics of the first stage regression are sufficiently larger than 10 for both spec-

¹⁶In Moretti (2004c), the cross sectional estimate of the correlation between the share of the college graduate workers and the productivity of plants varies from 0.807 to 0.847.

ifications. The results from the second stage provide further evidence against the existence of human capital spillovers as the magnitude of the main coefficient is smaller than that of the specification in the previous section. The magnitude of the coefficient from the preferred specification is close to zero, 0.08, and statistically indistinguishable from zero. In particular, the size of the coefficient is approximately one-seventh of the estimate from Moretti (2004c). That said, although the point estimate is significantly smaller, 95 percent confidence interval of the coefficient does not exclude the estimate from Moretti (2004c). In addition to the 2SLS result, Columns (5) and (6) report the reduced form result. Consistent with the 2SLS result, the coefficient on the $POST * PropFresh79_{rt}$ is close to zero and statistically insignificant. Instrumenting the proportion of the college graduates further addresses endogeneity and further corrects the bias in the coefficient of interest. Moreover, the decrease in the magnitude of the coefficient compared to the longitudinal estimate seems plausible, as the longitudinal estimate is most likely to be positively biased. Thus, the instrumental variable analysis of this paper provides more compelling estimates.

In short, despite finding a sizable correlation, the effect of the human capital level on productivity decreases and become statistically insignificant as I apply my instrumental variable which properly corrects the positive bias. Thus, the results provide little support for the existence of human capital spillovers beyond plant boundaries.

In remainder of this section, I perform several robustness checks.

1.5.1 Robustness Check

As a robustness check, I omit intermediate years when the impact of the reform was not fully realized and thus focus on the long term effects of the policy. In

particular, I exclude the years between 1986 and 1993 when the proportion of college graduates in the labor force was increasing steeply as young college graduates were replacing low skilled workers.

Table 5 describes the result from pooled regression which omits region fixed effects and the longitudinal estimate which includes region fixed effects. As expected, the size of the coefficient becomes larger than that in the specification which included the intermediate years. However, as described in Table 6, the estimated effect of human capital on productivity decreases by a large amount and becomes statistically indistinguishable from zero after I use the IV analysis.

Lastly, I use a more general form for the production function—a translog specification—instead of the Cobb-Douglas specification and estimate (1.3) including the square of each log input and the interaction between each log input. Table 7 reports the results under this production function. The magnitude of the coefficient from this specification is slightly different from the one obtained under the Cobb-Douglas specification. Consistent with the analysis using Cobb-Douglas production function, the results from Table 7 shows the sizable and significant correlation between the level of human capital and plant productivity.

Table 8 reports the results of the instrumental variable analysis under the translog production function. The coefficient of interest is somewhat sizable compared to the main specification, however, it is not statistically different from zero. Moreover, the point estimate of local human capital spillover is approximately half of that of translog specification in Moretti (2004c), although I cannot completely rule out the moderate effect of regional human capital level on productivity due to the large standard errors. Thus, this analysis shows that the main results are robust in regards to changes in the functional form of production function.

1.5.2 Internal Validity of the Reform

Although the variation of impact across regions induced by this reform was large and was exogenously imposed, one might worry about the internal validity of this policy. In particular, it is debatable whether the workers who became college graduates due to this reform are comparable in terms of human capital with college graduates who entered college prior to the education reform. In other words, if the reform simply increased the number of college graduates without adding any human capital, then one would not expect externalities from the increased proportion of college graduates.

To address this concern, I show that there were plant level responses to the increase in the share of college graduates. First, there was an increase in the proportion of white-collar workers, which I show closely mirrors the increase in the proportion of college graduates. If the workers who earned a college degree due to the increased freshmen quota had no additional human capital relative to high school graduates, there would be no reason for plants to hire them as white-collar workers. Moreover, the trend for the average capital per worker coincides with the increase in the proportion of college graduates. Figure 1.9 shows the average capital per worker in the manufacturing sector during the period of interest.¹⁷ Its trend closely follows the trend of the share of college graduates. This suggests that plants increased their investment in response to the increase in the share of college graduates.

Finally, I examine the wages by cohorts to see whether the increase in college education led to an increase in the overall level of human capital. In particular, due to the compulsory school entrance law in Korea, the cohorts that were born after 1962 were more likely to enter college in 1981 or later. Thus, the cohorts born after

¹⁷The monetary values are adjusted to the 1990 Korean Won.

1962 would have a higher chance of earning a college education than the cohorts born prior to 1961. Park and Son (2012) exploit this idea by adopting a regression discontinuity design and by comparing the share of individuals with some college education and the average wage by cohorts born around 1962. The authors document a discrete jump in the share of college graduates and a corresponding jump in income and wages for the cohort born in 1962. Figures 1.10 and 1.11 describe the proportion of college graduates among workers and age-adjusted average monthly wage, respectively. In each case the x-axis denotes birth year centered at 1961. The figures verify the discrete increase in both the level of education and wages, where the latter is a proxy of human capital, for cohorts born after 1962. Overall, the evidence shows that college education after the policy had sizable value added in terms of human capital; and thus, the increased proportion of college graduates due to the policy is valid for analyzing human capital externalities.

1.6 Conclusion and Discussion

The magnitude of the return to human capital has important policy implications, for example, on the appropriate level of government subsidies to education. Thus, there is a large body of literature documenting the private benefit from human capital accumulation on the various aspects of life—including wage, health and happiness (Card, 1999; Oreopoulos & Salvanes, 2009). However, social returns to human capital, despite their important implications on growth and public finance, have been documented to a lesser degree.

To address this partial gap in the literature, this paper examines the magnitude of human capital externalities on productivity using plant level data. In particular, it tests whether plants located in regions with higher levels of human capital can produce more with a similar amount of input. To address this issue, I explore the

education reform in Korea, which exogenously changed the level of human capital across regions by increasing existing differences in the supply of college graduates starting in mid-1980s.

Using this exogenous change, I empirically estimate the relation between the regional level of human capital and plant productivity. In particular, I explicitly control for the endogeneity in the change in the level of human capital by using an instrumental variable that extracts the portion of the change in human capital induced by this reform. Overall, I find little evidence of human capital spillovers beyond plant boundaries. That is, the productivity of a given plant in a given region is not affected by the level of human capital outside that plant after controlling for the plant's own human capital and other characteristics.

The results of this paper coincide with the recent literature that questions the plausibility of human capital spillovers beyond plant boundaries. In particular, it is not clear why skilled workers would teach their skills to less skilled workers working in other establishments. That is, even if the workers interacted with the workers in other plants, human capital spillovers beyond plant boundaries are unlikely to occur, since skilled workers have little incentive to pass along their skills without being compensated. Given the lack of convincing literature on a mechanism for human capital outside of plant affecting productivity, the results of this paper are not surprising.¹⁸

¹⁸It is important to note that this paper does not provides evidence that contradicts all types of human capital spillovers. For instance, human capital spillovers inside the plant or peer effects where workers are more likely to interact could still exist (Mas & Moretti, 2009).

Table 1.1: Summary Statistics

	1982-1986		1987-1996	
	Mean (1)	Std. Dev. (2)	Mean (3)	Std. Dev. (4)
total output (*1,000,000)	2519.0	30465.4	3844.2	52455.7
value added(*1,000,000)	874.8	9139.7	1596.8	23646.4
share of white-collar in region	0.198	0.038	0.270	0.049
share of white-collar in plant	0.206	0.139	0.251	0.152
employee <25	0.216	0.131	0.250	0.143
employee >25 and <50	0.198	0.144	0.250	0.164
employee>50	0.200	0.148	0.267	0.170
number of white-collar	14.4	88.9	12.6	94.0
number of blue-collar	59.3	292.6	35.8	208.7
capital (*1,000,000)	723.1	11989.0	1423.2	25697.5
average payment(*1,000,000)	2.685	1.159	7.162	3.593
area of building (m^2)	2084.8	17170.5	2275.2	25142.2
age of plants	8.005	7.152	8.155	8.246
number of obs	121573		447807	

Note : Monetary values are in 1990 Korean Won. 1 US dollar is approximately 1,000 Won

Table 1.2: Correlation between regional human capital levels and plant productivity

	(1)	(2)	(3)	(4)
share of white-collar in region	0.724*** (0.099)	0.749*** (0.081)	0.769*** (0.078)	0.728*** (0.083)
Additional Controls		y	y	y
Industry * Year effects			y	
Technology vary by Industry				y
adj. R-sq	0.809	0.815	0.816	0.819
N	569380	569380	569380	569380

All specification includes log number of white-collar and blue-collar workers, log of capital stock and year fixed effects. Specification (2),(3) and (4) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 1.3: Effect of regional human capital level on productivity – Longitudinal Specification

	(1)	(2)	(3)	(4)
share of white-collar in region	0.456** (0.221)	0.441** (0.210)	0.331* (0.179)	0.436** (0.208)
Additional Controls		y	y	y
Industry * Year effects			y	
Technology vary by Industry				y
adj. R-sq	0.809	0.816	0.816	0.819
N	569380	569380	569380	569380

All specification includes log number of white-collar and blue-collar workers, log of capital stock, year fixed effects and region fixed effects. Specification (2),(3) and (4) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 1.4: Effect of regional human capital level on productivity – IV analysis

	first stage		IV		reduced form	
	(1)	(2)	(3)	(4)	(5)	(6)
after1987*freshmen quota79	0.264*** (0.040)	0.263*** (0.040)			0.062 (0.117)	0.023 (0.112)
share of white-collar in region			0.235 (0.426)	0.087 (0.419)		
Additional Controls		y		y		y
First stage F	43.47	43.48				
adj. R-sq	0.978	0.978	0.809	0.816	0.809	0.816
N	569380	569380	569380	569380	569380	569380

All specification includes log number of white-collar and blue-collar workers, log of capital stock, year fixed effects and region fixed effects. Specification (2), (4) and (6) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 1.5: Robustness Check – Excluding intermediate years(pooled regression and longitudinal estimate)

	Pooled Regression		Longitudinal	
	(1)	(2)	(3)	(4)
share of white-collar in region	0.751*** (0.137)	0.748*** (0.1132)	0.675** (0.280)	0.567** (0.254)
Year Fixed Effects	y	y	y	y
Region Fixed Effects			y	y
Additional Controls		y		y
adj. R-sq	0.816	0.822	0.817	0.823
N	280021	280021	280021	280021

All specification includes log number of white-collar and blue-collar workers, log of capital stock. Specification (2) and (4) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 1.6: Robustness Check – Excluding intermediate years(IV analysis)

	first stage		IV		reduced form	
	(1)	(2)	(3)	(4)	(5)	(6)
after1987*freshmen quota79	0.289*** (0.044)	0.263*** (0.040)			0.077 (0.146)	0.055 (0.126)
share of white-collar in region			0.268 (0.485)	0.192 (0.428)		
Additional Controls		y		y		y
First stage F	41.71	41.66				
adj. R-sq	0.979	0.980	0.817	0.822	0.817	0.822
N	280021	280021	280021	280021	280021	280021

All specification includes log number of white-collar and blue-collar workers, log of capital stock, year fixed effects and region fixed effects. Specification (2), (4) and (6) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 1.7: Robustness Check – Translog production function(pooled regression and longitudinal estimate)

	Pooled Regression		Longitudinal	
	(1)	(2)	(3)	(4)
share of white-collar in region	0.635*** (0.101)	0.692*** (0.081)	0.367* (0.209)	0.397** (0.194)
Year Fixed Effects	y	y	y	y
Region Fixed Effects			y	y
Additional Controls		y		y
adj. R-sq	0.816	0.822	0.815	0.821
N	569380	569380	569380	569380

All specification includes log number of white-collar and blue-collar workers, log of capital stock, square term of each log input and interactions between the log input. Specification (2) and (4) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 1.8: Robustness Check – Translog production function(IV analysis)

	first stage		IV		reduced form	
	(1)	(2)	(3)	(4)	(5)	(6)
after1987*freshmen quota79	0.263*** (0.040)	0.262*** (0.040)			0.079 (0.104)	0.068 (.099)
share of white-collar in region			0.302 (0.383)	0.259 (0.419)		
Additional Controls		y		y		y
First stage F	43.12	43.12				
adj. R-sq	0.978	0.978	0.815	0.821	0.815	0.821
N	569380	569380	569380	569380	569380	569380

In addition to year and region fixed effects, all specification includes log number of white-collar and blue-collar workers, log of capital stock, square term of each log input and interactions between the log input. Specification (2), (4) and (6) additionally controls for individual plant specific characteristics such as industry and age of plants. The standard errors are clustered at region-year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

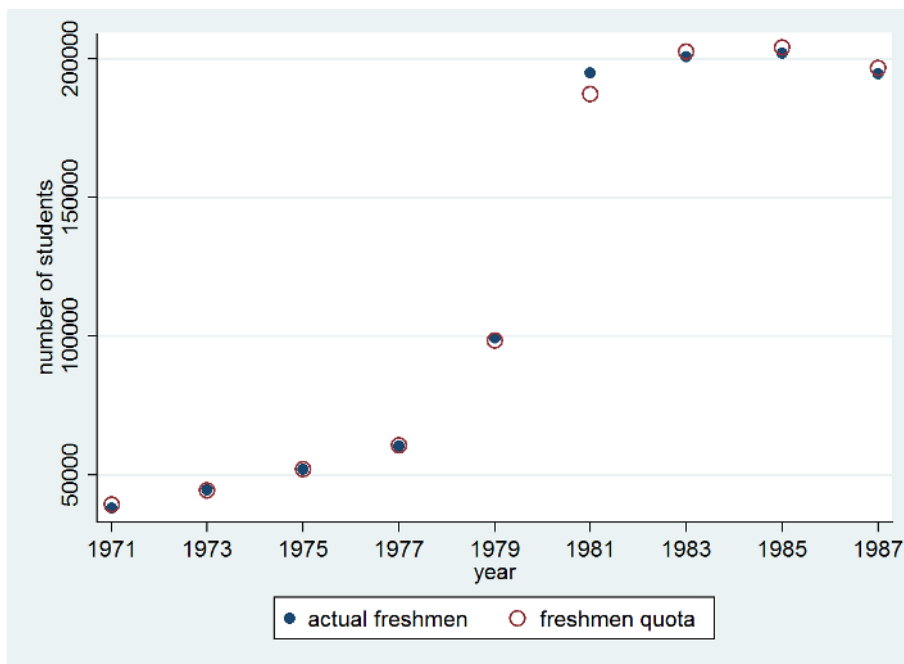


Figure 1.1: Trend of Freshmen Quota and Actual Freshmen Enrollment

Figure 1.2: Correlation between Freshmen Quota in 1979 and 1981 by Colleges

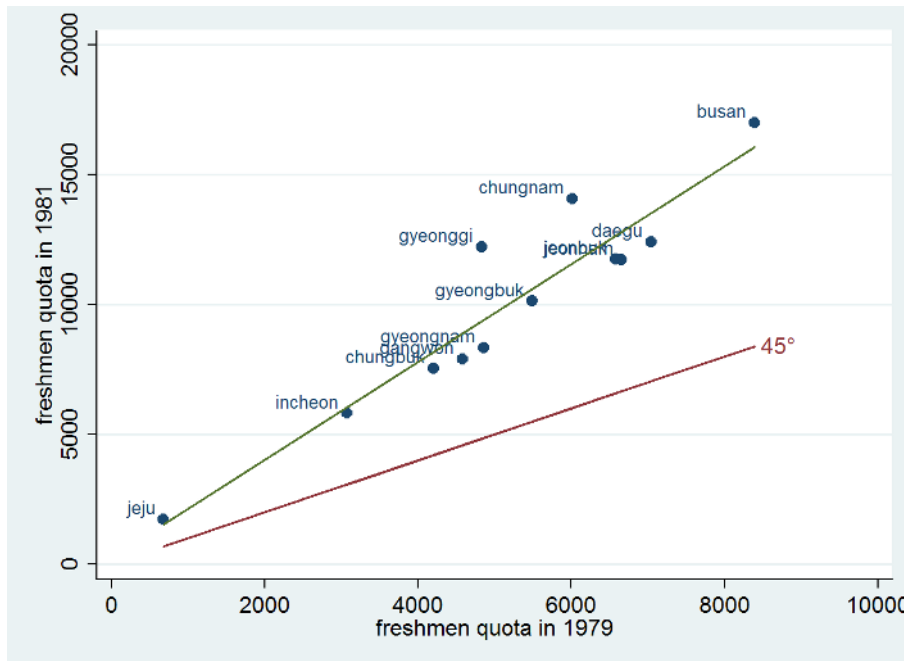
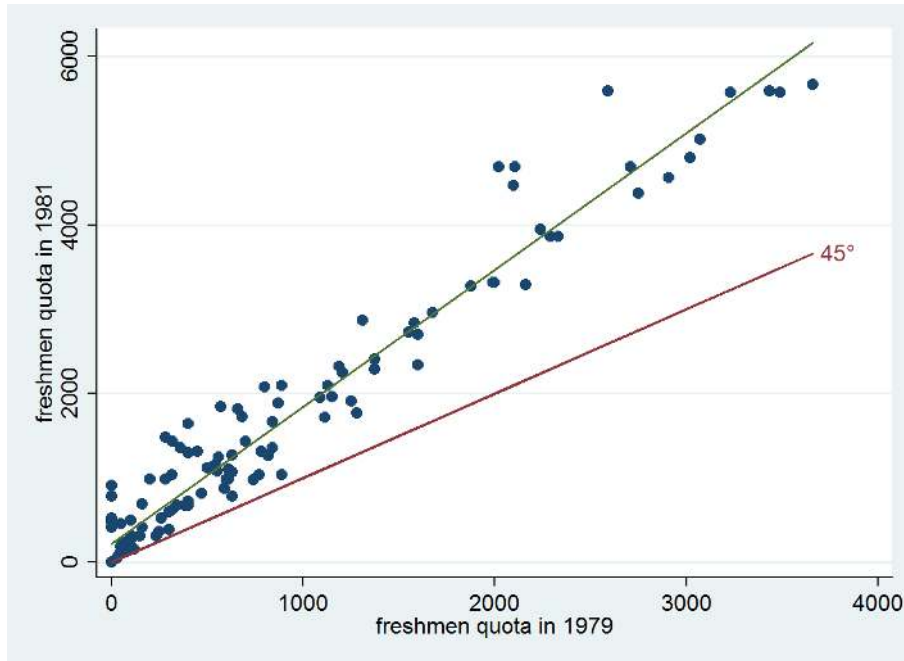


Figure 1.3: Correlation between Freshmen Quota in 1979 and 1981 by Region

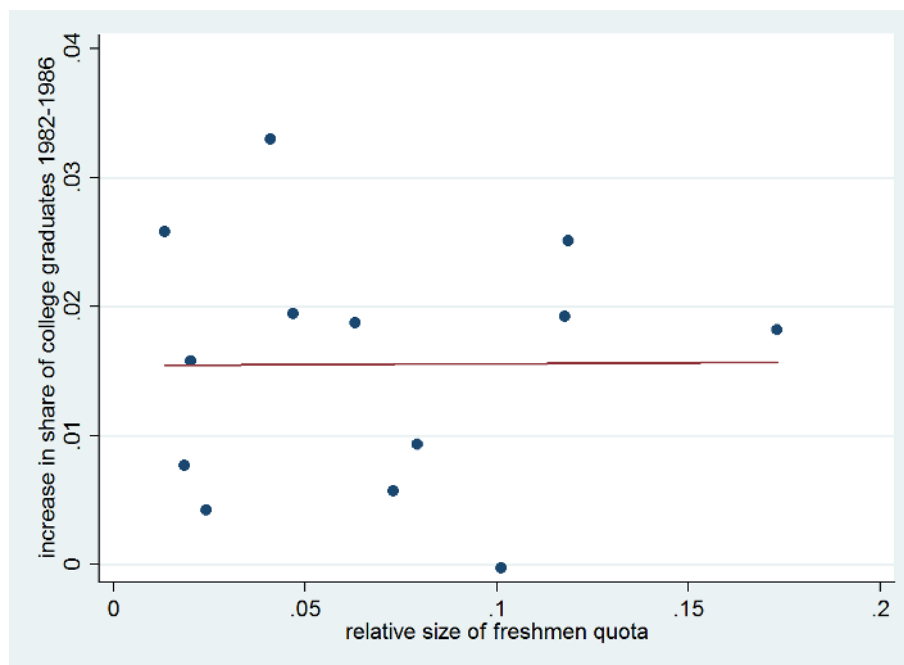


Figure 1.4: Correlation between Pre-trend of Change in Human Capital Level and Size of Freshmen Quota by Region

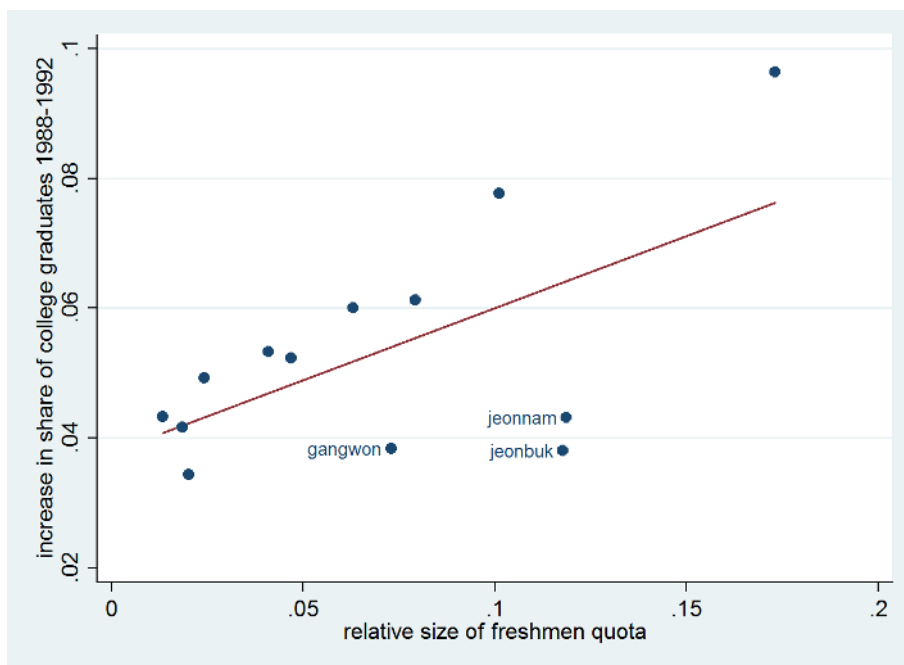


Figure 1.5: Correlation between Post-trend of Change in Human Capital Level and Size of Initial Freshmen Quota by Region

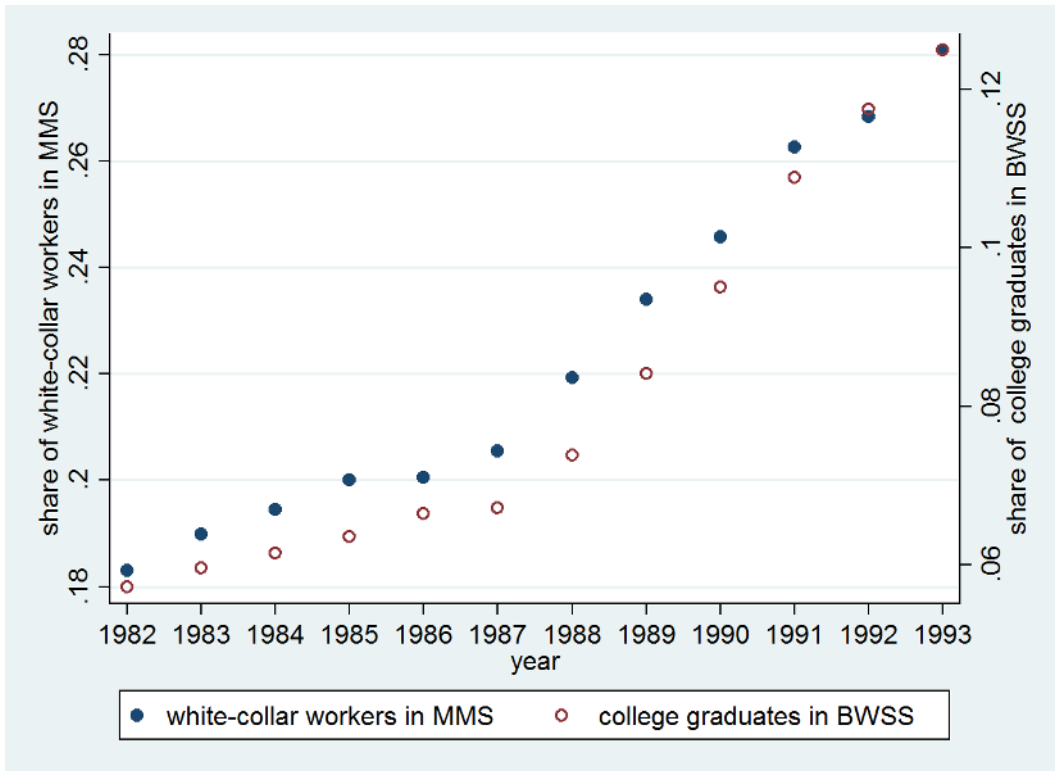


Figure 1.6: Proportion of College Graduate and White-Collar among Workers by Year

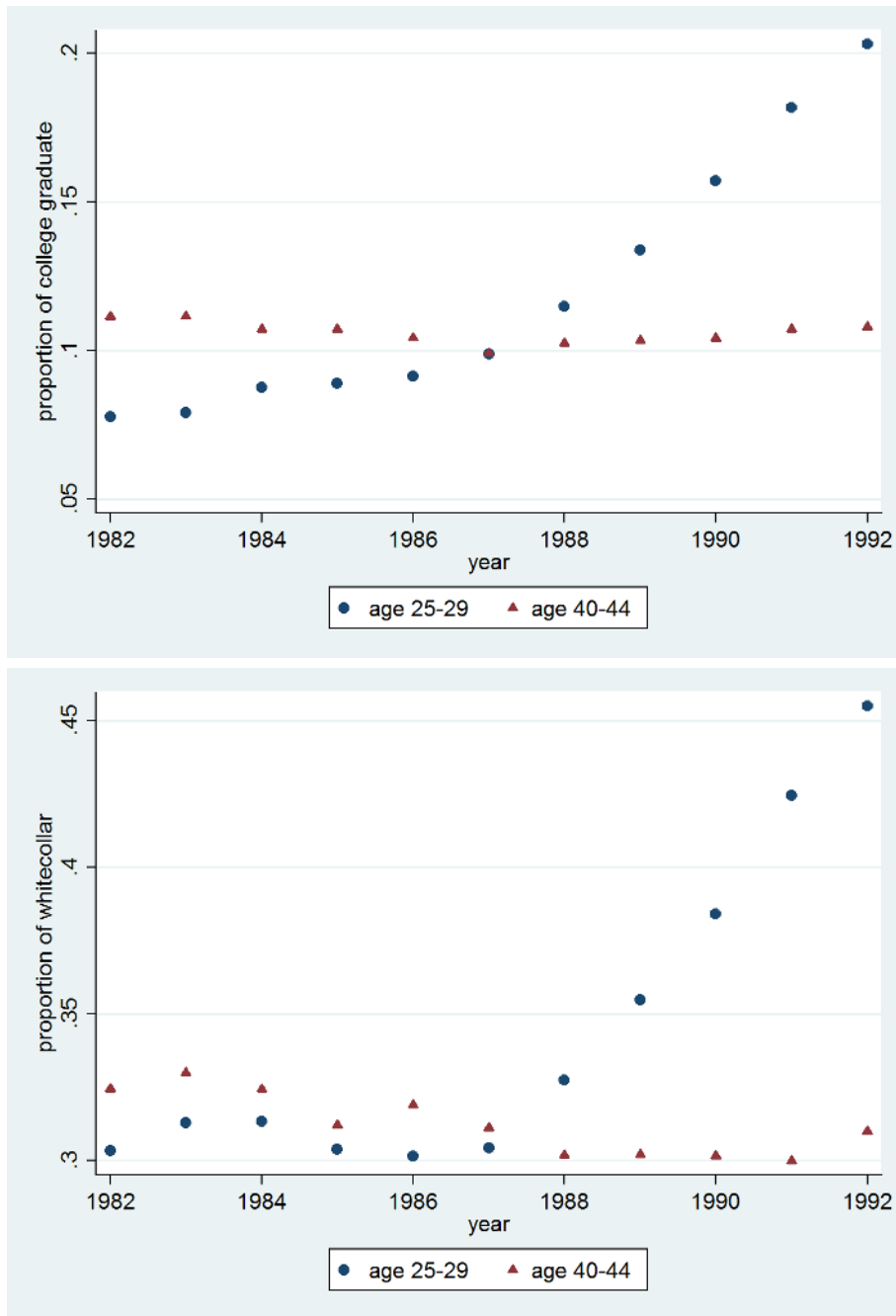


Figure 1.7: Trend of Proportion of College Graduates and White-Collar among Workers by Cohort

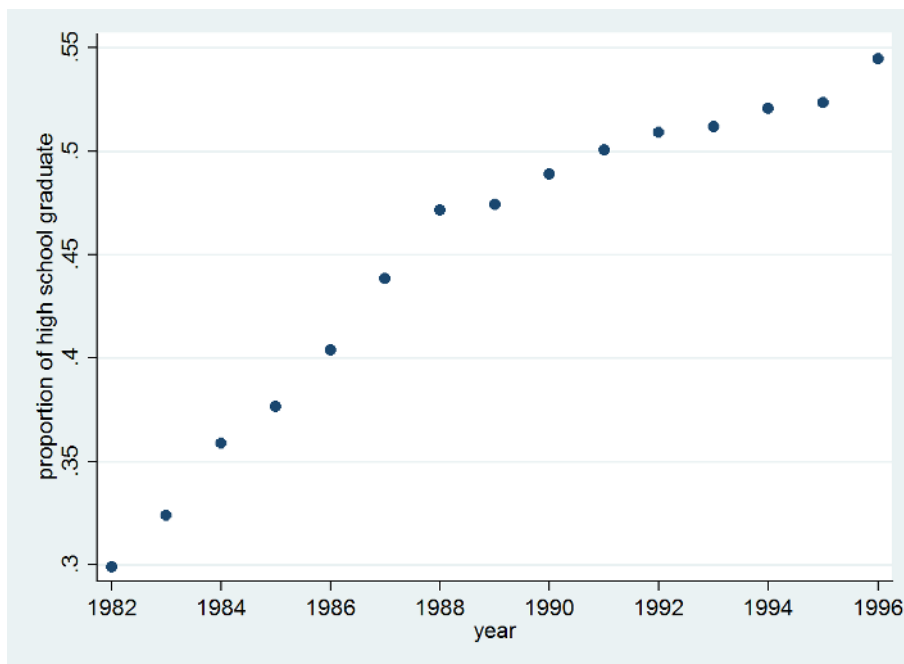


Figure 1.8: Proportion of High School Graduates among Workers by Year

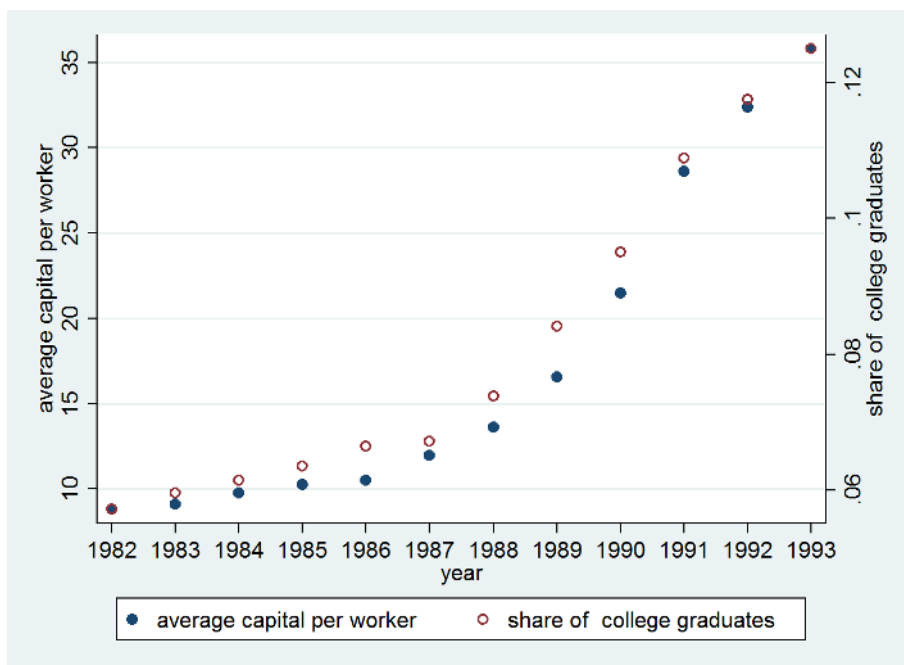


Figure 1.9: Trend of Average Capital Per Worker and Share of College Graduates among Workers

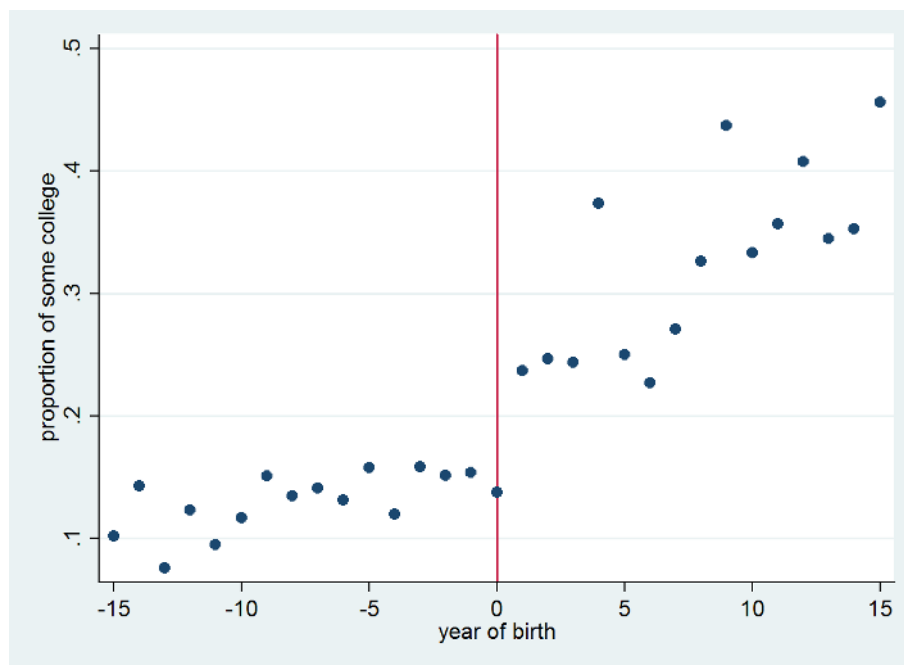


Figure 1.10: Proportion of individuals with Some College Education by Birth Cohort (Source: Park and Son (2012))

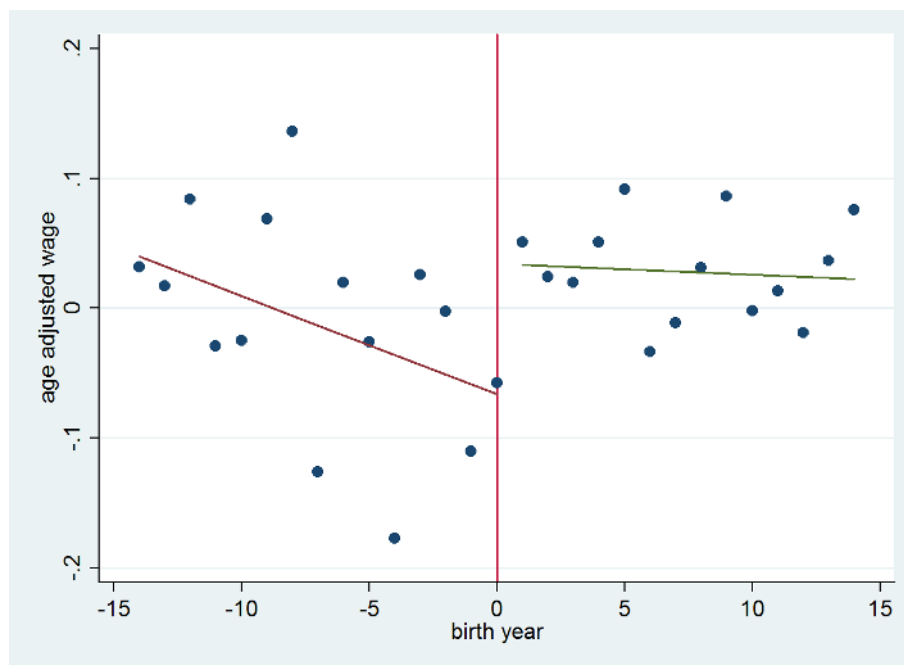


Figure 1.11: Age Adjusted Average Monthly Wage of Workers by Birth Cohort
(Source: Park and Son (2012))

Chapter 2

The Impact of College Education on Labor Market and Non-pecuniary Outcomes

2.1 Introduction

The past couple of decades have seen rapid increases in higher education enrollments. The pace of growth varies considerably across countries, with relatively little growth in countries like the United States and Israel, where higher education attainment was already quite high in the late 1990s: in contrast, historically low attainment countries such as South Korea, Belgium and France have experienced more than a 40% point increase in higher education attainment.¹

Despite the salience of these trends, there is only a limited understanding of

¹Source: OECD report of Education at a Glance 2011. OECD report have redefined tertiary education category to make international comparison possible hence the definition of tertiary education in this report could be different from what we define as higher education or college education in the sections that follow. Figure 2.1 graphically illustrates the trend in tertiary education.

the causal impact of this expansion, in part because it is difficult to observe exogenous variation in college enrollment. Most examples of exogenous variation in education come from institutional changes such as compulsory education or minimum school leaving age which allow one to examine returns to primary education or secondary education (Acemoglu & Angrist, 2000; Oreopoulos, 2006; Angrist & Krueger, 1991). Due to the lack of exogenous institutional variation in higher education, studies of the returns to college education have been limited. Currie and Moretti (2003) uses new college openings to identify the impact of mother's college education on children health. Card (1993) uses proximity to college as instrument to study the impact on earnings. However, it is hard to completely rule out that both college and residential location are endogenous.

In this paper, we contribute to the literature by providing an arguably causal estimate of the impact of college education on wages and health outcomes using a natural experiment in South Korea. Specifically, the education reform of July 1980 discretely increased the opportunity for college education by increasing the college freshman quota, the centrally mandated size of the freshman entering class. This resulted in a large increase in the proportion of individuals with some college education for cohorts born on or after 1962. We exploit this sharp difference in the proportion of population with college education across adjacent cohorts to apply a regression discontinuity design to identify the causal effect of higher education.

In addition to labor market outcome and health behavior, we explore outcomes that have not been previously addressed in the literature, such as private transfers and savings behavior. These analyses potentially shed light on the mechanism through which college education attainment operates to increase welfare.

We find that college education improves labor market outcomes of individuals mainly through an increase in labor income. In addition, we document that the

individuals with higher education are more aware of harmfulness of smoking. In particular, we document that the individuals with higher education are more likely to try quit smoking although we do not find any causal effect of higher education on incidence of smoking. We also find higher savings among the cohorts affected by the reform compared to the unaffected cohorts. This implies that the increase in earnings is not fully absorbed by an increase in expenditure, but some of the increased earnings induces positive savings. From the current analysis we cannot completely distinguish whether the increase in savings results from an increase in earnings or heightened propensity to save. However, we do find that individuals with college education are more likely to save regularly suggesting that there is some behavioral change induced by college education. These findings are in line with recent literature documenting the effect of education in various aspects of life (Oreopoulos & Salvanes, 2009; Dee, 2004).

Moreover, we find a positive impact on the likelihood of inter-vivo transfers between elderly parents and adult children, which suggests that college education could serve as old age insurance in developing countries. The motivation behind this transfer could be altruistic in which case the college educated child has a higher earnings capacity so that she has higher likelihood of providing transfer to her elderly parents. Another possible explanation could be an exchange, or *quid pro quo*, motive. Since the college educated individual received her parents' investment in education, the child repays her parents by providing transfers at old age. We might make progress in disentangling these two stories if we had education and earnings information on siblings, unfortunately with the current dataset we do not.

The main channels of higher education that positively affects each set of outcome are robust on different specifications for controlling the birth year trend in the outcome variable. The effect of the higher education on labor income and on

probability of attempting to try quit smoking is particularly robust across different specifications. In addition, the effect of higher education on the amount of savings and probability of transferring to their parents is mostly stable on the inclusion of higher order trends and splines.

The rest of the paper is organized as follows. Section 2 describes the background of the policy in Korea. Section 3 provides an overview of the main data, KLIPS. Section 4 presents the identification strategy, and Section 5 presents the main empirical results. Section 6 concludes.

2.2 Background

2.2.1 Education reform of 1980

Unlike other countries, the number of freshman admitted by colleges—the freshman quota—was controlled by the government in South Korea. The admission guidelines for both private and public colleges were centrally controlled, hence the freshman quota was applied to all types of colleges nationally. The freshman quota was strictly administered and was subject to a sizable noncompliance penalty including a loss of the government funding and/or subsidy and a reduction in freshmen quota the following year.

The supply of higher education institution was regulated centrally as well. Establishing a new college required government permission, and the government kept the number of colleges more or less stable during our period of interest.² These two restrictions rendered the supply of college graduates exogenous to the demand for college education and returns to college education. Despite the rising demand for college education, the government adjusted the of entrance quota only

²The government eventually made the restriction for establishing new college less strict in 1996

to a limited extent. This resulted in a large increase of the number of 'retakers' who took the college entrance exam and applied for college more than once.³

The freshman entrance quota was replaced by a graduation quota by the education reform of July 30, 1980. This change was completely unexpected as it was a strategic action by a military junta to gain political popularity. The reform quickly followed the formation of military junta by coup d'état of December, 1979 subsequent to President Park Chung-hee's assassination on October 1979. The main objectives of the reform were to reduce the pool of retakers, increase quality of college graduates through competition during college, and expand higher education opportunities to the disadvantaged population.

The details of the reform are as follows. Prior to the reform, the supply of college graduates were set using the freshman quota. After the reform, a graduation quota was set, stipulating the number of individuals that would be allowed to graduate. The freshman quota was calculated to correspond to 130% of the graduation quota. The reform stated that 30% of the admitted students would be discharged before graduation based on performance.

However, the discharge of students was not adhered to in practice. The government made discharge discretionary in 1983 so virtually none of the freshman affected by the 1980 education reform faced the possibility of dismissal.⁴ The graduation quota system was abolished in 1988 and the government returned to freshman quota as a single medium to regulate the supply of college graduates. As a result, the 1980 education reform effectively increased the number of college grad-

³In Korea, college entrance exam is held once a year at the end of the school year, so retakers were those whose exam results were unsatisfactory, or those couldn't get into the school they wanted and decided to wait until the next year to take the entrance exam again. There are no limits to how many number of college entrance exams they could retake. Students graduate after they finish their 3rd grade of high school, hence retakers are either high school graduates or G.E.D holders

⁴The government later allowed the student who was already discharged to reentered the school and finish his/her college degree

uates for the cohort affected by the reform. The resulting sizable increase in the freshman quota is presented in Figure 2.2.

Figure 2.3 illustrates the relationship between the freshmen quota in 1981 and freshmen quota in 1979. It verifies that the increase in 1981 freshman quota as a result of the reform was mostly proportional to 1979 freshman quota which was set by the previous government. Thus this figure provides strong evidence against the possibility that the quota increase was endogenous to regional demand or differences in the returns to education across regions.

2.2.2 The Education System in South Korea

The education system in South Korea consists of 6 years of elementary school, 3 years of middle school, 3 years of high school, and 2 or 4 years of college. The school year corresponds closely with the calendar year so the first semester is March to June and the second semester is September to December. An individual who is 7 years old as of March is mandated to enter elementary school. Elementary school became compulsory in 1952 and middle school became compulsory in 1998.

In this paper we utilize the fact that the first cohort that was affected by this reform is the cohort that took the entrance exam in December 1980. A single college entrance exam is administered at the end of each year and only students who completed 3 years of high school or the equivalent can take the exam. Hence the cohort first affected by the reform is the cohort born in 1962, since these are the individuals who are high school seniors in December 1980. Due to the discrete increase of freshman quota in 1980, we expect a discrete jump in the fraction of college educated individuals at the birth year of 1962. This exogenous discontinuity is our source of identification.

2.3 Data

This paper uses the 1st to 11th wave of the Korean Labor and Income Panel Study (KLIPS). KLIPS is similar to PSID in the U.S. as the data tracks the household and has information at both the household and the individual level for household members. The data is collected by the Korean Labor Institute to provide information about labor force participation, income and consumption, health and retirement. It is an annual panel of roughly 4,248-5,116 households and 11,541-13,321 individuals per wave, and contains detailed demographic information, labor market variables, income, assets, savings and various other economic variables. It also contains information about health related behavior and indicators such as ADL score, subjective health, smoking and drinking history. The first wave of KLIPS corresponds to 1998 and each year thereafter. Hence the 1962 birth year cohort are of age 36 in the 1st wave. Thus, these data allow researchers to examine the effect of the higher education when the individuals are at the prime of their career.

As the reform was mainly targeted to the disadvantaged population, we limit our sample to the population that initially had low college education attainment and hence are likely to be more affected by the increase in the college freshmen quota. In particular, we exclude individuals whose location of residence at age 14 is in Seoul Metropolitan area and 6 Metropolitan cities, since the college advance rate was already relatively high in urban areas prior to the reform.⁵ The number of individuals in the data is initially 17,989 and the exclusion brings the sample down to 8,852. We further restrict our sample to those individuals whose father has less than college education. We lose 974 individuals and the sample size becomes 7,878. Following the literature on labor outcomes, we focus on the male population to avoid complications related to labor market participation decisions by female

⁵The six metropolitan cities are: Busan, Daegu, Daejeon, Incheon, Gwangju and Ulsan

individuals. Finally, we limit the window of the main analysis to those whose birth year is 20 years before and after 1962. The resulting final sample size is 2,751.

We provide the following evidence that the reform indeed targeted the disadvantaged population. Figure 2.4 shows that prior to 1962, the fraction with college education was much higher in the non sample area than our sample area, despite having a similar trend.

We use measures of individual wage and/or individual labor income and household labor income to investigate pecuniary returns to college education. In analyzing individual labor income we look at all self-employed workers and employed workers who are regular workers aged between 27 and 55, with CPI adjusted monthly income of more than or equal to KRW 1,000,000.⁶

In addition to monetary returns to education, we explore the effect of higher education on savings and smoking behavior and examine whether education makes individuals more patient or forward looking and less likely to be susceptible to addiction. To perform these analyses, we examine whether the individuals has made certain behavior regularly during the period when data was collected.

Next, to explore intergenerational family dynamics we study the difference in private transfers to the elderly parents. In particular, we explore whether individuals make transfer to their parents regularly. In South Korea, the celebration of the 60th and 70th birthday is particularly important, hence it could be that even if there is no change in the general transfer behavior an individual might make a one-time transfer due to a specific event. In order to avoid counting the aforementioned instances as a behavioral change, we define regular private transfer behavior as taking that action more than twice or three times throughout the entire 11 waves.

Table 2.1 presents a summary of characteristics of individuals in the sample.

⁶\$1,000 using exchange rate of KRW1000/\$ 1

The first row shows the mean birth year of individuals in our sample. The second and third rows refer to the education level of individual's father. We see that for the individuals of interest, about 16% of the fathers have education levels of high school or more. The next two rows refer to the education level of the individuals of our interest. About 65% have education level of high school or more which is much higher than that of their fathers. About 19% of the individuals have education levels of college or more. 80% have been married and these individuals have on average 2.69 children. The last row of the summary table shows that there is a high prevalence of smoking behavior in South Korea for born 20 years before and after 1962.

2.4 Empirical Strategy

The 1980 education reform presents an opportunity to evaluate the impact of college education using a regression discontinuity design by comparing individuals born before and after 1962. The RD design relies on the idea that individuals born just before 1962 serve as a good control group for those born right after 1962. The running variable for the analysis is birth year as implied by the rules of the reform.

The underlying assumption is that college education and the outcome variables of interest are a smooth function of birth year in the absence of the education reform. For the first stage to be valid, we assume that unobservable characteristics such as the preference for college education and ability are smooth in birth year. To justify our assumption we show that observable characteristics that may be correlated with college education are smooth in the running variable. In particular, we show that father's education level is smooth around the birth year of 1962. Figure 2.5 and 2.6 present the proportion of individuals whose father's education level is more than middle school and more than high school, respectively.

Sorting is not a concern in our setting since the parents of the sample individuals could not have foreseen this reform of 1980 when planning birth. Figure 2.7 describes the density of the running variable. One can verify that there is little evidence of sorting across birth cohorts around 1962.

Our discontinuity is not sharp but fuzzy in birth year due to three reasons: i) not everyone desires to go to college ii) not everyone who desires is able to enter and iii) the existence of retakers.⁷ As we mentioned earlier, some of the students born prior to 1962 but re-taking the exam in 1980 and afterwards would also be affected by this reform. Thus we use the dummy variable for being born in or after 1962 as an instrument for college education. The first stage regression is as follows:

$$College_i = \delta_0 + \delta_1 Treat_i + f(birthyear_i) + \varepsilon_i \quad (2.1)$$

$College_i$ is a dummy variable for whether individual i has some college education. $f(birthyear_i)$ is a flexible function of birth year centered at 1962. We use a linear spline which allows the effect to vary on either side of the cutoff. ε_i is an error term clustered on birth year. $Treat_i$ is a binary variable that indicates whether the individual was affected by the 1980 education reform. This variable is defined as:

$$Treat_i = \begin{cases} 1 & \text{if } birthyear_i \geq 1962 \\ 0 & \text{if } birthyear_i < 1962 \end{cases}$$

Basically, this regression discontinuity design compares the outcome of cohorts affected by the education reform of 1980 to the cohorts born too early to be affected. The main coefficient δ_1 estimates first stage relationship between being born after 1962, and thus being affected by the policy, and receiving some college education.

⁷Being born after 1961 does not correspond directly to having some college education.

The reduced form effect estimation is as follows:

$$Y_{ib} = \beta_0 + \beta_1 \text{Treat}_i + f(\text{birthyear}_i) + \varepsilon_i \quad (2.2)$$

The coefficient β_1 is our intent-to-treat effect of interest. The calculation of treatment effect estimated by the usual 2SLS instrumental variables regression is attained by $\frac{\hat{\beta}_1}{\hat{\delta}_1}$.

2.5 Results

2.5.1 First Stage

As expected, Figure 2.8 displays a discrete increase in the fraction of individuals with some college education at the 1962 birth year. Prior to 1962, the fraction of college educated individuals was stable around 13% on average with very little growth for all the cohorts in our sample born prior to 1962. However, in 1962 the fraction jumps to more than 22% and rapidly increases thereafter. This graphical illustration is supported by the regression result presented in Table 2.2.

The coefficient of the binary treatment variable is highly significant: A strong first stage. It shows that individuals born after 1961 are 14 percentage points more likely to attain some college education than those born before 1962.

2.5.2 Labor Market Outcomes

We study the impact of some college education on employment and on two different measures of income: CPI-adjusted log monthly wage at the individual level, and CPI-adjusted log annual labor income at the household level.

The coefficients in Column (1) of Table 2.3 presents the intent-to-treat effect on

the likelihood of being employed to be 3% points.⁸ Figure 2.9 illustrates the findings. Column (2) of Table 2.3 evaluates the impact of college education on the probability of being a salary worker as oppose to being self employed. It shows that college education does not seem to have an effect on the probability that an individual is a salary worker. All in all, college education seems to have moderate effect on being employed, but little impact on being self employed conditional on employment.

Next, we examine the effect of college education on log monthly labor income. Table 2.4 documents the result. There is sizable and significant increase in labor income that is robust across different specifications which allow for various sets of controls including occupation and region of residence at age 14. In particular, we find that log monthly individual labor income increases by 9-12% for salary workers and 9-10% for all workers. Moreover, as describe in Column (3) and (4) of Table 2.A.1, the magnitude of the effect of higher education on labor income is consistent and statistically significant across different specifications for $f(\text{birthyear}_i)$ in equation (2.2). Figures 2.11 and 2.12 confirm this finding.

We summarize our findings on earnings by illustrating the life-time wage profile of workers born before and after 1962. Figure 2.13 shows life time wage profiles from age 35 to age 45 for workers born between 1959 to 1964. There exists a sizable gap between the wage profile of workers born in 1961 and 1962 compared to the wage profile gap between other adjacent cohorts, which are aligned closely.

These results suggest that the 1980 education reform had sizable labor market consequences on individuals affected by the reform. Considering South Korea's rapid growth in the late 1980s to early 1990s, which induced large demand for high

⁸The effect of higher education on the probability of being employed, however, is not robust across the different specification. In particular, as one can verify in Column (1) of Table 2.A.1, the reduced form effect of higher education becomes statistically insignificant as one a higher order spline is included.

skilled workers, combined with the low level of initial college graduates, the size of the impact on earnings and employment seems reasonable.

One interesting pattern is that despite the fact that the proportion of individuals with at least some college education continued to increase after 1962 as in Figure 2.8, the wage pattern in Figure 2.12 displays a discrete jump at 1962 and a decreasing slope thereafter. One possible explanation is that this results from a combination of the effect of decreasing wage premium for college graduates as the supply of college graduates increase and the effect of 1997 Asian Financial Crisis. The literature documents some evidence that initial labor market conditions have lasting effects on earnings and labor market outcomes of college graduates (Oreopoulos, von Wachter, & Heisz, 2012). Since the Asian financial crisis occurred at the end of 1997, the 1962 cohort was 35 and already in the labor market when the crisis had hit, but later cohorts experienced the crisis when they were just entering the labor market. Hence wage contracts were likely to be unfavorable to these later cohorts.

2.5.3 Savings Outcomes

In this section we study the impact of college education on savings behavior. Figure 2.14 displays a sizable positive effect of schooling on log savings. Column (1) of Table 2.5 shows that having some college education increases the average amount of CPI-adjusted new savings by 38%.⁹ We also show that the effect persists after we restrict the sample to individuals who save more than twice throughout 11 waves, in column (2) of Table 2.5. This implies that the increase in log average savings is not due to a one time lump sum increase in savings, but an average increase for regular monthly savings.

The discrete jump in savings could arise for several reasons. First, the increase

⁹New savings refers to the flow of new savings and not the existing stock

in monthly income may explain the increase in savings. This is a possible hypothesis as the pattern of discontinuity in Figure 2.14 is similar to that of Figure 2.12. Another possible explanation is that individuals with some college education may have lower discount factors or are more forward looking and accumulate more precautionary savings.

This savings result may not be generalizable to developed countries where interest on savings is low, but is pertinent to the developing world where savings interests are high and borrowing constraints might exist due to less developed financial markets. In South Korea, savings interest rates have been high enough to attract savings particularly in early to mid 1990s, and mortgage products are still undeveloped.

2.5.4 Smoking Behavior

In this section we study the impact of college education on three aspects of smoking behavior; namely ever smoking, tried to quit smoking, and successfully quit. Our results suggests that there is some behavioral gain through higher education attainment.

The literature on schooling and health generally agrees there is a positive correlation between health outcomes and education (Grossman, 2005). However, the literature has produced limited knowledge regarding whether education has a causal impact on health, and regarding what the operating mechanism is. For instance, Kenkel, Lillard, and Mathios (2006) finds little evidence of impact of high school completion on the probability of smoking currently using the cost and difficulty of high school graduation as an IV. Sander (1995) shows evidence that schooling increases the probability of quitting, but there is a high possibility that the instrument, parent's education, is does not satisfy the exclusion restriction.

We first examine the impact of college education on the probability of ever smoking. For all birth years prior to 1962, the percentage of individuals who ever smoke in our sample is fairly high, with an average of 80% as seen in Figure 2.15. A possible explanation for this initially high rate of smoking is that in the 1980s when the cohort born near 1962 were in their early 20s, the information regarding the harmfulness of smoking was less salient.¹⁰ Table 2.6, column (1) shows that there is negative but insignificant effect of college education on the likelihood of ever smoking. With such a high prevalence of smoking among males in South Korea during this period, college education does not seem to have discouraged individuals from starting to smoke.

Now we restrict ourselves to those who have previous smoking history and study their quitting behavior. The effect of college education on the likelihood of trying to quit is sizable. Figure 2.16 displays a large discrete jump at birth year 1962. Table 2.6 column (2) confirms this finding. The coefficient on the binary treatment variable is highly significant and positive, implying that people with some college education are roughly 15% points more likely to have tried to quit smoking.¹¹

However, our data suggest it is doubtful whether those people who tried to quit were actually successful. Figure 2.17 shows a decreasing trend in birth year of successfully quitting smoking. The high fraction of quitting for older individuals is consistent with the fact that older males have health reasons that provides them more immediate and salient reasons to quit, and the fact that there would be selection in that older males who do not quit are deceased and out of the sample. If we take these effects into account, it is probable that the fraction of successful quit-

¹⁰For example, it is recent that the tobacco companies started stating the harmfulness of smoking on cigarette packages

¹¹Column (2) -(4) of Table 2.A.2 provide a robustness check for the effect of higher education on smoking. In particular, Column (3) shows a sizable and consistent effect of higher education on quitting behavior.

ters is stable around the 1962 cutoff. The coefficient is insignificant as presented in column (2) of Table 2.6.

The three results combined suggest that college education has little impact on reducing the incidence of ever smoking but it has an effect in inducing individuals to try to quit smoking. Possible explanations for the positive impact on trying to quit are that college education increases exposure to new information on the harmfulness of smoking, or that college education increases self-control.

2.5.5 Transfer Behavior

Finally we examine whether private transfer behavior towards elder parents is different among individuals who attained some college from those who did not.¹²

Table 2.7 summarizes the regression results for inter-vivo transfers to parents. Column (1) displays that having some college education increases the probability of providing transfers by 10% points. The effect is positive and significant and confirmed by a discrete jump in birth cohort 1962 in Figure 2.18.

In column (2) we estimate a binary outcome variable that takes a value of one when the individual provides transfers more than 3 times in all 11 waves and zero otherwise. This variable captures whether the individual engages in regular transfer behavior. Comparing column (1) and column (2) suggests that having some college education has a greater impact on providing regular transfers. This finding is confirmed by comparing figures 2.18 and 2.19, as one can see the greater jump in the latter. However, column (3) shows that treatment has no effect on the log amount of transfers provided. Combined with the existence of the effect on the action of providing transfers, it suggests that individuals with some college edu-

¹²Note that the transfers are only recorded for the elderly parents who do not coreside with the individual. Thus if the proportion of individuals who do not coreside with their parents changes discretely around the 1962 cohort, the internal validity of this analysis will be compromised. Fortunately, the fraction of non-coresidency is smooth around the 1962 cutoff.

cation may have more frequent interaction with their parents and this interaction compensates for the smaller transfer amount. If South Korean parents regarded their child's college education as an investment for old age insurance, the benefit that they reap in the future is not necessarily monetary but may come in the form of non-pecuniary social interactions.¹³

2.6 Conclusion

In this paper we examined various returns to college education using an exogenous increase in the supply of college education induced by a reform in South Korea. Due to the school entry law, the education reform had the greatest impact on the birth cohorts born after 1962. Thus we employ a regression discontinuity design using birth cohort as running variable to estimate the impact of higher education on various outcomes: labor market outcomes, savings behavior and private transfer behavior. Consistent with the previous literature, we find that having college education improves labor market outcomes through increase in labor income. The earnings increase is present for both salary workers and self employed workers.

We also find that savings increase as the head of household has more college education and that the effects persist after we restrict attention to those who make regular savings. Smoking behavior is affected by college education as well. While ever smoking or quitting smoking are not significantly affected by college education, college education increases the likelihood that an individual who has a smoking history tries to quit smoking. Finally, we find that provision of private transfers from the adult child to his elderly parents becomes more likely and more regular as an individual attains some college education.

¹³Column (5) - (6) of Table 2.A.2 provide the regression discontinuity estimates for the various specifications for $f(\text{birthyear}_i)$ in equation (2.2). The results are mostly consistent with the main specification except for the specification with a quadratic spline.

The main policy implication of this paper is that promoting college education is beneficial not only in terms of earnings increase but in terms of non pecuniary and behavioral gains. The experience of South Korea might not be generalizable to countries that already have high proportion of higher education attainers, but it yields important implications for developing countries with low higher education-levels.

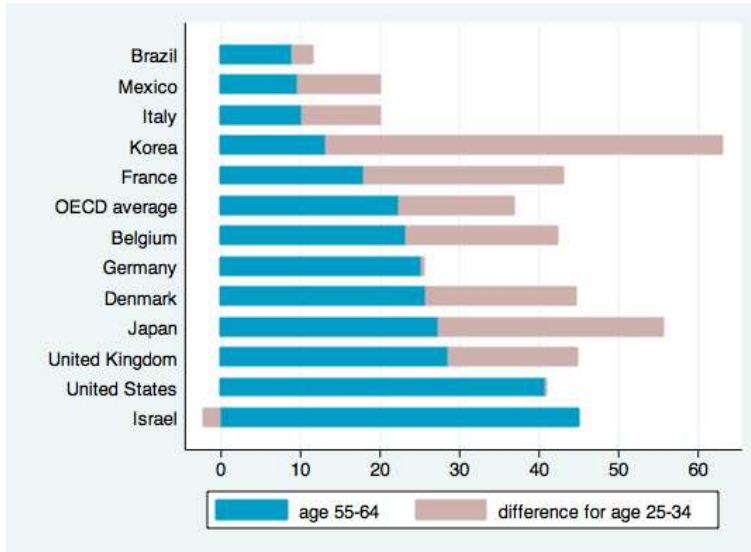


Figure 2.1: Percentage of Population that has attained tertiary education by age group(2009)

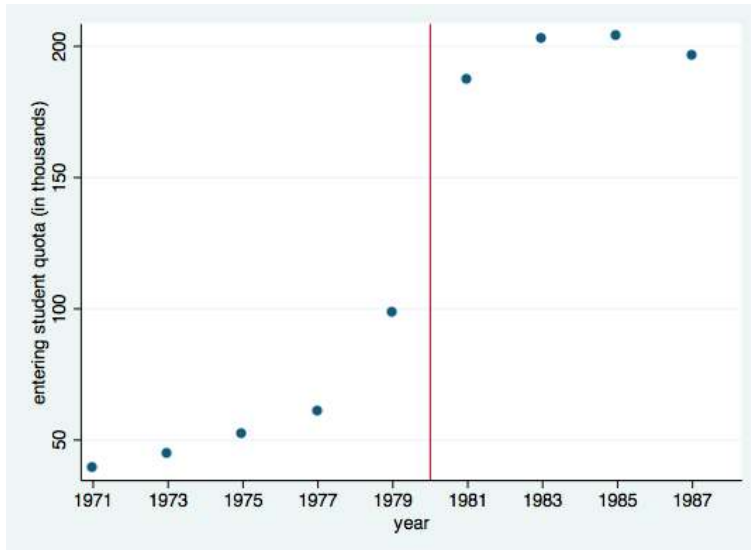


Figure 2.2: Freshman entrance quota

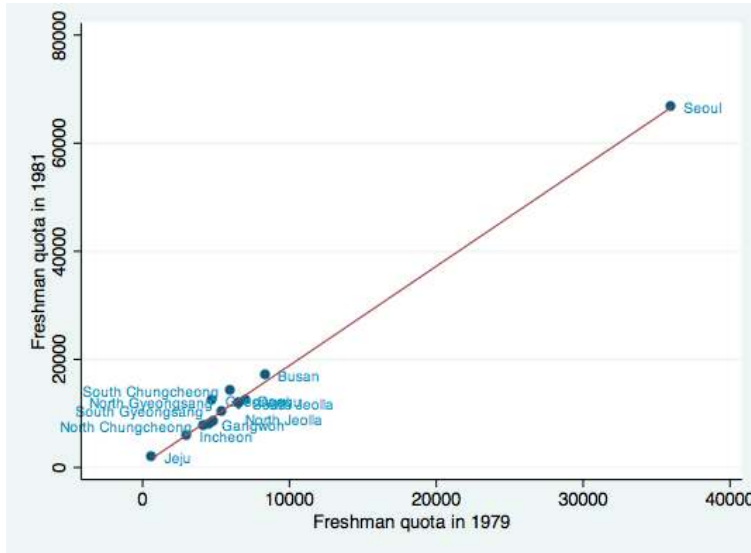


Figure 2.3: Freshman entrance quota in 1979 and 1981 by location

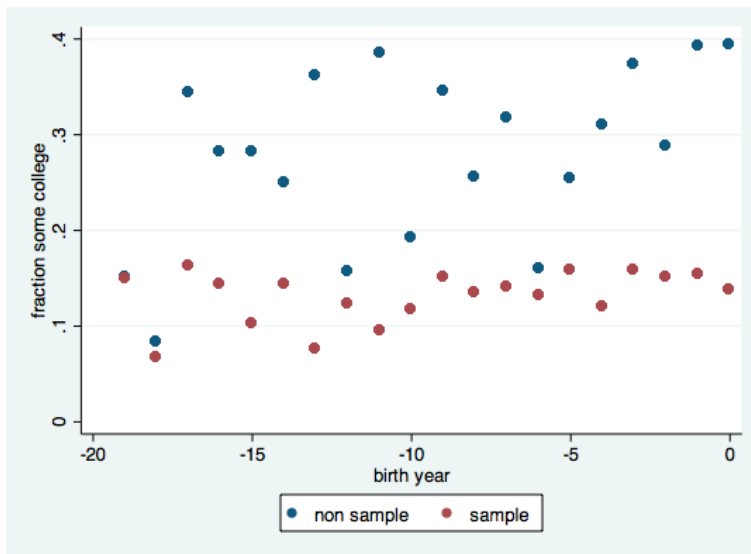


Figure 2.4: Pre trend in fraction with some college education

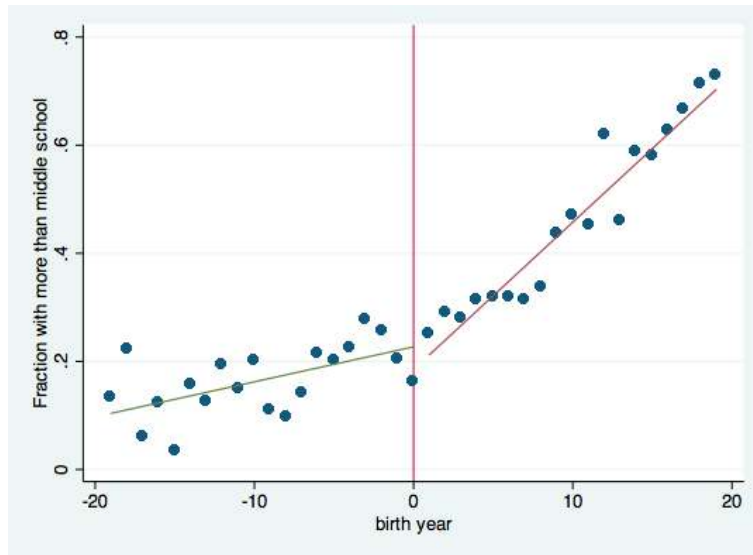


Figure 2.5: Fraction of father with more than middle school education

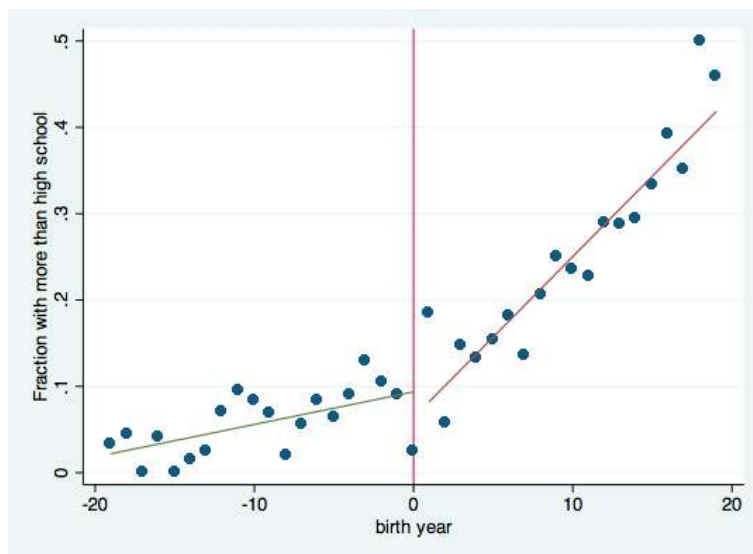


Figure 2.6: Fraction of father with more than high school education

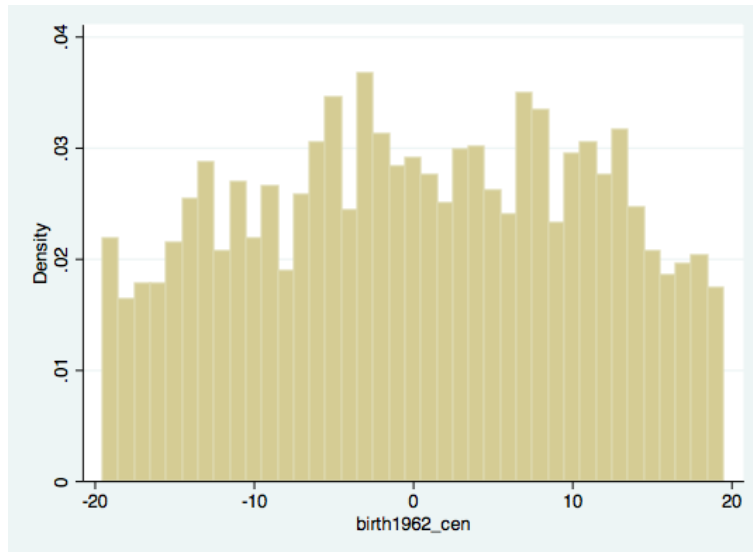


Figure 2.7: Density by birth year

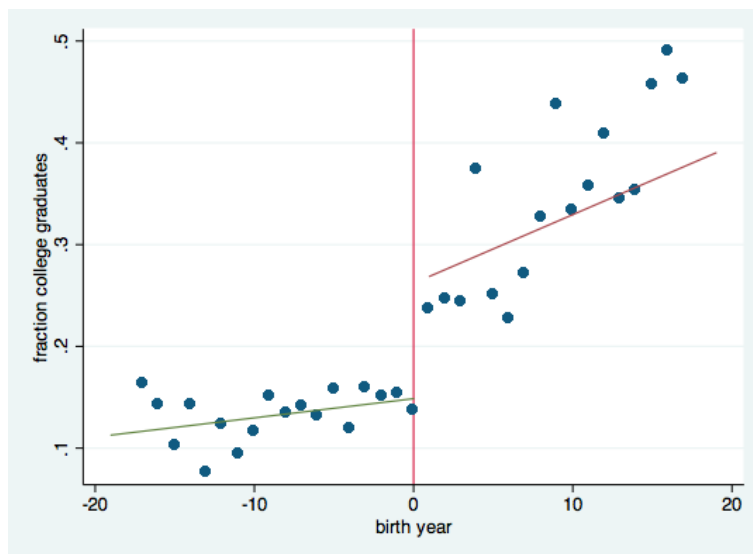


Figure 2.8: First Stage: Fraction with some college education

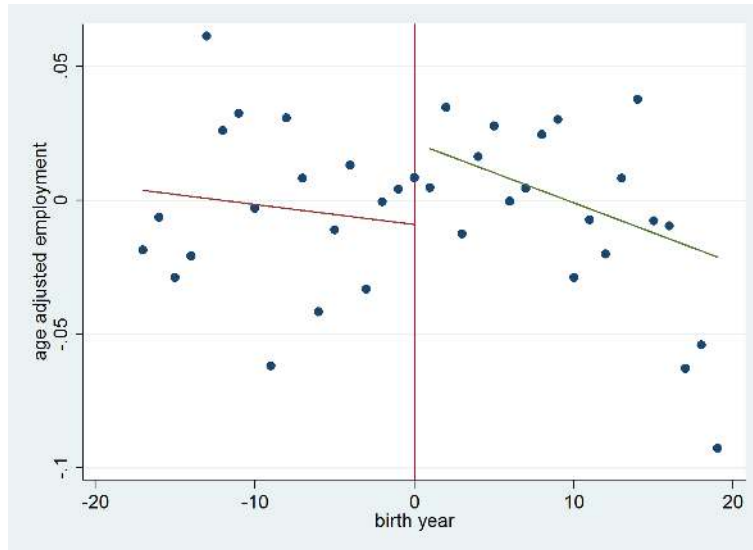


Figure 2.9: Fraction employed

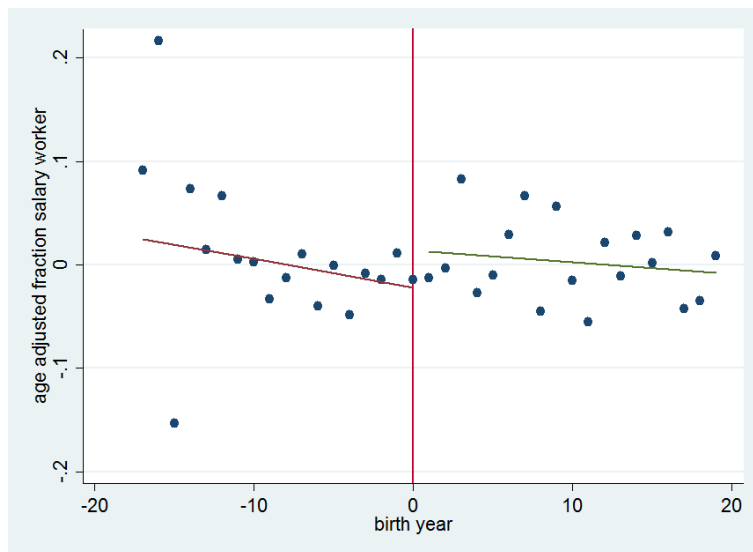


Figure 2.10: Fraction of salary workers

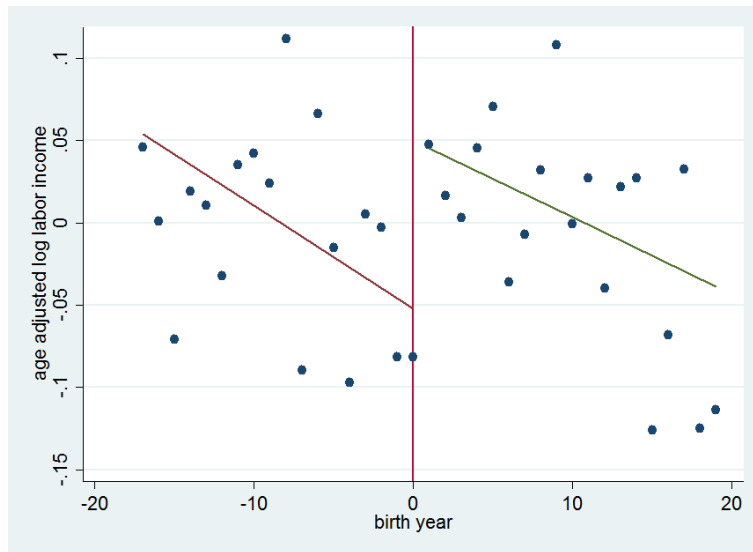


Figure 2.11: Age adjusted log monthly income

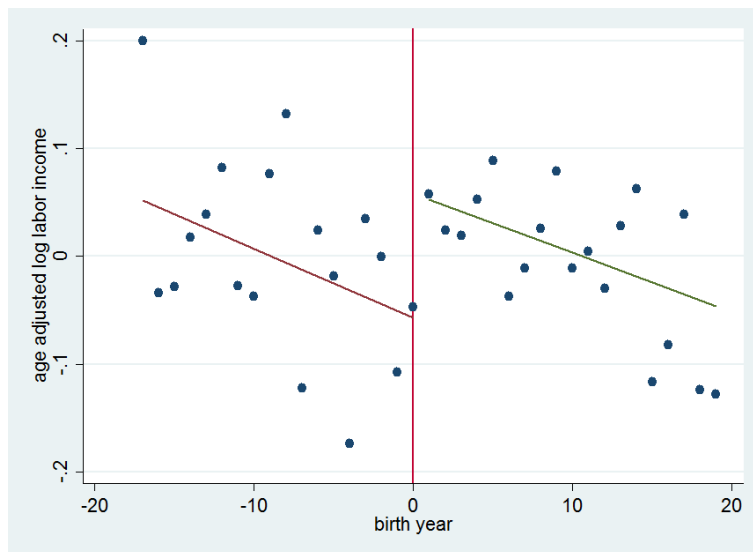


Figure 2.12: Age adjusted log monthly income

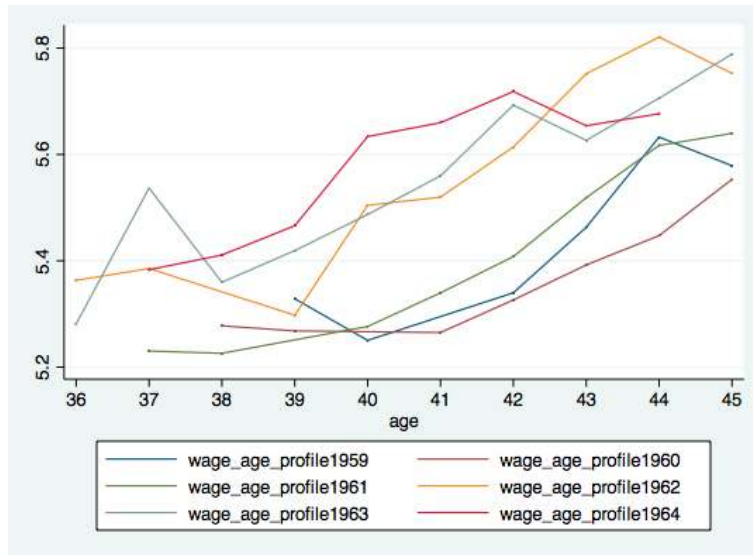


Figure 2.13: Life time wage profile of individuals born in 1959 -1964

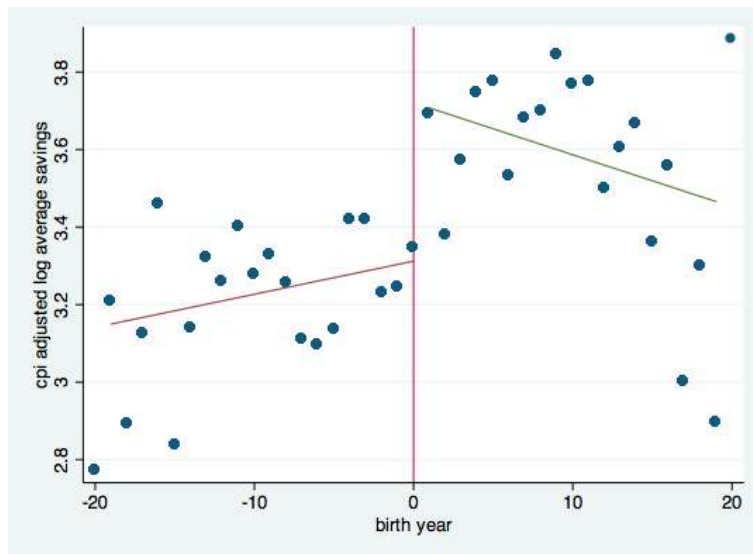


Figure 2.14: Cpi adjusted log monthly savings

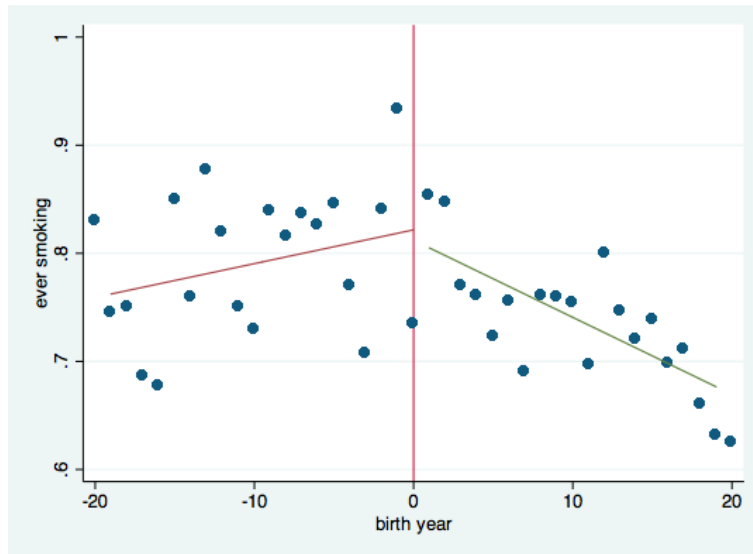


Figure 2.15: Fraction of individuals who ever smoked

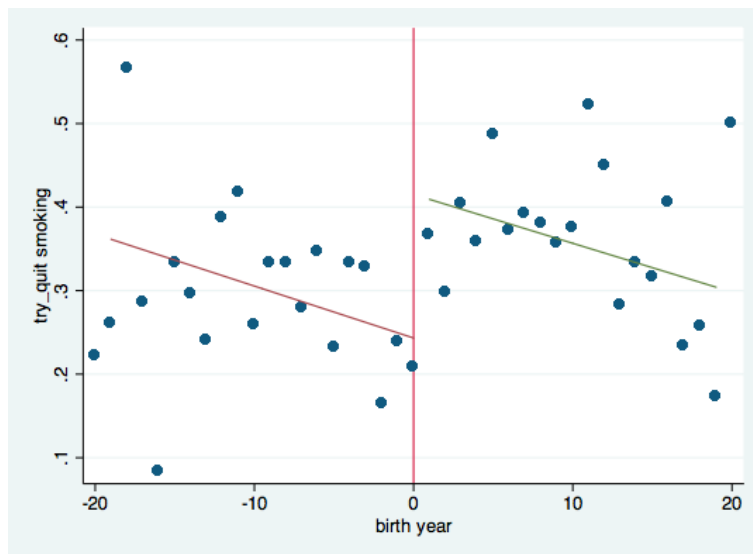


Figure 2.16: Fraction of individuals who tried quit smoking

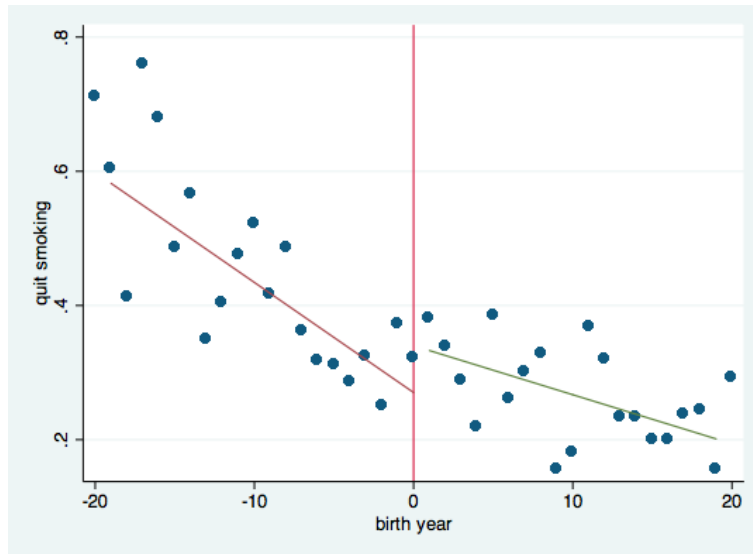


Figure 2.17: Fraction of individuals who quit smoking

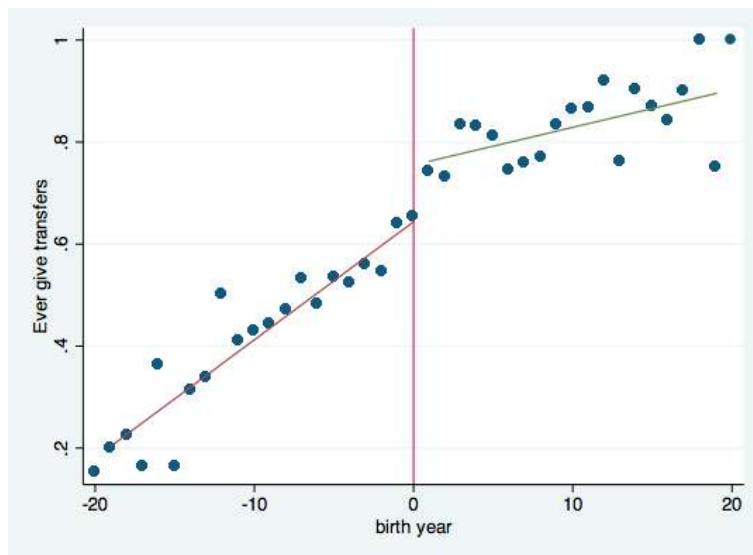


Figure 2.18: Ever provided private transfers to parents

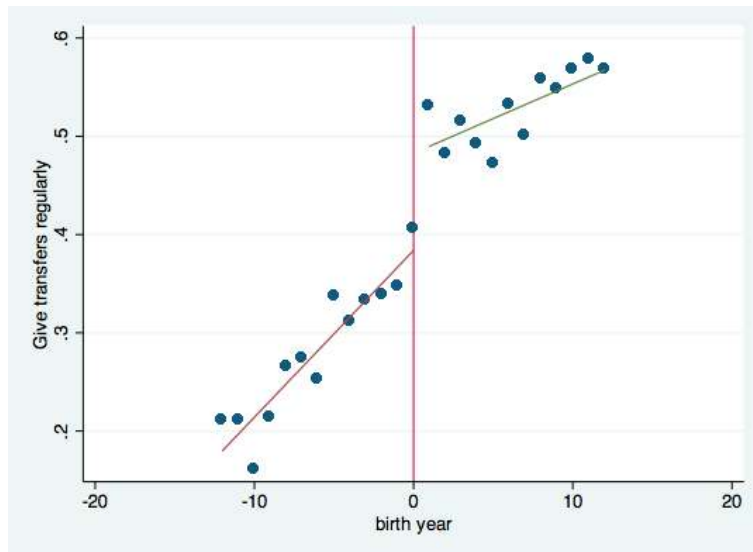


Figure 2.19: Provided private transfers regularly

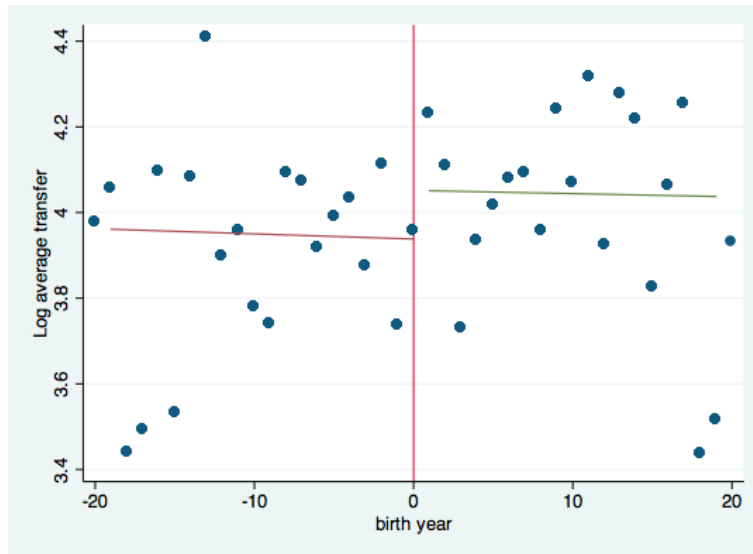


Figure 2.20: Log monthly private transfers to parents

Table 2.1: Summary Statistics

	mean	sd	N
birth year	1958.11	16.90	3742
middle school or more	0.30	0.46	3742
high school or more	0.16	0.37	3742
some college or more	0.19	0.39	3742
ever married	0.81	0.39	3738
number of children	2.69	1.50	2477
ever smoke	0.72	0.45	2913

Table 2.2: First Stage Regression

Dependent Variable	Education>High School (1)
treat	0.14034*** (0.0413)
Linear Spline	Y
adj. R-sq	0.049
N	2843

The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 2.3: Employment and Class of Workers

Dependent Variable	being employed		being salary worker	
	(1)	(2)	(3)	(4)
treat	0.03293** (0.0139)	0.03190** (0.0142)	0.03532 (0.0233)	0.03509 (0.0217)
adj. R-sq	0.02	0.021	0.050	0.055
first stage	0.09009*** (0.0184)	0.08819*** (0.0187)	0.10742*** (0.0195)	0.10630*** (0.0197)
Linear Spline	Y	Y	Y	Y
Additional Control		Y		Y
adj. R-sq	0.063	0.069	0.060	0.066
N	17808	17808	15774	15774

All specification includes year fixed effect and square in age. Specification (2) and (4) additionally controls for region where individual lived when they were 14. The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 2.4: Log amount of individual labor income

Sample	salary worker			all worker		
	(1)	(2)	(3)	(4)	(5)	(6)
treat	0.12283*** (0.0292)	0.09594*** (0.0245)	0.09499*** (0.0248)	0.10360*** (0.0244)	0.09843*** (0.0219)	0.09530*** (0.0214)
adj. R-sq	0.161	0.298	0.302	0.099	0.17	0.174
treat	0.19209*** (0.0373)	0.14220*** (0.0356)	0.13988*** (0.0345)	0.13867*** (0.0235)	0.11365*** (0.0212)	0.11229*** (0.0213)
Linear Spline	Y	Y	Y	Y	Y	Y
Additional Control		Y	Y		Y	Y
Predetermined Variables			Y			Y
adj. R-sq	0.045	0.3	0.303	0.057	0.288	0.29
N	7704	7702	7702	13113	13110	13110

All specification includes year fixed effect and square in age. Specification (2) and (5) controls for occupation of household head. Specification (3) and (6) additionally controls for region where individual lived when they were 14. The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 2.5: Savings

Dependent Variable	(1)	(2)
	new savings	# savings>2
treat	0.38324*** (0.0987)	0.28312*** (0.0648)
adj. R-sq	0.028	0.018
N	2018	1686
first stage	0.13382*** (0.0327)	0.14988*** (0.0323)
Linear Spline	Y	Y
adj. R-sq	0.060	0.067
N	2018	1686

The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 2.6: Smoking

Dependent Variable	ever smoke (1)	try quit smoke (2)	quit smoke (3)
treat	-0.00214 (0.0381)	0.14657*** (0.0384)	0.06216 (0.0458)
adj. R-sq	0.008	0.007	0.063
first stage	0.16791*** (0.0395)	0.12199*** (0.0318)	0.14871*** (0.0319)
Linear Spline	Y	Y	Y
adj. R-sq	0.060	0.048	0.055
N	2251	1417	1732

The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 2.7: Transfers to Parents

Dependent Variable	ever give (1)	num give>4 (2)	log transfer (3)
treat	0.10875*** (0.0245)	0.18430*** (0.0246)	0.11489 (0.1162)
adj. R-sq	0.190	0.098	-0.000
first stage	0.12316*** (0.0329)	0.12316*** (0.0329)	0.18041*** (0.0430)
Linear Spline	Y	Y	Y
adj. R-sq	0.056	0.056	0.078
N	2112	2112	1214

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

2.A Appendix

Table 2.A.1: Robustness check for effect of higher education on labor market outcomes

dependent variable	being employed	being salary worker	log wage(salary)	log wage(all)
	(1)	(2)	(3)	(4)
Linear trend	0.0296** (0.0147)	0.0371* (0.0216)	0.0930*** (0.0241)	0.0953*** (0.0214)
Quadratic trend	0.0295** (0.0145)	0.0372* (.0215)	0.0896*** (0.0243)	0.0945*** (0.0218)
Cubic trend	0.0128 (.0159)	0.0144 (0.0237)	0.0810*** (0.0263)	0.1045*** (0.0261)
Quadratic spline	0.0061 (0.0158)	0.007 (0.0273)	0.0771*** (0.0281)	0.1064*** (0.0292)
Cubic spline	0.0025 (0.0183)	.0039 (0.0280)	.0838*** (0.0301)	0.1292*** (0.0343)

The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 2.A.2: Robustness check for effect of higher education on saving, smoking and transfer

dependent variable	savings	ever smoke	try quit smoke	quit smoke	ever give	num give>4
	(1)	(2)	(3)	(4)	(5)	(6)
Linear trend	0.2533*** (0.0638)	-0.0204 (0.0475)	0.1663*** (0.0392)	0.0651 (0.0448)	0.0713** (0.0370)	0.1134** (0.0441)
Quadratic trend	0.2994*** (0.0621)	-0.0132 (0.0411)	0.1666*** (0.0394)	0.0564 (0.0442)	0.1096*** (0.0257)	0.1760*** (0.0235)
Cubic trend	0.2516*** (0.0792)	0.0107 (0.0580)	0.1534*** (0.0500)	0.0660 (0.0614)	0.1163*** (0.0320)	0.0893*** (0.0243)
Quadratic spline	0.1782 (0.1076)	0.0278 (0.0596)	0.1355*** (0.0448)	0.0740 (0.0624)	0.1258*** (0.0359)	0.0524 (0.0398)
Cubic spline	0.2850** (.1297)	0.1167* (0.0657)	0.1648*** (0.0545)	0.1208* (.0629)	0.1229*** (0.0440)	0.1345*** (.0337)

The standard errors are clustered at the birth year level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Chapter 3

The Effect of Higher Education on the Careers of Workers

3.1 Introduction

A large body of literature documents the pecuniary return to higher education by comparing the wages of high school and college graduates (Juhn, Murphy, & Pierce, 1993; Katz & Autor, 1999). However, the effects of higher education on other important aspects of individuals' careers—such as job mobility, training and sorting across jobs—have not been well documented.

Moreover, there is only a small amount of research relating how higher education affects the different career patterns among high school and college graduates. Since Becker (1964) and Spence (1973), the key functions of higher education have been described as human capital accumulation and the signaling of ability. Although these two functions have clear implications for the source of the return to higher education, it is not clear how they affect the subsequent careers of workers.¹

¹For instance, given the human capital accumulation function of higher education, college grad-

This paper documents the effects of higher education that yields clear predictions on the careers of workers after their graduations. Specifically, the productivity revealing function of higher education has been recently documented by Arcidiacono, Bayer and Hizmo (2010) (ABH (2010) hereafter). ABH (2010) asserts that college graduates' wages are correlated with their own abilities while the wages of high school graduates unrelated to their individual ability in the beginning of their careers. The authors interpret their findings as evidence that supports the existence of the productivity revealing function of higher education.

In addition to ABH (2010), there are several papers which also document the pooling of young high school graduates and the possible mechanisms for the phenomenon. For instance, Bishop (1994) asserts that high school graduates have difficulty promoting their high school achievements and firms have difficulty getting information on school performance. He insists that, as a result, during the first decade after leaving high school, young men do not receive rewards for developing competence in science, language arts and mathematical reasoning. Moreover, Hotchkiss (1984) and Rosenbaum (1990) find that non-cognitive traits such as maintaining low absenteeism, obeying the law, and using good study habits are also not positively related to labor market outcomes immediately after high school. These papers demonstrate that having both cognitive and non-cognitive skills—both of which are believed to be related to productivity—is not reflected in the wages of young high school graduates. Thus, at the early stages of their careers, high ability high school graduates will be 'pooled' with low ability high school graduates.

In contrast to high school graduates, many aspects of a college education make

uates can either have more post-schooling training than high school graduates or less training depending on the degree of complimentary between human capital obtained by schooling and human capital obtained by training. Since the traditional theory mainly focuses on the separation of college and high school graduates through different amount of schooling, it does not yield a testable prediction on how each group will engage in productivity revealing activities after they enter the job market.

the abilities of young college graduates readily identifiable. For instance, unlike high schools, most colleges have a dedicated department and/or personnel which issue transcripts and certificates verifying the achievements of their graduates. More importantly, as Hoxby (1997) documents, the abilities of students are homogenous within a university but heterogeneous across universities. Given the sorting of students by the ranking or selectivity of colleges, potential employers will obtain relatively accurate information about college graduates by simply observing the names of their alma maters. As a result, there will be a difference in earning among young college graduates which will roughly coincide with the different degree of selectivity across colleges. A recent paper by Hoekstra (2009) shows that the graduates from highly selective colleges earn more than their counterparts from less selective institutions in the early stages of their careers. He asserts that the signaling effect of being 'flagship' college graduates could lead to an increase in earnings.² Finally, MacLeod and Urquiola (2013) provide a novel framework that explains the selectivity of colleges and examines the effect of the selectivity of colleges on skill accumulation.

However, the sorting across high schools by students's ability is not as clear as with colleges since the admission to specific high schools is usually residence-based. In addition, rankings among high schools are not well established or publicly acknowledged like rankings among colleges are. Thus, the employer will need further information about high school graduates to evaluate their abilities. Overall, the evidence from the existing literature suggests that high school graduates are likely to be pooled together, whereas college graduates are separated at the beginning of their careers.

Based on the evidence of the productivity revealing function of higher educa-

²Other literature that examines the return from attending more selective colleges includes Loury & Garman (1995), Brewer, Eide & Ehrenberg (1999), Monks (2000) and Dale & Krueger (2002)

tion, I argue that this function of higher education yields clear and unambiguous predictions regarding worker's subsequent productivity revealing behaviors. To be concrete, if the individual abilities of high school graduates are not directly observable, high ability high school graduates will not be appropriately compensated, since their wages will be set based on the average ability of high school graduates. As a result, it is likely that high ability high school graduates will engage in activities that will separate them from low ability high school graduates after they start their careers. More specifically, I predict that the high ability high school graduates will be more likely to obtain off-the-job training, and more likely to sort themselves into performance pay jobs in which the wage is closely related to ability.

Unlike high school graduates, high ability college graduates are not expected to engage in costly activities to separate themselves from those of low ability since the abilities of college graduates are apparent at the beginning of their careers. Thus, the probability of participating in off-the-job training and sorting into performance pay jobs would not be positively correlated with the measure of ability among college graduates at the early stages of their careers.

Moreover, I expect that the job mobility of high ability high school graduates will be higher than that of low ability counterparts as they move to better jobs and differentiate themselves from low ability workers. However, their job mobility will not necessarily depend on ability, since college graduates are assigned to jobs according to their abilities from the beginning of their careers. Thus, the job mobility of college graduate workers will be determined by the factors that are not related to worker's ability such as a random job match between employer and employee. This mechanism provides an alternative explanation to the traditional search theory that has been applied to explain the positive return to job mobility among high school graduates in Topel & Ward (1992).

I verify these predictions using NLSY79 data by documenting the different relationships between AFQT scores and productivity revealing activities across high school and college graduates. From the analysis, I observe the different patterns of productivity revealing activities across high school and college graduates. Those patterns coincide with the prediction of the signaling model under a different degree of asymmetric information between employers and workers across two groups. The results also illustrate the role of productivity revealing activities of workers as an alternative mechanism for employer learning which helps explain how the wage of high school workers eventually reflects their individual abilities.

The rest of the paper is organized into the following sections. In section 2, I build a model of individual's sorting behavior into higher education, and the subsequent aspects of careers using a two stage model. Section 3 describes the testable implications of the model for job mobility and productivity revealing activities. In Section 4, an overview of NLSY79 and the sample construction are described, followed by the identification strategy and estimating equation in Section 5. Section 6 presents the main empirical results that verify the prediction of the model. Section 7 compares this paper with the employer learning model, and Section 8 concludes.

3.2 Model

This section illustrates a base model that can explain individuals' sorting into higher education and productivity revealing activities under imperfect information. The model is based on several assumptions about the cost of productivity revealing activities and the distribution of workers' ability.

1. There are individuals in an economy; each individual has innate ability, a distributed as $F(a)$. The employers do not have direct information about the

individual abilities of workers.

2. The return from higher education is not negatively correlated with ability and the cost of schooling is not positively correlated with ability.
3. The labor market is perfectly competitive. Thus, the wage of workers equals the expected productivity of the workers
4. The cost of productivity revealing activities is not extremely high and the dispersion of ability is large enough to make productivity revealing activities profitable for some portion of top ability workers.

At the first stage, people decide whether they will sort themselves into higher education or not. Under the commonly acknowledged functions of higher education—signaling and human capital accumulation—and reasonable assumptions about the costs of higher education, a certain portion of individuals from the top of the ability distribution will sort themselves into higher education. Specifically, there is an ability cutoff a^* where individuals with ability greater than a^* sort themselves into higher education. Individuals who sort themselves into higher education become college graduates and individuals who do not enter higher education remain high school graduates. For simplicity, I ignore high school dropouts and individuals who have not completed college.³⁴

At the beginning of the second stage, individuals finish their schooling and enter the job market. The individuals then decide whether to engage in productivity revealing activities that will further reveal their abilities. Employers know that

³It is worth noting that the prediction and implication of the model will not be dependent on the source of the return to education. That is, motivation for education does not matter as long as high ability individuals sort themselves into higher education. The productivity revealing function of higher education will be applied to college graduates *regardless* of the workers' motivation for entering higher education.

⁴Including workers with only some college education will only make the model more complicated without gaining meaningful implication.

the average ability of college graduates is higher than the average ability of high school graduates. Moreover, given the productivity revealing function of higher education, college graduates will receive wages according to their individual abilities. However, in regards to wages, high school graduates will be pooled at the beginning of their careers, since employers cannot verify the individual abilities of high school graduates. Thus, the wages of college workers whose abilities are a will be $a + H$, where H is human capital accumulation from college education whereas the wages of high school graduates will be $E(a|a < a^*)$ regardless of the value of individual abilities a .⁵

Thus, given these initial wages of high school graduates, some portion of high ability high school graduates will engage in productivity revealing activities to separate themselves from low ability high school graduates, and to ultimately get paid for their individual abilities. However, high ability college graduates will not engage in costly productivity revealing activities since they are already separated from *both* high school graduates and low ability college graduates. I exploit this predicted difference in productivity revealing activities between high school and college graduates to identify the effects of higher education on the subsequent careers of individuals.

3.3 Testable Implications

In this section, the prediction on productivity revealing activities based on the model described in Section 3.2 is provided in detail. In particular, I describe off-the-job training and sorting into performance pay jobs as productivity revealing activities. I also predict the relationship between ability and job mobility for high school graduates, and compare it with that for college graduates under differing

⁵The prediction of the model does not depend on the magnitude of human capital component, H .

degrees of imperfect information across the two groups.

3.3.1 Off-the-Job Training

The previous literature on training mainly focuses on the human-capital-mediated effect of training on wage increases or job mobility (Lynch, 1991, 1992; Parent, 1999). In contrast, here I view training mainly as a mean to reveal the productivity of workers. In particular, off-the-job training (OFT) is similar to schooling in the sense that the worker pays the cost of the training, and the contents of the training are not firm-specific. Given the similarities between off-the-job training and schooling, off-the-job training can be used as a signaling device. Thus, as traditional signaling theory (Spence, 1973) would predict, the high ability workers will be more likely to obtain OFT than their low ability counterparts if they are not differentiated from their low ability counterparts.

Therefore, for the high school graduates whose abilities are not revealed at the beginning of their careers, the probability of getting off-the-job training will be positively related with their AFQT scores, as high ability high school graduates use OFT as a productivity revealing device. However, for college graduates whose individual abilities are already apparent, the probability of obtaining OFT will not necessarily depend positively on measured ability. Moreover, since the return from being separated from low ability workers decrease with time, the probability of getting OFT will decrease faster with experience for high ability high school graduates compared to their low ability counterparts. In other words, the experience gradient will be steeper for the high ability high school graduates whose motivation for taking OFT depends on both signaling (productivity revealing) and human capital accumulation. However, I do not expect different experience gradient across college graduates since the high ability college graduates do not have additional

incentives to take OFT in the early stage of their careers.

3.3.2 Performance Pay

A recent paper by Lemieux, MacLeod and Parent (2009) asserts that as a result of imperfect information about workers, high ability workers will have an incentive to sort themselves into performance pay jobs so that they can reveal their high productivity and receive wages that more closely reflect their abilities. Lemieux, MacLeod and Parent support this argument by comparing the average AFQT score of the workers in performance-pay jobs with AFQT scores of the workers in non-performance-pay jobs. Adopting their view on performance pay jobs, one can categorize sorting behavior into performance pay jobs as a means to reveal the productivity of the workers. Thus, given the functions of higher education, the relation between ability and having a performance pay job among high school graduates will be different from that among college graduates.

To be more specific, since high school graduates are pooled with each other at the beginning of their careers, high ability high school graduates will try to sort themselves into performance pay jobs and receive pay in relation to their individual abilities. However, unlike high school graduates, college graduates are differentiated by their ability from the beginning of their careers. Thus, high ability college graduates will have little incentive to sort themselves into performance pay jobs and pay additional monitoring costs to reveal their high abilities. In other words, it is not necessary for high ability college graduates to sort themselves into performance pay jobs; in fact it could be considered wasteful in the early stages of their careers.

In sum, the probability of getting performance-pay jobs will depend positively on AFQT scores *among* high school graduates in the early stages of their careers,

whereas *among* college graduates the correlation between working at performance pay jobs and AFQT scores will not be positive.⁶

3.3.3 Job Mobility

The positive relationship between wage increases and job mobility for young high school graduates has been well documented by Topel & Ward (1992). They interpret the results as supportive evidence for the search theory and view job mobility as an important means for wage increases and as a step toward stable long-term employment for high school graduates.⁷

In my paper, the positive return of job mobility among high school graduates is regarded as a result of the positive return to productivity revealing behavior. More concretely, high ability high school graduates will have higher job mobility than low ability high school graduates as they engage in productivity revealing activities to differentiate themselves from their low ability counterparts so that they can move to better jobs in the early stages of their careers. Thus, there will be a positive relation between wage increases and job mobility, as high ability high school workers move to better jobs with higher wages. Moreover, as high ability high school graduates obtain the jobs they deserve, the incentive to move to other jobs will decrease over time, and, their careers will eventually stabilize. This implies that the negative relationship between job mobility and potential experience will be steeper for the high ability high school graduates than for low ability high school

⁶The difference in the probability of sorting themselves into performance pay jobs *between* high school and college graduate workers can still exist, as college graduates are more likely to sort themselves into performance pay jobs. This fact does not contradict the model since the difference *between* average high school and college graduates can be explained by other factors such as the differences in job characteristics of college and high school graduates

⁷Unlike Topel & Ward (1992), Neumark (2002) views job mobility as a wasteful procedure. He argues that the judgment of the job mobility can be different between high school and college graduates.

graduates.

However, high ability college graduate workers will not have an incentive to move between jobs at the cost of firm-specific human capital, since college graduates are offered jobs according to their individual abilities from the beginning of their careers. That is, high ability college graduate workers will not have to engage in costly job searches and the related job mobility to separate themselves from their low ability counterparts in the early stages of their careers. Moreover, since high ability college graduates do not have high job mobility at the beginning of their careers, the relationships between job mobility and potential experience will not differ across ability among college graduates.

3.4 Data

To empirically verify the predictions regarding productivity revealing activities and job mobility of workers, I use NLSY79 data for 1979-2006 period. The data have been collected annually since 1979 and biannually since 1994. The respondents were aged between 14 and 22 at the beginning of the survey. The data have a number of advantages for analyzing post-schooling signaling behavior. First, productivity revealing activities are most likely to be important in the early stages of workers' careers, and NLSY79 is precisely focused on this part of respondents' life cycle. Second, for the analysis of post-schooling behavior proposed in this paper, information regarding workers' ability is essential. NLSY79 contains the results of AVSAB test which can be converted to an AFQT score. The AFQT score in NLSY79 has been widely accepted as a pre-market measure of ability (or cognitive skill). Third, NLSY79 contains longitudinal information that enables the researcher to determine workers' transitions into the labor force. This information allows one to calculate potential experience which is more precise than using the commonly

used but arbitrary definition of potential experience (age-highest grade-6). Lastly, the data have detailed information about the training of workers and their job characteristics, including the payment structure of jobs.

For the main analysis, I restrict the sample to white males in order to avoid tracking the variations in careers that might arise from differences in race and/or gender. Following ABH (2010), I also limit the sample to respondents who have completed 12 or 16 years of education and exclude high school dropouts and individuals who have completed some college education. I do not include respondents who have military jobs or, jobs without pay, who are self-employed in CPS (main) jobs, or who work for a family business. I also exclude labor market experience accumulated before individuals left school for the first time. The potential experience is defined as the number of years since a respondent first finished schooling.

Furthermore, I restrict scope of the analysis to individuals for whom potential experience is less than 13 years, thereby focusing on the early stages of their careers. Another reason for this criteria of sample construction, as explained in ABH (2010), is to keep the analysis simple by focusing on the approximately linear region of the relation between log wages, AFQT scores, and potential experience.

The measure of ability, AFQT, is constructed using the definition provided by the Department of Defense, and is standardized by the age of the individual at the time of the test. The construction of performance pay indicator variable follows LMP (2009). The performance pay indicator takes a value equal to one if the wage of CPS jobs includes a variable pay component such as a bonus, commission or piece-rate. For the off-the-job training variable, I follow Parent (1999) and re-classify 12 training categories into three groups—on-the-job training (OJT), off-the-job training (OFT), apprenticeship. The OFT indicator variable takes a value equal to one if the respondent took any form of OFT—business colleges, nursing

programs, vocational-technical institutes, etc.—in a given year. I use the hourly wage rate of CPS jobs from the work history file as a measure of wages and obtain the real wage by using the CPI index. The number of jobs in a given year is used as a proxy for the job mobility of workers.

[Table 1 about here]

Table 1 shows the summary statistics for the main analysis sample. As expected, the average of log wages and the average AFQT scores are higher for college graduates than for high school graduates. College graduates are more likely to sort themselves into performance pay jobs and to obtain training. Additionally, the composition of training differs between the two groups as high school graduates are more likely to obtain OFT and apprenticeships and are less likely to obtain OJT. However, there is little difference in the number of jobs per year between college and high school graduates.

3.5 Identification Strategy and Empirical Specification

The scarcity of exogenous variations that induce people to engage in college education makes documenting the effect of college education challenging. There are a few papers such as Card (1993) and Currie and Moretti (2003) that exploit the distance to college and college opening as an instrument for higher education. However, the validity of those instruments is perhaps more open to question—due to the endogenous location of individuals and colleges—relative to other instruments that induce people to take additional K-12 schooling, such as a change in a compulsory schooling law.

My paper sidesteps this issue by following ABH (2010) and documents the different relationship between ability and outcomes *between* high school and college graduates. I claim this difference as evidence supporting the effects of higher edu-

cation on the subsequent careers of the workers.⁸ To be specific, I verify a positive and statistically significant relationship between the incidence of productivity revealing activities and the ability among high school graduates, while I find a non-positive relationship among college graduates. I attribute this difference between the two groups to the differences in the productivity revealing activities across the two groups given the functions of college education.

The main empirical specification follows employer learning literature (Altonji and Pierret (2001)) and regresses the outcome variable on a measure of ability, potential experience and the interaction of the two. The following equation will be estimated separately for high school and college workers:

$$Y_{it} = \beta_0 + \beta_1 AFQT_i + \beta_2 Exp_{it} + \beta_3 AFQT_i * Exp_{it} + f(Exp_{it}) + \delta_t + \Phi' X_{it} + \epsilon_{it} \quad (3.1)$$

where Y_i is the outcome variable such as the wages of the workers, the number of jobs held in a given year and the dummy variable for a having performance pay jobs and engaging in off-the-job training. The coefficient of $AFQT_i$, β_1 , indicates the correlation between the outcome variable and AFQT scores at the beginning of individual's career—when their potential experience is equal to zero. The coefficient of the interaction term, β_3 , captures the difference in the correlation between experience and outcome across workers with different ability. The prediction of the model will be supported by the examining difference in the statistical significance and the sign of coefficients in each group. To be more concrete, β_1 and β_3 are expected to be positive and negative respectively for high school graduates. On the other hand, for the college graduates, the coefficients for AFQT scores and the

⁸ABH (2010) assert the difference in the statistical significance of the key coefficients across the two groups as an evidence for the productivity revealing function of college education

interaction term are expected to be non-positive and non-negative respectively.

In order to test the implications regarding performance pay jobs, the main specification will only have the AFQT score and a measure of potential experience as an independent variable due to the data limitation.⁹ Thus, the implication of the model will be verified by examining whether there is a difference in the relation between having a performance pay job and the ability in the first 13 years of an individual's career across the two groups.

3.6 Results

This section provides the empirical results that verify the prediction of the model regarding productivity revealing activities and job mobility of workers. Before presenting the main results, I first replicate the main result of ABH (2010) to show the productivity revealing function of higher education.

3.6.1 Replication of ABH (2010)

Table 2 shows the replication of ABH (2010). The results are qualitatively similar to ABH (2010), for both college graduates and high school graduates. The AFQT coefficient in column(3) is positive but small and statistically insignificant, which implies that the wages of the high school graduates do not reflect their cognitive abilities at the beginning of their careers (when their potential experience is zero).

⁹The data from the question about performance job are collected between 1988~1990 and 1996~2000 when most of respondents had already gained over 7 to 8 years of potential experience. As a result, the estimation of β_1 in equation (1) which estimates the AFQT scores and the outcome at the beginning of workers' careers will be unreliable. Moreover, since the collection of information about performance pay is not continuous, β_3 which estimates the relation between performance pay and experience will also be unreliable. Thus, I only look at whether sorting into performance pay depends on AFQT for the first 13 year of workers' careers. The prediction of the model implies that the AFQT coefficient will be positive and significant for high school graduates but insignificant for the college graduates.

The coefficient on the interaction term between AFQT scores and potential experience is positive and significant, which implies the wages of high school graduates eventually reflecting their individual abilities. In other words, the high school graduates are pooled with each other at the beginning of their careers but are separated by AFQT scores eventually.

[Table 2 about here]

On the other hand, the results for college graduates show a different pattern, as ABH(2010) finds. The AFQT coefficient in column(6) is sizable, positive and significant whereas the interaction term is small and insignificant. Thus, unlike high school graduates, college graduates are separated by their AFQT scores from the beginning of their careers, and the additional separation associated with experience is insignificant. Figure 2 and Figure 3 below illustrate the wage dynamics for high school and college graduates.

[Figure 2 and Figure 3 about here]

Taking into account that the variations in AFQT scores are much smaller among college graduates than among high school graduates, this result seems to provide a strong support for the argument that higher education fulfills a role for productivity revealing. Moreover, the result also provides evidence against the assertion stating that job mobility and productivity revealing are due to the different variance in AFQT scores between each group.

3.6.2 Job Mobility(Number of Jobs)

Table 3 describes the results for the job mobility of workers. As expected, the job mobility of high school graduates is positively related with ability at the beginning of their careers. The coefficient of AFQT in column (3) is positive and significant at the 5% level. In particular, one standard deviation increase in AFQT is associated

with 0.12 more jobs per year in the early stage of high school graduates' career. The coefficient for the interaction term is negative and significant for high school graduates. This result coincides with the career of high ability high school graduates which eventually stabilizes over with time. In other words, the potential experience gradient is steeper for high ability high school graduates since they will take more jobs in the beginning of their careers than low ability high school workers will take, although they will have similar job mobility later in their careers. Column (1) also shows that the job mobility in the first 13 years of career is positively related with the ability for high school graduates.

[Table 3 about here]

However, the results for college graduates display different patterns between ability and job mobility. The data in column (6) suggest that, unlike the high school graduates, job mobility does not depend on AFQT scores for college graduates. The coefficients on both AFQT scores and the interaction term are statistically insignificant for college graduate workers. These data suggest that factors, such as the random job match quality between employers and employees, which will not depend on the abilities of workers, might be a major determinant of the job mobility among young college graduates. The results from column (4) also show that job mobility and ability are not positively related in the first 13 years of college graduates' careers.

Overall, the results show that job mobility has different patterns among high school and college graduates. These differences could shed light on the source of return from job mobility which is described in Topel & Ward (1992). The results suggest that the return from job mobility among high school graduates arises from the correlation between ability—which is positively related with wages in the long run—and job mobility. Moreover, given the positive return from firm specific hu-

man capital, different patterns of job mobility also suggest a possible source of positive pecuniary returns from higher education.

Since average job mobility, measured by the number of jobs in a given year, is similar among high school graduate and college graduate workers, the results imply that high ability high school graduates will have higher job mobility than *both* low ability high school graduates and low ability college graduates in the beginning of their careers. Thus, the low ability college graduates will accumulate more firm specific human capital than high ability high school workers and can accelerate their wage growth as they do not have to move between jobs as high ability high school graduates (Neumark, 2002). Since most of the literature documents the return of higher education by comparing high ability high school graduates and low ability college graduates, these results could be further interpreted as a source of monetary return to higher education documented in those papers.

[Figure 4 and Figure 5 about here]

3.6.3 Post Schooling Productivity Activity (Off the Job Training and Performance Pay Jobs)

Table 4 summarizes the results of off-the-job training. The probability of taking OFT does not depend positively on the AFQT scores of college graduates in the early stages of their careers as the AFQT coefficient in column (6) is negative and not statistically significant at 5%. Further, the coefficient of the interaction term between AFQT scores and potential experience is positive which would reject the possibility of OFT being used as a productivity revealing device for high ability college graduates. If OFT is used as a productivity revealing device, it should be used more intensively by high ability college graduates in the early stages of their careers. Overall, the evidence supports the view that for college graduates, pro-

ductivity revealing is not a dominant motivation for receiving OFT. Column (4) shows that there is little correlation between the incidence of off-the-job training and ability in the first 13 years of the careers of college graduates.

[Table 4 and Table 5 about here]

However, for high school graduates, the results coincide with the prediction that high ability high school graduates will use OFT as a mean for productivity revealing. The AFQT coefficient in Column (3) is positive and significant, which implies that at the beginning of careers, high ability high school graduates are more likely to engage in OFT than their low ability counterparts. Moreover, the coefficient of the interaction term between AFQT scores and potential experience is negative which implies high ability high school graduates are more likely to undertake OFT at the beginning of their careers compared to low ability high school graduates. This result also coincides with the prediction of the model since the return of the productivity revealing component of OFT is higher in the early stages of a career, and high ability high school graduates will engage in OFT more intensively in the earlier stages of their careers.

The results for workers' sorting behavior into performance pay jobs also provide evidence of different productivity revealing behaviors between high school and college graduates. As described in Column (1) of Table 5, the probability of having performance pay jobs depends positively on the AFQT scores for high school graduates in the first 13 years of their careers. However, for college graduates AFQT scores do not affect the probability of obtaining performance paid jobs during the early stages of their careers as the coefficient in Column (4) is not statistically significant. Moreover, Column (3) and Column (6) also show that estimation result using the potential experience and the interaction term between AFQT scores and experience are fairly consistent with the prediction of the model.

Based on the results discussed in this section, Figures 4 and 5 highlight the different patterns of job mobility and productivity revealing activities across high school and college graduates. Overall, the results provided in this section fit the prediction of the model, thus, supporting evidence on the effects of higher education on the subsequent careers of workers.

3.7 Comparison with Employer Learning Literature

Since the seminal work by Farber and Gibbons (1996), the role of employer learning on wage dynamics—the wages of young workers eventually being positively related with AFQT scores—has been well documented by several papers such as Altonji and Pierret (2001) and Bauer and Haisken-DeNew (2001). The basic employer learning model hinges on the public or symmetric employer learning which assumes that the current employer's information about the workers is being shared with *all* potential employers. However, the existence of private or asymmetric learning of employers makes the plausible mechanism of employer learning complicated. As a result, only a small number of papers—Schoenberg (2007) and Pinkston (2009)—proposed an employer learning mechanism that explains wage dynamics under the private or asymmetric learning of employers. However, given the high mobility of high school graduates in the early stages of their career (Topel & Ward, 1992), it seems unrealistic that information about average young workers could be accumulated in a short time and then passed to outside employers through a rather complicated process without a significant amount of loss in the information as suggested in Schoenberg (2007) and Pinkston (2009).

By focusing on the incentives of high ability workers to reveal their productivity, this paper provides an alternative story for the wage dynamics of young workers. Unlike the employers who do not have an incentive to reveal information

about their high ability workers, the high ability workers have incentive to reveal their abilities to their potential employers through productivity revealing activities. The property of the productivity revealing activity will simplify analysis of wage dynamics since one does not have to consider the transmission of information across employers. Moreover, explaining the wage dynamic using the incentives of workers is more intuitive than relying on employer learning as it emphasizes the role of workers who will actually gain from productivity revealing and the related wage increases.¹⁰

3.8 Conclusion and Discussion

In this paper, I documented the effects of the productivity revealing function of higher education on the subsequent careers of individuals. Unlike the traditional signaling and human capital accumulating functions, the productivity revealing function of higher education yields a simple and unambiguous prediction on the subsequent productivity revealing activities of high school and college graduates. Using the model that extends the traditional signaling model, I linked the workers' decisions to sort themselves into higher education and the subsequent productivity revealing activities of individuals.

Given the productivity revealing function of higher education, the model predicts active productivity revealing behavior for high ability high school graduates and little productivity revealing activity for high ability college graduates. Thus, for the high school graduates, the productivity revealing activity will be positively related to their ability since the high ability high school graduates will engage in activities to separate themselves from low ability high school graduates. How-

¹⁰The employers will be indifferent about the wage distribution in this setting as long as the average wage equals the average productivity of workers.

ever, among college graduates, productivity revealing activities and ability will not be positively correlated since the high ability college graduates are already distinguished from low ability college graduates and have little incentive to engage in costly productivity revealing activities.

Moreover, I predict that high ability high school graduates will have higher mobility than low ability high school graduates at the beginning of their careers as they are differentiated from low ability high school graduate workers and move to the better jobs. Unlike high school graduates, the job mobility of college graduates will not positively depend on their ability since the high ability college graduates will have decent jobs from the beginning of their career and will not have an incentive to move between jobs at the cost of firm specific human capital. Using NLSY79 data, I tested the prediction of the model by regressing the measure of job mobility and productivity revealing activities on the measure of ability separately for high school graduates and college graduates. Overall, the data precisely confirm the predictions of the model.

The model and the supporting empirical evidence highlight the importance of the function of higher education in understanding the subsequent careers of high school and college graduates. Thus, the traditional signaling model and the employer learning literature that categorize young workers into two groups—high school and college graduates—are misleading since the employers will more closely observe heterogeneity among college graduates. I believe that acknowledging the productivity revealing function of higher education will improve the traditional signaling theory, giving it richer empirical implications.

Moreover, this analysis demonstrates the importance of the productivity revealing activities of workers which have been ignored in previous literature. The previous literature assumed that workers' productivity revealing activities ended when

the workers finished schooling.¹¹ Thus training—regardless of the its type—has been mostly analyzed under the human capital framework. Furthermore, job mobility of workers was analyzed under the search theory framework that emphasized the limited ability of workers to evaluate the employers. Contrary to the previous literature, this paper views the incidence of off-the-job training and the job mobility of young workers as a result of productivity revealing activities. This study also supports this view by verifying that productivity revealing activities will more likely to be undertaken by the group of workers whose benefit from the activity is larger than that of their counterparts.

Lastly, the different degree of asymmetric information across high school and college graduates has implications for the wage distribution. For instance, under the assumption of assortative matching, increases in heterogeneity across colleges in terms of student ability will not only increase the inequality among college graduates (Hoxby & Long, 1999) but will also increase the mean wage difference between college and high school graduate workers (Maskin & Kremer, 1996). That is, as the employers can observe the individual abilities of college graduates more closely, the assortative matching between college graduates and employers will prevail, and *both* spread and mean wage of college workers will increase compared to the wages of high school graduates.

¹¹Lemieux, MacLeod & Parent (2009) is a notable exception

Table 3.1: Summary Statistics

	High School		College		Total	
	Mean	S.D	Mean	S.D	Mean	S.D
AFQT	0.2303	0.7761	1.2391	0.4569	0.4753	0.8329
Number of jobs per year	2.2212	0.9003	2.2025	0.7362	2.2167	0.8641
Log of real wage	6.4233	0.4856	6.8430	0.5913	6.5227	0.5428
Potential experience	6.4272	3.2861	5.6792	3.3683	6.2495	3.3210
% Performance pay	23.21		42.64		29.69	
Training (%)	9.42		16.94		11.21	
% On the job training	34.12		61.11		43.81	
% apprenticeship	10.65		0.51		7.01	
% Off the job training	55.23		38.38		49.18	
Region(%)						
Northeast	19.25		25.82		20.8	
North Central	36.73		30.79		35.32	
South	27.66		28.06		27.75	
West	16.36		15.32		16.12	
Urban residence(%)	70.89		86.73		74.60	
Observations	11258		3507		14765	
# of individuals	1815		569		2384	

Average and standard deviations are calculated over individual by year observation coming from a panel from 1979-2006.

Table 3.2: Replicating ABH (2010)

Model	High School			College			Test : College=HS P-value		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AFQT	0.0844*** (0.00624)	0.00789 (0.0122)	0.00202 (0.0124)	0.162*** (0.0204)	0.128*** (0.0386)	0.118*** (0.0390)	0.000	0.001	0.001
Exper	0.102*** (0.0137)	0.0920*** (0.0137)	0.0961*** (0.0139)	0.102*** (0.0327)	0.0941*** (0.0333)	0.0859** (0.0337)	0.801	0.586	0.683
AFQT*Exper/10		0.120*** (0.0180)	0.119*** (0.0182)		0.0617 (0.0588)	0.0738 (0.0587)		0.338	0.442
Observations	10,280	10,280	9,984	3,279	3,279	3,140			
R_sq	0.112	0.116	0.128	0.132	0.132	0.144			
Additional Controls	No	No	Yes	No	No	Yes	No	No	Yes

All specification includes year fixed effect and a cubic in potential experience. Specification (3) and (6) additionally controls for region of region and urban residence. In column (7), I report the p-values for the difference in the coefficients of specifications (1) and (3). Similarly, specification (8) and (9) compares (2) and (4) and (3) and (6) respectively. The White/Huber standard errors in parenthesis control for correlation at the individual level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 3.3: Number of Jobs

Model	High School			College			Test : College=HS P-value		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AFQT	0.0389*** (0.0110)	0.126*** (0.0255)	0.126*** (0.0257)	-0.0738** (0.0295)	-0.0970 (0.0699)	-0.0971 (0.0710)	0.000	0.000	0.001
Exper	-0.0643** (0.0310)	-0.0528* (0.0311)	-0.0453 (0.0315)	0.106** (0.0439)	0.100** (0.0473)	0.0875* (0.0483)	0.014	0.024	0.030
AFQT*Exper/10		-0.137*** (0.0327)	-0.135*** (0.0328)		0.0420 (0.0942)	0.0301 (0.0950)		0.053	0.139
Observations	10,559	10,559	10,254	3,386	3,386	3,238			
R_sq	0.029	0.031	0.035	0.082	0.082	0.082			
Additional Controls	No	No	Yes	No	No	Yes	No	No	Yes

All specification includes year fixed effect and a cubic in potential experience. Specification (3) and (6) additionally controls for region of region and urban residence. In column (7), I report the p-values for the difference in the coefficients of specifications (1) and (3). Similarly, specification (8) and (9) compares (2) and (4) and (3) and (6) respectively. The White/Huber standard errors in parenthesis control for correlation at the individual level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 3.4: Off-the-Job Training

Model	High School			College			Test : College=HS P-value		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AFQT	0.0111*** (0.00268)	0.0255*** (0.00601)	0.0238*** (0.00603)	-0.000465 (0.00928)	-0.0291* (0.0172)	-0.0287 (0.0177)	0.255	0.002	0.003
Exper	-0.0253*** (0.00771)	-0.0234*** (0.00767)	-0.0223*** (0.00774)	0.0150 (0.0116)	0.00768 (0.0125)	0.00817 (0.0127)	0.008	0.054	0.068
AFQT*Exper/10		-0.0227*** (0.00866)	-0.0216** (0.00867)		0.0518* (0.0274)	0.0518* (0.0280)		0.006	0.008
Observations	10,559	10,559	10,254	3,386	3,386	3,238			
R_sq	0.015	0.015	0.017	0.022	0.023	0.025			
Additional Controls	No	No	Yes	No	No	Yes	No	No	Yes

All specification includes year fixed effect and a cubic in potential experience. Specification (3) and (6) additionally controls for region of region and urban residence. In column (7), I report the p-values for the difference in the coefficients of specifications (1) and (3). Similarly, specification (8) and (9) compares (2) and (4) and (3) and (6) respectively. The White/Huber standard errors in parenthesis control for correlation at the individual level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

Table 3.5: Performance Pay Jobs

Model	High School			College			Test : College=HS P-value		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AFQT	0.0335*** (0.0109)	0.105** (0.0505)	0.102** (0.0508)	-0.0503 (0.0326)	-0.154** (0.0720)	-0.149** (0.0726)	0.014	0.004	0.004
Exper	0.00888 (0.0728)	-0.00428 (0.0736)	-0.000391 (0.0741)	0.237*** (0.0633)	0.219*** (0.0646)	0.223*** (0.0655)	0.020	0.025	0.038
AFQT*Exper/10		-0.0785 (0.0545)	-0.0768 (0.0547)		0.164 (0.103)	0.166 (0.103)		0.047	0.030
Observations	2145	2145	2,128	1,093	1,093	1,076			
R_sq	.009	0.010	0.014	0.019	0.022	0.031			
Additional Controls	No	No	Yes	No	No	Yes	No	No	Yes

All specification includes year fixed effect and a cubic in potential experience. Specification (3) and (6) additionally controls for region of region and urban residence. In column (7), I report the p-values for the difference in the coefficients of specifications (1) and (3). Similarly, specification (8) and (9) compares (2) and (4) and (3) and (6) respectively. The White/Huber standard errors in parenthesis control for correlation at the individual level.

*** statistical significance at the 99% level

** statistical significance at 95% level

* statistical significance at 90% level

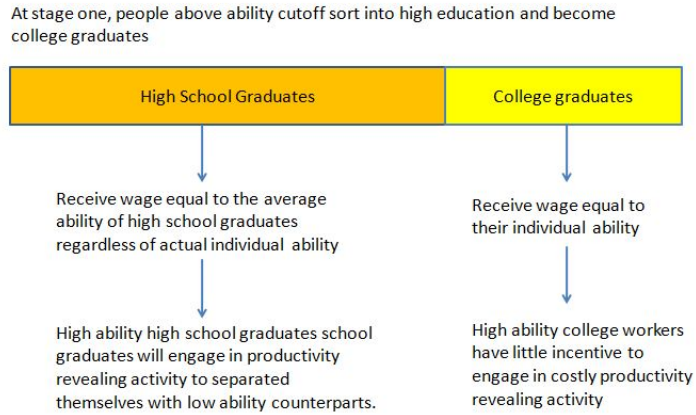


Figure 3.1: Illustration of the Two Stage Model

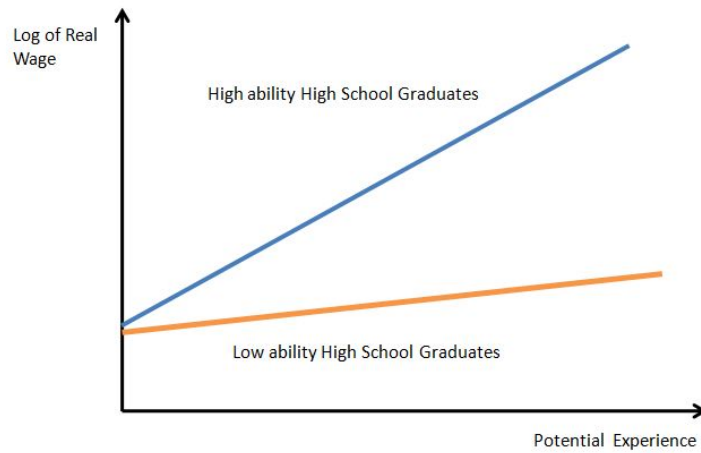


Figure 3.2: Illustration of Wage Dynamics among High School Graduates

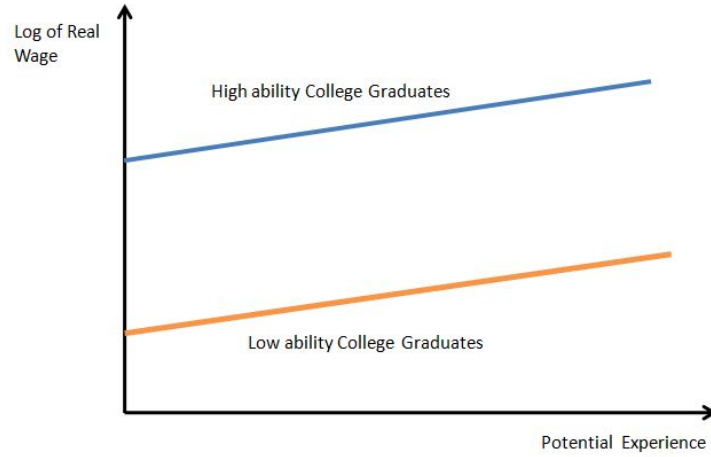


Figure 3.3: Illustration of Wage Dynamics among College Graduates

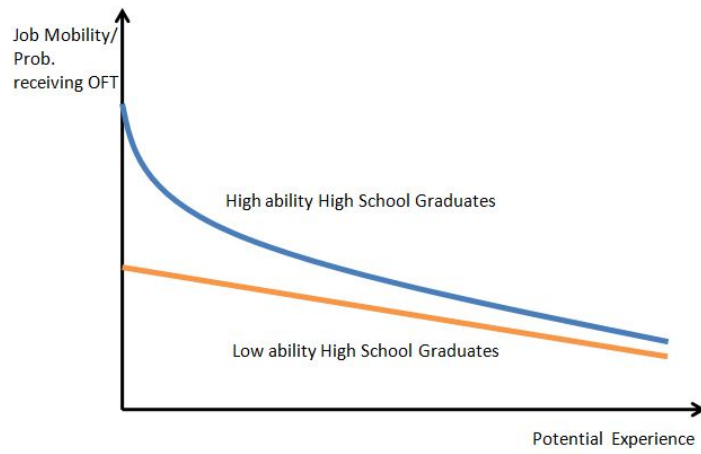


Figure 3.4: Illustration of Post-Schooling Productivity Activity for High School Graduates

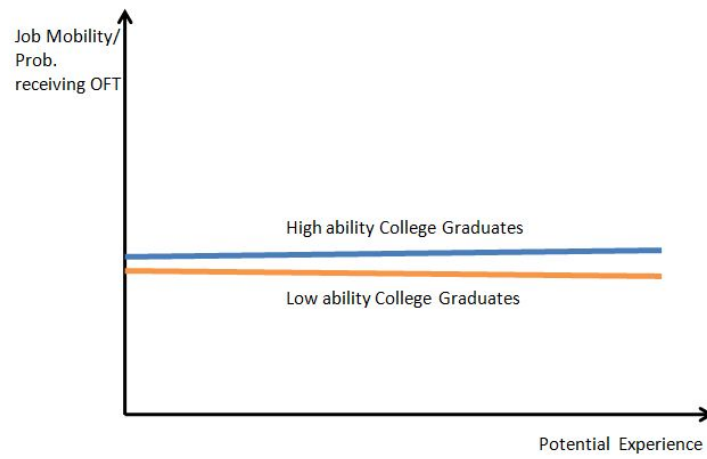


Figure 3.5: Illustration of Post-Schooling Productivity Activity for College Graduates

Bibliography

- Acemoglu, D. (1996). A microfoundation for social increasing returns in human capital accumulation. *The Quarterly Journal of Economics*, 111(3), 779-804.
- Acemoglu, D., & Angrist, J. (2000). How large are human-capital externalities? evidence from compulsory-schooling laws. In *Nber macroeconomics annual 2000, volume 15* (p. 9-74). National Bureau of Economic Research, Inc.
- Altonji, J. G., & Pierret, C. R. (2001). Employer learning and statistical discrimination. *Quarterly Journal of Economics*, 116(1), 313-350.
- Angrist, J. D., & Krueger, A. B. (1991). Does compulsory school attendance affect schooling and earnings? *The Quarterly Journal of Economics*, 106(4), 979-1014.
- Arcidiacono, P., Bayer, P., & Hizmo, A. (2010). Beyond signaling and human capital: Education and the revelation of ability. *American Economic Journal: Applied Economics*, 2(4), 76-104.
- Arrow, K. J. (1962). The economic implications of learning by doing. *The Review of Economic Studies*, 29(3), 155-173.
- Bauer, T. K., & Haisken-Denew, J. P. (2001). Employer learning and the returns to schooling. *Labour Economics*, 8, 104-123.
- Becker, G. (1964). *Human capital*. Columbia University Press for the National Bureau of Economic Research.
- Bishop, J. H. (1994). Signaling the competencies of high school students to employ-

- ers. *CAHRS Working Paper Series, Working Paper 94-18*.
- Brewer, D. J., Eide, E. R., & Ehrenberg, R. G. (1999). Does it pay to attend an elite private college? cross-cohort evidence on the effect of college type on earnings. *Journal of Human Resources*, 34(1).
- Card, D. (1993, Oct.). Using geographic variation in college proximity to estimate the return to schooling. *NBER Working Paper*, 4483.
- Card, D. (1999). The causal effect of education on earnings. In O. Ashenfelter & D. Card (Eds.), *Handbook of labor economics* (Vol. 3, p. 1801-1863). Elsevier.
- Choi, K.-S. (1996). The impact of shifts in supply of college graduates: Repercussion of educational reform in Korea. *Economics of Education Review*, 15(1), 1-9.
- Ciccone, A., & Peri, G. (2006). Identifying human-capital externalities: Theory with applications. *Review of Economic Studies*, 73(2), 381-412.
- Currie, J., & Moretti, E. (2003). Mother's education and the intergenerational transmission of human capital: Evidence from college openings. *The Quarterly Journal of Economics*, 118(4), 1495-1532.
- Dale, S. B., & Kreuger, A. B. (2002, Nov.). Estimating the payoff to attending a more selective college: An application of selection on observable and unobservable. *Quarterly Journal of Economics*, 117(4), 1491-1527.
- Dee, T. S. (2004). Are there civic returns to education? *Journal of Public Economics*, 88(9-10), 1697-1720.
- de la Fuente, A., & Domenech, R. (2001). Schooling data, technological diffusion, and the neoclassical model. *American Economic Review*, 91(2), 323-327.
- Farber, H. S., & Gibbons, R. (1996). Learning and wage dynamics. *Quarterly Journal of Economics*, 111(4), 1007-1047.
- Greenstone, M., Hornbeck, R., & Moretti, E. (2010). Identifying agglomeration spillovers: Evidence from winners and losers of large plant openings. *Journal*

- of Political Economy*, 118(3), 536-598.
- Grossman, M. (2005). *Education and nonmarket outcomes* (Tech. Rep.).
- Hall, R. E., & Jones, C. I. (1999). Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics*, 114(1), 83-116.
- Hoekstra, M. (2009, Nov.). The effect of attending the flagship state university on earnings: A discontinuity-based approach. *Review of Economics and Statistics*, 91(4), 717-724.
- Hoxby, C. M. (1997). How the changing market structure of u.s higher education explains college tuition. *NBER Working Paper Series*(6323).
- Hoxby, C. M. (2009). The changing selectivity of american colleges. *Journal of Economic Perspectives*, 23(4), 95-118.
- Hoxby, C. M., & Long, B. T. (1999). Explaining rising income and wage inequality among the college-educated. *NBER Working Paper Series*(6873).
- Huber, F. (2012). Do clusters really matter for innovation practices in information technology? questioning the significance of technological knowledge spillovers. *Journal of Economic Geography*, 12(1), 107-126.
- Iranzo, S., & Peri, G. (2009). Schooling externalities, technology, and productivity: Theory and evidence from u.s. states. *The Review of Economics and Statistics*, 91(2), 420-431.
- Jacobs, J. (1970). *The economy of cities*. New York: Vintage.
- Juhn, C., Murphy, K. M., & Pierce, B. (1993). Wage inequality and the rise in return to skill. *Journal of Political Economy*, 101(3), 410-442.
- Katz, L. F., & Autor, D. H. (1999). Changes in the wage structure and earnings inequality. *Handbook of Labor Economics*, 3(26), 1463-1555.
- Kenkel, D., Lillard, D., & Mathios, A. (2006). The roles of high school completion

- and ged receipt in smoking and obesity. *Journal of Labor Economics*, 24(3), 635-660.
- Kremer, M., & Maskin, E. S. (1996, Aug.). Wage inequality and segregation by skill. *NBER Working Paper*, 5718.
- Lange, F., & Topel, R. (2006). The social value of education and human capital. In E. Hanushek & F. Welch (Eds.), (Vol. 1, p. 459-509). Elsevier.
- Lemieux, T., MacLeod, W. B., & Parent, D. (2009, Feb). Performance pay and wage inequality. *Quarterly Journal of Economics*, 124(1), 1-49.
- Lochner, L., & Moretti, E. (2004). The effect of education on crime: Evidence from prison inmates, arrests, and self-reports. *American Economic Review*, 94(1), 155-189.
- Loury, L. D., & Garman, D. (1995, Apr.). College selectivity and earnings. *Journal of Labor Economics*, 13(2), 289-308.
- Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), 3-42.
- Lucas, R. (1993). Making a miracle. *Econometrica*, 61(2), 251-72.
- Lynch, L. M. (1991, May). The role of off-the-job vs on-the-job training for the mobility of women workers. *American Economic Review : Papers and Proceedings*, 81, 151-156.
- Lynch, L. M. (1992, May). Private-sector training and the earning of young workers. *American Economic Review*, 82(1), 299-312.
- MacLeod, W. B., & Urquiola, M. (2013). Anti-lemons:reputation and educational quality. *Columbia University, Mimeo*.
- Marshall, A. (1890). *The principles of economics*. New York: Macmillan.
- Mas, A., & Moretti, E. (2009). Peers at work. *American Economic Review*, 99(1), 112-45.

- Milligan, K., Moretti, E., & Oreopoulos, P. (2004). Does education improve citizenship? evidence from the united states and the united kingdom. *Journal of Public Economics*, 88(9-10), 1667-1695.
- Monks, J. (2000). The returns to individual and college characteristics : Evidence from the national longitudinal survey of youth. *Economics of Education Review*, 19, 279-289.
- Moretti, E. (2004a). Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data. *Journal of Econometrics*, 121(1-2), 175-212.
- Moretti, E. (2004b). Human capital externalities in cities. In J. V. Henderson & J. F. Thisse (Eds.), *Handbook of regional and urban economics* (Vol. 4, p. 2243-2291). Elsevier.
- Moretti, E. (2004c). Workers' education, spillovers, and productivity: Evidence from plant-level production functions. *American Economic Review*, 94(3), 656-690.
- Neumark, D. (2002). Youth labor markets in the united states: Shopping around vs. staying put. *Review of Economics and Statistics*, 84(3), 462-482.
- Niehaus, P. (2012). Education and knowledge spillovers. *UC San Diego, Mimeo*.
- Oreopoulos, P. (2006). Estimating average and local average treatment effects of education when compulsory schooling laws really matter. *American Economic Review*, 96(1), 152-175.
- Oreopoulos, P., & Salvanes, K. G. (2009). *How large are returns to schooling? hint: Money isn't everything* (NBER Working Papers No. 15339). National Bureau of Economic Research, Inc.
- Oreopoulos, P., von Wachter, T., & Heisz, A. (2012). The short- and long-term career effects of graduating in a recession. *American Economic Journal: Applied*

- Economics*, 4(1), 1-29.
- Parent, D. (1999, Apr.). Wages and mobility : The impact of employer-provided training. *Journal of Labor Economics*, 17(2), 298-317.
- Park, W., & Son, H. (2012). Impact of college education on labor market and non-pecuniary outcomes. *Columbia University, Mimeo*.
- Pinkston, J. C. (2009). A model of asymmetric employer learning with testable implicatons. *Review of Economics Studies*, 76, 367-394.
- Rauch, J. E. (1993). Productivity gains from geographic concentration of human capital: Evidence from the cities. *Journal of Urban Economics*, 34(3), 380-400.
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002-37.
- Rosenbaum, J. (1990). Do school achievements affect the early jobs of high school graduates? results from the high school and beyond surveys in the us and japan. *Northwestern University, Mimeo*.
- Rudd, J. (2000). Empirical evidence on human capital spillovers. *Federal Reserve Board, Mimeo*.
- Sander, W. (1995). Schooling and quitting smoking. *The Review of Economics and Statistics*, 77(1), 191-99.
- Schoenberg, U. (2007). Testing for asymmetric employer learning. *Journal of Labor Economics*, 25(4), 651-691.
- Topel, R. H., & Ward, M. P. (1992). Job mobility and the careers of young men. *Quarterly Journal of Economics*, 107(2), 439-479.