NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

Julia Kuzmina, Martin Carnoy

THE EFFECTIVENESS OF VOCATIONAL VERSUS GENERAL SECONDARY EDUCATION: EVIDENCE FROM PISA 2012 FOR COUNTRIES WITH EARLY TRACKIN

BASIC RESEARCH PROGRAM

WORKING PAPERS

SERIES: EDUCATION
WP BRP 23/EDU/2015

Julia Kuzmina[1], *Martin Carnoy*[2]

THE EFFECTIVENESS OF VOCATIONAL VERSUS GENERAL SECONDARY EDUCATION: EVIDENCE FROM PISA 2012 FOR COUNTRIES WITH EARLY TRACKING

In this paper, we examine the relative academic effectiveness of vocational education in three countries with early tracking systems: Austria, Croatia and Hungary. Our measures of academic effectiveness are the results of an international test, the Organization for Economic Cooperation and Development's (OECD's) Program of International Student Assessment (PISA). Our results show few, if any, differences between students attending the vocational track in secondary school and those in the academic track. Specifically, the results show that attending the vocational or academic track results in similar achievement gains in the 10th grade.

Keywords: academic effectiveness, tracking, vocational education, PISA

JEL: I21

[1] National Research University Higher School of Economics, The International Laboratory of Educational Policy Analysis, researcher; email: papushka7@gmail.com

[2] Stanford University, School of Education, Professor of Education; email: carnoy@stanford.edu

1. Introduction

For many years research comparing secondary vocational and academic education focused almost entirely on the economic returns of these two types of secondary education (in the U.S., for example, Meyer and Wise, 1982; Hotchkiss, 1993; Meer, 2005; for Israel, see Neumann and Ziderman, 1989; for Switzerland, see Falter et al., 2008; for England, see McIntosh, 2006; for multiple country summaries, see Psacharopoulos, 1994; Middleton, 1993; Chung, 1995). In the past decade, however, with increasing interest in the "quality" of education—especially student cognitive gains while in school—this focus has shifted to the comparative educational effectiveness of secondary vocational and academic schooling, where effectiveness is measured by the test score gains of students in vocational and academic tracks.

The advantage of estimating the relative labour market value of vocational and academic education is that a declared purpose of vocational education is to prepare students for jobs, and understanding how effective vocational education is in achieving this goal is fundamental to its stated *raison d'etre.* The advantage of focusing on the cognitive gains of vocational and academic education is more nuanced. There is a strong argument that in the labour markets of the 21st century, workers change jobs more frequently, placing more emphasis on trainability rather than a fixed set of skills, and demanding more "critical thinking" than specific vocational skills (Carnoy, 2000; Murnane and Levy, 1996; Castells, 1998). The relative learning gains of such critical thinking skills in vocational and academic secondary education may therefore help us understand the potential longer-term productivity impact on students in the two programs.

Vocational education is designed both to provide an alternative path to acquiring further education for less academically motivated or able students and to develop specific skills for specific types of jobs. The division into general and vocational education tracks usually occurs at the entry point into secondary education. In some countries, there is early tracking (after the 8th grade); in others, countries, tracking is later, after the 9th grade. The pattern of tracking is the product of political and social arrangements developed over a long period of time. Tracking is imbedded in the political, economic, and social cultures of each society, and this influences how it serves to allocate students of different socioeconomic status (SES) and genders into various economic and social roles.

The main concern about the economic returns to academic and vocational secondary education in market economies has been whether the specific skill focus of vocational education results in significantly lower gains in productivity (wages) to those taking vocational tracks compared to those who end up on the general track. Similarly, the research on learning gains in the two types of schooling is concerned with whether students increase their cognitive (problem-solving) skills more in one type of schooling than the other. These issues of economic gains and problem-solving skills are related and all have their roots in questions concerning the effectiveness and equity aspects of such tracking.

Studies both of labour market returns and learning gains face two major issues: the first is that students are not randomly assigned to academic and vocational education, and the second is that the two tracks have different educational and possibly social objectives. Generally, students who are oriented into general secondary education come from higher social backgrounds and perform better academically in primary and middle school. Academic education is more broadly oriented and provides students with general knowledge for further learning, particularly in universities, and for higher-level job specific skills. Thus, estimating the economic or educational effectiveness of different tracks has been difficult because of the unobserved characteristics of those in the vocational and academic tracks which bias the effect on economic and educational outcomes of the skills taught in the track itself. In terms of educational outcomes, only measuring cognitive gains underestimates the total package of skills (cognitive, non-cognitive, and specific vocational skills) that students learn in school (Carneiro and Heckman, 2003) and this may bias the results in favour of academic education.

From an equity standpoint, the choices for educators and society are also complex. Students attending vocational schools are more likely to be from lower socioeconomic backgrounds . If the value added by vocational education were lower than that of academic, it would imply that tracking contributes to increasing the skill gap between students of initially lower and higher academic assets. However, students who are not academically engaged might otherwise drop out of school and therefore acquire lower levels of overall skills if not given the opportunity to have a more “practical” and more directly job-oriented education. Even if the value added by cognitive skills (educational “quality”) were lower in vocational education for a given year or level of schooling, the retention value of vocational education measured by the cognitive gains in additional years of schooling could have great benefits to students and the economy relative to skills students would have had, if they had left school. That argument suggests that tracking contributes to reducing the gap in cognitive and critical thinking skills.

In this paper, we address the recent efforts to measure the relative academic effectiveness of vocational education. Our measure of academic effectiveness is student performance on an international test, the Organization for Economic Cooperation and Development’s (OECD’s)

Program of International Student Assessment (PISA), which claims to measures critical thinking skills of 15 year-olds attending schools in a large number of countries.

Many of the countries participating in PISA track students into vocational or academic education either in the 9th or 10th grade. PISA measures the cognitive skills of 15 year-olds, and in most countries, students of the same age can be in different grades, allowing us to use a fuzzy regression discontinuity approach based on school system age of entrance rules to estimate the gain in test scores over an academic year and to compare the gain for students in the vocational and academic tracks. We find that three European countries (Austria, Croatia, Hungary) are suitable for this type of analysis because their students took PISA, they track students in the 9th grade, and their cut-off dates to register in school are reasonably well enforced.

Our results show few, if any, differences in student outcomes between the vocational and general tracks.[3]

2. Literature Review

There is a substantial literature that discusses the impact of tracking on student achievement on PISA. For example, the OECD has compared differences across countries with different tracking systems and found that countries taking PISA with the lowest degree of tracking achieved "the highest mean student performance in reading literacy" (OECD, 2005:62). Other research using PISA data suggests that early tracking reduces the mean performance (Hanushek & Wößmann, 2006). Furthermore, in countries with early selection, the correlation between student SES and student performance is higher, suggesting that tracking increases differences in student achievement across socioeconomic groups (Marks, Cresswell & Ainley, 2006; OECD, 2005).

In addition to the cross-country research on the effects of tracking, other work focuses on cross-country differences between general and vocational tracks. One seemingly obvious finding is that academic secondary students achieve at much higher levels than vocational school students (Altinok, 2011; Kuzcera et al., 2008; Dronkers, Velden, Dunne, 2011), and that the lower SES of students in the vocational track explains part of this achievement difference. In a very extensive recent study comparing the gains in achievement of the high proportion (40%) of post-basic education (post 9th grade) Chinese students channelled into the vocational track,

[3] We also estimate comparative gains in countries that track in the 10th grade (Czech Republic, Taipei) but these estimates are subject to considerable error, since we cannot compare students in the 10 and 9th grades of vocational/academic schools directly and must rely on developing a match of students in the 9th grade who can be compared to their 10th grade counterparts in vocational and academic 10th grades.

Loyalka and colleagues (Loyalka et al, 2014) show that secondary students in that track make much smaller academic achievement gains than students in the general track. Yet, this research also recognizes that socioeconomic (and ability) selection of students into the two tracks may overestimate the difference in how much cognitive learning takes place in each track (Field, Kuczera, and Pont, 2007).

The major problem for studies comparing student achievement in academic and vocational tracks is to identify the unbiased effect of track on achievement. The students in the two tracks are not strictly comparable. To solve this identification problem, we would ideally want to assign students in each country randomly to each track and measure their initial and final achievement in the period of exposure to the treatment of being in the general versus the vocational track. However, given the difficulty of undertaking such an experiment, our alternative is to apply quasi-experimental methods to correct for selection bias in the assignment to the two tracks. Loyalka et al (2014) were able to measure test score gains of students in vocational and general education and use propensity score matching and, alternatively, an instrumental variable approach to compare the gains of students with a similar probability of being in the two tracks. Other researchers have used various aspects of grade effects employing international test score data to measure student test score gains (Luyten et al., 2008; Luyten, 2006; Cliffordson, 2010).

As we face the same limitations with our PISA data as these grade effect studies, they are relevant to our analysis. They have shown that the achievement gain associated with one year of schooling can vary according to students' gender and SES (Luyten, 2006; Frenette, 2008). It is also likely that the impact of a year of schooling on academic achievement may vary for students who end up in the vocational or academic track, for two major reasons: First, students from lower SES backgrounds may disproportionately be headed towards the vocational track from an early age (Aypay, 2003). The impact of a year of schooling may be less for students of lower SES and thus also for students who later enter the vocational track. Second, the impact of a year of schooling may be less for students who enter the vocational track because, in contrast to general schooling, vocational schooling may put less emphasis on academic subjects (Gangl et al., 2003).

Disentangling the effects of a year of schooling on student achievement is not a simple task. To address issues of selection bias, we use an instrumental variable (IV) strategy based on a fuzzy regression discontinuity design. The strategy exploits the variation in a student's age relative to age cut-offs for entering primary school in each country.

Although the quasi-experimental design we use diminishes the selection biases associated with measuring the impact of a year of schooling, our results are subject to limitations and need to be interpreted with care. First, a significant proportion of students in our sample do not comply with the age cut-off rules for school entry. We therefore only estimate the local average treatment effects (LATE) of a year of schooling for an unidentifiable group of compliers (Lee and Lemieux, 2010). Second, our IV strategy assumes that the PISA achievement score *gains* of students on either side of the age cut-off only differ because of differences in grade level at the time of PISA (an assumption also implicitly made by Luyten et al., 2008; Luyten 2006; Cliffordson, 2010). However, students or their parents may react differently to a student being on either side of the age cut-off. The reactions to being younger or older in a grade may also vary by observable student characteristics, particularly social class and gender, and unobservable student characteristics, such as student ability. Our estimates may thus pick up the cumulative effects of differential student/parent behaviour which can affect year-to-year gains, invalidating our identification strategy. We control for observable characteristics (for example, SES and gender), but we do not have data to control for ability. A higher proportion of low ability students may be in our vocational education sample than in our general education sample. In that case our IV would not produce an unbiased estimate of the differential grade effect in vocational and general schooling. We will discuss the validity of our approach in the methodology section below.

3. Data, Research Design, and Statistical Approach

3.1 General and vocational secondary education in selected countries

Austria tracks students relatively early compared to other OECD countries. At the age of 10, pupils are separated into two different types of school, *Hauptschule* and *Gymnasium*. At the end of compulsory schooling, at age 14, corresponding to the first year of the second cycle, the school system becomes further differentiated. Four pathways are open to pupils, of which three offer vocational training: 1) mainstream secondary education, leading to A-levels (*Reifeprüfung*, also called *Matura*), and giving pupils access to tertiary education including university; 2) long-term vocational education, (*berufsbildend höheren Schulen* or BHS), a 5-year course giving pupils access to university (for example technical and business institutes)—this pathway awards two diplomas, *Reife und Diplomprüfung* (A-levels and a vocational diploma); 3) medium-term vocational schools **(***Berufsbildenden mittleren Schulen* or BMS), providing full-time education over a three- or four-year course (for example, specialized technical and business schools)—this pathway does lead to tertiary education, but does allow pupils to enter employment immediately after passing a final examination; and 4) vocational training and apprenticeship (*Polytechnische Schule* and *Berufsschule*), which consists of a polytechnic school year, followed by three years of additional training, of which 80% is spent in the workplace.[4]

After completing their elementary education (8th grade), pupils in Croatia can continue optional secondary education which is divided into gymnasiums, vocational schools (technical, industrial and craft based), and art schools (music, dance, art). There are two types of vocational school—those that provide classical school-based vocational education and training programs, and those that offer dual programs based on the German model. Three and four-year vocational schools offer students a route into higher education. Gymnasiums are four-year academic high schools that end in a final examination, the state *matura*. Programs in vocational and art schools last from one to five years, and usually end with a final project, but it is also possible to sit the state *matura* if pupils have completed four years of secondary education at their school. Since 2010, state *matura* results have been the basis for entry to higher education institutions.

In Hungary at the end of elementary school, which combines primary and lower secondary education and enrols students up to age 14, students are directed into one of three types of upper secondary education. Gymnasiums (*gimnázium*) offer four years of general education and prepare students for the *maturata*. Vocational secondary schools (*szakközépiskola*) provide four years of general education and also prepare students for the *maturata*. Unlike gymnasiums, these schools combine general education with some specific subjects, referred to as "pre-vocational education" and "career orientation." Vocational training schools (*szakiskola*) provide two years of general education, combined with some "pre-vocational education" and "career orientation," followed by two or three years of vocational education and training. Students obtain a vocational qualification, but not a *maturata*, at the end of a successfully completed program.

3.2 Data

[4] The transition from compulsory education in *Hauptschule* (lower level secondary school) to further education is complicated by the fact that *Hauptschule* ends at the 8th grade, typically at age 14, yet students can only start apprenticeship-based education after age 15 because of labor laws that also include apprenticeship contracts. Thus students have to spend one year in another institution after *Hauptschule* before they can start their apprenticeship, imposing a disruptive double transition—they have to spend a year either in a polytechnic school, a full-time VET school, or a college before they can begin their apprentice training.

We use 2012 PISA data to compare the effects of a year of schooling across two different tracks in three countries. The 2012 PISA data has information on the achievement levels of a representative population of 15 year-old students in 65 countries worldwide. Students were tested in three subjects: math, science, and reading. The achievement scores in the three subjects are the outcome variables in all of our subsequent analyses. PISA scores for OECD countries are set at a mean of 500 and a standard deviation of 100.

One major advantage of using the PISA data is that it contains information on a random sample of 15 year-old students in each country. Students were sampled by age (and not on grade level), so not all students were in the same grade. In most of the national samples, students were concentrated in two proximate grade levels. Which grade students were in was partially determined by national rules that strictly set a minimum age requirement for entry into primary school. We will explain in subsection 3.3 how these age entry rules are important for our identification strategy.

We use the grade level of 15-year old students as our treatment variable. We define grade level as a binary variable equal to 1 if the student was in 10th grade at the time of the PISA and 0 if the student was in 9th grade. In our later identification strategy, we also instrument for grade level using the “relative age” of each student. “Relative age” is a dummy variable equal to 1 if a student is on the right side of the age cut-off and 0 otherwise.

We also use the student background characteristics in the 2012 PISA data as control variables in our subsequent analyses. Specifically, we control for student gender and SES. The SES variable was created by OECD researchers using principal component analysis and three sets of variables related to family background: parents’ highest occupational status, parents’ highest level of education (in years), and an index of home possessions, which includes indices of wealth, cultural possessions, and books in the home.[5] We analysed the impact of a year of schooling in three specific European countries: Austria, Croatia and Hungary. We chose these three countries because a) their education systems have a fairly strict age cut-off for when students can enter primary school and the systems are characterized by a small proportion of repeaters[6] (which is important for our identification strategy); and b) the countries have an early

[5] The SES score is standardized with a mean of zero (for the average student across all OECD countries) and a standard deviation of one.
[6] In the effort to obtain unbiased estimates, we use data from countries that had a low percentage of students who repeated grades. Including students who repeat grades can bias the results of the IV analyses because the IV (whether a student is born to the right or left of the age cutoff) may impact grade repetition, which in turn could impact achievement on the PISA.

tracking system (after 8th grade) into general and vocational tracks. Thus, we can estimate the effect of one year of schooling for general and vocational track separately as there are 9th and 10th graders in each track.

To facilitate our analyses of the effects of attending an year of school on student outcomes, we limit our analytical sample to those students that were in the 9th or 10th grade at the time of the PISA exam and who did not repeat a grade prior to the administration of the exams. In our comparison countries, about 95% or more of the students in the total PISA sample were in 9th or 10th grade. Also, about 90% or more of the 9th and 10th grade students had not repeated a grade (Table 1).

[Table 1 about here]

3.3. Empirical Strategy

We first use an ordinary least squares (OLS) regression to descriptively examine the difference between general and vocational tracks. The basic specification of the OLS model is:

$$Y_{ij} = \alpha_0 + \alpha_1 General_{ij} + X_{ij}\alpha + u_{2ij} \qquad (1)$$

where Y_{ij} represents the outcome variable of interest of student i in school j. $General_{ij}$ is an indicator for track orientation, taking on a value of 1 if the student is in general track and 0 if the student is vocational track. u_{1ij} is a random error term. The additional term X_{ij} represents a vector of control variables (such as student gender and SES) for student i in school j.

Subsequently, we estimate the relationship between a year of schooling and our outcomes for each track separately. We first use an OLS model:

$$Y_{ij} = \alpha_0 + \alpha_1 Year_{ij} + X_{ij}\alpha + u_{2ij} \qquad (2)$$

where Y_{ij} represents the outcome variable of interest of student i in school j. $Year_{ij}$ is an indicator for grade level, taking on a value of 1 if the student is in grade 10 and 0 if the student is in grade 9. u_{1ij} is a random error term. The additional term X_{ij} represents a vector of control variables (such as student age, gender, SES) for student i in school j. We call the regression analyses without control variables our "unadjusted" analyses and those with control variables our "adjusted" analyses.

To identify the causal effect of a year of schooling on student achievement, we use an IV strategy based on a regression discontinuity design (RDD). In RDD, the probability of receiving a treatment jumps at the cut-off point (Hahn et al., 2001). The cut-off point, when established by policymakers, can often be used as a source of exogenous variation in the treatment assignment (Imbens and Lemieux, 2008). In the fuzzy RDD, where the probability of receiving the treatment jumps by less than one at the cut-off point, a local average treatment effect (LATE) can be identified by using a variation in the treatment assignment because of the cut-off as an instrument for the treatment variable.[7]

To estimate the causal impacts of a year of schooling on student outcomes, we run IV regressions for students from each track separately. Specifically, we use the relative age as an IV for grade level in equation 2. We assume that relative age is a pre-treatment variable that plausibly affects student PISA scores through the grade level but not through any other (observed or unobserved) pre-treatment covariate (this is the exogeneity assumption of IV—see Murnane and Willett, 2010). The analysis assumes, for example, that parents do not invest systematically more before schooling in children who are on the left or right side of the entry cut-off by dint of their age. Given the general level of compliance with the age cut-off rule in most countries, relative age should also be correlated reasonably well with grade level (this is another important assumption underlying the use of IV—see Murnane and Willett, 2010).[8]

We can apply fuzzy RDD to our country samples because each country established a fairly strict age cut-off to determine when students were old enough to attend primary school. Students just to the left of the age cut-off for each country were more likely to enter primary school one year earlier than students just to the right of the age cut-off. As shown in Figures 1a-1c, the probability of being in grade 10 was distinctly higher in each country for students who were slightly older around the age cut-off (which is centred at 0 in Figures 1a-1c) compared to students who were slightly younger around the age cut-off.

[Figures 1a-1c about here]

[7] The probability jumps by less than one at the cutoff point in the fuzzy RDD because individuals do not comply with the treatment (or control) condition to which they are assigned.
[8] We indeed test whether relative age is correlated strongly enough with grade level in the student data in each country. The F-test shows a strong correlation between the IV and treatment variable.

A certain proportion of students in each country did not comply with the age cut-off (see Table 2). For the three countries in our sample, the proportion of students that did not comply with the age cut-off was 20% or less. Because of imperfect compliance around the age cut-off, we estimate the LATE of a year of schooling in each country using student's relative age (age relative to the cut-off point in each country) as an IV for grade level.

We adjust all of the above regression analyses according to the particulars of the survey sampling design in each country. Specifically, we account for the clustered nature of our samples by constructing Huber-White standard errors corrected for school-level clustering. We also use sampling weights. We finally make the standard adjustments for PISA's use of plausible values for achievement scores in each subject (OECD, 2012).

As noted, the IV strategy should help deal with the selection bias problem associated with students selecting themselves into higher grades. Even so, there are some limitations to the strategy. First, parents may choose to make different investments in their children because they are on the right or left side of the age cut-off (McEwan&Shapiro, 2008). Second, there may be an "age effect" associated with falling to the right or left side of the age cut-off. Students to the right (who are the youngest students in their grade) may be disadvantaged in terms of learning compared to students to the left of the age cut-off (who are the oldest students in their grade). While there is little consistent evidence of an age effect on student achievement among 15 years-olds (Suggate, 2009), heterogeneous age effects may exist for students with particular background characteristics.

[Table 2 about here]

Since our focus is on comparing the grade effect for students in the general versus the vocational track, an additional threat to our fuzzy RDD identification strategy is that the IV is correlated with cumulated gain scores in a way that makes it more likely for early entrants to end up in the vocational or general education track. Most importantly, if early entrants with (unobserved) lower ability suffer a learning disadvantage relative to early entrants with higher ability, this would result in more early entrants going into the vocational track. However, we do not find this to be the case. Tables 3 shows that the proportion of early entrants in the two tracks is identical in the general and vocational track in Croatia and close to identical in Austria and

Hungary. This suggests that entering the vocational/general track is not affected by early entrance (being younger in the grade) into school.

[Table 3 about here]

4. Results

4.1 Descriptive Results

According to our basic descriptive results (unadjusted for covariates), there are significant differences in the achievement levels of students in general (secondary and those in vocational programs. Students in the general track score much higher than vocational students in all countries (Table 4). In mathematics, achievement differences range from 66 to 102 PISA scale points (0.66–1 SDs), in reading, achievement differences range from 82 to 103 scale points (0.8–1 SDs), and in science from 69 to 91 PISA scale points (0.7–0.9 SDs).

Our descriptive results also show significant differences in background characteristics between students in the general and vocational tracks. Students in general secondary schools have a higher mean SES and are more likely to be female than students in vocational schools in all three countries. The likelihood of a student studying in one program or the other is undoubtedly related to individual student characteristics, including gender, SES and the student's academic performance in earlier grades.

[Table 4 about here]

To gain some understanding of how these factors affect a student's likelihood of being tracked into one program or the other, we divide the students in our sample into four groups, according to their SES and PISA reading achievement, and we compare the proportion of general versus vocational education in each group (Table 5). There is a problem with this type of analysis because the student test scores are in part the result of being exposed either to vocational or to general secondary schooling for a year or two. If there are significant differences in achievement gains in the two types of schooling, one of our "outcome" variables (the likelihood of being in general/vocational school) may have affected one of our "categorizing" variables, namely the PISA test score. If we had "pre-track point" test scores for these students, those in our vocational education category may have had somewhat higher test scores and those entering the general track, somewhat lower scores. This could overestimate the proportion of students in vocational school with either low or high SES and low achievement, and overestimate the proportion in general school with either low or high SES and high achievement. Keeping in mind this potential bias, we suggest that except in Austria, students from the higher SES group (higher then mean) and lower reading achievement group (lower than the mean) have a lower probability of attending general school than students with low SES and high achievement. The proportion of general students with high SES and low achievement ranges from 13% to 31%, and the proportion of general students from the group with low SES and high achievement ranges from 23% to 51%. Nevertheless, high SES students with high achievement have a much higher probability of being in the general track than students with low SES and high achievement. Also noteworthy is the relatively large proportion of high SES and high achievement students in the vocational track in each of these countries—from 23% in Hungary to 44% in Austria.

[Table 5 about here]

4.2. Estimating the Differences in Achievement between Students in General and Vocational Programs Using OLS Regressions

As noted, the "usual" analysis of the differences in student achievement in different educational tracks uses OLS regressions controlling for student background characteristics. Before moving to the estimates for our Austria, Croatia, and Hungary data which are corrected for selection bias, we estimate the differences using simple OLS. The results of our OLS regressions show that the difference in PISA achievement levels between general and vocational students decreases somewhat for all three countries when we control for student background characteristics, but they still remains statistically significant. For mathematics, the "net" achievement difference across countries ranges from 46.6 to 96 scale points, for reading from 59 to 86 scale points, and for science from 46 to 83 scale points (Table 6). All this suggests that student background differences explain only part of the differences in student PISA scores between general and vocational students.

[Table 6 about here]

The differences in achievement scores of general and vocational education students estimated in Table 6 using OLS are useful for describing the differences in the outcomes of 9th and 10th grade students in these two programs. Since general programs are, by definition, oriented toward students that are more adept academically, the results in Table 6 are consistent with what we would expect. However, although the estimated differences in achievement scores for general and vocational shown in those tables are adjusted for student SES and gender, they are not necessarily accurate estimates of the relative "effectiveness" of general and vocational education in these countries. That is, the estimated differences we observe in Table 6 are likely to be not the result of the one or two years students have spent in these different types of programs and may not even have resulted from the cumulative academic effectiveness of the previous eight years they spent in primary and middle schools. Students in the two programs may, on average, have lower scores because they entered first grade with those differences.

4.3. Estimating the Relative Effectiveness of General and Vocational Education Using Grade Differences

In order to estimate more accurately the relative effectiveness of the general and vocational tracks, we exploit the fact that the 15 year-olds in the PISA sample are distributed across grades. We can simulate achievement gains in the two tracks by estimating inter-grade differences of these outcome measures. We then adjust the inter-grade differences for student characteristics in the whole sample, and finally, compare those students in 10^{th} grade in each track whose birthday fell on the right side of the cut-off date for entry into primary school with students in the 9^{th} grade in the same track whose birthday fell on the left side of the cut-off data. Thus, we use the cut-off date as a means to correct for unobserved differences in student characteristics in the two tracks.

4.3.1. Unadjusted Differences in Student Achievement in 9^{th} and 10^{th} Grades

Table 7 shows the simple, unadjusted differences in PISA achievement scores for students in the general and vocational tracks. Overall, 10^{th} graders achieve at higher levels than 9^{th} graders in both tracks in the higher grade. Overall, the gains in achievement are higher in Austria than in Hungary, especially in the academic track, and in Hungary, higher than in Croatia, especially in the vocational track. The differences in achievement scores are generally greater in the academic track in Austria and Croatia, but the opposite is true in Hungary.

[Table 7 about here]

4.3.2. Adjusted Differences in Student Achievement in 9th and 10th Grades

When we adjust the inter-grade differences in student achievement for student characteristics, the results (see Table 8) show that the achievement differences increase substantially, probably because older students in each grade score lower in the PISA sample, and students in the 10th grade tend to be somewhat older than students in the 9th grade because the cut-off date delays them entering. Students in Austria continue to make the largest achievement gains in both tracks, and the differences in gains between the tracks are small in Austria and Hungary across all subjects, and, except in mathematics, this is also the case in Croatia. It is interesting to note that female students have a smaller negative gap in mathematics and science achievement in the vocational track and a much larger positive reading achievement gap vocational track.

[Table8 about here]

4.3.3. Adjusted Differences in Student Achievement in 9th and 10th Grades, Using Instrumental Variable (IV) Estimates.

Our adjusted IV estimates in Table 9 show that the effect of a year of schooling on PISA test achievement in mathematics, reading, and science is positive and significant for both tracks in all three of our early tracking countries. The gains for one year of schooling are much smaller than in the adjust results in Table 8, suggesting that controlling for selection bias using this strategy to identify comparable students greatly reduces differences due to unobservable characteristics of students in 9th and 10th grades. A year of schooling increases math scores 14-16 points (about 0.15 standard deviations) in vocational secondary education and 14-27 points in general education (about 0.15 to 0.3 standard deviations). The gain is as large or greater in the general track in Austria than in Croatia and Hungary in all three subjects, but the gain in Austria is the same or smaller in the vocational track. Similarly, the gain from a year in general education in Austria seems to be greater than in vocational education in all three PISA subject tests, but this is not the case for either Croatia or Hungary.

[Table 9 about here]

We test whether the differences we report in Table 9 in 10th grade PISA test score gains for general and vocational education students are statistically significant by regressing test scores on grade (10th versus 9th), track (general versus vocational), and the interaction term of grade and track (Table 10). The results in Table 10 show that although the coefficients of the interaction of general education and grade are positive for all of the subject test scores, they are not statistically significant.

[Table 10 about here]

5. Discussion and Conclusions

It is widely known that students who are tracked into vocational secondary education are likely to be from lower SES families and to perform worse academically than students who are tracked into general secondary education. In addition to meeting particular skill needs in the labour market, vocational education has traditionally been organized at least in part to keep young people who are not as engaged academically in school longer to develop more general academic skills.

Most studies suggest, however, that vocational education does not produce these general academic skills nearly as effectively as general secondary education does. In a global environment which emphasizes general problem solving skills and the flexibility of workers to learn to do multiple types of tasks and multiple types of jobs over their lifetime (Carnoy, 2000), the potential ineffectiveness of vocational education in producing cognitive and affective learning gains in general subjects could have negative economic and social effects.

Our estimates for three European countries that track students early—Austria, Croatia, and Hungary—confirm that the achievement scores on the PISA test in mathematics, reading, and science of students in the general track of secondary schools are typically much higher than for students in vocational schools (Table 4) and that this is the generally the case even when we control for student SES and gender (Tables 6).

Nevertheless, when we compare the PISA test score gains in mathematics, reading, and science in 10th grade versus 9th grade, we do not find significant differences in gains between the general and the vocational track. The closest the general track comes to outperforming the vocational track is in Austria, but even there, the differences are not statistically significant

(Table 10). The Austrian results may be due to the effect of the group of students moving from the *hauptschule* by way of polytechnics into apprenticeships in the 10^{th} grade. The results in Table 9 also show (again) that students in the general track of secondary school average much higher on the PISA in all tested subjects (about a standard deviation higher in Croatia) than students in vocational schools, and that, in addition, higher SES students do much better on the PISA than lower SES students regardless of track. The results also show that controlling for track, SES, and gender, students who were assigned to 9^{th} and 10^{th} grade by dint of their birthdays falling on the left side of the entrance age cut-off data in each country typically do better on the PISA test because they spend a year more in school. The gains are similar (but not very large) in all three countries except for the insignificant gains in reading and science in Austria. We may have questions about the efficacy of the IV used to correct for selection bias in the grade achievement gain, yet the grade gains estimated in the non-IV regressions also indicate no (Austria and Hungary) or small (Croatia) differences between students in vocational and general tracks (Table 8).

Our estimates suggest that in these three countries, vocational education is not less effective than general secondary education in increasing students' mathematics, reading, and science skills. The estimates essentially mean that in these three countries channelling less academically well performing, and generally lower SES students into the vocational track does not reduce these students' opportunity to increase their general knowledge.

It is difficult to draw any systematic conclusions from the variation in results across the three countries in terms of what we would expect given the percentage of students in the vocational and general tracks. In Austria, a high percentage (72%) of students are in the vocational track in both grades (Table 1), including a group that is in transition from *hauptschule* to apprenticeship training/education in 10^{th} grade. Not surprisingly, Austria is the one country in our group that almost shows a significant difference in gains between general and vocational education. In Croatia, general education is the most elite of the three education systems (Tables 1 and 5), so, again, it is not surprising that Table 9 shows very high differences in test scores between Croatia's vocational and general tracks. We would think that the gains in the general track would be higher because of the "elite" nature of that track, but that is not the case. In Hungary, in contrast, only a small percentage of students go to the vocational track (Table 1). We might expect that vocational school students in Hungary would represent a strongly negatively selected group, but their average vocational test scores do not seem to be any lower than those in Austria or Croatia. Again, the grade gains in Hungary are no higher for the general track than for the vocational track.

That said, for most vocational education students in all three countries, their average academic experience becomes increasingly less academic after 10^{th} grade. This implies that general track students in these countries would continue to make academic achievement gains beyond 10^{th} grade whereas these gains could decline for vocational education students. Since general track students already score so much higher on the PISA test, we would expect that the gap in mathematics, reading, and science would increase as these young people continue their education to enter the labour force.

References

Altinok, N. (2011). General versus vocational education: Some new evidence from PISA 2009. *Final Draft of the Background Paper to the Education for All Global Monitoring Report 2012*. Retrieved from http://unesdoc.unesco.org/images/0021/002178/217873e.pdf

Aypay, A. (2003). The Tough Choice at High School Door: An Investigation of the Factors That Lead Students to General or Vocational Schools. *International Journal of Educational Development*, *23*, *5*, 517–527.

Carneiro, P., Heckman, J. J. (2003). Human Capital Policy. In: Heckman J, Krueger A, editors. *Inequality in America: What Role for Human Capital Policy?* MIT Press; 2003. pp. 77–240.

Carnoy, M. (2000). *Sustaining the New Economy*. Cambridge, MA: Harvard University Press.

Castells, M. (1998). *The Rise of the Network Society*. London: Blackwell.

Cliffordson, C. (2010). Methodological issues in investigations of the relative effects of schooling and age on school performance: the between-grade regression discontinuity design applied to Swedish TIMSS 1995 data. *Educational Research and Evaluation, 16,* 39–52.

Dronkers, J., van der Velden, R., Dunne, A. (2011). The effects of educational systems, school-composition, track-level, parental background and immigrants' origins on the achievement of 15-years old native and immigrant students: A reanalysis of PISA 2006. ROA-RM-2011/6, Maastricht: ROA.

Falter, J.-M., Luzzi, G. F., & Sbergami, F. (2008). Intergenerational Links and Upper Secondary Track Choice: Pattern and Consequences. Working Paper, Leading house in the economics of vocational education, University of Geneva.

Field, S., Kuczera, M., Pont, B., & Organisation for Economic Co-operation and Development. (2007). *No more failures: ten steps to equity in education*. Paris: OECD.

Frenette, M. (2008). The Returns to Schooling on Academic Performance: Evidence from Large Samples Around School Entry Cut-off. *Analytical Studies Branch Research Paper Series, 317.*

Gangl, M., Muller, W.,& Raffe D. (2003). Conclusions: explaining cross-national differences in school-to-work transitions. In *Transition from Education to Work in Europe: The Integration of Youth into EU Labour Markets*. Edited by Walter Muller; Markus Gangl, 277-305. Oxford University Press.

Hahn, J., Todd, P., Van Der Klaauw, W., 2001. Identification and estimation of treatment effects with a regression discontinuity design. *Econometrica*, *69,* 201–209.

Hanushek, E. A., & Wößmann, L. (2006). Does Educational Tracking Affect Performance and Inequality? Differences-in-Differences Evidence Across Countries. *The Economic Journal*, *116*(510), C63–C76.

Hotchkiss, L. (1993). Effects of Training, Occupation, and Training-Occupation Match on Wage. *Journal of Human Resources*. 482-496.

Imbens, G.W., & Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of Econometrics, 142, 2,* 615–635.

Kuczera, M., & others. (2008). *VET in PISA: Results from PISA 2003 and 2006*. OECD, Paris. Retrieved from http://www.oecd.org/education/innovation-education/41538731.pdf

Lee, D.S., & Lemieux, T. (2010). Regression Discontinuity Designs in Economics. *Journal of Economic Literature*, *48, 2,* 281-355.

Loyalka, P., Huang, X.T., Zhang, L.X., Wei, J.G., Yi, H.M., Song, Y.Q., Yao, S.J, Chu, J. Rozelle, S. (2014). "The Impact of Vocational Schooling on Human Capital Development in Developing Countries: Evidence from China." Stanford University, Freeman Spogli Institute, Rural Education Action Project (REAP) Working Paper.

Luyten, H., Peschar, J., & Coe, R. (2008). Effects of Schooling on Reading Performance, Reading Engagement, and Reading Activities of 15-Year-Olds in England. *American Educational Research Journal , 45, 2,* 319–342. doi:10.3102/0002831207313345.

Luyten, H. (2006). An empirical assessment of the absolute effect of schooling: regression-discontinuity applied to TIMSS-95. *Oxford Review of Education, 32, 3,* 397–429. doi:10.1080/03054980600776589.

Marks, G. N., Cresswell, J., & Ainley, J. (2006). Explaining socioeconomic inequalities in student achievement: The role of home and school factors. *Educational Research and Evaluation, 12*(2), 105–128. doi:10.1080/13803610600587040

McEwan, P. J., & Shapiro, J. S. (2008). The Benefits of Delayed Primary School Enrollment Discontinuity Estimates Using Exact Birth Dates. *Journal of Human Resources, 43, 1,* 1–29.

McIntosh, S. (2006). Further Analysis of the Returns to Academic and Vocational Qualifications. *Oxford Bulletin of Economics and Statistics, 68, 2,* 225-251

Meer, J. (2007). Evidence on the Returns to Secondary Vocational Education. *Economics of Education Review, 26, 5,* 559-573.

Meyer, R., & Wise, D. (1982). High School Preparation and Early Labor Force Experience. In Freeman, R. and D. Wise (eds.). *The Youth Labor Market Problem: Its Nature, Causes, and Consequences*. Chicago: University of Chicago Press.

Middleton, J. (1993). *Skills for Productivity: Vocational Education and Training in Developing Countries*. New York: Oxford University Press.

Murnane, R.,& Levy, F. (1996). *Teaching the New Basic Skills. Principles for Educating Children to Thrive in a Changing Economy*. New York: Free Press.

Murnane, R.,& Willett, J. (2010). *Methods Matter: Improving Causal Inference in Educational and Social Science Research*. Oxford University Press, USA.

Neuman, S.,& Ziderman, A. (1989). Vocational Schools Can be More Cost Effective than Academic Schools: The Case of Israel. *Comparative Education*, *25, 2,* 151-163.

Organization for Economic Cooperation and Development (OECD). (2005). *School factors related to quality and equity: Results from PISA 2000*. Paris: OECD Publishing.

Organization for Economic Cooperation and Development (OECD). (2012). *PISA 2009 Technical Report.* PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264167872-en

Psacharopoulos, G. (1994). Returns to Investment in Education: A Global Update. *World Development, 22 , 9,* 1325-1343.

Suggate, S. (2009). School entry age and reading achievement in the 2006 Programme for International Student Assessment (PISA). *International Journal of Educational Research,* 48, 3, 151–161.

Tables

Table 1: Educational Status of Students in each Country: Grades, Repetition, Tracking

	PISA Sample			9th Grade			10th Grade		Repeaters		
Country	*Number*	*9th grade*	*10th grade*	*General*	*Vocational*	*Prevocational*	*General*	*Vocational*	*General*	*Vocational*	*All*
Austria	4755	44%	52%	28%	50%	22%	28%	72%	13%	10%	11%
Croatia	5008	80%	20%	28%	72%		32%	68%	1%	3%	3%
Hungary	4810	72%	23%	84%	16%		87%	13%	6%	11%	7%

Table 2: The birth cutoffs and proportion of non-compliers in each country

Country	Birth cutoff	% 9th and 10th graders who did not follow the birth cutoff rule	10th graders born after birth cutoff (as % of all 10th graders)	9th graders born before birth cutoff (as % of all 9th graders)
Austria	September, 1st	11%	4%	21%
Croatia	April, 1st	7%	13%	6%
Hungary	June,1st	20%	5%	26%

Table 3: Proportion of Students in Each Track and Country, Born Before and After Cut-off Date

	Austria		**Croatia**		**Hungary**	
Categories	Born before cut-off date	Born after cut-off date	Born before cut-off date	Born after cut-off date	Born before cut-off date	Born after cut-off date
General	65%	35%	23%	77%	43%	57%
Vocational	62%	38%	23%	77%	42%	58%

Source: Estimates by authors from PISA 2012.

Table 4. Unadjusted Differences in PISA Scores and SES by Country and Program (General/Vocational), Repeaters Not Included

	Austria			**Croatia**			**Hungary**		
	General	*Vocational*	*Difference*	*General*	*Vocational*	*Difference*	*General*	*Vocational*	*Difference*
Math PISA score	565	499	66***	546	444	102***	543	452	91***
	(5)	(3.1)	(5.9)	(6.6)	(3)	(7.3)	(5.9)	(3.6)	(6.9)
Reading PISA score	560	478	82***	560	457	103***	555	465	90***
	(4.9)	(2.9)	(5.7)	(4.6)	(3.4)	(5.7)	(4.4)	(4)	(5.9)
Science PISA score	568	499	69***	558	467	91***	555	471	84***
	(4.8)	(3)	(5.6)	(5.4)	(2.9)	(6.1)	(4.2)	(3.8)	(5.6)
SES	0.65	-0.06	0.71***	0.2	-0.57	0.77***	0.65	-0.08	0.73***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.04)
Female	58%	47%	0.09***	61%	45%	0.16***	59%	49%	0.1***
			(0.01)			(0.01)			(0.02)

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

Table 5: Proportion of General/Vocational Students. By Socio Economic Background, PISA Reading Achievement, and Country

	Austria		**Croatia**		**Hungary**	
Categories	*General*	*Vocational*	*General*	*Vocational*	*General*	*Vocational*
Low SES and low achievements	7%	93%	4%	96%	13%	87%
Low SES and high achievements	23%	77%	34%	66%	51%	49%
High SES and low achievements	23%	77%	13%	87%	31%	69%
High SES and high achievements	56%	44%	67%	33%	77%	23%

Table 6: Adjusted differences in PISA scores between general and vocational students in each country Using OLS Regression

	Austria			**Croatia**			**Hungary**		
Outcomes	*Math*	*Reading*	*Science*	*Math*	*Reading*	*Science*	*Math*	*Reading*	*Science*
General vs. vocational	46.6***	59***	46.7***	96.4***	86***	83.4***	72.2***	69.3***	64.8***
	(5.7)	(5.4)	(5.2)	(7.1)	(5.3)	(3.1)	(6.2)	(5.5)	(5.3)
SES	29.3***	26.5***	32.5***	12.7***	13.8***	11.3***	25.7***	22.1***	25.1***
	(1.9)	(2)	(2.2)	(1.7)	(1.7)	(1.8)	(5.3)	(2.2)	(2)
Female	-26.5***	32.2***	-13.4***	-25.1***	36***	-9.4***	-22.1***	26.9***	-13.8***
	(4.4)	(4.3)	(4.3)	(3.7)	(3.5)	(3.5)	(3.1)	(2.9)	(2.9)
Constant	513.8	464.3	507.1	461.9	448.6	477.6	476.4	463.3	491.2
	(3.9)	(3.9)	(3.9)	(4.3)	(4.1)	(3.9)	(4.1)	94.4)	(2)
R-squared	0.19	0.25	0.21	0.33	0.37	0.26	0.34	0.35	0.31
N	4157	4157	4157	4684	4684	4684	4356	4356	4356

Clustered standard errors in parentheses, *** p<0.01, ** p<0.05, p* <0.1

Table 7: Unadjusted Differences between Grades in PISA Scores, by Program and Country (repeaters excluded)

		Austria			**Croatia**			**Hungary**		
Variable		*9th grade*	*10th grade*	*Difference*	*9th grade*	*10th grade*	*Difference*	*9th grade*	*10th grade*	*Difference*
PISA Math Score	General	543	580	37***	540	567	27***	535	564	29***
		(6.7)	(4.6)	(5.7)	(6.6)	(7.6)	(4.4)	(6.3)	(6.3)	(5.3)
	Vocational	480	514	34***	440	458	18***	445	476	31***
		(3.9)	(3.7)	(4.5)	(3.2)	(3.8)	(3.5)	(4.8)	(4.4)	(3.6)
PISA Read Score	General	540	573	33***	554	577	22***	548	574	26***
		(6.5)	(4.4)	(5.6)	(4.7)	(5.6)	(4.1)	(4.8)	(4.6)	(4.6)
	Vocational	463	490	27***	452	475	23***	459	487	28***
		(3.8)	(3.8)	(4.8)	(3.5)	(4.1)	(3.2)	(4.2)	(4.8)	(3.9)
PISA Science Score	General	548	582	34***	554	569	15***	548	573	25***
		(6.3)	(4.5)	(5.2)	(5.5)	(6.5)	(4.5)	(4.5)	(4.8)	(4.6)
	Vocational	484	509	25***	464	478	14***	464	494	30***
		(4.4)	(3.1)	(4.7)	(3)	(3.9)	(3.6)	(4.9)	(4.4)	(3.7)

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

Table 8: Adjusted differences between Grades in PISA scores for general and vocational students

		Austria		**Croatia**		**Hungary**	
		General	*Vocational*	*General*	*Vocational*	*General*	*Vocational*
PISA Math Score	9^{th} vs. 10^{th} grade	55.9***	51.2***	37.2***	29.1***	38.3***	39.1***
		(6.7)	(6.4)	(8.7)	(5.5)	(6.6)	(4.6)
	Age (dummy)	-23.1***	-27.8***	-11.8	-10*	-12.9**	-11.9***
		(7.6)	(6.6)	(8.3)	(5.1)	(5.4)	(3.9)
	SES	20.7***	28.9***	8.3***	14.6***	25.9***	24.5***
		(3.8)	(2.2)	(2.5)	(2.2)	(4.2)	(2.5)
	Female	-34.8***	-26.8***	-39.9***	-20.7***	-36.2***	-15.5***
		(4.6)	(5.9)	(5.1)	(4.9)	(3.1)	(4.7)
	Constant	551.8	503.1	562.6	457.5	552.5	468.8
		(6.9)	(5.3)	(7.7)	(4.9)	(5.6)	(4.6)
	R-squared	0.18	0.13	0.11	0.06	0.16	0.13
PISA Reading Scores	9^{th} vs. 10^{th} grade	45.3***	41.5***	32.3***	33.1***	26.4***	28.8***
		(7)	(6.7)	(8.5)	(4.6)	(5.8)	(5.4)
	Age (dummy)	-20.6**	-26.1***	-14.3*	-15.3***	-5.1	-6.5
		(8.2)	(6.9)	(8.1)	(4.9)	(5.2)	(4.3)
	SES	16.1***	27.7***	10.8***	14.9***	19.9***	22.8***
		(3.4)	(2.3)	(2.1)	(2.2)	(3.2)	(2.9)
	Female	16.4***	35.2***	17***	42.2***	15.1***	33***
		(3.3)	(5.8)	(4.7)	(4.5)	(3.1)	(4.3)
	Constant	525.1	456.4	542.7	443.3	535.6	457
		(7.1)	(5.3)	(5.6)	(4.5)	(4.8)	(4.9)
	R-squared	0.12	0.13	0.06	0.11	0.1	0.13
PISA Science Scores	9^{th} vs. 10^{th} grade	44.1***	38.8***	26.5***	24***	31.4***	38.2***
		(6.7)	(6.8)	(8.9)	(5.9)	(5.7)	(5.3)
	Age (dummy)	-16.1*	-23.5***	-13.3*	-11.4*	-9.4*	-13.3***
		(8.1)	(6.8)	(7.9)	(6.2)	(5.3)	(4.5)
	SES	26.2***	32***	5.4*	14.1***	23.5***	25.3***
		(3.9)	(2.4)	(2.2)	(2.3)	(2.9)	(2.8)
	Female	-22.9***	-12.5**	-26.1***	-3.7	-25.3***	-9**
		(5.3)	(5.8)	(4.9)	(4.7)	(3)	(4.4)
	Constant	547.1	500	569.4	474.4	559.2	486
		(7.2)	(5.7)	(6.2)	(4.4)	(4.5)	(4.6)
	R-squared	0.17	0.11	0.05	0.03	0.14	0.12
	N	1207	2950	1404	3280	1943	2413

Clustered standard errors in parentheses, *** p<0.01, ** p<0.05, p* <0.1

Table 9: Estimates of One Year Students' PISA Achievement Gains, by Educational Track and Country, IV Results

		Austria		**Croatia**		**Hungary**	
		General	*Vocational*	*General*	*Vocational*	*General*	*Vocational*
PISA Math Scores	9th vs. 10th grade	26.9***	15.9***	21.9***	16***	14.9**	14.9**
		(6.5)	(5.8)	(5.3)	(4.2)	(7.1)	(6.2)
	SES	22.5***	30.5***	8.4***	14.8***	26.2***	24.7***
		(4)	(5.3)	(2.5)	(2.2)	(4.1)	(2.5)
	Female	-32.5***	-26***	-39.3***	-20.2***	-34.7***	-13.9***
		(4.7)	(5.8)	(5.1)	(4.9)	(3.3)	(4.7)
	Constant	552.2	504.7	562.9	457.7	552.1	468.5***
		(7.1)	(5.4)	(7.6)	(4.9)	(5.7)	(4.6)
	R-squared	0.17	0.12	0.11	0.05	0.15	0.11
PISA Reading Scores	9th vs. 10th grade	19.5**	8.4	13.8***	13.1***	17.2***	15.5**
		(7)	(6.5)	(4.8)	(4.1)	(6.7)	(6.4)
	SES	17.7***	29.2***	11**	15.2***	20.1***	23***
		(3.7)	(2.3)	(2.2)	(2.2)	(3.2)	(2.9)
	Female	18.5***	35.9***	17.9***	42.9***	16.8***	34.4***
		(4.4)	(5.8)	(4.8)	(4.5)	(4.4)	(5.1)
	Constant	525.4	457.9	543.1	443.3***	534.8	456.8***
		(7.3)	(5.4)	(5.5)	(4.5)	(5.5)	(5)
	R-squared	0.11	0.12	0.06	0.11	0.1	0.13
PISA Science Scores	9th vs. 10th grade	23.9***	9.0	9.2*	9.2*	14.4**	11.1*
		(6.9)	(5.9)	(5)	(4.7)	(7)	(6.2)
	SES	27.4***	33.3***	5.5*	14.2***	23.8***	25.6***
		(4.2)	(2.4)	(2)	(2.3)	(2.9)	(2.7)
	Female	-21.3***	-26***	-25.3***	-3.2	-24.2***	-7.2
		(5.4)	(5.8)	(4.9)	(4.7)	(3.3)	(4.4)
	Constant	547.4	501.4	569.7***	474.6***	558.9	485.7***
		(7.3)	(5.9)	(6.2)	(4.4)	(4.5)	(4.6)
	R-squared	0.16	0.1	0.05	0.03	0.13	0.1
	N	1207	2950	1404	3280	1942	2413

Clustered standard errors in parentheses, *** p<0.01, ** p<0.05, p* <0.1

Table 10: Estimates of Differences in PISA Achievement Gains Between Secondary Educational Tracks, by Country (IV Results)

	Austria			**Croatia**			**Hungary**		
	Math	*Reading*	*Science*	*Math*	*Reading*	*Science*	*Math*	*Reading*	*Science*
9th vs. 10th grade	16.1***	8.6	9.1	16.1***	13.4***	9.3*	14.5**	15.3**	10.9*
	(5.8)	(6.5)	(5.8)	(4.2)	(4.1)	(4.7)	(6.3)	(6.5)	(6.2)
General	40.7***	53.4***	38.5***	94.8***	85.6***	83.2***	71.8***	68.5***	63.8***
	(7.7)	(7.8)	(7.7)	(7.1)	(5.2)	(5.9)	(6.5)	(5.8)	(5.9)
General*9th vs. 10th grade	10.3	9.9	14.2	5.9	0.7	0.06	0.86	2.1	3.7
	(8.8)	(9.1)	(8.8)	(6.8)	(6.1)	(6.8)	(9.6)	(9.8)	(9.4)
SES	28.1***	25.8***	31.6***	12.6***	13.8***	11.2***	25.4***	21.8***	24.8***
	(1.9)	(2.0)	(2.2)	(1.6)	(1.7)	(1.8)	(2.3)	(2.2)	(2)
Female	-27.5***	31.5***	-14.2***	-25.9***	35.4***	-9.8***	-22.9***	26***	-14.5***
	(4.4)	(4.4)	(4.3)	(3.7)	(3.5)	(3.5)	(3.1)	(2.8)	(2.9)
Constant	505.2***	459.8***	502.4***	459***	446.1***	475.9***	473.4***	460.2***	489***
	(4.9)	(5.0)	(5.4)	(4.3)	(4.1)	(3.9)	(4.3)	(4.7)	(4.3)
R-squared	0.22	0.26	0.22	0.34	0.38	0.27	0.36	0.36	0.33
N	4157	4157	4157	4684	4684	4684	4356	4356	4356

Clustered standard errors in parentheses, *** p<0.01, ** p<0.05, p* <0.1

Figures

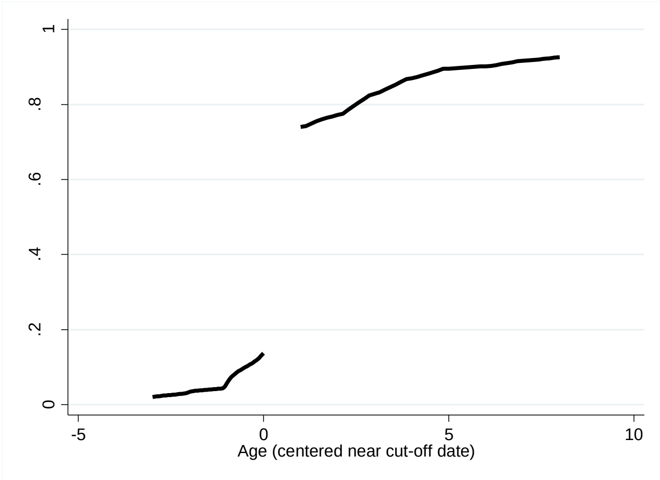

Figure 1a. Probability of being at the 10th grade according to age in Austria

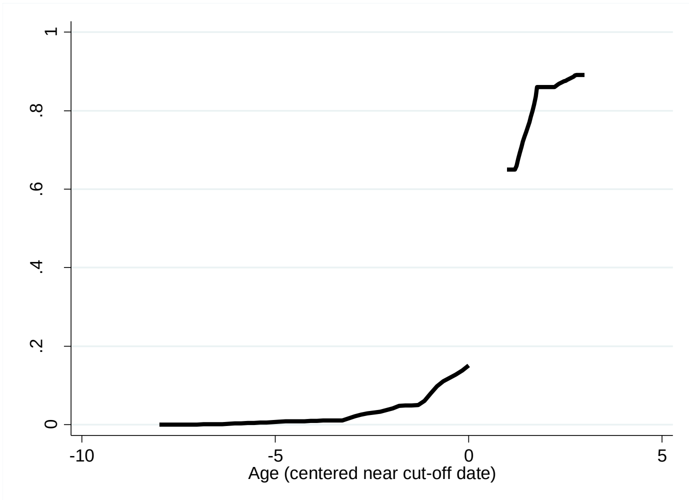

Figure 1b. Probability of being at the 10th grade according to age in Croatia

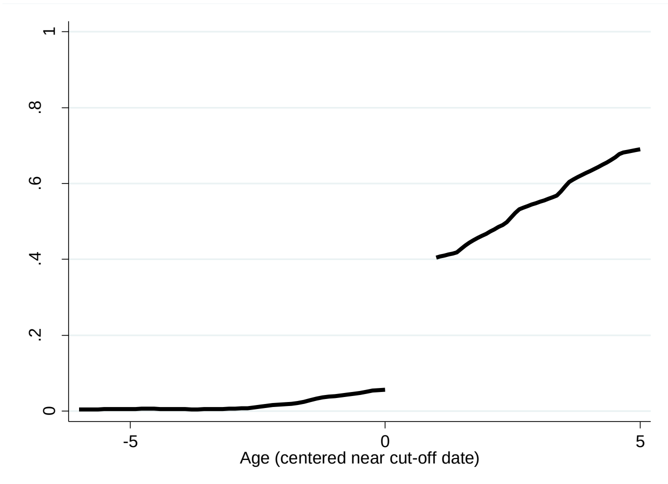

Figure 1c. Probability of being at the 10th grade according to age in Hungary

Julia Kuzmina, National Research University Higher School of Economics (Moscow, Russia), Institute of Education, The International Laboratory of Educational Policy Analysis, Researcher; email: papushka7@gmail.com

Martin Carnoy, Stanford University, School of Education, Professor of Education; email: carnoy@stanford.edu