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The effectiveness of vocational versus general secondary education

Evidence from the PISA 2012 for countries with early tracking

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Abstract
Purpose – The purpose of this paper is to examine the relative academic effectiveness of vocational education in three countries with early tracking systems: Austria, Croatia, and Hungary.
Design/methodology/approach – The authors use an instrumental variables approach to estimate vocational education's relative academic effectiveness in terms of achievement on an international test, the Organization for Economic Cooperation and Development's Program of International Student Assessment (PISA), and two possible indicators of non-cognitive outcomes – self-efficacy in mathematics and intrinsic motivation in mathematics, both also available from the PISA student survey.
Findings – The results show few, if any, differences in student gains from attending the vocational track in secondary school as opposed to the academic track. Specifically, the results show that attending the vocational or academic track results in similar achievement gains in the tenth grade and generally similar gains in self-efficacy and motivation in mathematics.
Originality/value – The study is unique because in the three countries, the authors can use a fuzzy regression discontinuity approach based on school systems' age entrance date 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. The results contradict almost all other studies by showing that in these countries student academic gains in vocational education are about the same as in the academic track.
Keywords Public policy, Education, Learning organizations, Disadvantaged groups
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1. Introduction
For many years, research comparing secondary vocational and academic education focussed almost entirely on the economic returns to these two common types of secondary education (in the USA, e.g. Meyer and Wise, 1982; Hotchkiss, 1993; Meer, 2007; for Israel, see Neuman and Ziderman, 1989; for England, see McIntosh, 2006; for multiple country summaries, see Psacharopoulos, 1994; Middleton, 1993).

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In the past decade, however, with increasing interest in the "quality" of education – especially students' 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. This is a complex task because students who enter different education tracks usually differ in unobservable ways, biasing estimates of gains. In this paper we use an instrumental variables (IV) approach to identify differences in cognitive and motivational gains to students in the vocational and academic tracks. We do this in three European countries with suitable conditions for applying our approach – Austria, Croatia, and Hungary.

The advantage of estimating the relative labor 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 focussing on the cognitive gains of vocational and academic education is more nuanced. There exists a strong argument that in the labor markets of the twenty-first 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 general education for less academically motivated 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 eighth grade); in others, countries, tracking is later, after the ninth grade. It is also important to note that 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 backgrounds and genders into various economic and social roles.

The main concern in market economies has been whether the specific skill focus of vocational education results in significantly lower gains in productivity to vocational students compared to those in the academic 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, they both have their roots in the effectiveness and equity aspects of such tracking.

Studies of both labor 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 academic secondary education come from higher social class 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 unobserved characteristics of those in the vocational and academic tracks that 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 underestimate 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 favor 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 of vocational education were lower than that of academic, tracking could contribute to increasing the skill gap between students of lower and higher initial 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 take more "practical" and more directly job-oriented education. Even if the gain in cognitive skills were lower in vocational education for a given year or level of schooling, its retention value as measured by the cognitive gains from additional years of schooling could have great benefits to students and the economy relative to students' skills had they left school. That argument suggests that tracking could reduce the gap in cognitive, critical thinking skills.

In this paper, we address the recent efforts to measure the relative academic effectiveness of vocational education. Our measures of academic effectiveness are: first, an international test, the Organization for Economic Cooperation and Development's (OECD's) Program of International Student Assessment (PISA), which claims to measure critical thinking skills of 15-year olds attending school; and second, two possible indicators of non-cognitive outcomes – self-efficacy in mathematics and intrinsic motivation in mathematics, both available from student questionnaires that are part of the PISA survey.

Many of the countries participating in PISA track students into vocational or academic education either in the ninth or tenth grade. The PISA aims at measuring 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 systems' age entrance date 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 the PISA, they track students in the ninth grade, and their cutoff dates to register in school are reasonably well enforced.

Our results show few, if any, differences in student outcomes from attending the vocational track of secondary school as opposed to the academic track. Specifically, the results show that attending the vocational track results in similar achievement gains in the tenth grade as attending the academic track. In addition, our estimates show no significant difference between the general and vocational track in students' gains in intrinsic motivation, and only in Croatia do students have significantly higher gains in mathematics self-efficacy in the general than in the vocational track.

2. Literature review

There is a substantial literature that discusses the impacts of tracking on student achievement on the PISA. For example, the OECD has compared differences across countries with different tracking systems and found that countries taking the PISA with the lowest degree of tracking achieved "the highest mean student performance in reading literacy" (Organization for Economic Cooperation and Development (OECD), 2005, p. 62). Other research using PISA data suggests that early tracking reduces mean performance (Hanushek and Wößmann, 2006). Furthermore, in countries with early selection, the correlation between students' socioeconomic background and students' performance is higher, suggesting that tracking increase differences in student achievement across socioeconomic groups (Marks *et al.*, 2006; OECD, 2005).

In addition to the cross-country research on the effects of tracking, other work focusses 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; Kuczera, 2008; Dronkers *et al.*, 2011), and that the lower socioeconomic background of students in the vocational track explains part of this achievement difference. Others have argued that although students with lower socioeconomic background are more likely to be in vocational programs, the difference in achievement between the vocational and academic secondary students is statistically significant even after controlling socioeconomic background characteristics (Altinok, 2011; Arum and Shavit, 1994). Analysis of the PISA 2009 data shows that family background can explain less than one-third of the achievement difference between two tracks (Altinok, 2011). Loyalka *et al.* (2014) show that Chinese secondary students in the vocational 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 *et al.*, 2007).

The major problem for these 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 vs 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 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 IV approach to compare the gains of students with 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 gains (Luyten *et al.*, 2008; Luyten, 2006; Cliffordson, 2010).

We face the same limitations in our PISA data as these grade effect studies, so 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 according to students' socio-economic status (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 social class backgrounds may disproportionately be headed toward the vocational track from an early age (Aypay, 2003). The impact of a year of schooling may be less for lower social class students 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 attending a year of schooling on student achievement is not a simple task. To address issues of selection bias, we use an IV strategy based on a fuzzy regression discontinuity design (RDD). The strategy exploits variation in a student's age relative to age cutoffs 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 cutoff 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 cutoff only differ because of differences in grade level at the time of the 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 cutoff. 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 behavior that can affect year-to-year gains, invalidating our identification strategy. We control for observable characteristics (e.g. student social class and gender), but we do not have data to control for early ability. A higher proportion of low-early 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

Austrian pupils are separated at the age of ten into two different types of school, *Hauptschule* and *Gymnasium*. At age 14, corresponding to the first year of the second cycle, the school system becomes further differentiated into four pathways. Three offer vocational training: first, mainstream secondary education, leading to A-levels (*Reifeprüfung*, also called *Matura*) and access to tertiary education; second, long-term vocational education, (*berufsbildend höheren Schulen*), a five-year course giving access to tertiary education; third, medium-term vocational schools (*Berufsbildenden mittleren Schulen*), providing a three- to four-year course leading either to tertiary education or employment immediately after passing a final examination; and finally, vocational training and apprenticeship (*Polytechnische Schule* and *Berufsschule*), consisting of a polytechnic school year, followed by three years of additional training, of which 80 percent is spent in the workplace[1].

After completing their elementary education (eighth grade), pupils in Croatia can continue optional secondary education that is divided into gymnasiums, vocational schools (technical, industrial, and craft based), and art schools (music, dance, art). There are two types of vocational schools – 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 in 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 (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, ending in a vocational qualification, but not a *maturate*.

3.2 Data

We use 2012 PISA data to compare the effects of a year of schooling across two different tracks and 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 the total of OECD countries are set at a mean of 500 and a standard deviation of 100. We also use two PISA-defined standardized indexes – the Math Self-efficacy Index and the Index of Intrinsic Motivation to Learn Mathematics. Each index is standardized across the OECD countries, with mean 0 and SD equal to 1.

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 on 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. Students' grade 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.

Our treatment variable is the grade level of 15-year old students. Grade level is a binary variable equal to 1 if the student was in tenth grade at the time of the PISA and 0 if the student was in ninth 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 cutoff and 0 otherwise.

Further, we control for students' gender and socioeconomic status (SES). The OECD's SES variable (ESCS) is a standardized index (mean equal to zero; SD equal to 1) composed of highest parents' occupational status, parents' highest level of education (in years), and an index of home possessions, including indices of wealth, cultural possessions, and books in the home. We chose Austria, Croatia, and Hungary for our analysis because: first, their education systems have a fairly strict age cutoff for when students can enter primary school and the systems are characterized by a small proportion of repeaters[2] (which is important for our identification strategy); and second, the countries have an early tracking system (after eighth 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 ninth and tenth graders in each track.

We limit our analytical sample to those students that were in the ninth or tenth 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 percent or more of the students in the total PISA sample were in ninth or tenth grade. Also, about 90 percent or more of the ninth and tenth grade students had not repeated a grade (Table I).

3.3 Empirical strategy

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

$$Y_{ij} = \alpha_0 + \alpha_1 \text{ General}_{ij} + X_{ij}\alpha + u_{2ij} \tag{1}$$

where Y_{ij} is 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_{2ij} 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:

$$Y_{ij} = \alpha_0 + \alpha_1 \text{Year}_{ij} + X_{ij}\alpha + u_{2ij} \tag{2}$$

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_{2ij} 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.

A major problem in estimating the effect of an additional year of schooling, particularly in two different types of schooling in the same country, is that students may not be randomly assigned to grades, and they are surely not randomly assigned to academic and vocational schooling.

To identify the causal effect of a year of schooling on student achievement, we use an IV strategy based on a RDD. In the RDD, the probability of receiving a treatment jumps at a cutoff point (Hahn *et al.*, 2001). The cutoff point, when established by policymakers, can often be used as a source of exogenous variation in treatment assignment (Imbens and Lemieux, 2008). In the fuzzy RDD, where the probability of receiving the treatment jumps by less than one at the cutoff point, a LATE can be identified by using variation in treatment assignment because of the cutoff as an instrument for the treatment variable[3].

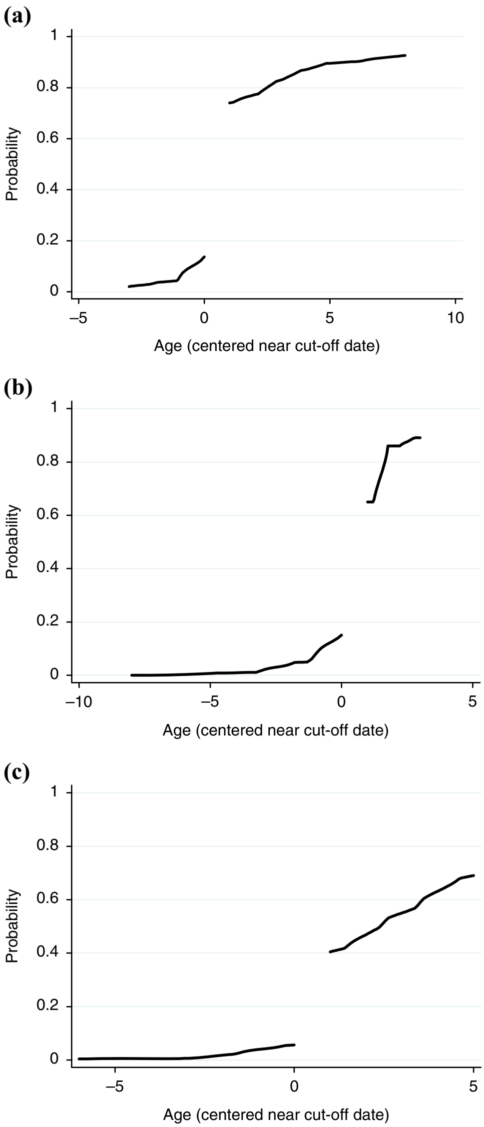
To estimate the causal impacts of a year of schooling on student outcomes, we run IV regressions for students from each track separately. Specifically, we use relative age as an IV for grade level in Equation (2). We assume that relative age is a pre-treatment variable that plausibly affects student PISA scores, self-efficacy, and motivation through the grade level but not through any other (observed or unobserved) pretreatment 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 cutoff by dint of their age. Given the general level of compliance with the birth cutoff 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)[4].

Table I.
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	4,755	44	52	28	50	22	28	72	13	10	11
Croatia	5,008	80	20	28	72		32	68	1	3	3
Hungary	4,810	72	23	84	16		87	13	6	11	7

Source: Estimates by authors from PISA 2012

We can apply the fuzzy RDD to our country samples because each country established a fairly strict age cutoff to determine when students were old enough to attend primary school. Students just to the left of the age cutoff for each country were more likely to enter primary school one year earlier than students just to the right of the age cutoff. In other words, students just to the left of the age cutoff were more likely to be in grade 10 (vs grade 9) at the time of the 2012 PISA. As shown in Figure 1(a)-(c), the probability of being in grade 10 was distinctly higher in each



Notes: (a) Austria; (b) Croatia; and (c) Hungary

Figure 1. Probability of being in tenth grade in countries, by age

country for students that were slightly older around the age cutoff (which is centered at 0 in Figure 1(a)-(c)) compared to students that were slightly younger around the age cutoff.

A certain proportion of students in each country did not comply with the age cutoff (see Table II). For the three countries in our analytical sample, the proportion of students that did not comply with the age cutoff was 20 percent or less. Because of imperfect compliance around the age cutoff, we estimate the LATE of a year of schooling in each country using student's relative age (age relative to the cutoff 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 (Organization for Economic Cooperation and Development, 2012).

The IV strategy should help deal with the selection bias problem associated with students selecting themselves into higher grades, but, there are still 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 cutoff (McEwan and Shapiro, 2008). Second, there may be an "age effect" associated with falling to the right or left side of the age cutoff. Students to the right of the age cutoff (who are the youngest students in their grade) may be disadvantaged in terms of learning compared to students to the left of the age cutoff (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.

Since our focus is on comparing the grade effect for students in the general vs 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 important, 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. Table III 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.

We tested whether our pre-treatment variables (socio-economic status and gender) change the correlation between relative age and treatment. The correlation between

Table II. 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 1	11	4	21
Croatia	April 1	7	13	6
Hungary	June 1	20	5	26

Source: Estimates by authors from PISA 2012. Birth cutoff dates are from national documents

SES, gender and relative age is not significant in any country or track. Moreover, the correlation between the probability of a student's receiving the treatment and his or her relative age does not change when we account for SES or gender.

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 (academic) secondary and vocational programs. Students in the general track score much higher than vocational school students in all countries (Table IV). 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). Students in general education also have a significantly higher sense of self-efficacy in mathematics in all three countries and a significantly higher intrinsic motivation in mathematics in Croatia and Hungary.

Our descriptive results also show that students in general secondary schools have 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, socioeconomic background, and a student's academic performance in earlier grades.

To understand 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 socioeconomic background and PISA reading achievement, and compare the proportion of general vs vocational education in each group (Table V). Since 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 exist 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, 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, the results 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 percent, and the proportion of

Table III. Proportion of students in each track and country, born before and after cut-off date

Categories	Austria		Croatia		Hungary	
	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 IV. Unadjusted differences in PISA scores, self-efficacy, intrinsic motivation 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 (5)	499 (3.1)	66 (5.9)***	546 (6.6)	444 (3)	102 (7.3)***	543 (5.9)	452 (3.6)	91 (6.9)***
Reading PISA score	560 (4.9)	478 (2.9)	82 (5.7)***	560 (4.6)	457 (3.4)	103 (5.7)***	555 (4.4)	465 (4)	90 (5.9)***
Science PISA score	568 (4.8)	499 (3)	69 (5.6)***	558 (5.4)	467 (2.9)	91 (6.1)***	555 (4.2)	471 (3.8)	84 (5.6)***
Math self-efficacy	0.37 (0.03)	0 (0.02)	0.37 (0.04)***	0.56 (0.03)	−0.11 (0.02)	0.66 (0.04)***	0.4 (0.02)	−0.32 (0.02)	0.72 (0.07)***
Math intrinsic motivation	−0.33 (0.03)	−0.32 (0.02)	−0.01 (0.04)	−0.18 (0.03)	−0.29 (0.02)	0.11 (0.04)***	−0.13 (0.03)	−0.24 (0.02)	0.11 (0.05)**
SES	0.65 (0.02)	−0.06 (0.02)	0.71 (0.03)***	0.2 (0.02)	−0.57 (0.01)	0.77 (0.02)***	0.65 (0.02)	−0.08 (0.02)	0.73 (0.04)***
Female	58%	47%	0.09 (0.01)***	61%	45%	0.16 (0.01)***	59%	49%	0.1 (0.02)***

Notes: Standard errors in parentheses. *** $p < 0.01$; ** $p < 0.05$

general students from the group with low SES and high-achievement ranges from 23 to 51 percent. 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 percent in Hungary to 44 percent in Austria.

4.2 Estimating differences in achievement between students in general and vocational programs using OLS regressions

The "usual" analysis of differences in student achievement in different educational tracks uses OLS regressions controlling for student background characteristics. Before moving to estimates for our Austria, Croatia, and Hungary data that corrects for selection bias, we estimate differences using simple OLS. Results show that the difference in PISA achievement levels between general and vocational students decreases somewhat in all three countries when we control for student background characteristics. Yet they remain statistically significant. For mathematics, the "net" achievement difference across countries ranges from 46.6 to 96 scale points. For reading, the "net" achievement difference across countries ranges from 59 to 86 scale points, and for science, from 46 to 83 scale points (Table VI). Results adjusted for student background characteristics show that math self-efficacy in all three countries and intrinsic motivation in Croatia and Hungary also remain higher for general secondary school students (Table VII). This suggests that student background differences explain only part of differences in student PISA scores and a very small part of math self-efficacy and math intrinsic motivation between general and vocational education students.

Since general programs are, by definition, oriented toward students that are more adept academically, and vocational programs, toward students that are less adept academically, the results in Tables VI and VII are consistent with what we would expect in levels of outcomes of ninth and tenth grade students in these two programs. However, these estimated differences in achievement scores, math self-efficacy, and math motivation for general and vocational education we observe in Tables VI and VII are likely 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.

	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

Source: Estimates by authors from PISA 2012

Table V. Proportion of general/vocational students. by socio-economic background, PISA reading achievement, and country

Table VI. Adjusted differences in PISA scores between general and vocational students in each country, using OLS regression

Outcomes	Austria Mathematics	Austria Reading	Austria Science	Croatia Mathematics	Croatia Reading	Croatia Science	Hungary Mathematics	Hungary Reading	Hungary Science
General vs vocational	46.6 (5.7)***	59 (5.4)***	46.7 (5.2)***	96.4 (7.1)***	86 (5.3)***	83.4 (3.1)***	72.2 (6.2)***	69.3 (5.5)***	64.8 (5.3)***
SES	29.3 (1.9)***	26.5 (2)***	32.5 (2.2)***	12.7 (1.7)***	13.8 (1.7)***	11.3 (1.8)***	25.7 (5.3)***	22.1 (2.2)***	25.1 (2)***
Female	−26.5 (4.4)***	32.2 (4.3)***	−13.4 (4.3)***	−25.1 (3.7)***	36 (3.5)***	−9.4 (3.5)***	−22.1 (3.1)***	26.9 (2.9)***	−13.8 (2.9)***
Constant	513.8 (3.9)	464.3 (3.9)	507.1 (3.9)	461.9 (4.3)	448.6 (4.1)	477.6 (3.9)	476.4 (4.1)	463.3 (94.4)	491.2 (2)
R^2	0.19	0.25	0.21	0.33	0.37	0.26	0.34	0.35	0.31
n	4,157	4,157	4,157	4,684	4,684	4,684	4,356	4,356	4,356

Notes: Standard errors in parentheses. $^{***}p < 0.01$

Students in the two programs may, on average, have lower scores and lower math self-efficacy and math motivation because they entered first grade with those differences.

4.3 Estimating the relative effectiveness of general and vocational education using grade differences

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 estimate inter-grade differences in achievement, self-efficacy, and motivation gains in the two tracks. We then adjust the inter-grade differences for student characteristics in the whole sample, and finally, we instrument the cutoff date for entry into primary school as a means to correct for unobserved differences in student characteristics in the two tracks. We compare those students in tenth grade in each track whose birthday fell on the "right" side of the cutoff date with students in the ninth grade in the same track whose birthday fell on the "wrong" side of the cutoff data.

4.3.1 Unadjusted differences in student achievement, math self-efficacy, and math motivation in ninth and tenth grades. Table VIII shows the simple, unadjusted differences in PISA achievement scores, math self-efficacy, and math motivation for students in the general and vocational tracks. In general, tenth graders achieve at higher levels than ninth graders in both tracks, have higher self-efficacy, but, not surprisingly, have no higher intrinsic mathematics motivation 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. Similarly, students' unadjusted gains in math self-efficacy are greater in the academic track than in the vocational track in Austria and Croatia but not in Hungary, where the gains are relatively high in both.

4.3.2 Adjusted differences in student achievement, math self-efficacy, and math motivation in ninth and tenth grades. When we adjust the inter-grade differences in student achievement, self-efficacy, and math motivation for student characteristics, the results in Table IX show that the achievement differences increase substantially. This is probably so because older students in each grade score lower and, in the PISA sample, students in the ninth grade tend to be somewhat older than students in the tenth grade because the cutoff date delays them in entering. Students in Austria continue to make the largest achievement gains in both tracks. The differences in gains between the tracks are small in Austria and Hungary across all subjects, and, except in

Table VII. Adjusted differences in math self-efficacy and intrinsic motivation between general and vocational students in each country, using OLS regression

	Austria		Croatia		Hungary	
Outcomes	Math self-efficacy	Intrinsic motivation	Math self-efficacy	Intrinsic motivation	Math self-efficacy	Intrinsic motivation
General vs vocational	0.27 (0.07)***	0.01 (0.06)	0.64 (0.06)***	0.16 (0.06)***	0.57 (0.06)***	0.13 (0.06)**
SES	0.26 (0.03)***	0.02 (0.02)	0.15 (0.02)***	−0.02 (0.03)	0.25 (0.02)***	0.01 (0.02)
Female	−0.48 (0.05)***	−0.38 (0.04)***	−0.42 (0.04)***	−0.17 (0.04)***	−0.34 (0.04)***	−0.26 (0.04)***
Constant	0.24 (0.05)***	−0.16 (0.04)***	0.17 (0.04)***	−0.23 (0.03)***	0.21 (0.05)	−0.11 (0.04)***
R^2	0.14	0.04	0.17	0.01	0.20	0.02
n	2,757	2,761	3,105	3,104	2,896	2,905

Notes: Clustered standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$

Table VIII. Unadjusted differences between grades in PISA scores, self-efficacy, and math intrinsic motivation, by program and country

Variable	Program	Austria 9th grade	Austria 10th grade	Austria Difference	Croatia 9th grade	Croatia 10th grade	Croatia Difference	Hungary 9th grade	Hungary 10th grade	Hungary Difference
PISA math score	General	543 (6.7)	580 (4.6)	37 (5.7)***	540 (6.6)	567 (7.6)	27 (4.4)***	535 (6.3)	564 (6.3)	29 (5.3)***
	Vocational	480 (3.9)	514 (3.7)	34 (4.5)***	440 (3.2)	458 (3.8)	18 (3.5)***	445 (4.8)	476 (4.4)	31 (3.6)***
PISA read score	General	540 (6.5)	573 (4.4)	33 (5.6)***	554 (4.7)	577 (5.6)	22 (4.1)***	548 (4.8)	574 (4.6)	26 (4.6)***
	Vocational	463 (3.8)	490 (3.8)	27 (4.8)***	452 (3.5)	475 (4.1)	23 (3.2)***	459 (4.2)	487 (4.8)	28 (3.9)***
PISA science score	General	548 (6.3)	582 (4.5)	34 (5.2)***	554 (5.5)	569 (6.5)	15 (4.5)***	548 (4.5)	573 (4.8)	25 (4.6)***
	Vocational	484 (4.4)	509 (3.1)	25 (4.7)***	464 (3)	478 (3.9)	14 (3.6)***	464 (4.9)	494 (4.4)	30 (3.7)***
Self-efficacy in math	General	0.27 (0.05)	0.44 (0.04)	0.17 (0.07)**	0.51 (0.03)	0.69 (0.07)	0.18 (0.07)**	0.6 (0.03)	0.8 (0.05)	0.2 (0.06)***
	Vocational	−0.05 (0.03)	0.04 (0.03)	0.09 (0.05)**	−0.11 (0.02)	−0.12 (0.04)	−0.01 (0.05)	−0.13 (0.03)	0.1 (0.05)	0.23 (0.05)***
Math intrinsic motivation	General	−0.35 (0.05)	−0.33 (0.05)	0.02 (0.07)	−0.2 (0.03)	−0.11 (0.07)	0.09 (0.08)	−0.15 (0.03)	−0.08 (0.06)	0.07 (0.06)
	Vocational	−0.31 (0.04)	−0.33 (0.03)	−0.02 (0.05)	−0.28 (0.02)	−0.35 (0.04)	−0.06 (0.05)	−0.23 (0.03)	−0.3 (0.05)	−0.07 (0.05)

Notes: Standard errors in parentheses. ***$p < 0.01$; **$p < 0.05$

	Austria		Croatia		Hungary	
	General	Vocational	General	Vocational	General	Vocational
(a) PISA scores for general and vocational students						
PISA math score						
9th vs 10th grade	55.9 (6.7)	51.2 (6.4)***	37.2 (8.7)***	29.1 (5.5)***	38.3 (6.6)***	39.1 (4.6)***
Age (dummy)	−23.1 (7.6)***	−27.8 (6.6)***	−11.8 (8.3)	−10 (5.1)*	−12.9 (5.4)**	−11.9 (3.9)***
SES	20.7 (3.8)***	28.9 (2.2)***	8.3 (2.5)***	14.6 (2.2)***	25.9 (4.2)***	24.5 (2.5)***
Female	−34.8 (4.6)***	−26.8 (5.9)***	−39.9 (5.1)***	−20.7 (4.9)***	−36.2 (3.1)***	−15.5 (4.7)***
Constant	551.8 (6.9)	503.1 (5.3)	562.6 (7.7)	457.5 (4.9)	552.5 (5.6)	468.8 (4.6)
R^2	0.18	0.13	0.11	0.06	0.16	0.13
PISA reading scores						
9th vs 10th grade	45.3 (7)***	41.5 (6.7)***	32.3 (8.5)***	33.1 (4.6)***	26.4 (5.8)***	28.8 (5.4)***
Age (dummy)	−20.6 (8.2)**	−26.1 (6.9)***	−14.3 (8.1)*	−15.3 (4.9)***	−5.1 (5.2)	−6.5 (4.3)
SES	16.1 (3.4)***	27.7 (2.3)***	10.8 (2.1)***	14.9 (2.2)***	19.9 (3.2)***	22.8 (2.9)***
Female	16.4 (3.3)***	35.2 (5.8)***	17 (4.7)***	42.2 (4.5)***	15.1 (3.1)***	33 (4.3)***
Constant	525.1 (7.1)	456.4 (5.3)	542.7 (5.6)	443.3 (4.5)	535.6 (4.8)	457 (4.9)
R^2	0.12	0.13	0.06	0.11	0.1	0.13
PISA science scores						
9th vs 10th grade	44.1 (6.7)***	38.8 (6.8)***	26.5 (8.9)***	24 (5.9)***	31.4 (5.7)***	38.2 (5.3)***
Age (dummy)	−16.1 (8.1)*	−23.5 (6.8)***	−13.3 (7.9)*	−11.4 (6.2)*	−9.4 (5.3)*	−13.3 (4.5)***
SES	26.2 (3.9)***	32 (2.4)***	5.4 (2.2)*	14.1 (2.3)***	23.5 (2.9)***	25.3 (2.8)***
Female	−22.9 (5.3)***	−12.5 (5.8)**	−26.1 (4.9)***	−3.7 (4.7)	−25.3 (3)***	−9 (4.4)**
Constant	547.1 (7.2)	500 (5.7)	569.4 (6.2)	474.4 (4.4)	559.2 (4.5)	486 (4.6)
R^2	0.17	0.11	0.05	0.03	0.14	0.12
n	1,207	2,950	1,404	3,280	1,943	2,413
(b) Self-efficacy and intrinsic motivation for general and vocational students						
Math self-efficacy						
9th vs 10th grade	0.13 (0.10)	0.15 (0.07)**	0.20 (0.12)	0.08 (0.07)	0.32 (0.07)***	0.30 (0.07)***
Age (dummy)	0.01 (0.11)	−0.10 (0.07)	0.02 (0.11)	−0.07 (0.07)	−0.12 (0.06)*	−0.07 (0.05)
SES	0.28 (0.05)***	0.24 (0.03)***	0.10 (0.03)***	0.17 (0.03)***	0.26 (0.04)***	0.22 (0.03)***
Female	−0.49 (0.07)***	−0.48 (0.06)***	−0.57 (0.07)***	−0.37 (0.04)***	−0.54 (0.06)***	−0.24 (0.05)***
Constant	0.41 (0.09)***	0.21 (0.06)***	0.86 (0.07)***	0.16 (0.04)***	0.87 (0.07)***	0.11 (0.05)**
R^2	0.13	0.10	0.10	0.07	0.13	0.08
n	817	1,940	933	2,172	1,293	1,603
Math intrinsic motivation						
9th vs 10th grade	0.25 (0.16)	0.01 (0.07)	0.17 (0.13)	−0.21 (0.09)**	0.13 (0.07)*	−0.06 (0.07)
Age (dummy)	−0.28 (0.16)*	0.02 (0.08)	−0.04 (0.12)	0.18 (0.09)**	−0.07 (0.07)	0.02 (0.06)
SES	0.06 (0.05)	0 (0.03)	0.02 (0.04)	−0.04 (0.03)	0.08 (0.03)**	−0.05 (0.03)*
Female	−0.22 (0.08)***	−0.44 (0.05)***	−0.17 (0.07)**	−0.16 (0.04)***	−0.34 (0.06)***	−0.20 (0.06)***
Constant	−0.25 (0.08)***	−0.15 (0.05)***	−0.10 (0.08)	−0.24 (0.04)***	0.04 (0.07)	−0.17 (0.04)***
R^2	0.02	0.05	0.01	0.01	0.04	0.01
n	817	1,944	933	2,171	1,298	1,607

Notes: Clustered standard errors in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table IX. Adjusted differences between grades, Using OLS regression mathematics, this is also the case in Croatia. Female students have a smaller negative gap in mathematics and science achievement in the vocational track and a much larger positive reading achievement gap in the vocational track.

The results for adjusted self-concept and math motivation differences are less consistent (Table IX). Generally, the gain in self-efficacy from ninth to tenth grade is positive (but not significant in Croatia), and is especially large in Hungary. Also, there is no apparent difference between the general and vocational tracks. However, the adjusted differences for gains in mathematics motivation do seem to show significantly larger gains in motivation for students in the general track than in the vocational track.

4.3.3 Adjusted differences in student achievement, math self-efficacy, and math motivation in ninth and tenth grades, using IV estimates. Our adjusted IV estimates in Table X 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 countries. The gains for one year of schooling are much smaller than in the adjusted results in Table IX, suggesting that controlling for selection bias using this strategy greatly reduces differences due to unobservable characteristics of students in ninth and tenth 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 0.15-0.3 standard deviations). The gain is as great 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 is greater than in vocational education in all three PISA subject tests, but this is not the case for either Croatia or Hungary.

Table X shows the IV results for math self-efficacy and math intrinsic motivation. These better-identified estimates indicate that there is no increase in math intrinsic motivation in any of the three countries, either in the general or the vocational track. Nevertheless, gains in math self-efficacy are positive and significant in Croatia's general education track and positive and significant in Hungary's vocational education track. In each country the other track (vocational in Croatia and general in Hungary) show no significant gains in math self-concept.

We estimate whether the differences we report in Table X in tenth grade PISA test score gains and math self-efficacy gains for general and vocational education students are statistically significant by regressing test scores, self-efficacy, and intrinsic motivation on grade (tenth vs ninth), track (general vs vocational), and the interaction term of grade and track (Table XI), self-efficacy and track, and intrinsic motivation and track (Table XII). To make the results comparable to the results in Table X, we also include controls for the interaction of general track with SES and general track with gender.

The results in Table XI 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[5]. The interaction terms for self-efficacy and grade are positive and statistically significant in Croatia, but not for either Austria or Hungary. The difference in gain in intrinsic math motivation between general and vocational is not significant in any of the countries (Table XII).

5. Discussion and conclusions

It is widely known that students who are tracked into vocational secondary education are likely to be from lower socioeconomic background families and to perform worse academically than general secondary education students. In addition to meeting

	Austria		Croatia		Hungary	
	General	Vocational	General	Vocational	General	Vocational
(a) PISA achievement gains						
PISA math scores						
9th vs 10th						
grade	26.9 (6.5)***	15.9 (5.8)***	21.9 (5.3)***	16 (4.2)***	14.9 (7.1)**	14.9 (6.2)**
SES	22.5 (4)***	30.5 (5.3)***	8.4 (2.5)***	14.8 (2.2)***	26.2 (4.1)***	24.7 (2.5)***
Female	−32.5 (4.7)***	−26 (5.8)***	−39.3 (5.1)***	−20.2 (4.9)***	−34.7 (3.3)***	−13.9 (4.7)***
Constant	552.2 (7.1)***	504.7 (5.4)***	562.9 (7.6)***	457.7 (4.9)***	552.1 (5.7)***	468.5 (4.6)***
R^2	0.17	0.12	0.11	0.05	0.15	0.11
PISA reading scores						
9th vs 10th						
grade	19.5 (7)**	8.4 (6.5)	13.8 (4.8)***	13.1 (4.1)***	17.2 (6.7)***	15.5 (6.4)**
SES	17.7 (3.7)***	29.2 (2.3)***	11 (2.2)**	15.2 (2.2)***	20.1 (3.2)***	23 (2.9)***
Female	18.5 (4.4)***	35.9 (5.8)***	17.9 (4.8)***	42.9 (4.5)***	16.8 (4.4)***	34.4 (5.1)***
Constant	525.4 (7.3)***	457.9 (5.4)***	543.1 (5.5)***	443.3 (4.5)***	534.8 (5.5)***	456.8 (5)***
R^2	0.11	0.12	0.06	0.11	0.1	0.13
PISA science scores						
9th vs 10th						
grade	23.9 (6.9)***	9.0 (5.9)	9.2 (5)*	9.2 (4.7)*	14.4 (7)**	11.1 (6.2)*
SES	27.4 (4.2)***	33.3 (2.4)***	5.5 (2)*	14.2 (2.3)***	23.8 (2.9)***	25.6 (2.7)***
Female	−21.3 (5.4)***	−26 (5.8)***	−25.3 (4.9)***	−3.2 (4.7)	−24.2 (3.3)***	−7.2 (4.4)
Constant	547.4 (7.3)***	501.4 (5.9)***	569.7 (6.2)***	474.6 (4.4)***	558.9 (4.5)***	485.7 (4.6)***
R^2	0.16	0.1	0.05	0.03	0.13	0.1
1st stage						
F-test	1,738	4,882	901.65	2,533.6	722.6	745.02
n	1,207	2,950	1,404	3,280	1,942	2,413
(b) PISA math self-efficacy and math motivation gains						
Math self-efficacy						
9th vs 10th						
grade	0.14 (0.09)	0.03 (0.07)	0.22 (0.09)**	−0.01 (0.06)	0.09 (0.10)	0.17 (0.08)**
SES	0.28 (0.04)***	0.24 (0.03)***	0.10 (0.04)***	0.17 (0.03)***	0.27 (0.04)***	0.23 (0.03)***
Female	−0.49 (0.07)***	−0.48 (0.06)***	−0.57 (0.07)***	−0.36 (0.04)***	−0.52 (0.06)***	−0.23 (0.06)***
Constant	0.41 (0.09)***	0.22 (0.07)***	0.86 (0.07)***	0.16 (0.04)***	0.86 (0.07)***	0.11 (0.05)**
R^2	0.13	0.10	0.10	0.07	0.13	0.07
n	817	1,940	933	2,172	1,293	1,603
Math intrinsic motivation						
9th vs 10th						
grade	−0.09 (0.10)	0.04 (0.07)	0.11 (0.08)	0.03 (0.07)	0.00 (0.10)	−0.02 (0.09)
SES	0.08 (0.04)*	0.00 (0.03)	0.02 (0.04)	−0.04 (0.03)	0.08 (0.03)**	−0.06 (0.03)*
Female	−0.20 (0.08)**	−0.44 (0.05)***	−0.17 (0.07)**	−0.17 (0.04)***	−0.33 (0.06)***	−0.20 (0.05)***
Constant	−0.23 (0.08)***	−0.15 (0.06)***	−0.10 (0.07)	−0.24 (0.04)***	0.04 (0.07)	−0.17 (0.04)***
R^2	0.01	0.05	0.01	0.01	0.04	0.01
n	817	1,944	933	2,171	1,298	1,607

Notes: Clustered standard errors in parentheses. ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Table X. Estimates of one year students' educational track and country, IV results

particular skill needs in the labor 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 does general secondary education. In a global environment that emphasizes general problem solving skills and the flexibility of workers

Table XI. 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	15.9 (5.8)***	8.4 (6.5)	9.0 (5.9)	16.0 (4.2)***	13.1 (4.1)***	9.2 (4.7)*	14.9 (6.2)**	15.5 (6.4)**	11.1 (6.2)*
General	47.5 (8.8)***	67.5 (8.9)***	46.0 (9.1)***	105.1 (9.1)***	99.5 (6.9)***	95.1 (7.4)***	83.6 (7.2)***	78.6 (6.6)***	73.2 (6.3)***
General*9th vs 10th grade	10.9 (8.8)	11.1 (9.1)	14.8 (8.9)	5.9 (6.9)	0.6 (6.2)	0.02 (6.9)	0.02 (9.2)	1.7 (8.8)	3.3 (9.2)
SES	30.5 (2.3)***	29.2 (2.3)***	33.3 (2.4)***	14.8 (2.2)***	15.2 (2.2)***	14.2 (2.3)***	24.7 (2.5)***	22.9 (2.8)***	25.6 (2.7)***
General*SES	−8.00 (4.7)*	−11.4 (4.4)**	−5.9 (4.7)	−6.3 (3.4)	−4.2 (2.9)	−8.7 (2.9)***	1.5 (4.8)	−2.9 (4.2)	−1.8 (3.9)
Female	−26 (5.8)***	35.9 (5.8)***	−11.8 (5.7)***	−20.2 (4.9)***	42.9 (4.5)***	−3.2 (4.7)	−13.9 (4.7)***	33.9 (4.4)***	−7.2 (4.4)
General*Female	−6.5 (7.4)	−17.5 (7.3)**	−9.5 (8.1)	−19.0 (7.2)**	−25.1 (6.6)***	−22.1 (7)***	−20.8 (5.6)***	−18.2 (5.4)***	−16.9 (5.5)***
Constant	504.7 (5.4)***	457.9 (5.4)***	501.4 (5.9)***	459 (4.3)***	443.6 (4.5)***	474.6 (4.4)***	468.5 (4.6)***	456.8 (4.9)***	485.7 (4.6)***
R^2	0.22	0.26	0.22	0.34	0.38	0.27	0.36	0.36	0.33
n	4,157	4,157	4,157	4,684	4,684	4,684	4,356	4,356	4,356

Notes: Clustered standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Variable	Austria Math self-efficacy	Austria Intrinsic motivation	Croatia Math self-efficacy	Croatia Intrinsic motivation	Hungary Math self-efficacy	Hungary Intrinsic motivation
9th vs 10th grade	0.03 (0.07)	0.04 (0.07)	−0.01 (0.07)	0.03 (0.07)	0.17 (0.08)**	−0.02 (0.09)
General	0.19 (0.11)*	−0.08 (0.10)	0.70 (0.09)***	0.14 (0.09)	0.76 (0.09)***	0.21 (0.08)***
General* 9th vs 10th grade	0.11 (0.11)	−0.13 (0.13)	0.23 (0.11)**	0.09 (0.11)	−0.08 (0.13)	0.02 (0.14)
SES	0.24 (0.03)***	0.00 (0.03)	0.17 (0.03)***	−0.04 (0.03)	0.22 (0.03)***	−0.06 (0.03)*
General* SES	0.04 (0.06)	0.08 (0.06)	−0.07 (0.05)	0.06 (0.05)	0.04 (0.05)	0.14 (0.05)***
Female	−0.48 (0.06)***	−0.44 (0.05)***	−0.36 (0.04)***	−0.17 (0.04)***	−0.23 (0.06)***	−0.20 (0.05)***
General* Female	−0.01 (0.09)	0.24 (0.09)***	−0.20 (0.08)**	0.01 (0.08)	−0.29 (0.08)***	−0.13 (0.08)
Constant	0.22 (0.07)***	−0.15 (0.06)***	0.16 (0.04)***	−0.24 (0.04)***	0.11 (0.05)***	−0.17 (0.04)***
R^2	0.14	0.04	0.18	0.01	0.21	0.03
n	2,757	2,761	3,105	3,104	2,896	2,905

Notes: Clustered standard errors in parentheses. ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Table XII. Estimates of differences in gains in math self-efficacy and math intrinsic motivation between secondary educational tracks, by country, IV results

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 confirm that PISA achievement scores, self-efficacy in mathematics, and intrinsic mathematics motivation of students in the general track of secondary schools are typically much higher than for students in vocational schools (Table IV) and that this is generally the case even when we control for students' socio-economic background and gender (Tables VI and VII).

Nevertheless, when we compare the PISA test score gains in tenth grade vs ninth grade, we do not find significant differences between the general and the vocational track. The closest the general track comes to outperforming the vocational track is in Austria (Table XI). 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 tenth grade. Table X also shows that students in the general track of secondary school average higher on the PISA in all tested subjects than students in vocational school, and that, in addition, higher SES students do much better on the PISA regardless of track. The results also show that in each country, students who were assigned to ninth and tenth grade by dint of their birthdays falling on either side of the entrance age cutoff date typically do better on the PISA test because they spend a year more in school. The gains are similar 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 IX). Neither are the ninth to tenth grades gains significantly different between tracks in students' math self-efficacy and intrinsic motivation in math, with one important exception: the much higher gains in general education students' self-efficacy in Croatia (Table XII).

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 as well as math self-efficacy and intrinsic math motivation. Thus, channeling academically less well performing and generally lower SES students into the vocational track does not appear 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, given difference in the percentage of students in the two tracks. A high percentage (72 percent) of Austrian students are in the vocational track in both grades (Table I), including a group that is in transition from *hauptschule* to apprenticeship training/education in tenth grade. Austria almost shows a significant difference in gains between general and vocational education. In Croatia, general education is the most elite of the three countries' education (Tables I and V). Table X shows very high differences in test scores between Croatia's vocational and general tracks. Croatian general education track students have a much higher sense of self-efficacy than vocational school students, perhaps reflecting the relatively high SES of students in the academic track. The test score gains in the general track should probably 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 I), and math self-efficacy increases the most from ninth to tenth grades. We might expect that vocational school students in Hungary would represent a strongly negatively selected group, but their average vocational test scores are not 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, the average academic experience for most vocational education students in all three countries becomes increasingly less academic after tenth grade. This implies that general track students in these countries would continue to make academic achievement gains beyond tenth grade whereas these gains could decline for vocational education students. Since general track students already score much higher on the PISA test, the gap in mathematics, reading, and science should increase as students continue their education.

Notes

1. 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.
2. 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.
3. 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.
4. We test whether relative age is correlated significantly with grade level in the student data in each country. The *F*-test values (722-4,882) show a strong correlation between the IV and treatment variable (Table X).
5. The IV typically tends to increase error terms, so it is possible that, especially in Austria, our results may incorrectly identify the general*grade test score gain coefficient as insignificant because of noise in the data.

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