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Does high school achievement predict success and enrolment in STEM higher education?

An analysis using longitudinal Dutch register data.

Melvin Vooren, Carla Haelermans,
Wim Groot & Henriette Maassen van den Brink

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Colofon

**Melvin Vooren[2,3], Carla Haelermans[4], Wim Groot[5]
& Henriëtte Maassen van den Brink[3]**

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Authors: Melvin Vooren, Carla Haelermans, Wim Groot & Henriëtte Maassen van den Brink
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For more information:
Website: houseofskillsregioamsterdam.nl
E-mail: houseofskills@amsterdam.nl

2 Corresponding author. M.Vooren@uva.nl.
3 University of Amsterdam, Amsterdam School of Economics and Top Institute for Evidence Based Education Research
4 Maastricht Univerity, School of Business and Economics
5 Maastricht University, School of Governance, Faculty of Science and Engineering

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Abstract

In this paper we investigate the predictors for enrolment and success in Science, Technology, Engineering, and Mathematics (STEM) programs in higher education. We estimate a sequential logit model in which students enrol in STEM education, may drop out from STEM higher education, or continue studying until they graduate in a STEM field. We use rich Dutch register data on student characteristics and high school exam grades to explain the differences in enrolment, success and dropout rates. We find that females are less likely to enrol in STEM-related fields while students with higher high school mathematics grades are more likely to enrol in STEM. Female students have lower first-year dropout rates at university of applied sciences STEM programmes. With respect to study success we find that conditional on enrolment in STEM, women are less likely to graduate than men within the nominal duration or the nominal duration plus one additional year. However, female students do perform equally well as male students in terms of graduation within ten years. We conclude that although STEM programmes are less popular among female students, they do perform equally well in STEM higher education in the long run. Yet, policy should be geared at increasing the return in terms of nominal graduation rates among female STEM students.

1 Introduction

For some years now, the question of how to increase the number of graduates from higher education studies in Science, Technology, Engineering, and Mathematics (STEM) has been high on many political agendas, including the European Union's (EU) Horizon 2020 strategy regarding science education. There is a high demand for STEM graduates from both the private and the public sector, not only from tech firms, but also from governments and research institutes (Giffi et al., 2018). However, the inflow of students in STEM studies is (too) low, there is discussion about the lack of diversity of students in these studies, and dropout rates are high.

Improving study success in higher education is a priority (European Commission, 2015). In the Netherlands, for example, only 59 per cent of the bachelor graduates from universities of applied sciences (UAS) and 72 per cent of the bachelor graduates from research universities graduated within the nominal duration of the programme plus one additional year (time-to- degree) in 2017 (Inspectie van het Onderwijs, 2018, p. 174). For STEM-related studies, these figures are even more problematic. In the present study, we identify the underlying factors that predict enrolment, dropout and study success.

In the United States, high dropout rates in STEM fields are also reported to be a problem (Chen, 2013). In analysing this, Meyer and Marx (2014) describe the experiences of students who dropped out from engineering in the United States. The most common reasons why students drop out from engineering include performance- related issues, which are most likely the result of difficulties with fitting into the engineering field and the requirements of the programme. In terms of self-confidence and motivation Litzler et al. (2014) break down the self-reported levels of STEM confidence between gender and ethnicity groups and find that women on average report less confidence than men. Studies on interventions to improve study success (in general, and in STEM studies in particular) (see Brock (2010) for a review) look for example at improving the fit between secondary education and higher education. Using structural equation modelling, Torenbeek et al. (2010) find that a closer resemblance between the higher education programme and the courses students take in secondary education, improves first year study success in the Netherlands significantly. In the case of STEM higher education, this translates to knowing whether previous mathematics and science achievement are a good predictor of study success.

Improving study success in STEM higher education could potentially also help the shortage on the labour market for STEM graduates. However, before one can focus on improving study success and decrease the time-to-degree, it is important to first gain insights in the determinants of study choice for a STEM study. Therefore, this paper explores the factors underlying the decision of students to pursue an educational career in higher education in a STEM-related field and study success over the course of the education programme extended with at maximum one additional year. We utilise rich register data from Statistics Netherlands from 2007 to 2011. These data contain detailed information on student background characteristics, students' grades in secondary education, and their careers in higher education. We use a sequential logit model to model students' educational careers from the enrolment decision until the moment when the students can graduate. We model the dropout decisions for each year separately.

By doing so, we contribute to the literature in a number of ways. First, we are able to follow individuals throughout their entire career in higher education, starting with their high school exam. This allows us to both analyse the factors that underlie the decision to enrol in STEM higher education, as well as the factors that predict dropout from STEM-related programmes and the probability of graduation. Second, since the high school exam is the same for each student from a specific cohort in the entire country, these grades are comparable for all individuals that took the high school exam in a specific year. Because of this, we are able to give a robust answer to the question to what extent high school exam grades predict enrolment and success in STEM higher education. These insights are useful to target potentially successful groups and to increase the return to STEM education.

In our study, we find that conditional on enrolment, women are less likely to graduate on time than men in STEM-related fields. However, in terms of first year dropout rates, women perform better than men at university of applied sciences STEM programmes. Higher grades for both mathematics and Dutch are associated with higher success rates, but higher grades for English correlate with higher first-year dropout rates and lower graduation rates. In universities of applied sciences STEM programmes, students with a non-Western migration background perform worse in terms of first-year dropout rates. Also, graduation rates for these students are much lower at one year after the final year of the programme.

In the next section, we briefly describe the literature on study choice and study success. We give a description of the data of Statistics Netherlands in section 3. In section 4 we introduce and explain our model. We describe our results in section 5. Then, section 6 concludes and discusses our findings.

2 Literature

2.1 Study choice

There is a sizable literature that investigates the determinants of the choice for a study programme. This strand of literature points at different factors that influence a student's decision to enrol into a STEM programme. A review study by Van Tuijl and Van der Molen (2015) focuses on factors in the early childhood that explain why certain students enrol in STEM and why other students do not. They argue that stereotypical views negatively affect ability beliefs among pupils, and cause low STEM enrolment rates in certain groups. These stereotypical views might influence the STEM enrolment decision of both males and females in later life.

From a cohort study of 6,000 students in the United States, Sadler et al. (2012) conclude that the difference in STEM interest between males and females increases during the high school years. During high school, the percentage of females interested in a STEM career decreases every school year, while for males this percentage remains stable over the course of high school. Jouini et al. (2018) confirm that women are underrepresented in STEM study programmes and careers, and argue that this is due to lower self-confidence in mathematics ability.

Another reason for lower STEM enrolment rates among females could be that girls might perform worse in mathematics than boys in high school. In PISA data gender differences in math scores exist, with boys outperforming girls in many countries (Guiso et al., 2008; Nollenberger et al., 2016). This difference, however, could be driven by the competitive setting of test-taking: boys perform better in competitive environments than girls (Niederle and Vesterlund, 2010; Wang and Degol, 2017).

Wang (2013) argues that the mathematics grade in the 12th grade is the best predictor for STEM enrolment, next to beliefs about self-ability in math and science subjects. Moakler and Kim (2014) also find that self-confidence in mathematics is an important factor in the decision to enrol into STEM. In addition, they confirm that female students are less likely to enrol into STEM, but find no differences with respect to ethnic minorities. In conclusion, the scientific literature on study choice points out that gender and 12th grade math achievement are important determinants for STEM enrolment.

2.2 Study success

In addition to the differences in STEM enrolment rates, there are also differences in terms of study success in STEM fields. Using national survey data from the United States, Griffith (2010) gives a descriptive exploration of the factors that explains why students drop out from STEM and switch to different majors. Especially female students tend to frequently drop out from STEM fields and switch to a different bachelor. According to the authors, persistence of women in STEM study programmes is higher at institutions with a higher percentage of female STEM graduate students. However, they do not find that having a larger share of female STEM faculty members leads to lower dropout rates among female students in STEM. In a cohort study at a research university in the Midwestern United States, Whalen and Shelley (2010) investigate the predictors for study success in STEM majors. The authors find that the previous grade point average is the strongest predictor for graduation in STEM programmes.

Kokkelenberg and Sinha (2010) make use of student-level data from Binghamton University in the state of New York to investigate the factors associated with academic success in STEM study programmes. In Binghamton University, the difference among male and female persistence in STEM fields is mainly driven by the field of engineering: female students drop out more frequently from engineering than from other STEM fields. According to the authors, the differences in study success in the field of engineering is mainly explained by differences in high school mathematics levels. Still, from the existing literature it is unclear whether differences in study success are due to gender differences, or differences in mathematics ability, because differences in science and mathematics test scores occur between genders (Miyake et al., 2010).

3 The Dutch education system

3.1 Secondary education

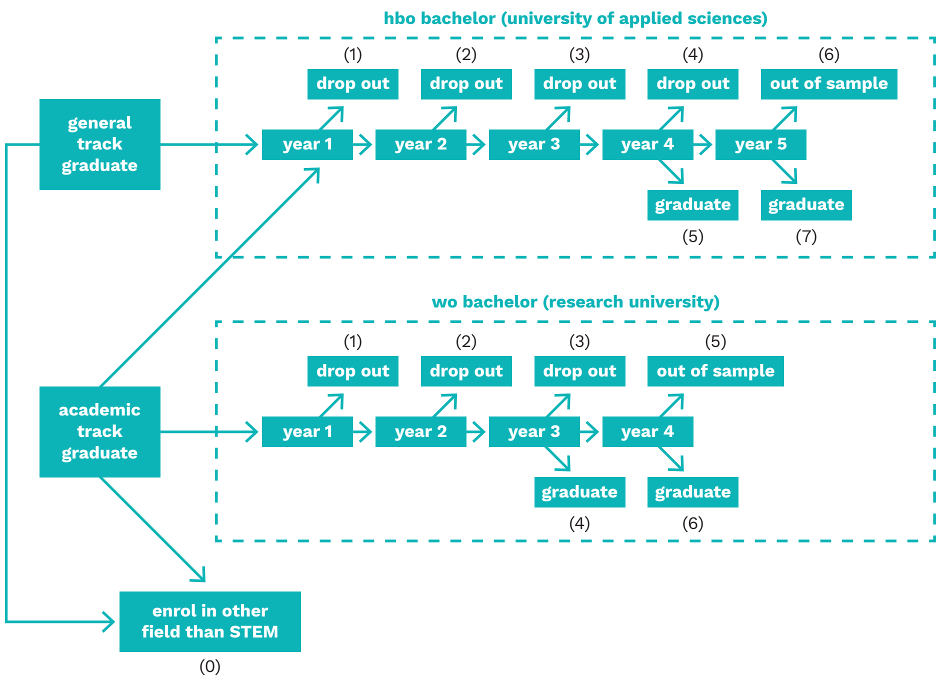
In the Dutch system, a school advice from primary school determines track placement of student in secondary education, from grade 7 on. Dutch secondary education consists of three tracks: prevocational education, higher general education, and pre-academic education (known by the Dutch acronyms *vmbo*, *havo*, and *vwo*, respectively). Prevocational education takes 4 years, higher general education 5 years, and pre-academic education 6 years. Despite the early tracking in the Dutch system, it is possible to move up a track in secondary education, however, this is less common than grade repetition or stepping back a track.

In order to gain access to higher education directly from high school, a student needs to hold a high school degree from either the general or the pre-academic track. In almost all cases, only students that hold a high school degree from the pre-academic track can enrol into research university bachelor's programmes directly from high school.

All students in the general and the academic high school tracks take the subjects Dutch, English, and mathematics. However, not all students take the same type of mathematics as in Dutch secondary education two types of mathematics are offered, one type that focuses more on statistics (e.g. diagrams, tables, formulas and probabilities), the so-called mathematics A, and the other type that is more technical, focussing on e.g. algebra, goniometry, differentials and functions, which is the so-called mathematics B. Mathematics B is more challenging and has a deeper focus on calculus. Students that are more interested in math, as well as students that follow the science specialisation in high school, are obliged to follow mathematics B instead of mathematics A. The admittance requirements for most STEM fields include that students should have graduated in either mathematics A or B, although the final exam grade does not necessarily have to be a pass grade.

In their graduation year, all high school students take standardised national written exams. The exam is the same for each student in a cohort, and is marked by two different teachers: by both the student's own teacher and a randomly drawn teacher from a different school in the Netherlands. This makes the grades on the standardized national exams comparable and a robust predictor in our analyses.

Figure 1 Sequential logit model: simplified version of the Dutch higher education system



Notes: After high school, graduates from the academic track can choose to either go research universities, or universities of applied sciences. Bachelor's programmes at research universities have a duration of three years, whereas their counterparts at universities of applied sciences have a duration of four years. For this reason we model the students' choice sets differently depending on the type of higher education they are enrolled into: research university students can graduate one year earlier than their colleagues at universities of applied sciences. Out of sample means that the student does not graduate within the nominal duration plus one year.

3.2 Higher education

After high school, graduates from the academic track can choose to either go research universities, or universities of applied sciences. Bachelor's programmes at research universities have a duration of three years, whereas their counter-parts at universities of applied sciences have a duration of four years.
Figure 1 shows a stylised diagram of the Dutch higher education system in function of the analysis we perform in this paper. We consider a subsample of high school graduates that choose to enrol in higher education directly after graduating from high school. At first, both higher general and pre-academic high school graduates decide whether they enrol into STEM higher education, or if they enrol into a different field than STEM.

Conditional on the decision to enrol into STEM, pre-academic students also have the choice to enrol into a STEM programme at a research university, instead of a STEM programme at a university of applied sciences. However, only around 10 per cent of the students in our sample that are enrolled in university of applied sciences STEM programme are pre-academic education graduates. Note that a bachelor's degree from a university of applied sciences does not automatically give access to a master programme at a research university. After the STEM enrolment decision, every year students either drop out from STEM higher education, or to continue studying within STEM. Not dropping out means that the student continues on to the next year of the current STEM programme, or switches to another programme within STEM at the same level of higher education.

After studying for a set number of years, the students can graduate. This is after at least 3 years for research university programmes and after at least 4 years for university of applied sciences programmes. We distinguish between students that graduate at the first possible opportunity, and students that graduate within one year after that.

4 Data and model

4.1 Statistics Netherlands

We use data from Statistics Netherlands. This facility provides longitudinal register microdata about every Dutch citizen and inhabitant. The source of the educational data that we use for our analysis is the Dutch Dienst Uitvoering Onderwijs (DUO) of the Ministry of Education which administers the educational data of Dutch citizens. Their registers contain information about enrolments, degrees, and secondary education exam courses and grades. For the analysis in this paper, this data has two main advantages. First, we can follow individual's educational careers over multiple years. This allows us to identify which students enrol into higher education, which programme they enrol into, whether they drop out, at what stage they drop out, whether they switch to another programme, and when they graduate. Second, the microdata facility of Statistics Netherlands also allows us to link this data on higher education to secondary educational data. This allows us to incorporate high school grades in our predictions of dropout probabilities.

4.2 Sample

We include all the students that wrote the high school exams between 2007 and 2011 in our sample. The lower bound of this time period is constituted by data availability. The data on secondary education is only available for individuals that took the high school exam from 2007 onwards. The upper bound is constituted by the availability of data on higher education, since we need to follow the students for a sufficient number of years in order to estimate our model. Another crucial reason why we select this time period is that the high school exam requirements were the same over all these years. The requirements to pass the high school exam havo and vwo students have been gradually made more stringent since 2011.

Furthermore, we only include students who directly enrol into higher education after graduating from high school for the sake of comparability. Also, the share of students that take a gap year between graduating from high school and enrolment in higher education in the Netherlands is low (Warps, 2018). Our final sample consists of 281,806 students over five cohorts. Out of these, 51,948 enrolled into a STEM programme, equal to around 18 per cent of all enrolments.

4.2.1 Background characteristics and descriptive information

Table 1 provides the descriptive information of the variables included in our analyses, for the secondary school cohorts that immediately enrolled into any higher education programme, right after graduating from secondary school in

Table 1 **Frequency table, complete sample**

	University of Applied Sciences		Reseach University		Total	
	No.	%	No.	%	No.	%
(a) higher education cohort (starting year)						
2007	34,632	20.6	21,126	18.6	55,758	19.8
2008	36,217	21.5	22,781	20.0	58,998	20.9
2009	32,552	19.4	24,234	21.3	56,786	20.2
2010	32,260	19.2	22,589	19.9	54,849	19.5
2011	32,434	19.3	22,981	20.2	55,415	19.7
Total	168,095	100.0	113,711	100.0	281,806	100.0
(b) mathematics level						
Basic math (A)	117,813	70.1	52,353	46.0	170,166	60.4
Advanced math (B)	50,282	29.9	61,358	54.0	111,640	39.6
Total	168,095	100.0	113,711	100.0	281,806	100.0
(c) high school exam track						
General track (havo)	147,735	87.9	2,585	2.3	150,320	53.3
Academic track (vwo)	20,360	12.1	111,126	97.7	131,486	46.7
Total	168,095	100.0	113,711	100.0	281,806	100.0
(d) migration history						
Native	143,588	85.4	95,555	84.0	239,143	84.9
Migrant	24,507	14.6	18,156	16.0	42,663	15.1
Total	168,095	100.0	113,711	100.0	281,806	100.0
(e) gender						
Male	77,571	46.1	55,236	48.6	132,807	47.1
Female	90,524	53.9	58,475	51.4	148,999	52.9
Total	168,095	100.0	113,711	100.0	281,806	100.0

Notes: Advanced math (B) contains more calculus than basic math (A). Native students are students of which both parents are born in the Netherlands. Migrant students have one or more parent that is born outside of the Netherlands.

2007. Table 2 gives the same information as table 1, but only for students that enrolled in a STEM-related programme in higher education.

In both tables 1 and 2, the observations are equally divided over the five cohorts. Also, native and migrant students are equally divided in the whole sample and in the sample that enrols in STEM. However, there are far less female students that choose for STEM. In research university STEM programmes, the share of female students is slightly larger than in universities of applied sciences.

Because mathematics is a requirement for STEM education (as explained before), this provides us with high school mathematics grades for all students in our sample. All students are obliged to include both Dutch and English in their exam, so we have grades for those subjects as well. We focus on the final grades on the standardised national exams.

Table 2 Frequency table, sample subject on STEM enrolment

	University of Applied Sciences		Reseach University		Total	
	No.	%	No.	%	No.	%
(a) higher education cohort (starting year)						
2007	5,182	19.1	4,557	18.4	9,739	18.7
2008	5,612	20.7	4,844	19.5	10,456	20.1
2009	5,440	20.1	5,247	21.1	10,687	20.6
2010	5,371	19.8	4,960	20.0	10,331	19.9
2011	5,520	20.4	5,215	21.0	10,735	20.7
Total	27,125	100.0	24,823	100.0	51,948	100.0
(b) mathematics level						
Basic math (A)	5,416	20.0	1,038	4.2	6,454	12.4
Advanced math (B)	21,709	80.0	23,785	95.8	45,494	87.6
Total	27,125	100.0	24,823	100.0	51,948	100.0
(c) high school exam track						
General track (havo)	24,372	89.9	527	2.1	24,899	47.9
Academic track (vwo)	2,753	10.1	24,296	97.9	27,049	52.1
Total	27,125	100.0	24,823	100.0	51,948	100.0
(d) migration history						
Native	23,343	86.1	21,223	85.5	44,566	85.8
Migrant	3,782	13.9	3,6	14.5	7,382	14.2
Total	27,125	100.0	24,823	100.0	51,948	100.0
(e) gender						
Male	21,960	81.0	18,355	73.9	40,315	77.6
Female	5,165	19.0	6,468	26.1	11,633	22.4
Total	27,125	100.0	24,823	100.0	51,948	100.0

Notes: Advanced math (B) contains more calculus than basic math (A). Native students are students of which both parents are born in the Netherlands. Migrant students have one or more parent that is born outside of the Netherlands.

For our analysis, we standardise all high school grades to mean zero and standard deviation one. This will simplify the interpretation of the estimated coefficients later on and will make the results easier to generalise. As a result, there are no additional descriptive statistics to report that provide more information than shown in frequency tables 1 and 2.

4.3 Student dropout and graduation

To determine whether a student has graduated or dropped out from the STEM programme, we took the following approach. We created two dummy variables: *dropout* and *graduated*. The dropout variable takes value one when we observe a change in the main programme that the student is enrolled in, compared with the preceding year, without observing a change in their level of education status, and zero otherwise. In this case the student has either switched to a different major, switched to a lower level of post-secondary education, or dropped

Table 3 Distribution of outcomes

	University of Applied Sciences		Reseach University	
	No.	%	No.	%
Panel A: STEM enrolment decision: *Enrol in:*				
Enrol in STEM higher education	23,420	14.2	20,008	18.4
STEM higher education	140,970	85.8	88,888	81.6
Total sample	164,390	100.0	108,896	100.0
Panel B: Outcomes subject on STEM enrolment: *Drop out:*				
year 1	4,906	26.5	3,042	15.2
year 2	2,255	12.2	943	4.7
year 3	1,247	6.7	5,286	26.4
year 4	6,669	36.0	931	4.7
year 5	1,713	9.3	-	-
Total drop out	16,790	71.7	10,202	51.0
Graduate:				
nominal duration	5,167	27.9	6,463	32.3
nominal +1 year	1,463	7.9	3,343	16.7
Total graduate	6,630	28.3	9,806	49.0
Total STEM students	**23,420**	**100.0**	**20,008**	**100.0**

Notes: Panel A shows the share of students from the total sample that choose to enrol in STEM higher education. Panel B shows the distribution of outcomes for the students that are enrolled in STEM higher education.

out from the educational system as a whole. When both the student's level of education status and the main programme variable changes, this implies that the student has graduated, in which case the graduated variable takes value one.

4.4 Descriptive statistics outcome variable

Table 3 gives an overview of the distribution of the outcome variables. About 16 per cent of the high school graduates in our sample enrol in a STEM-related bachelor programme, universities of applied sciences and research universities combined. A large share of students that drop out, do so during the first year. It is also worth noticing that many students drop out during the final year of the programme: the fourth year in universities of applied sciences, and the third year in research universities. Effectively, student dropout is spread out over all years, but it peaks during the first and final years of the programme.
Among the students in our sample who graduate, the majority of them graduate within the nominal duration. It is notable that a comparatively larger share of students graduate at re- search universities than at universities of applied sciences. In research universities in our sample of students starting between 2007 and 2011, roughly half of students that enrol in STEM-related programmes eventually graduate, whereas at universities of applied sciences this is 28 per cent.

4.5 Econometric model

We estimate a sequential logit model (McFadden and Domencich, 1975) to estimate the educa- tional decisions of the students in our sample. We assume that each year, students can either decide to continue studying for another year, or drop out. After having studied for a number of years (the nominal study duration, i.e. 3 or 4 years, for research universities and universities of applied sciences, respectively), students that have passed all courses can also graduate. The outcome variable is a categorical variable that captures the final outcome state corresponding to the model in figure 1. In figure 1, the values of the outcome variable corresponding to the student's outcome state are shows in brackets.

To estimate the sequential logit model, we perform a set of logistic regressions for each transition that the students can make after each year. The first transition is the decision to enrol in STEM higher education or not. Conditional on the decision to enrol into STEM higher education, we estimate students' drop out decisions, followed by estimating the probability of graduation in either the nominal duration or the nominal duration plus one more year.

5 Results

The results of the estimation of the sequential logit models are presented in table 4. Given the fact that many students drop out during the first year of study, we focus on this transition in our analysis, in addition to the probabilities of graduation. The estimation results that are not presented in table 4 can be found in appendix table A1. Columns 1, 2, and 3 show the odds ratios, coefficients and their standard errors for students at universities of applied sciences, and columns 4, 5, and 6 show the results for students at research universities.

5.1 STEM enrolment

First, we estimate the probability of enrolling into STEM higher education. The first panel of table 4 gives the results of this step. A higher grade for mathematics seems to correlate with a higher probability of enrolling into STEM. For students at universities of applied sciences, this only holds when the student followed advanced math in high school. This is an interesting and unexpected result. It could be that this is driven by the fact that in the general high school track, mathematics is not a requirement in every specialisation: students who do not like math have the option not to follow mathematics. Also, the focus of the advanced mathematics high school subject is more geared towards STEM applications, whereas the general mathematics subject focuses more on social sciences. In other words, students in the general track who are more interested in social sciences beforehand might select the general mathematics subject. Combined with the fact that 90 per cent of the students in universities of applied sciences followed the general track in high school (see table 2), this might explain why we find a negative relation between the high school math grade and the probability of enrolment into STEM for universities of applied sciences, but a positive coefficient for programmes at research universities.

For both research universities and for universities of applied sciences, a higher grade for English seems to increase the probability that a student enrols into a STEM programme. This is an expected result, since many Dutch universities advocate that good knowledge of the English language is a requirement to be successful in many programmes. On the contrary, a higher grade for Dutch language seems to decrease the probability that a student chooses to enrol into STEM. This could be driven by the fact that students who are interested in a STEM career do not perform well in the high school Dutch exam. In accordance with the recent literature, female students are less likely to enrol in STEM higher education. The same holds for migrant students. We do not observe a statistically significant difference in university of applied sciences STEM

Table 4 Results sequential logit model

	University of Applied Sciences			Reseach University		
	Odds ratio (1)	Coeff. (2)	Standard error (3)	Odds ratio (4)	Coeff. (5)	Standard error (6)
(i) enrol in STEM						
vwo	0.853	-0.159	(0.026)***			
math	1.235	0.211	(0.009)***	1.305	0.266	(0.008)***
advmath	13.385	2.594	(0.019)***	24.901	3.215	(0.035)***
dutch	0.847	-0.166	(0.009)***	0.846	-0.167	(0.010)***
english	1.206	0.188	(0.009)***	1.092	0.088	(0.010)***
female	0.235	-1.449	(0.020)***	0.354	-1.039	(0.019)***
migrant	1.098	0.093	(0.025)***	0.861	-0.149	(0.025)***
constant	0.079	-2.537	(0.025)***	0.031	-3.476	(0.039)***
(ii) continue versus drop out in first year						
vwo	2.104	0.744	(0.063)***			
math	1.453	0.374	(0.018)***	1.511	0.413	(0.019)***
advmath	2.101	0.742	(0.040)***	1.797	0.586	(0.081)***
dutch	1.004	0.004	(0.017)	1.044	0.043	(0.022)*
english	0.951	-0.050	(0.018)***	1.012	0.012	(0.023)
female	1.217	0.197	(0.044)***	0.824	-0.194	(0.044)***
migrant	1.065	0.063	(0.049)	0.822	-0.197	(0.055)***
constant	1.759	0.565	(0.052)***	3.144	1.146	(0.093)***
(iii) graduate in nominal duration versus drop out						
vwo	0.683	-0.382	(0.059)***			
math	0.937	-0.065	(0.020)***	0.848	-0.165	(0.018)***
advmath	1.348	0.299	(0.056)***	1.547	0.436	(0.097)***
dutch	0.925	-0.078	(0.020)***	0.960	-0.041	(0.021)**
english	1.053	0.052	(0.020)***	0.924	-0.079	(0.022)***
female	0.645	-0.439	(0.048)***	0.821	-0.197	(0.041)***
migrant	1.153	0.142	(0.06)**	1.041	0.040	(0.056)
constant	0.668	-0.403	(0.07)***	1.028	0.027	(0.108)
(iv) graduate versus drop out in nominal duration plus one year						
vwo	0.262	-1.338	(0.141)***			
math	0.880	-0.127	(0.043)***	1.208	0.189	(0.036)***
advmath	2.672	0.983	(0.113)***	4.627	1.532	(0.169)***
dutch	0.894	-0.112	(0.042)***	1.014	0.014	(0.041)
english	0.821	-0.198	(0.044)***	0.923	-0.080	(0.043)*
female	0.543	-0.611	(0.109)***	0.669	-0.402	(0.088)***
migrant	0.676	-0.392	(0.110)***	1.102	0.097	(0.108)
constant	0.459	-0.779	(0.135)***	0.986	-0.014	(0.186)
N	137,443			106,140		

Notes: ***, **, * denote 1%, 5%, and 10% significance levels, respectively. Columns (1) and (2) show the coefficients and their corresponding standard errors for universities of applied sciences, and columns (3) and (4) show the same for research university STEM programmes. We include cohort fixed effects in all specifications.

enrolment between students that graduated from the academic high school track and students that graduates from the general high school track. This might also be due to the fact that only 10 per cent of the students in universities of applied sciences graduated from the academic high school track.

5.2 First year dropout

Now that we have estimated the probabilities of enrolment into STEM higher education, we proceed to estimate the dropout probabilities in year one of higher education. The results of this estimation are shown in the second panel of table 4. University of applied sciences students who followed the academic track in high school are less likely to drop out in the first year (so more likely to continue, hence the positive coefficient). In both research universities and universities of applied sciences, a higher mathematics grade goes hand in hand with lower first year dropout rates. This means that students with higher high school grades for mathematics perform better during the first year of STEM education, which is an expected result. This relation is stronger for students who took the advanced mathematics subject in high school. A high grade for Dutch language does not seem to explain first year dropout rates, it only has a statistically significant effect for research universities, but the coefficient is small.

Students with a higher grade for English in high school seem to be more likely to drop out from STEM bachelor programmes at universities of applied sciences. However, the coefficient is small and we do not observe this relation at research university STEM bachelor programmes. Interestingly, we find that female students are more like likely to drop out from STEM programmes in year one at research universities, while they are less likely to drop out from STEM programmes at universities of applied sciences. We observe a similar disparity for migrant students: student from migrant descent are more likely to drop out from STEM programmes at research universities, while we do not find any difference in first year dropout rate for migrant students at universities of applied sciences.

5.3 Study success

In our analysis, we measure study success in two different ways: graduation in the nominal duration of the programme, and graduation in the nominal duration plus at maximum one additional year. In universities of applied sciences, students who graduated from the academic track in high school perform worse in both terms. These students from the academic high school track especially perform worse in terms of graduation rates at year five.

With respect to graduation within the nominal duration of the programme, the predictive power of high school exam grades seems to diminish. The effects of high school grades are negative for mathematics and Dutch language for university of applied sciences programmes. There is only a small positive effect of the English language grade on the probability of graduating after four years. For research university STEM programmes, the coefficients are not significant, except for a small negative effect for the English language high school exam grade. When we look at the probability to graduate instead of drop out in the nominal duration plus one year, this result does not change. For university of applied sciences STEM programmes, the coefficients for high school grades are all negative. For research university programmes, all coefficients for high school programmes are insignificant as well, except for a negative coefficient for the high school exam grade for the English language.

Female students appear to perform worse in terms of graduation rates in both universities of applied sciences and in research universities. This is the case for both the probability of graduation in the nominal duration, as well as for the probability of graduation in the nominal duration plus one year. Interestingly, we do not observe that female students perform worse in terms of first year dropout rates at universities of applied sciences. For university of applied sciences STEM programmes, we also observe that migrant students are less likely to graduate after five years. We do not observe differences in graduation probabilities for research university programmes.

5.4 Do female and minority students graduate within 10 years?

From the sequential logit model, we find that female students performs worse in terms of nominal graduation rates in both universities of applied sciences and in research universities. Because we estimate our sequential logit model

Table 5 Logit model for the probability of STEM graduation within ten years, 2007 cohort only.

	University of Applied Sciences			Reseach University		
	Odds ratio (1)	Coeff. (2)	Standard error (3)	Odds ratio (4)	Coeff. (5)	Standard error (6)
vwo	2.274	0.821	(0.821)***			
math	1.461	0.379	(0.379)***	1.418	0.349	(0.349)***
advmath	2.601	0.956	(0.956)***	1.493	0.401	(0.401)
dutch	1.041	0.041	(0.041)	1.104	0.099	(0.099)***
english	0.822	-0.197	(-0.197)***	0.905	-0.100	(-0.100)***
female	1.462	0.380	(0.380)***	1.100	0.096	(0.096)
migrant	1.006	0.006	(0.006)	0.712	-0.340	(-0.340)***
constant	0.577	-0.550	(-0.55)***	1.734	0.550	(0.550)**
N	4,646			4,402		

Notes: ***, **, * denote 1%, 5%, and 10% significance levels, respectively. Columns (1) and (2) show the coefficients and their corresponding standard errors for universities of applied sciences, and columns (3) and (4) show the same for research university STEM programmes.

Table 6 **2007 cohort, comparison with cohorts 2008-2011**

	University of Applied Sciences				Reseach University			
	2007		2008-2011		2007		2008-2011	
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev
vwo	0.102	0.303	0.101	0.302				
math	-0.069	0.929	0.008	0.968	0.196	1.093	0.291	1.158
advmath	0.872	0.334	0.783	0.412	0.978	0.002	0.954	0.001
dutch	-0.191	1.060	-0.317	0.996	0.068	0.959	0.064	1.031
english	0.028	0.910	0.145	1.017	0.220	1.001	0.285	0.949
female	0.172	0.378	0.195	0.396	0.253	0.435	0.262	0.440
migrant	0.154	0.361	0.136	0.343	0.148	0.355	0.144	0.351
N	21,943		5,182		20,266		4,557	

Notes: A comparison of the 2007 cohort with the 2008-2011 cohorts on descriptive statistics for all regression variables, subject on STEM enrolment for universities of applied sciences and research universities separately.

for several cohorts, we only track students until the nominal duration of the programme plus one additional year due to data availability. In order to investigate the performance of female and minority students in STEM higher education in the long run, we estimate a logit model for the probability of STEM graduation within ten years for the cohort that started in 2007 only.
The results of this cohort analysis are presented in table 5. Interestingly, we see that female students are more likely to graduate in STEM within ten years time than male students in universities of applied sciences. In research universities, the coefficient for females is not statistically significant, so female and male students perform equally well in terms of graduation within ten years. In the 2007 cohort, migrant students perform worse than native Dutch students in research universities, but not in universities of applied sciences.

In order to assess whether this finding is not just driven by one cohort, we would ideally run the 10 year analysis for the other cohorts as well. However, this is not possible due to data availability constraints. In table 6, we compare the descriptive statistics of the regression variables from the 2007 cohort with the 2008-2011 cohorts. It shows that the share of female and migrant students are comparable between the 2007 and the 2008-2011 cohorts. This shows that the composition of the 2007 cohort is comparable with the other cohorts, and therefore it is unlikely that the findings from table 5 are driven by cohort effects.

6 Concluding remarks

In this paper we model the Dutch educational system from the moment in time where students start their higher educational career, up until one year after the nominal duration of the programme. These data allow us to track the students' educational career for multiple years. We focus on enrolment and success in STEM programmes. In different phases of the model students can either drop out, continue studying, or graduate from a STEM programme. We use longitudinal Dutch register data including grade achievements at high school exams. Because all students in the Netherlands take the same high school exam, this allows for a robust comparison between students from different schools. We account for the low STEM enrolment rates among females (Arcidiacono et al., 2016; Hunt, 2015; Reuben et al., 2014; Venkatesh et al., 2003; Volman and Van Eck, 2001) by first estimating the STEM enrolment decision. This is vital to get a fair comparison between different groups that are more and less likely to enrol in STEM.

For STEM programmes at research universities, we find that migrant students primarily drop out in the first year of study. If they continue, we see that migrant students do not perform worse in terms of graduation rates than non-migrant students in research universities. However, in universities of applied sciences, we do not observe higher first year dropout rates for migrant students, but we do observe lower graduation rates. They collectively drop out during the year after the final year of the programme. It seems that universities of applied sciences are successful in keeping these students from dropping out during the programme, but eventually they do not graduate on time or drop out at the end of the programme. In research university STEM programmes, migrant students are more likely to drop out during the first year.

Female students seem to perform worse than male students in both research universities and in universities of applied sciences. Only with respect to the first year dropout probability in universities of applied sciences, we observe that females are less likely to drop out. We find that females are less likely to graduate, both within the nominal duration as within a year after the end of the nominal duration of the programme. This difference, however, does not appear when we look at graduation rates within 10 years. From our results it seems that, when controlling for ability, measured by high school mathematics and language grades, female students are less likely to graduate, conditional on STEM enrolment. From a randomised experiment, Russell (2017) concludes that individual learning communities might benefit the success of female and minority students in STEM higher education. This might explain the differences in the results that we find between research universities and universities of applied sciences, since university of applied sciences bachelor's programmes tend to work in smaller size groups that students remain in during the course of the programme.

It is interesting to see that female students are less likely to choose for STEM when they enrol into higher education. When we look at the probabilities to graduate in the nominal duration and within the nominal duration plus one year, females perform worse compared to male students. Based on this, once could argue that it is a wise decision for many females not to choose for STEM. However, based on a deeper analysis of one cohort, we conclude that females do not perform worse than men in terms of graduating within ten years. Altogether, we conclude that the gender differences within STEM higher education are most prominent in terms of on-time graduation rates. Therefore, policy should be geared to increase on-time graduation rates and to lower first year dropout rates among female students.

Although this paper benefits from unique longitudinal Dutch registration data, the conclu- sions are drawn in the setting of the Dutch higher educational system. While this can be seen as a threat to external validity, the division of higher education into bachelor's and master's programme has become common in the European Union gradually since the ratification of the Bologna treaty in 1999. Similar to Anglo-Saxon countries such as the United Kingdom and the United States, the Dutch higher education system is divided into bachelor's and master's programmes since 2002. There is still the distinction between bachelor's programmes at research universities and universities of applied sciences however. Yet, this division is common in other European countries as well, namely Germany, Austria, Switzerland, Belgium, and several Scand- inavian countries. Given this, we believe that there are many similarities between the Dutch system and other American and European systems, which makes it plausible that the results from this paper are generalisable to other countries at least to a certain degree.

In summary, we find that high school exam grades explain most of the variation for the dropout decision in the first year. Students with higher mathematics grades seem to be less likely to drop out in the first year. This is especially true for students who took the advanced mathematics subject in high school. However, there is little predictive power of high school exam grades for the graduation rates. Selecting students based on high school grades might only improve first year dropout rates, but it will not improve graduation rates. The predictive power of high school grades on first year dropout might be due to the bindend studieadvies, an academic dismissal programme that is in effect in the first year of higher education in the Netherlands. When students do not get enough credits during the first year, they are forced to quit the programme.

We also find evidence that female and minority students perform worse in STEM higher education, but not in every aspect. In short, female students are less likely to enrol in STEM, more likely to survive the first year, but less likely to graduate in the nominal duration or the nominal duration plus one additional year. However, when we look at the 2007 cohort, we conclude that female students are equally or even more likely to graduate within ten years than men. We therefore conclude that female students in general do perform well in STEM, but attention is required to the fact that female students perform less in terms of on time graduation.

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Appendix

Table A1 Full estimation results sequential logit model (complemented with table 4)

	University of Applied Sciences			Reseach University		
	Odds ratio (1)	Coeff. (2)	Standard error (3)	Odds ratio (4)	Coeff. (5)	Standard error (6)
(i) continue versus drop out in second year						
vwo	2,169	0,774	(0,091)***			
math	1,417	0,349	(0,025)***	1,569	0,450	(0,032)***
advmath	2,236	0,805	(0,055)***	2,289	0,828	(0,129)***
dutch	1,092	0,088	(0,024)***	1,138	0,129	(0,037)***
english	0,815	-0,205	(0,025)***	0,850	-0,163	(0,039)***
female	1,327	0,283	(0,063)***	1,096	0,091	(0,078)
migrant	0,830	-0,186	(0,064)***	0,801	-0,223	(0,091)**
constant	3,525	1,260	(0,074)***	6,140	1,815	(0,146)***
(ii) continue versus drop out in third year						
vwo	0,982	-0,018	(0,093)			
math	1,348	0,298	(0,032)***	0,751	-0,287	(0,020)***
advmath	1,966	0,676	(0,073)***	1,334	0,288	(0,107)***
dutch	1,090	0,086	(0,031)***	0,853	-0,160	(0,023)***
english	0,724	-0,323	(0,033)***	0,924	-0,079	(0,024)***
female	1,335	0,289	(0,082)***	0,556	-0,588	(0,049)***
migrant	0,728	-0,317	(0,082)***	1,115	0,109	(0,062)*
constant	7,615	2,030	(0,099)***	1,296	0,259	(0,117)**
(iii) continue versus drop out in fourth year (university of applied sciences only)						
vwo	0.683	-0.382	(0.059)***			
math	0.937	-0.065	(0.020)***	0.848	-0.165	(0.018)***
advmath	1.348	0.299	(0.056)***	1.547	0.436	(0.097)***
dutch	0.925	-0.078	(0.020)***	0.960	-0.041	(0.021)**
english	1.053	0.052	(0.020)***	0.924	-0.079	(0.022)***
female	0.645	-0.439	(0.048)***	0.821	-0.197	(0.041)***
migrant	1.153	0.142	(0.06)**	1.041	0.040	(0.056)
constant	0.668	-0.403	(0.07)***	1.028	0.027	(0.108)
(iv) graduate versus drop out in nominal duration plus one year						
vwo	0,823	-0,195	(0,067)***			
math	0,832	-0,183	(0,024)***			
advmath	0,792	-0,233	(0,059)***			
dutch	0,926	-0,076	(0,023)***			
english	1,265	0,235	(0,024)***			
female	0,766	-0,267	(0,055)***			
migrant	1,561	0,445	(0,065)***			
constant	0,648	-0,434	(0,076)***			
N	137,443		106,140			

Notes: ***, **, * denote 1%, 5%, and 10% significance levels, respectively. Columns (1) and (2) show the coefficients and their corresponding standard errors for universities of applied sciences, and columns (3) and (4) show the same for research university STEM programmes. We include cohort fixed effects in all specifications.