Persistent Inequality & Education Policy during Adolescence.

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Abstract

Individuals from low income backgrounds perform worse than their higher income peers early in their schooling career and are more likely to enter university after having worked or having followed vocational education before. I specify a dynamic model of education that explicitly accounts for the situation that most low income individuals are faced with and that allows for different paths to university. Despite initial achievement gaps many low-income backgrounds have high returns from finishing a bachelor's degree later in their lives. They, however, face substantial dropout risk when entering higher education. Nonstandard paths to university are important as many low income individuals only discover that they want to enter university later in their lives. Making the tracking system more flexible and decreasing the duration of vocational programs would reduce inequality across socioeconomic status. I test the model with a recent reform to student income subsidies to understand the effect of income subsidies. While the model provides a smaller point estimate than the reform it correctly predicts the characteristics of complier.

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1 Introduction

Children from lower income backgrounds perform worse than their higher-income peers in school[1]. This achievement gap has a lasting impact on educational attainment and future outcomes of individuals from low-income households. They face more academic risk and are more likely to be retained in grade or to drop out of secondary schooling. In schooling systems with a tracking component, they are more likely to be selected into less academic tracks[2].

Later in life, many low-income individuals enter higher education despite earlier achievement gaps. Consistent with these earlier achievement gaps, they are more likely to do so after finishing vocational education or dropping out of high school and working before. In the Netherlands, I document that university graduates from low-income backgrounds are twice as likely to have entered university after completing vocational education. In the United States, many low-income individuals enter higher education after dropping out of high school earlier and obtaining a GED certification (see, e.g., (Maralani, 2011)).

Prior literature has focused on early childhood interventions to address early achievement gaps and persistent inequality in education. If measures during early childhood fail to close the achievement gap across socioeconomic backgrounds, it is essential to develop policy that can decrease persistent inequality despite existing achievement gaps. Doing so requires considering that individuals from low-income backgrounds face a different situation at school and thus take different paths to university than their higher-income peers.

Research Question: This analysis investigates how education policy during adolescence can decrease persistent economic inequality despite existing achievement gaps in school.

To reach this goal, I estimate a dynamic model of education in the Netherlands. Unlike prior literature, I explicitly account for the situation most low-income individuals face at school due to early achievement gaps. Furthermore, I allow different paths to university consistent with what can be observed in the data. Additionally, I analyze a recent reform to student income subsidies. I use the reform to validate model predictions and to gather further evidence on the importance of income subsidies.

[1] See OECD (2019) for a detailed analysis of achievement gaps by socioeconomic status across OECD countries.

[2] See OECD (2020) for grade retention and track choice across socioeconomic backgrounds. See OECD (2012) for completion of secondary school across socioeconomic background.

Policies: I use the model to consider two sets of policies in this paper. First, I consider the structure of secondary schooling. This includes tracking rules, the design of secondary schooling tracks, and the availability of vocational programs. The structure of secondary schooling has a significant impact on the schooling experience of individuals at the bottom of the grade distribution. It is thus an essential policy margin in this context.

Secondly, I consider income subsidies during higher education. To my knowledge, prior literature has mostly considered how income subsidies affect individuals considering entering university after high school. If low-income individuals take alternative paths to university, they are older and have received less academic education. They may thus have higher opportunity costs and face more risks, making them more reliant on income subsidies.

Model: In the first part of the paper, I introduce a dynamic discrete choice model of education based on Keane and Wolpin (1997). In particular, I introduce a model of further educational careers of graduates of vocational middle school in the Netherlands. I focus on graduates of the vocational middle school because most low-income individuals are tracked into vocational education, which is why the population is well suited to address the research question. After graduating from vocational middle school, individuals can pursue various schooling careers. Right after graduating, they decide between pursuing a vocational program or moving up to high school[3]. The model contains two paths to higher education. Individuals can either enter applied university[4] after high school, which is the traditional path, or after they have finished the highest vocational program. Finishing a vocational program takes longer and contains no explicit preparation for higher education. Individuals who pursue the vocational path to education are thus older and potentially less prepared when they enter applied university.

Estimation: I leverage data on schooling careers, enrollment, and wage outcomes to estimate key model parameters. One challenge in the identification of the model is endogenous selection into different schooling careers. The usual procedure in structural models is to include unobserved

[3]The Netherlands has three different education tracks. The academic track (VWO) prepares individuals for academic university and takes six years. The mid-level track (HAVO) prepares individuals for applied university and takes five years. The vocational track (VMBO) prepares individuals for vocational programs and takes five years. Under some circumstances, graduates of VMBO can also transit to the fourth year of HAVO

[4]The Netherlands has two types of higher education institutions. Academic Universities and Applied Universities. Applied Universities are less abstract and include more practical training for future jobs. If graduates of vocational middle school enter higher education, it is most likely at an applied University. Thus, I focus on these institutions throughout.

discrete types that improve the overall model fit (Keane and Wolpin, 1997). I complement this procedure by adding differences in choices across schools to the set of targeted moments.

The transition to high school after graduating from vocational middle school is not organized in a centralized way. High Schools have employed their own rules for admitting students from vocational middle school[5]. The number of individuals that transfer to high school from a particular middle school thus varies by the specific rules that high schools in the area use and by the amount of assistance that the school offers students for their transition to high school. I identify school types by grouping schools with different residual transition rates after controlling for the composition of students. The joint distribution of choices and unobservable characteristics should differ across school types rates since individuals face different barriers to entering high school. I allow unobservable characteristics to differ across schools to deal with selection into middle school and reverse causality. The degree to which outcomes differ across schools, controlling for the composition of observed and unobserved characteristics, helps to identify the nature of selection in the model.

Mechanisms: Having estimated the model, I first summarize the estimated parameters and discuss their policy implications. Wage returns to applied university differ substantially across the population. At age thirty, some people receive substantial returns to having a bachelor's degree, while others earn negative returns. The most crucial difference between university graduates and everyone else is returns to experience. Wages of applied university graduates increase substantially after thirty such that most people have substantial positive returns from holding a bachelor's degree at age forty. Returns do not differ across parental income, which implies that increasing the number of low-income individuals with applied university degrees would narrow the wage gap across different socioeconomic backgrounds.

The next factor I consider is dropout risk. Dropout risk is the most important factor generating inequality in outcomes across individuals with different characteristics in the model. Particularly, individuals with low grades face substantial risk at applied university. The option to enroll in a vocational program is thus valuable for many low-income individuals as it provides them with a lower-risk outside option with substantially higher returns than dropping out after middle school. Another finding is that individuals from low-income backgrounds face a substantially higher likelihood of dropping out of university, holding other factors constant. Addressing this risk gap across

[5]Make a reference

socioeconomic backgrounds is essential as it contributes to persistent economic inequality.

Counterfactual Policies: Next, I run several simulations to predict the effect of counterfactual policies. First, I simulate an alternative model with lower transition costs to high school. As I have pointed out, transitioning to high school was not equally simple for everyone. Allowing more individuals to enroll in high school after graduating from middle school may increase university graduation as they are younger and better prepared when considering university. I find that the policy increases university graduation by around three percent and substantially increases average wages. For individuals with low grades, the policy would also substantially increase the number of people with only a high school degree. This is because the policy induces them to enroll in high school and enter university afterward. However, individuals with low grades are more likely to drop out of university, which is why they end up with more people who only hold a high school degree in the counterfactual scenario. Labor market returns to high school returns are lower than to vocational degrees. The policy thus increases risk for this group and may only benefit individuals with higher grades.

In the second counterfactual, I remove the option to enter university having finished vocational education while decreasing transition costs to high school like I just analyzed. I find that this policy would lead to a significant decrease in individuals holding a bachelor's degree. This shows that providing alternative routes to university is essential as many low-income individuals may either consider the straight path to university too risky or may only discover their taste for university later. The latter motive is driving the decrease in enrollment in this context.

In the last policy simulation, I decrease the duration of vocational programs. When individuals graduate at a higher age, their opportunity costs of entering higher education are rising. If vocational programs are shorter, they graduate earlier and may thus be more likely to enroll in higher education. I find that decreasing the length of vocational programs to three years would increase the number of university graduates by around two percent.

Income Subsidies: In the final part of the paper, I investigate the effect of income subsidies in the presence of achievement gaps and different paths to university. I use the model and a recent reform to student income subsidies in the Netherlands to do so.

I analyze a reform to student income subsidies that was implemented in 2015. The Dutch government pays income subsidies to students to increase the accessibility of higher education. The

reform in 2015 has abolished privileges for individuals who moved out of their parental home while studying and has completely removed grants for higher income individuals[6]. Low-income individuals who would have studied and stayed at their parental home before the reform was introduced are unaffected and can thus be used as a control group. It is, however, not known what people subject to the new policy would have done under the old policy scheme.

I thus use machine learning techniques to predict treatment status with a large set of observable characteristics and estimate the effects of the reform with a difference in difference specification.

I find that reform has decreased enrollment by four percent. Degree completion has also decreased but much less strongly, which implies that the complier had a relatively large dropout risk on average.

The substantial reaction to the reform shows that many individuals considering entering university after vocational education face a double burden. They have a lower capacity to stay at home since they are older on average and receive fewer parental transfers since they are poorer on average. Subsidies are thus an important tool to increase the accessibility of higher education. The model, however, also shows that the effectiveness of subsidies could be increased if they were accompanied by measures to decrease dropout risk.

Comparing Model and Reduced Form: The model only predicts an enrollment decline of around one percent. There are two reasons why the model can potentially not reproduce the effect of the reform. The treated group differs from the broad population, and the treatment effect on the treated is potentially larger than that on the entire population. Furthermore, the model is not perfectly suited to predict the effect of income subsidies as it includes no consumption component and no risk aversion.

Thus, the reform likely reduces the utility of studying to a larger extent than the monetary value that individuals miss out on. I simulate an additional model where the decrease in utility is larger than the monetary value of the reform. This counterfactual produces a three percent reduction in enrollment. Complier of the simulated policy have considerable academic risk, and the reduction in graduation is less than two-thirds of the decrease in enrollment. The model and the reform thus agree on the characteristics of complier to the reform. While the model cannot precisely reproduce the reform, it gets the selection right, which increases confidence in the other policy simulations.

[6]See section 4 for a detailed description.

Policy Implications: The results imply that increasing university graduation among graduates of vocational education would increase wages of low-income individuals. Thus, it is essential to design secondary schooling accordingly. Individuals with high grades during vocational middle school should face no barriers to mid-level high school as they will likely succeed in higher education. The results also show that a good vocational outside option can increase college education as some individuals only decide to pursue higher education later in life or because they want to decrease dropout risk. Vocational programs should thus be designed in a way that takes into account that some individuals may want to enter higher education after graduating. Income subsidies should be accompanied by other measures to improve graduation rates.

Contribution to the literature: This article contributes to different strands of the literature. First, it contributes to earlier work that uses dynamic choice models to understand how education policy affects educational attainment and other long-run outcomes of young individuals. (Keane and Wolpin (1997), Keane and Wolpin (2001), Altonji et al. (2012)). More recent work has added information friction and learning to these models. (Arcidiacono et al. (2016)) In contrast to earlier models, my model explicitly accounts for nonacademic education and alternative routes to university.

Secondly, I contribute to a recent literature that analyzes returns to alternative schooling options such as vocational education in Europe or community college in the US. Recently, several papers have analyzed program choice and return to alternative education. Matthewes and Ventura (2022) analyze returns to vocational programs in the United Kingdom and find substantial heterogeneity across individuals. In particular, the returns vary by the second-best option that individuals have. Eckardt (2019) analyzes program choice in vocational education in Germany. They show a substantial mismatch in program choice, and later switching is usually associated with earnings losses. Another set of contributions aims to identify return community colleges in the US. Mountjoy et al. (2020) find that wage returns to community colleges depend on the relevant alternative of a particular individual.

The analysis is also relevant for a recent literature identifying returns to college for marginal students. Zimmerman (2014) analyzes the returns to college education for marginal students. He finds that marginal students have sizeable returns to university education in the US.

2 A model of further education.

I now introduce a structural model of education. I will first describe the setting in more detail. Thereafter I will summarize all model components.

2.1 Tracking in the Netherlands

Dutch students are tracked at age 12 after they finish primary school. Between 2008 and 2010 which is the period of interest both teacher recommendations and results in centralized tests where combined to create a track recommendation for each student. Individuals with lower academic performance were more likely to be sent to a vocational track. There are different types of vocational middle schools. This study focuses on the technical vocational middle school which is the largest branch and also the most most ambitious. After finishing middle school individuals can enroll in various vocational programs or mid-level high school (HAVO) which I refer to as high school in this paper. Vocational programs have different levels and durations. The highest level (MBO4) takes four to five years and allows graduates to enroll in a university of applied sciences. The lower ranked programs (MBO3)[7] take between two and three years and do not allow students to progress to university directly. High school takes two years and qualifies graduates to enroll in applied university. There are academic and applied universities in the Netherlands. Applied universities are four year programs with a less abstract and more practical focus than academic universities. The transition to high school is not organized in a central way. High Schools have employed their own rules for admitting students from vocational middle school[8]. The number of individuals that transfer to high school from a particular middle school thus varies by the specific rules that high schools in the area use and by the amount of assistance that the school offers students for their transition to high school.

2.2 Decision Tree

The model allows agents to choose most of the career options that graduates of vocational middle school can pursue. Graph 1 shows an illustration of the decision tree that agents face in the model. In the first period agents chose individuals vocational programs and mid level high school. The

[7] There are further even shorter programs. These are however not picked frequently by the population of interest.
[8] Make a reference

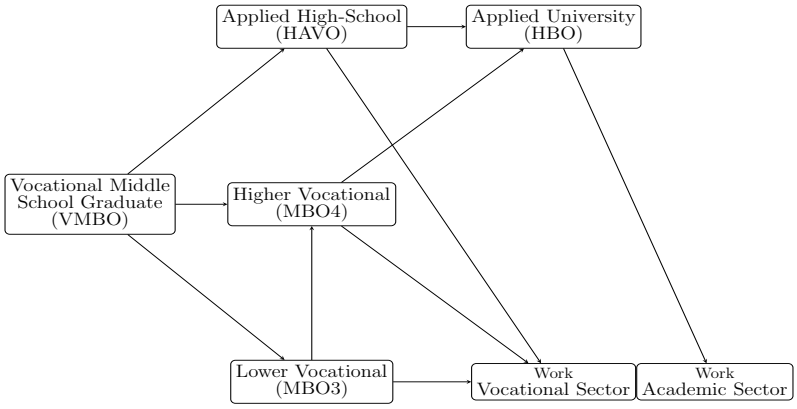


Figure 1: This graoph shows the decision tree

model features two paths to university. One direct path that goes through mid level high school and one vocational path where students choose a vocational program first. If students complete the lower vocational program they can choose to do the higher level vocational program which will qualify them for applied university afterwards. After each of the schooling options individuals can either leave school and work or continue with schooling to receive a higher degree. The model abstracts from academic university and master degrees because both options are not chosen very often among graduates of vocational middle school.

2.3 States & Fixed Hetereogeneity

Each individual is characterized by fixed characteristics and dynamic states. Fixed characteristics include observable ability G, unobservable type θ, parental income Y and school type U. Observable ability G_i is individual i's quartile of middle school grades. These grades include a central and a school specific exam. Y_i denotes the quartile of parental household income of individual i. School Type U denotes the type of transit policy in individual i's school. This variable captures that transition to high school after graduating from vocational middle school is easier at some schools than at others. I identify school types by grouping school fixed effects obtained from a regression of schools and individual characteristics on high school attendance. Unobserved ability ν is assumed to be one dimensional and supposed to capture the remaining dependence between choices and outcomes.

Dynamic states include age A, current level of schooling S and lagged choice $d_{\tau-1}$. One state is

a tuple that consists of all fixed characteristics and dynamic states $s_\tau = (a_\tau, S, C^{\tau-1}, G_i, \nu_i, Y_i)$. Individuals start the model with 16 which is the age that most people have when finishing vocational middle school.

2.4 Choices and Timing

Individuals do not take a new decision after each period but only after each spell. Let $\tau \in \{0, 1, 2, 3, ...\}$ denote the decision periods of individual i. Let $d_{i,\tau}$ denote the choice of individual i at decision period τ. At each decision period an individual takes a choice. Afterwards the individual stays with that choice for a potentially stochastic number of periods. After the spell is over the individual takes the next decision.

$C(s_\tau)$ maps a state into a set of admissible choices. This function is consistent with the decision tree above. An individual that has for example just finished a higher vocational program can either enroll in university or leave education and work. Moreover individuals are not allowed to repeatedly enroll in the same program. This is why the lagged choice is part of the state space. Individuals decide between academic schooling and vocational programs in the first stage and between university and work in the second stage.

If individuals enroll in a particular schooling program they are not guaranteed to finish it. Schooling programs are associated with varying levels of dropout risk and uncertain length. Depending on their choice and the realization of academic risk they will transit to a new stage. The stochastic function $T(s_\tau, d_{i,\tau})$ maps a state and a choice into a state at the end of the current spell.

Taking a decision thus has the following consequences. First the transition function realizes and determines the state that an individual will end up in. Function $N(s_\tau, s_{\tau+1}$ determines all the states in between the state of departure and the state of arrival. Thereafter the individual receives utility for each of these states and makes a new decision in the arrival state which corresponds to the next decision period. If the transition function for example determines that an individual that has enrolled in a higher vocational program will graduate within 4 years the individual will receive utility for these four years and make a new decision after she graduated from the vocational program.

If an individual decides to leave education and starts working the choice is terminal. Individuals receive the discounted life time income associated with their characteristics and their final educa-

tion.

I choose this alternative way of specifying the model in order to reduce the computational complexity model. The model contains both a detailed representation of heterogeneity and six different choices. Using decision periods allows me to substantially reduce the number of states because I do not have to include experiences for each choice in the state space.

2.5 Transitions & Uncertainty

The transition function T consists of two components, dropout risk and duration risk. Individuals are uncertain about graduating from a particular program. Dropout risk depends on academic ability and unobserved type but also on parental income. This is because individuals from lower income families may have less academic support from their family or may face higher dropout risk for other reasons. The other component is duration risk which means that individuals cannot be entirely sure how long a particular degree will take. Especially graduates of vocational education often take more than four years to finish their applied university degree. This may have important implications for the decision to enter a particular program since individuals that have a low capacity to live with low income may be particularly sensitive to that risk.

Degree risk is represented by a "logit" model of individual characteristics on an indicator of graduation. The coefficient of all these equations are model objects which are estimated jointly with all other parameters.

$$Logit(d_{i\tau} = 1) = \beta_0 + \beta_1 * Y_i + \beta_2 * age + \beta_3(agexY_i) + \xi_1 * G_i + xi_2 * \theta_i + \nu_i$$

The inclusion of type and academic ability reflects the fact that people with less academic ability are less likely to graduate form a particular program. The inclusion of parental income reflects the fact that children from low income backgrounds are less likely to receive support by their environment or that they are more likely to be subject to shocks that lead to dropout. If individual i completes a degree successfully she faces a poison process that determines the duration of her degree:

$$T_{si}^{pass} = Poison(0, \beta_0 + \beta_1 * Y_i + \xi_1 * G_i + xi_2 * \theta_i)$$

Type, observed academic ability and parental income are included for the same reasons as in the equation above. If the individual drops out the length is determined by:

$$T_{si}^{pass} = Poison(0, \beta_0)$$

This equation contains less variables because there may be a lot of reasons why individuals may take different amounts of time before they dropout. For the sake of this analysis I abstract from these particular reasons and assume that they are orthogonal to the individual characteristics featured in the model. The exact parametrization differs between the particular programs and can be found in the appendix.

Agents additionally face taste shocks $\nu_{i,\tau}(d)$ to their utility. Taste shocks are modeled as an extreme value type one distribution. They are independent and identically distributed across all individuals and all choices.

2.6 Wages & Nonpecuniary Preferences

Wages are modeled as two separate mincer equations for individuals with higher education diploma and individuals without. Once students enter the labor market they receive income for the rest of their life. I estimate a mincer regression for log wages and assume that everyone works full time after they leave school. Wages are modeled separately for bachelor degree holders and everyone else. Log wages for the vocational sector look as follows:

$$W_{i,s,t} = \alpha_{0,s} + \alpha_{1,s} * degree_i + \alpha_{2,s} * exp + \alpha_{2,s} * exp^2 + \alpha_{3,s} * age + \xi_{1,s} * G_i + \xi_{2,s} * \theta_i + \xi 3, s * Y_i + \epsilon_{i,s,t}$$

Log wages depend on experience, age, parental income, ability, type, highest degree completed and highest degree completed interacted with experience. Wages for the academic sector are modeled separately to allow for a flexible form of the college premium. Wages in the academic sector looks as follows:

$$W_{i,s,t} = \alpha_{0,s} + \alpha_{1,s} * degree_i + \alpha_{2,s} * exp + \alpha_{2,s} * exp^2 + \alpha_{3,s} * age + \xi_{1,s} * G_i + \xi_{2,s} * \theta_i + \xi 3, s * Y_i + \epsilon_{i,s,t}$$

They depend on experience, age, parental income, ability, type and educational career. Similar to Keane and Wolpin (1997) every choice is associated with non pecuniary utility that is measured in the same scale as wages wages. I allow nonpecuiary returns $P(S_i, d_{i,t})$ to depend on parental income, type and dynamic characteristics such as experience or age. Observed grades are only part of nonpecuniary rewards for high school where higher grades may be associated with lower transition costs. For high school there is furthermore school type that changes the value. See appendix a for a detailed description. If an agent reaches a terminal state she receives discounted life time utility from working which can be written as:

$$\sum_{t \in \{s,..T\}} \beta^t U^w(s)$$

2.7 The Agent's Problem

Expected utility is the weighted average over all possible paths that a decision could lead to. One needs to sum over all states that could possibly be reached, from a particular state choice combination. Let $R(s_\tau, d_{i\tau})$ be the range of potential outcomes one can reach from state (s_τ and decision $d_{i\tau}$) and let $P_{s_\tau, d_{i\tau}}(s_{\tau+1})$ be a probability distribution over the range of outcomes. The agent's problem can thus be formulated as follows:

$$\max_{d \in C(s_\tau)} \sum_{s_{\tau+1} \in R(s_\tau, d)} \sum_{s \in N(s_\tau, s_{\tau+1})} \beta^s U(s) + \beta^t V(s_{\tau+1}) + \nu_{i,\tau}(d)$$

Taste shocks are distributed according to type one extreme value distribution.

3 Data & Implementation

In this section I explain relevant features of the Dutch education system and introduce the data used for estimating the model. This section summarizes relevant features of the Dutch education system presents descriptive statistics about schooling careers of students with lower grades.

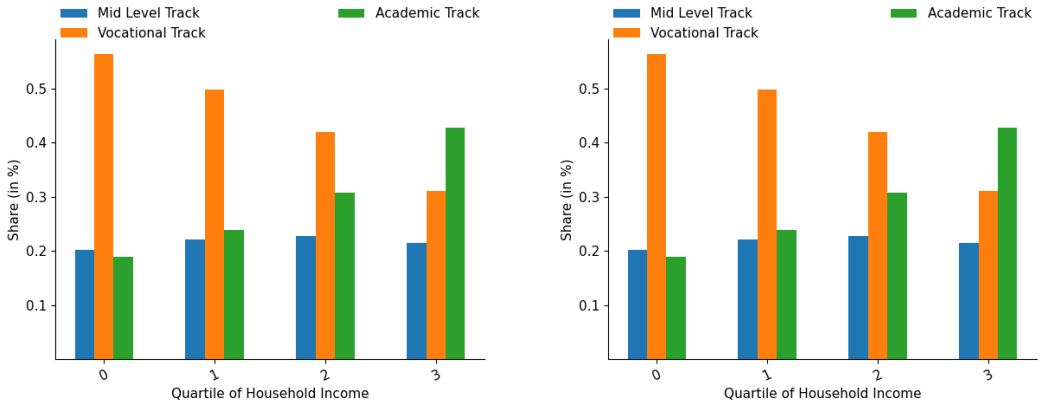
3.1 Data

I use Dutch administrative records to follow graduates of vocational middle school. The main sample consists of individuals that graduated from vocational middle school between 2008 and 2010. I focus on this time period because there is less information available for earlier cohorts and I do not observe labor market outcomes for later cohorts. I then combine information on educational careers, grades in middle school, the economic situation of their parents, school characteristics and future labor market outcomes.

3.2 Descriptive Statistics

I now show some basic facts about tracking and inequality in Dutch education.

Tracking by parental income: Figure **??** summarizes the gradient in track choice after primary school. Individuals from higher income backgrounds are more likely to visit academic high school. Lower income individuals are most likely to visit a vocational middle school. A substantial part



(a) Track Choice (b) University Career

Figure 2: ...

of this difference can be explained by grade differentials at the end of primary school. There is however also evidence that children for low income backgrounds are systematically evaluated worse than higher income children. Figure two shows how careers differ by parental income. Conditional on reaching a tertiary degree individuals from low socioeconomic background are more likely to enter university from vocational education.

Inequality in Education and Differences in Wages Schooling track at age 12 explains a substantial part of wage inequality at age 30 and incomes of bachelor degree holders begin to diverge at age 30. Figure 3 shows that schooling track at age 12 accounts for a substantial part of wage differences between students from low income and high income households at age 30. Further controlling for final education at age 30 conditional on being in vocational education also decreases the income gap but much less significantly. While part of the differences in wages can be reflected by differences in relevant ability the results nonetheless show that Figure 4 shows that particularly

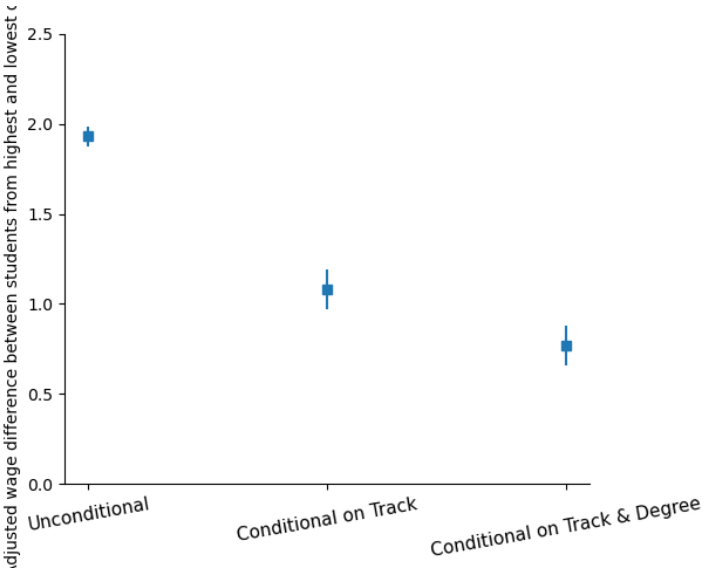


Figure 3: ..

between 30 and 40 vocational and academic wages begin to diverge. This shows that for the main payoff to receiving an academic degree only builds up slowly over time which may have important consequences.

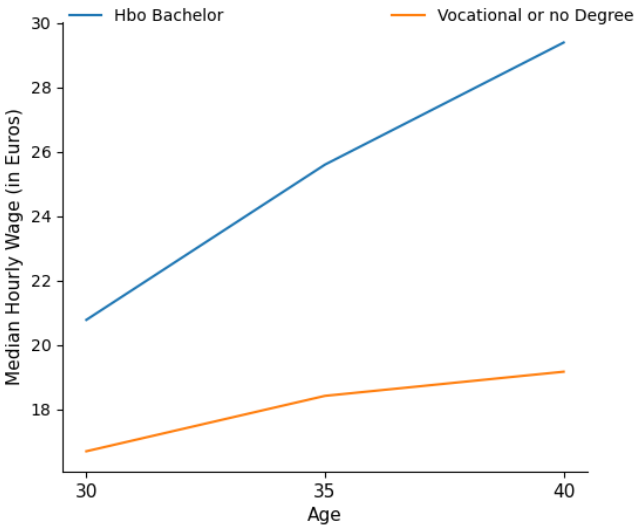


Figure 4: ..

3.3 Identification

Construction of Moments: I will now describe all the empirical moments used to estimate the model. Table **??** summarizes all moments in the model. Final degree combination indicates all

Moments	Identification	Number
Percentage enrolled in each program by income, grade, school type		
Degree combination by income, grade, school type	6	64
Last schooling age by income, grade, school type	7	32
Wage quartiles over time		
Coefficients of wage equations		

Table 1: This table includes all moment categories used to estimate the model. The right column indicates the number of moment that each category has.

post middle school degrees that an individual receives before starting to work. If a person first graduates from a vocational program and then graduates form applied university her degree will be higher-vocational & bachelor. I combined some programs and removed some individuals with very uncommon careers. The exact procedure can be found in the appendix. Enrollment percentage for a particular program indicate how many people have been enrolled in that respective program. Both sets of moments are included for income, grade and school type. The combination of final degree combination and enrollment percentages helps to jointly identify preferences and risk associated

with different education programs. Furthermore I include last schooling age for all observed ability and income groups. Last schooling age refers to the age where an individual is done with education and starts to work. This moment is included for all ability and income groups. Final schooling age helps to identify the degree length process. Since I do not allow re-enrollment there is always one age were individuals leave education. In practice I however allow individuals to take a gap of one year between spells which will be part of the degree duration. Wage quartiles over time are wage quartiles for individuals with and without applied university degree at ages 30, 35 and 40. Wage quartiles contribute to the identification of age processes and the returns to experience. Finally I match coefficients of three separate wage equations. Two of them are wage regressions for individuals with and without bachelor degree respectively.

$$w_{i,t} = exp_{i,t} + exp_{i,t}^2 + t + h_{i,t} + \epsilon_{i,t}$$

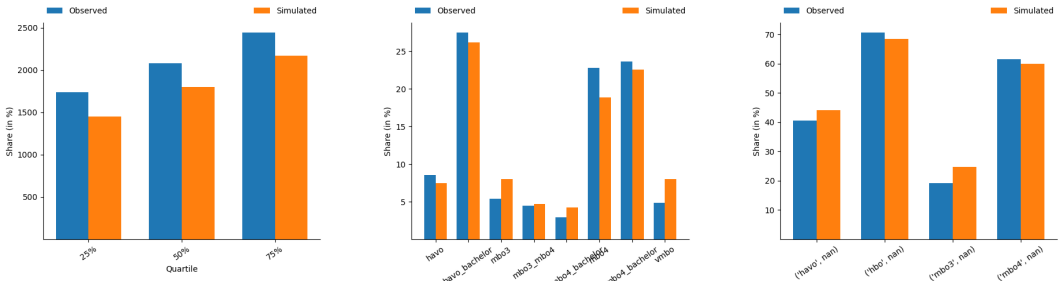
Both of these regressions suffer from selection bias. The model can however reproduce selection and thus the equations help to identify wage returns to different degrees. The last equation regresses controls and school type indicators on future wages.

School Types and Selection: I use school types to improve the identification of unobserved factors in the model. Observed moments will suffer from selection bias as unobserved factors may drive differences across groups and across individuals with different choices. The usual procedure in structural models is to include unobserved discrete types (Keane and Wolpin, 1997). I complement this procedure by additionally adding differences in choices across different school types. As I have explained last section the ease of transition to high school varied over the population. The joint distribution of unobserved factors and choices should differ across schools with different transition costs which allows me to directly identify the importance of unobserved factors. The main issue is however that individuals at different school may also differ in terms of unobserved characteristics. I use all other moments and the structural assumptions to identify the degree of selection across schools and use the remaining variation to identify the importance of unobserved factors. The intuition for this is that different degrees of selection across schools would imply different patterns in the data. If there was no selection and all variation was only caused by transition costs one would expect to see that individuals at schools with high transition costs are more likely to enter

university via vocational education. This is because more people with high unobserved academic ability have been kept out of high school due to high transition costs.

3.4 Estimation & Model Fit

I use the simulated method of moments to estimate model parameters. The estimated model fits the empirical moments well. The figure below provides a short summary. A more extensive summary can be found in the appendix. The model manages to reproduce educational careers of individuals



(a) Wage Quantiles Academics 30 (b) Degree Combination (c) Enrollment Proportion

Figure 5: ..

with different characteristics. Furthermore it fits dropout and enrollment patterns. Wage regression is also close to how observed wages look like in the data. The long run evolution of wages until 40 is also fit well.

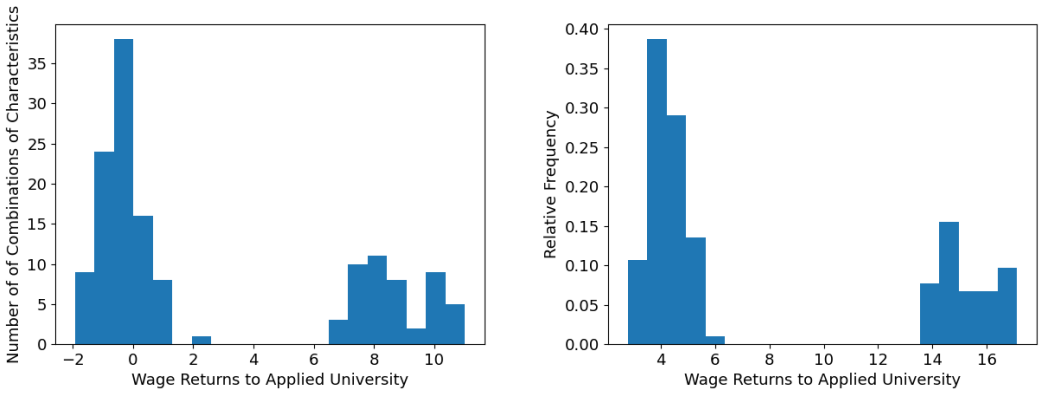
4 Results

I now present the empirical findings of the structural model. I first discuss estimated parameters and their implication for education policy. Thereafter I simulate three explicit policies and discuss the resulting predictions.

4.1 Mechanisms

I summarize estimated parameters and discuss their implications for policy in this section. I first discuss the implied distribution of returns to university. Then I discuss dropout risk and selection. Finally I discuss the role of the vocational path to university.

Wage Returns to Applied University: The model parameters show that wage returns to applied university are substantial and that wage gaps are not driven by selection only. The most important difference between the wage process in the academic and vocational sector are returns to experience. Individuals with a bachelor degree enjoy substantially larger returns to experience than people without. The college wage premium increases particularly strongly between the ages of 30 and 40. To understand how expected returns to university are distributed I calculate returns for each combination of observed and unobserved characteristics in the model.



(a) Age 35 (b) Age 40

Figure 6: This figure shows a histogram visualizing the distribution of wage returns. This figure is obtained by calculating college wage gaps for each combination of observed and unobserved characteristics in the model.

Figure 6 shows the distribution of wage returns to applied university. The bimodal nature is driven

by discrete approximation of unobservable factors. Particularly wages at the upper part of the distribution are growing strongly between age 30 and 40. The right panel of figure 6 shows that wage returns at the upper end of the wage distribution at age 40 are very large. Some people have very large returns to receiving a applied university degree. Other individuals are growing much slower and may only receive positive returns in their late thirties. Returns at the bottom of the return distribution may not justify incurring the costs of studying for everyone. The distribution of wage returns highlight that understanding the long term effect of policy requires to understand what kind of individuals are shifted. Returns to applied university do not substantially differ by parental income. Increasing the amount of low income individuals with an applied university degree would thus contribute towards narrowing the income gap across socioeconomic background.

Wage Returns to Vocational Degrees: Wages also differ by the non-academic degree an individual pursues. Figure 7 shows how log wages differ by non-academic degree. The baseline is only

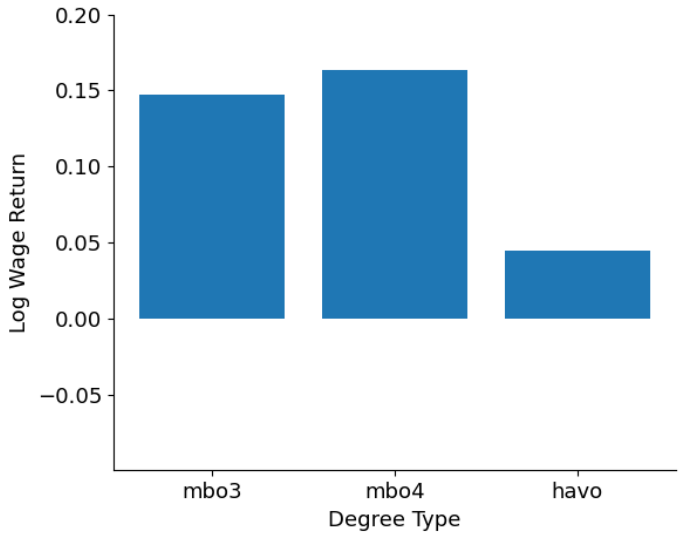


Figure 7: Summary in here

holding a vocational middle school degree. Graduates from a vocational program tend to earn more than individuals with high school degree only. Individuals may thus choose a vocational degree before the enter university as it is associated with a higher paying outside option if they dropout of university . The gap is however not particularly large and declines over time.

Dropout Risk: Heterogenous dropout risk across people is the most dominant factor generating heterogeneity in outcomes across individuals in the model Taking into account that the model suggest that returns to applied university are substantial for most of the population the relevant question is what factors drive substantial differences in applied university graduation. Parameter estimates suggest that differences in dropout risk as opposed to differences in other unexplained preferences are particularly important. Figure **??** shows the distribution of dropout risk in the

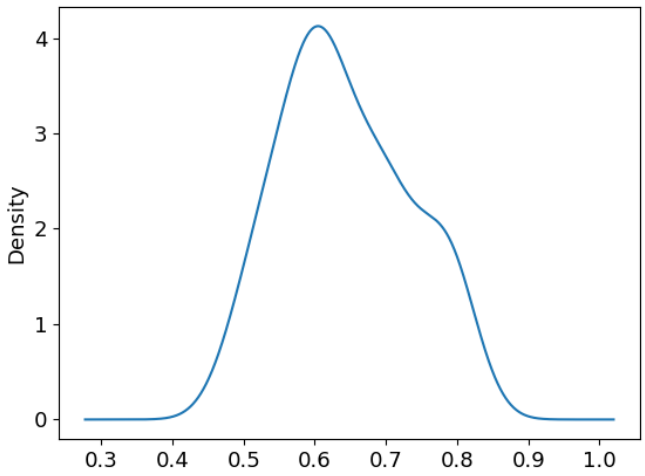
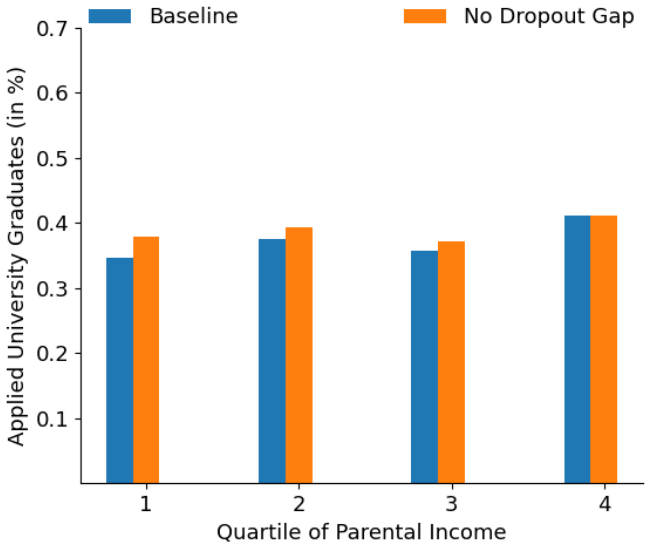


Figure 8: This figure shows a histogram visualizing the distribution of dropout risk. This figure is obtained by calculating the fraction of dropouts out of all individuals that enrolled in university for each combination of observed and unobserved characteristics in the model.

population. The figure shows that degree risk is large and that some groups only graduate from university with a chance of 50 percent. The most important difference in academic risk is along grades. Individuals that enter university from vocational education are slightly more likely to dropout than individuals that enter university from high school. During high school individuals are explicitly prepared for university while vocational programs usually set a different focus. The difference in dropout rates is however not particularly large. This finding is remarkable since it shows that pursuing more practical education for some time does not have a large effect on eventual success at applied university. Unobserved factors also matter for dropout risk. Individuals with large returns to applied university also have a larger probability of passing applied university. It is thus even more important to understand which individuals are shifted by a particular policy. If

people with modest returns and large risk are marginal for a certain reform the effect on wages will be substantially smaller.

Dropout Gap by Parental Income: Parental income is associated with substantially larger dropout risk even after controlling for all of the previous factors. Particularly individuals from the lowest income quartile appear to be more likely to dropout of university holding other factors fixed. This is very important as it contributes to overall inequality. Figure **??** shows how applied

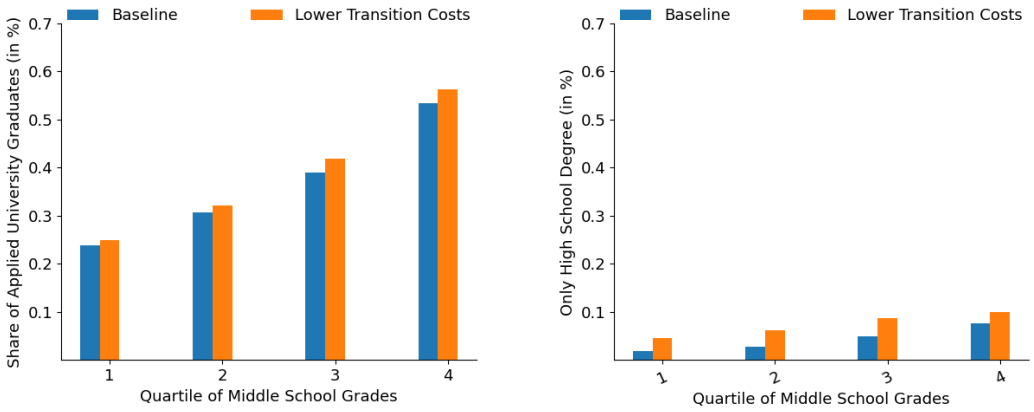


university graduation would change if the risk gap between students from different socioeconomic backgrounds was removed. The applied university graduation rate among individuals from low income backgrounds would increase substantially. There could be several reasons for the estimated risk gap. Individuals from low income backgrounds may have to work on the sides or face more economic which makes them more likely to dropout after they have received an initial shock. Another potential reason is that they have less information and have a harder time choosing a university subject that suits them. It is important to understand which factors are driving this gap and how it can be addressed by policy.

4.2 Counterfactuals

I use the estimated model to run several counterfactual policies. I estimate the potential impact of changed tracking policies, of removing the vocational path to university and of changed program characteristics. I will discuss the effect of income subsidies next chapter together with reduced form results on a recent reform to income subsidies for students. I show the effect of policies on individual outcomes for each group of observable ability since the differences there are particularly interesting. Whenever patterns differ substantially between individuals from lower and higher income backgrounds I discuss these differences.

Transition Costs Lower transaction costs would benefit people at the higher end of the grade distribution while it would have an ambiguous effect on individuals at the lower end of the distribution. Transition costs to applied high school are substantial and constitute a barrier to higher education for individuals with high grade. To understand how a more flexible tracking system would shift outcomes I change two aspects of the model. I abolish school types and simulate a world where every school is part of the class of the most liberal schools. Secondly I decrease costs for individuals with lower grades since these individuals are facing more barriers to transit to mid level high school. Figure **??** shows how the simulated policy would change graduation. I plot the

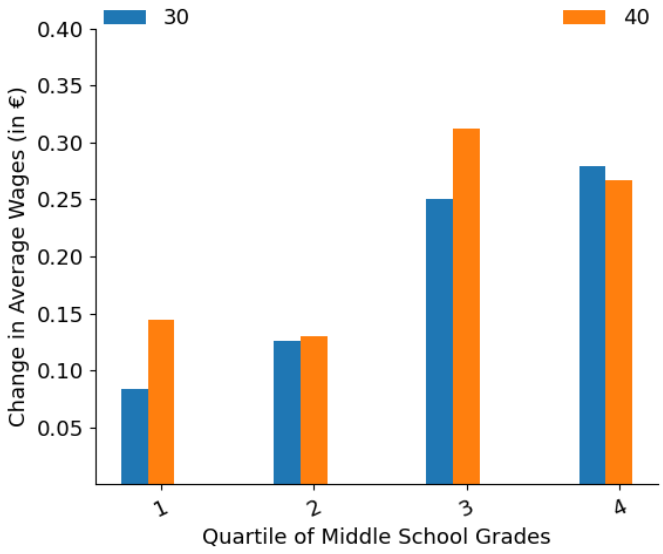


(a) University Graduates

(b) HAVO only

change in university graduation and high school graduation for each group of observed ability. The policy increases applied university graduation by around two percent. There are however also more people who only complete a high school degree. Individuals with low observed ability see a smaller

increase in university graduations but a larger increase in individuals who only hold a high school degree. Many of them thus dropout of university or do not enroll in university after graduating from mid level high school. Figure **??** shows changes in average hourly wages caused by the reform.



The increase in average hourly wages show that the complier have substantial returns from the reform.

The simulated effect of the policy shows that high school is associated with large risks for lower grade groups but may lead to substantial returns if these individuals manage to graduate. It is important to point out that the increases number of individuals with a high school degree may have consequences that are not contained in the model. Holding a mid level high school degree could be associated with lower job security or different job amenities. This information is important to decide whether more individuals with low grades should attend high school. Increasing flexibility for individuals with higher grades appears to be a good policy since they have lower dropout risk and their long-run returns are positive.

Vocational path to university: The vocational path to university increases university graduation as it allows individuals to hedge risk and to reconsider their initial decision. In the absence of any uncertainty there would be no value to the vocational path to university. Entering university from vocational education usually takes longer and is associated with a slightly higher dropout

risk. In a world with uncertainty the vocational path however plays two important roles. First of all it allows individuals to manage risk. If they directly proceed to high school and dropout of university later they only have high school degree which is associated with lower labor market returns. Moreover there is also substantial risk to dropout of high school which could also cost people years. Vocational programs are associated with lower dropout rates and higher labor market returns than high school degrees. If an individual thus faces substantial academic risk it may make sense to pursue a vocational degree first and continue to try entering university afterwards. Another role is that some individuals may only discover their interest in academic education at a later stage. In particular if they are not from an academic background they may not know whether they would like higher education at the age of 16. Model parameters suggest that both motives are important in the model. Figure **??** shows a simulated model without vocational path to university but with lower transition costs to high school. The figure shows that across all grade levels university graduation

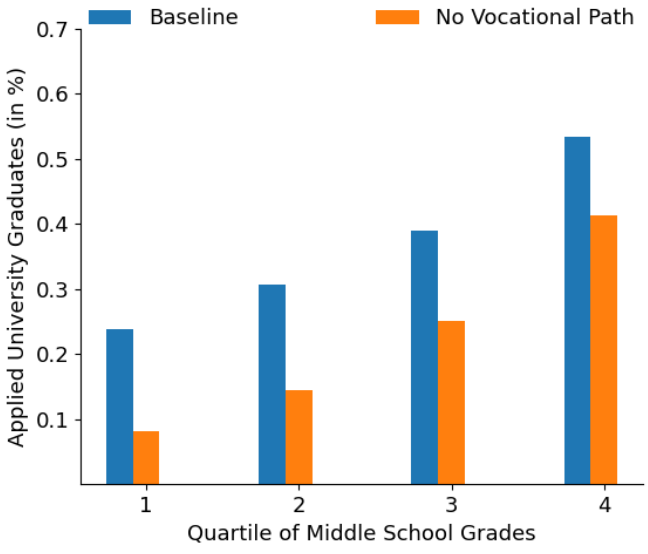


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Figure 9: ..

would fall quite drastically.

There could be a lot of motives behind changing your mind about wanting to go to university. Simply not having a lot of information about university could be a reason. Maturing over time could also be important. In particular as children from academic households are more likely to get pressured into academic education as opposed to non academic households. Yet another reason

could be learning about returns or about own ability over time. It is beyond the scope of the model to separate these factors. The results show however that this block of reasons appears to be important for individual decisions. Understanding what exact factors are relevant may be an important path for future research.

Changing Program Characteristics Shorter vocational programs would increase university enrollment as it is easier to forgo earnings at a younger age. To understand the effect of shorter program duration I simulate a model where vocational programs only take 3 years. It is important to mention that many programs already offer the option to get a vocational degree within 3 years. Many people however take longer between four and six years. This may also be partly due to individuals switching or repeating classes. It is thus likely not possible to exactly implement this policy. The results however show effects of measures that would decrease time until graduation in vocational education. Figure **??** shows how shorter programs would change university graduation.

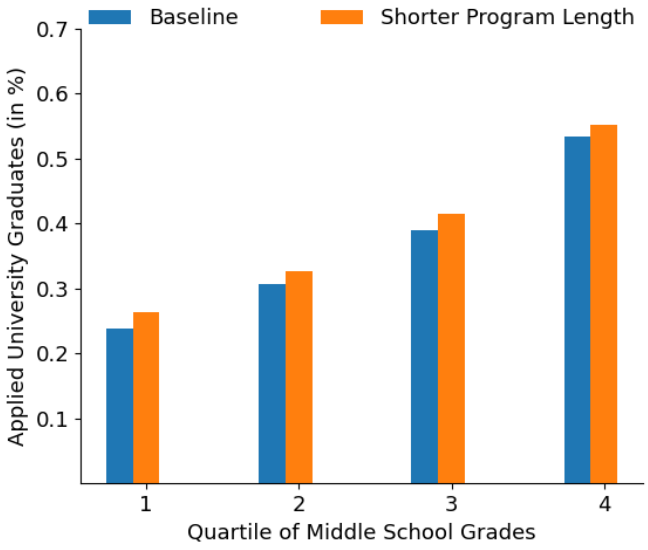

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Figure 10: ..

Decreasing program length is associated with an increase in university graduation of around 3 percent. The effect is slightly smaller for individuals in the lowest observed ability group but relatively similar for everyone else. Increasing opportunity costs are thus an important factor in individuals decision. Vocational programs should thus encourage quicker programs to the extent that this is possible. Figure **??** shows the change in wages that the simulated reform would trigger.

The effect is larger at age 35 because individuals in the simulated data also graduate earlier which

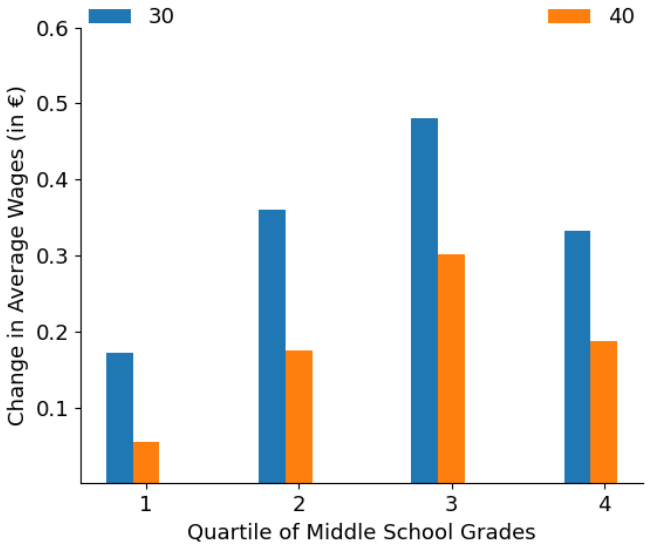

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Figure 11: ..

leads to more experience at any given point in time. The effect on average wages however remains substantial at age 40. Decreasing time spent until obtaining a vocational degree may thus facilitate more university degrees. While it may not be possible to make everyone graduate within three years policy makers should trade off the volume of programs with the fact that people may want to proceed to university afterwards.

5 The Effect of Income Subsidies

I now discuss the impact of income subsidies. I first introduce a recent reform to student income subsidies.

5.1 A Reform to Student Income Subsidies

A reform to student income subsidies in 2015 raised the costs of studying and moving out while leaving the costs of other options unchanged. The Dutch government gives out monthly loans to university student that are converted to grants upon successful graduation from university. Initially individuals that moved out of their parental home received higher payments. In 2015 the Dutch government introduced a reform to the loan scheme. Figure **??** summarizes the changes that have

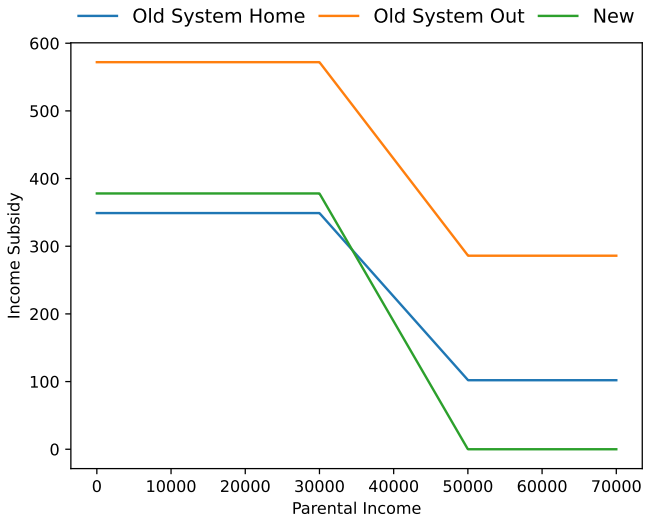

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Figure 12: ...

been introduced. Subsidies for individuals from higher income households have been removed. For lower income households privileges for individuals that would want to move out have been removed. Individuals from low income households that want to move out have lost 200 euros after the reform.

5.2 Empirical Strategy

I now summarize the empirical strategy to derive treatment effects from the reform I have just introduced. I will first characterize a latent control group. Thereafter I will introduce a method to

identify this latent group and finally I will show how I use this information to obtain the effect of the reform.

Characterization of a latent control group: Individuals who would not have moved out and entered university before the reform are less affected by the reform itself and can thus be used as a control group. Figure 3 has shown that the reform has mainly changed subsidies for people that would have moved out and entered university. Let $D_i = (H_i, W_i)$ be the joint housing and education decision of an individual, where $H_i \in \{0, 1\}$ denotes the decision to remain at home and $W_i \in \{0, 1\}$ denotes the decision to attend university. Let $T(d)$ be a function that maps a joint decision d into a monthly subsidy amount, additionally let T_0 refer to the old subsidy scheme and T_1 to the reformed scheme that has been in place after 2015. Individual i picks the combination of housing and education that maximizes her utility depending on the subsidy scheme she faces $D_i(T_t)$. According to figure 3 it holds that $T_0((0,1)) - T_1((0,1)) > T_0(d) - T_1(d)$ for any $d \neq (0,1)$. For individuals with lower income parents and a prior intention of studying and staying at home the expression on the right hand side is even slightly negative which implies that they should not have been adversely affected by the reform at all. People that would not have been attending university will not change their decision because of the reform since it largely makes studying less attractive. Finally people with higher income parents have lost some subsidies but relatively little compared to everyone else. Thus I assume that $D_i(T_0) = D_i(T_1)$ for any $d \neq (0,1)$ which implies that the reform should only change decisions for people with an intention to study and move out. If this assumption holds one can compare enrollment changes across the latent control and treatment group to identify how the reform has changed choices. If there are parallel trends between treatment and control group effects one can recover the impact of the reform with a difference in difference strategy. In reality some people in this control group have been affected. Moreover it could also be that people do not perfectly whether they move out or not and just place an option value of the value of moving out. Furthermore some people could stay at home for the first half of their studies and leave home thereafter. The difference in differences is thus likely to be a lower bound of the effects of the reform.

Empirical approximation of latent treatment: Identifying the treatment and control group requires predicting latent choices with pre-reform data. Potential choices under the old subsidy scheme $d_i(T_{pre})$ cannot be observed after the reform is introduced which implies that one cannot

directly compare treatment and control group. Instead I predict latent treatment status with a prediction algorithm and a large set of observable characteristics retrieved form administrative data. Each individual i can be characterized by a vector of observable variables X_i. Now let $P_{T_0}(X) = P(d_i(T_0) = (1,1)|h_i(T_0) = 1, X_i = X)$ be the probability that an individual with characteristics X would stay at home if she would attend university. I can observe X for all individuals and $d_i(T_0)$ only for individuals that graduated before the reform has been introduced. Thus I use data from the pre-reform period to train a prediction algorithm that associates X with latent treatment status $m(X) = d(T_0)$. X includes spatial factors, personal characteristics, data on the family situation and information on the prior schooling career [9]. I use a gradient boosting algorithm to predict $P_{T_0}(X)$ where I use data on university enrollees between 2011 and 2013 as training data and data on individuals that graduated in 2014 as test data. I predict the probability of staying at home conditional on going to university instead of the probability of staying home and going to university since the latter one allows one to retrieve a better prediction in practice. I additionally use similar data to predict the probability of going to university which I will use as a control variable in the analysis. Figure three summarizes the out of sample performance of the algorithm.

Estimation Strategy If one assumes that treated and untreated individuals would have been would have been subject to parallel trends absent the reform one can retrieve lower bounds of the effect by comparing individuals with high and low probability of being treated. Since we can not directly observe latent treatment status we can only compare how the reform changed choices across individuals with different probabilities of being treated. Comparing individuals with a high probability of staying at home $P_{T_0}(X) = P_H$ with individuals that have a low probability of staying at home $P_{T_0}(X) = P_L$ leads to a treatment effect on the people with high probability and a term that captures treatment heterogeneity across probability scores. If the group with the high probability

[9] For more information on the variables consider appendix A

Parallel Trends across propensity scores. The main assumption underlying the empirical strategy is that individuals with high and low treatment propensity exhibit parallel trends in the absence of the reform:

$$E[d_{i,t}(T_{pre}) - d_{i,t-1}(T_{pre})|d_{i,pre} = (0,1), Z_i] = E[d_{i,t}(T_{pre}) - d_{i,t-1}(T_{pre})|Z_i] \textbf{ for } m \in [0,1]$$

. Where Z_i denotes some individual controls I condition on. Z_i cannot include too many variables since otherwise most of the variation in the propensity score is controlled away. I will include very few controls in the main analysis. To show robustness to some problems such as treatment effect heterogeneity I include specifications with a more extensive set of controls in the appendix. I compare individuals that graduated in the same year. The issue that arises in practice is that some individuals that graduated earlier could also have been affected because many people take one or two gap years before they enter university. Thus it is well possible that the effect is gradually building up rather than appearing only after the reform has been introduced.

Treatment Effects There are different ways of comparing people with low and high probability and they have different interpretation. Comparing a group with low and high propensity score can then be written as follows.

$$E[d_{i,t} - d_{i,t-1}|m(X_i) = m, Z_i] - E[d_{i,t} - d_{i,t-1}|m(X_i) = m', Z_i]$$

$$= (m - m')E[d_{i,t}(1) - d_{i,t}(0)|m(X_i) = m] - (m - m')(m - m')E[d_{i,t}(0) - d_{i,t}(0)|m(X_i) = m] + (m)$$

As the propensity score gets bigger the group of treated people increases. The composition of the treated group however also changes. Treated people can differ across different propensity scores. Thus the comparison across different propensity scores has two elements. A more detailed composition of the effect is provided in the appendix. One way to derive effects of the reform is to run a continuos two way fixed effects regression where the coefficient of interest is the interaction between time and propensity score. This allows one to use the full range of people. The estimate is however sensitive to treatment effect heterogeneity across propensity scores. This is because the change in choices as the propensity score increases could be both due to effect heterogeneity and the effect of more people being treated. Another approach is to use a group with sufficiently small

scores as control group and comparing different groups with higher propensity scores to this group. In this case the base group does not contain too many treated individuals.

5.3 Results

I now summarize empirical results on the effect of income subsidies. I first summarize the performance of the estimation procedure and treatment effects derived from the reform. Thereafter I simulate a similar policy with the structural model introduced earlier.

5.4 Prediction Performance

The prediction algorithm does a good in job in predicting people with a high likelihood of moving out.

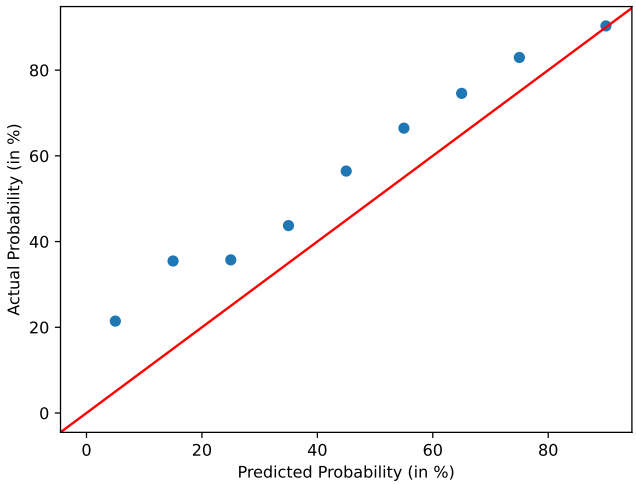


Figure 13: ...

Figure **??** shows the prediction performance of the algorithm. The prediction is trained on data between 2011 and 2013. The year 2014 is used as a holdout sample. The figure shows the actual proportion of people staying at home for each decile of predictions. The dot above the predicted probability of twenty percent is the actual proportion of individuals staying at home among all individuals that are predicted to have a probability of staying between twenty and thirty percent. The dots are always close to the forty five degree which shows that the algorithm predicts well.

Changes in Enrollment: The predicted treatment group reduces enrollment by four percent after the reform has been introduced.

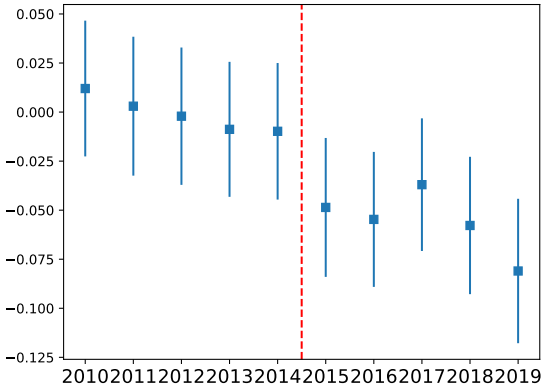
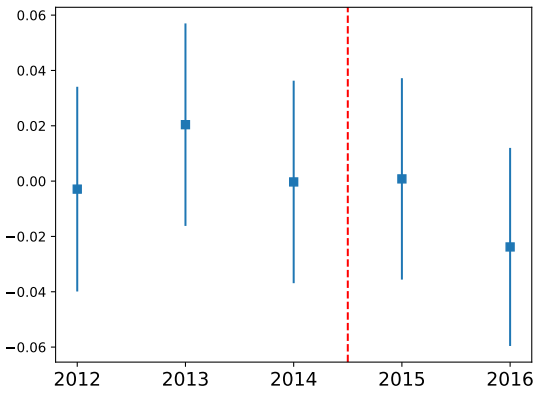


Figure 14:
This figure shows coefficients from a two way fixed effects regression comparing individuals with different propensities to move out. The coefficients depict the evolution of university enrollment of the group that is most likely to move out relative to the control group that is least likely.

Figure **??** shows the evolution of university enrollment for the group that is most likely to leave home relative to the group that is least likely to leave home. The results are based on the population of individuals with low income parents. The most affected group has dropped by four percent relative to the least affected group which is a substantial reduction taking into account the size of the income subsidy. The estimates however show that the control group also reduces their enrollment by five percent. It is not clear whether they also drop because of the reform or whether they respond to other trends. Individuals with a low probability of leaving home should not be affected by the reform. Some individuals may however not be informed about the reform and others may not know about means tested grants that they are entitled to receive. On the other hand it is important to mention that overall labor market conditions improved between 2010 and 2020 and that this may also have an impact on enrollment decisions. The four percent decline is thus very likely a lower bound for the effect of the reform. **Graduation: ??** shows the evolution of university graduation. The evolution of graduation looks more noisy. There is no significant drop after the reform has been introduced. One potential issue is that some people take very long to finish their degree and may still be in university six years after the reform has been introduced. If I include people still



studying after six years in the definition the decline is a bit larger but the overall evolution remains noisy. It is important The change in university degrees is however much less pronounced as the decline in enrollment and more difficult to distinguish from the general trend. The reform has thus pushed people with relatively large degree risk out of higher education.

Reform Simulation in the model: Reduction of income subsidies are associated with modest declines in enrollment according to the structural model. I simulate an alternative model with lower non-pecuniary returns to university. Figure **??** shows that the model predicts an enrollment

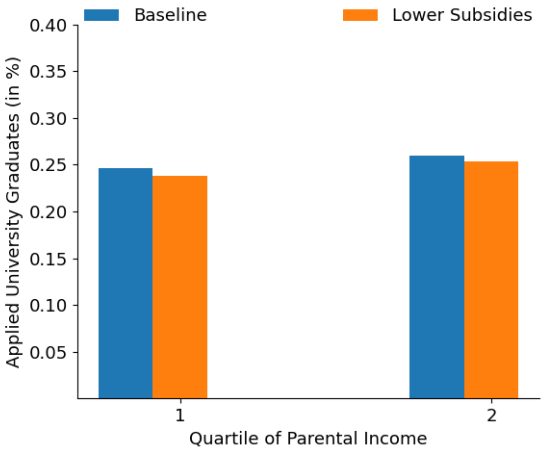


Figure 15:

decline of around one percent. Degree completion is predicted to be much lower particularly for individuals from low income backgrounds. There are two reasons why the model can potentially not reproduce the effect of the reform. The treated group is different from the broad population

and the treatment effect on the treated is potentially larger than the treatment effect on the treated group. Furthermore the model is not perfectly suited to predict the effect of income subsidies as it includes no consumption component and no risk aversion.

It is thus likely that the reform reduces utility of studying to a larger extent than the monetary value that individuals miss out on. I thus simulate an alternative model were I reduce utility of university until the reduction in enrollment is similar to what the reform predicts. Complier of the

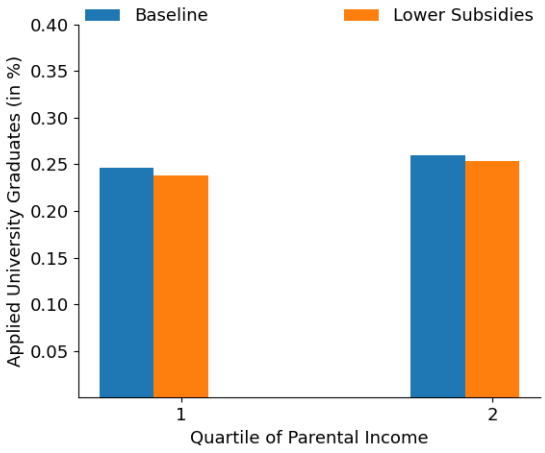


Figure 16: This figure shows coefficients from a two way fixed effects regression comparing individuals with different propensities to move out. The coefficients depict the evolution of university enrollment of the group that is most likely to move out relative to the control group that is least likely.

simulated policy have large academic risk and the reduction in degrees is less than two thirds of the reduction in enrollment. The model and the reform thus agree on the characteristics of complier to the reform. While the model cannot exactly reproduce the reform it gets selection right which increases confidence in the other policy simulations.

6 Conclusion

I have investigated the effect of education policy in the presence of early achievement gaps. I have found that returns to applied university are substantial for many low income individuals despite early achievement gaps. I found that increasing flexibility of the tracking system would increase graduation and wages of low income individuals. Furthermore I established that alternative paths to university are important for low income individuals as many people only find their interest in academic studies later in life. Thus it is important to design the education system such that individuals that opted out of academic education earlier can still go to university without having to incur large transition costs. Future research should investigate reasons for large dropout rates among low income individuals.

7 Appendix

7.1 Parameter Estimates

7.2 Model Fit

7.3 Additional Policy Simulations

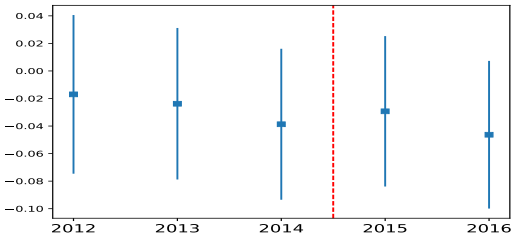
7.3.1 Robustness Reduced Form

Debt and Spatial Factors Not enrolling in university is not the only margin of adjustment to the reform. Affected individuals can also stay at home, increase work hours or take up more study debt. All of these factors could itself have important consequences for individual outcomes. There are two major complications with this approach. First and foremost the incentive to truthfully report housing status falls away after the reform ha been introduced. Thus it is difficult to say whether individuals stay at home or left home after the reform. Another important issue is that the population of university entrants changes since many people decide to opt out in response to the reform. This makes comparisons over time difficult and requires to carefully think about selection into higher education.

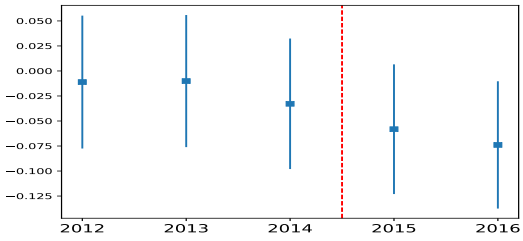
Figure **??** shows how debt, hours worked while studying and university locations have been affected by the reform. There is no substantial change in any of these dimensions. It is important to note that affected individuals were already likely to have much higher debt levels before the reform which potentially reduces their capacity to take up further debt. Furthermore individuals already worked relatively high hours before the reform and thus there is limited potential to increase work hours while studying. There is also no trend in university location. This could be expected if people are more likely to live at home. However the reform also led many people to enroll at all. The most marginal people are potentially less likely to leave their region all together which would contaminate the comparison.

Differences by initial heterogeneity The most plausible explanation for the patterns induced by the reform are individuals selecting based on expected academic risk. Academic risk is substantial among vocational graduates. Dropout rates are high and many individuals require more than 5 years to finish their studies. Taking up debt could be particularly costly if individuals are at risk to study for an extended amount of time. Furthermore wage returns to university differ greatly

by vocational subject. While some degrees are associated with substantial wage returns others are not associated with any return right after graduating. To explore the relative importance of these factors I compare individuals with high and low dropout risk and high and low wage expectations respectively. I obtain dropout risk in the same way as I obtain the probability of staying at home. I use observables to train and predict dropout risk of vocational graduates.



(a) Lowest Dropout Risk



(b) High Dropout Risk

?? shows the evolution of enrollment for individuals with and low risk of dropping out. The figures demonstrate that larger dropout risk is associated with substantially bigger responses to the reform.

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