ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics

Master Thesis Policy Economics

Do teacher shortages harm students?

Teacher labor market tightening, teacher mobility and the quality of education

By: Harmco Dijkslag
Student ID number: 413507

Supervisor: Prof. dr. H.D. Webbink
Second assessor: Prof. dr. A.C. Gielen

Date final version: October 8, 2019

"Results based on calculations by Harmco Dijkslag, intern at the Ministry of Education under supervision of dr. Marc van der Steeg, using non-public microdata from Statistics Netherlands."

Abstract:
Little is known about the impact of teacher shortages on teacher mobility, or on the determinants of teacher mobility. It is also unclear how teacher mobility in a tight teacher labor market impacts education quality. This paper, using teacher and student microdata in regression models with school fixed effects, provides evidence that teacher shortages have an impact on teacher mobility determinants. Teachers are more likely to move from schools with a high share of disadvantaged students and from schools in urban areas in a tight teacher labor market. Subsequently, teacher mobility is found to have a negative effect on the quality of education. Thereby, the proportion of young teachers in schools with above average turnover seems to increase when teacher turnover increases and the teacher labor market is tight. Despite that teacher turnover is found to have a negative effect on student test scores, analyses do not provide conclusive evidence that the effect is amplified in a tight teacher labor market.

Acknowledgements

For the successful completion of this thesis I have to thank several people, without them I would not have had the opportunity to do this nice project. Firstly, my supervisor from the Erasmus School of Economics, prof. dr. Dinand Webbink who supported me to pursue the thesis internship in the Ministry of Education, Culture and Science and who gave quick and to the point feedback notwithstanding the ambitious planning I had set for graduating. Secondly, the people of DUO Informatieproducten who provided me with the data for my thesis. In particular I want to thank dr. Herman Jonker who connected me to the right people and solved many administrative issues. I also want to thank André Dickmann and Karlijn Mensink who helped me to get the necessary data and the correct understanding of the variables. Thirdly, I want to acknowledge my colleagues of Directie Kennis who were very welcoming and made my time in the Ministry enjoyable. I also want to thank Bas Scheer of CPB Netherlands Bureau for Economic Policy Analysis, Friso Snijders of DUO, Nick Jelicic of Dialogic, Sander Dijksman of ROA and the Statistics Netherlands Microdata staff who all played a role in the project. Finally, I would like to express my gratitude to my supervisor from Directie Kennis, dr. Marc van der Steeg, who gave me the opportunity to write my thesis on a currently highly relevant topic and who provided me with the necessary conditions to start it of right away. I am very grateful for the tons of ideas he provided, for his insights in the stories behind the data and for all the time he spent to help me get to this final version of my thesis.

Table of Contents

1. Introduction

In 2007 an advisory committee on teacher policy appointed by the Dutch Minister of Education predicted a shortage of qualitatively good teachers within four years (Commissie Leraren, 2007). In 2013 the shortage did not yet materialize. To the contrary, at that time CPB Netherlands Bureau for Economic Policy Analysis (CPB) concluded that in primary education the unfilled vacancies as a percentage of employment had been declining from 0.7% in 2008 to 0.1% in 2012 and starting teachers were having a hard time to find a job (CPB, 2013). However, in recent years teacher shortages in primary education have become a very pressing issue. Schools mainly in the west of The Netherlands have a hard time filling their vacancies, but also schools in the rest of The Netherlands do face teacher shortages or will face it in the near future (Bouma, 2018; NOS Nieuws, 2019). According to the teachers, the shortages lead to a deterioration of the quality of education (Musch, 2019). Recently also the Inspectorate of Education pointed out the negative effects of the current teacher shortage on the equality of opportunities for pupils (Inspectie van het Onderwijs, 2019).

In times of teacher shortages, the demand for teachers exceeds the supply of teachers and schools need to compete for teachers. If a teacher decides to move to another school this leads to an increase in teacher mobility, but this does not solve the problem (Jackson, 2012). Thereby, a shortage of teachers might increase a teacher's workload, which could make teachers decide to leave the primary education sector also increasing teacher mobility (Den Brok, Wubbels, & Van Tartwijk, 2017). Scientific research shows that there are several determinants of teacher mobility. For example, teachers are more likely to leave schools with a high share of disadvantaged or minority students, and teachers also prefer to teach in less urban areas (Hanushek, Kain, & Rivkin, 2004; Falch & Strøm, 2005; Scafidi, Sjoquist, & Stinebrickner, 2007; Barbieri, Rossetti, & Sestito, 2011). There is however no scientific research available that studies the impact of a tightening teacher labor market on teacher mobility or on the determinants of teacher mobility. Literature also points out that teacher mobility negatively influences the quality of education (Ronfeldt, Loeb, & Wyckoff, 2013; Hanushek, Rivkin, & Schiman, 2016) but there is no research available about the impact of teacher mobility in a tighter teacher labor market on education quality. Therefore, this paper intends to answer the following question: How does a tightening of the teacher labor market effect teacher mobility determinants and how does teacher mobility in a tighter teacher labor market impact the quality of education in primary education in The Netherlands.

To answer the question OLS regressions with school fixed effects are estimated for several outcome variables. Microdata has been provided by the Education Implementation Service of

the Ministry of Education (DUO) and by Statistics Netherlands. This allows for the compilation of a comprehensive dataset with information on teacher contracts, teacher characteristics and school characteristics for all schools in The Netherlands for the years 2011 up to and including 2017 as well as a dataset containing information on students, student enrollment, student test scores and school characteristics for the same period.

Teacher labor market tightening is found to increase teacher mobility, in particular the probability that a teacher decides to move to another school. Thereby, teachers between 30 and 40 years old seem to be even more likely to move to another school in a tight teacher labor market, while teachers between 60 and 65 seem to postpone retirement in a tight teacher labor market. Teachers working in schools with a high share of disadvantaged students and teachers working in schools in very urban areas are also more likely to move to another school. This points at an heterogeneous impact of teacher labor market tightening on teacher mobility. Evidence is also found that teacher mobility in a tightening teacher labor market has an heterogeneous impact on the quality of education. Schools with above average turnover face a statistically significant increase in the proportion of young teachers when turnover increases and the labor market tightens, but schools with a relatively low level of turnover see their proportion of young teachers decrease. No effect is found for the interaction between teacher mobility and the state of the labor market on student test scores, though student test scores seem to suffer from an increase in teacher mobility particularly in the 4 big cities of The Netherlands. An increase of teacher mobility seems to decrease the probability of student grade retention, there is also some evidence that the effect is even bigger in a tighter teacher labor market. According to economic literature grade retention is beneficial for student test scores (See for example: Jacob & Lefgren, 2004; Winters & Greene, 2012; Schwerdt, West, & Winters, 2017), so a decrease in the probability of grade retention might point at a negative effect on education quality. Though this study doesn't find conclusive evidence for the negative impact of teacher mobility on the quality of education in a tightening teacher market, it calls for careful monitoring of teacher shortages and the consideration of targeted policies to manage the potential negative impacts of teacher mobility in a tighter teacher labor market.

This paper is further organized as follows. Section 2 discusses the findings of literature related to the main question. Section 3 elaborates on the data used in the analyses. Section 4 presents the methodology. Section 5 describes the teacher mobility determinants in the Netherlands. In section 6, the main results will be presented. These results be discussed in section 7, which also concludes.

2. Review of related literature

The framework often used in teacher mobility literature is derived from the supply and demand framework of labor (Borman & Dowling, 2008). The labor supply of teachers is determined by their preferences over teacher wages, a set of job and workplace characteristics and by alternative job opportunities (Hanushek, Kain, & Rivkin, 2004; Falch & Strøm, 2005; Jackson, 2012; Bonhomme, Jolivet, & Leuven, 2016). Labor demand for teachers is determined by the number of students and school policies, such as the distribution of resources and class size (Murnane, 1981; Falch & Strøm, 2005; Jackson, 2012; Boyd, Lankford, Loeb, & Wyckoff, 2013). Teacher mobility can be broken down by teachers moving from one school to another school and teachers quitting teaching either by moving to another sector or by moving into nonemployment (Borman & Dowling, 2008). This paper studies both teacher movement and teacher quits.

Teacher mobility and teacher wages

Murnane and Olsen (1989) find that teacher salaries positively influence the time a teacher stays in teaching using generalized least squares models with district fixed effects. Alternative job opportunities on the other hand negatively influence the time a teacher stays in teaching. Research by Dolton and Van der Klaauw (1999) supports these findings. However, these studies do not control for time-varying district characteristics. Clotfelter, Glennie, Ladd and Vigdor (2008) do control for time-varying district characteristics in an evaluation of a bonus program providing annual bonuses to certified math, science and special education teachers in middle and high schools serving low-income or low-performing students in North Carolina. They use a combined difference-in-difference and regression discontinuity design framework. The salary bonus seems to significantly reduce turnover rates for the affected teachers. It is not clear though if these results generalize to teachers at primary schools who are not serving low-income or low-performing students. Hendricks (2014) shows robust evidence that higher teacher wages reduce turnover. He uses Texan longitudinal administrative teacher data with over 5 million teacher-year observations from the years 1996-2012 in a model with district-by-year fixed effects accounting for time-varying district characteristics, district-by-experience fixed effects accounting for fixed school policies within a district varying by teacher experience and experience-by-year fixed effects accounting for time-varying factors that are specific for experience groups. The negative effect of teacher wages on turnover is largest for teachers with the least experience, it decreases by experience and eventually disappears.

Teacher mobility and student characteristics

Teacher wages are not the only determinant of teacher mobility. Hanushek et al. (2004) document for Texas that teacher mobility is more strongly associated with student characteristics than with teacher wages. The probability that a teacher moves to another school or quits teaching entirely is higher for schools with large numbers of black students, Hispanic students or lower achieving students. These probabilities are higher for less experienced teachers than for more experienced teachers. Similarly, Scafidi, Sjoquist and Stinebrickner (2007) show for Georgia that teachers seem not to prefer to work in schools with many minority students or in high poverty schools. This evidence is only correlational however. Jackson (2009) presents causal evidence that teacher preferences for student race influence teacher mobility. He uses exogenous variation in student race caused by the end of a student busing policy in a district in North-Carolina. A school in a black neighbourhood should experience an inflow of black students after the end of student busing. The expected inflow of black students in a district after the end of student busing is used as instrument in an analysis which proofs that teachers start moving after the policy change. The proportion of experienced teachers and teacher value added decreases in schools with an inflow of black students.

Teacher mobility and school characteristics in Europe

Falch and Strøm (2005) point out that teacher wages in most European countries are determined by centralized wage bargaining, hence non-wage characteristics of a teacher job are more important factors influencing teacher mobility between schools. They argue that the centralized wage bargaining system in Norway and the Norwegian national regulations enable them to study those non-wage characteristics without identification problems caused by wages responding to differences between school districts. Using matched individual teacher-school data from 1992-2000 they find that in schools with a high share of minority students and schools with a high share of students with special needs the probability for teachers to leave those schools is higher. Barbieri, Rossetti and Sestito (2011) analyze transfer application data of Italian teachers in a logit model with fixed effects for the local living area where a teacher in a particular school is supposed to live. They also find that teachers prefer to leave schools with many disadvantaged and minority students, for example schools in areas with low employment and schools with many foreign-born students. Thereby, geographical location effects teacher mobility. Teachers are more likely to apply for a transfer when they teach far from their birth-place and when a school is in a (sub) urban area. This is consistent with research by Reininger (2012) who finds that teachers prefer to work close to the town where they went to high school. Boyd et al. (2013) came to equivalent conclusions for New York State using a model based on a game-theoretic two-

sided matching model. They show that teachers prefer to work in schools that are geographically close, preferably located in a suburban area and schools with a small share of students in poverty. For The Netherlands, Bonhomme et al. (2016) conclude that teachers dislike working in schools with many disadvantaged students and schools in densely populated areas. On the other hand teachers like to work in schools with higher student achievement. The authors calculate teacher's marginal willingness to pay for these job characteristics using a model based on job search theory.

Teacher mobility and teacher characteristics

The evidence of the effect of teacher's gender on teacher mobility is mixed, though more recent research claims female teachers to be less mobile than male teachers (Stinebrickner, 1998; Falch & Strøm, 2005; Barbieri et al., 2011; Clotfelter, Ladd, & Vigdor, 2011). More experienced teachers are also less likely to move than starting teachers (Murnane, 1981; Theobald, 1990; Barbieri et al., 2011), probably because they have accumulated more (school-specific) human capital in teaching (Guarino, Brown, & Wyse, 2011). Part-time teachers and school leaders are less likely to quit (Falch & Strøm, 2005) and also teachers in schools with higher quality staff have lower turnover rates (Falch & Strøm, 2005; Bonhomme et al., 2016). Teachers prefer not to work in schools with high student-teacher ratios (Theobald, 1990; Stinebrickner, 1998; Bonhomme et al., 2016) and in small schools (Falch & Strøm, 2005; Barbieri et al., 2011).

Assessing teacher quality

The literature has recognized the importance of teacher mobility for the quality of education and for the equal availability of quality education for all students, see for example Hanushek et al. (2004), Barbieri et al. (2011) and Hanushek, Rivkin and Schiman (2016). An education production function can be used to evaluate the quality of education. Education production functions are derived from economic models of production. The inputs in an education production function are the characteristics of teachers, schools, families, peers and the characteristics of a student him- or herself. Those inputs generate student achievement as an output (Hanushek, 1986). The quality of the inputs can be determined by assessing their effect on student achievement measured by student test scores. To assess teacher quality the contemporary literature mainly uses so called value-added models. Teacher value-added is measured by a teacher fixed or random effect in a regression of student, school, family and peer characteristics on student achievement (Kane & Staiger, 2008). After estimating teacher value-added, it is used to study the determinants of this measure of teacher quality. There is consensus among researchers that teacher experience positively influences teacher quality (Rockoff, 2004; Harris & Sass, 2011; Wiswall, 2013; Papay & Kraft, 2015; Gerritsen,

Plug, & Webbink, 2017). Teacher value-added increases over the first years of teaching, in particular. Moreover, recent literature suggests that increasing experience leads to increases in teacher quality also later in the teacher career.

Teacher mobility and teacher quality

Education quality suffers when teacher turnover rates increase. Lankford, Loeb and Wyckoff (2002) state that more qualified teachers are more likely to quit teaching or move to another school and they state that teachers who remain in schools with minority or low-income students are of lower quality than those who leave. However, they use proxies for teacher quality that have little or no relation to teacher value-added according to later literature. Wiswall (2013) uses a value-added framework and corroborates that higher quality teachers are more likely to quit teaching. Feng and Sass (2017) reach a similar conclusion, in addition they find that also lower quality teachers are more likely to quit teaching. Likewise, Boyd, Grossman, Lankford, Loeb and Wyckoff (2008) find that lower quality first-year teachers are more likely to quit teaching, but this tendency disappears for second- and third-year teachers. Thereby, they find that the lowest quality teachers, from the moving teachers, move to the minority or low-income schools. On the other hand, according to Krieg (2006) higher quality female teachers are less likely to quit teaching. He finds no effect of teacher quality on the decision to quit teaching for men. Also Goldhaber, Gross, and Player (2011) find that higher quality teachers are less likely to quit teaching or move to another school and furthermore they find that low quality teachers are more likely to quit teaching or move to another school. Consequently, it seems that the literature agrees that lower quality teachers are more likely to turnover, however the turnover pattern of higher quality teachers is disputed.

Teacher mobility and its impact on the quality of education

Teacher quality is unequally distributed over schools. Minority students and students from low-income families are more likely to be exposed to inexperienced teachers than non-minority students and students who are not from low-income families (Lankford et al., 2002; Clotfelter, Ladd, & Vigdor, 2005; Kalogrides & Loeb, 2013; Steele, Pepper, Springer, & Lockwood, 2015; Goldhaber, Quince, & Theobald, 2018). Those students are also more likely to face teachers with lower value-added (Sass, Hannaway, Xu, Figlio, & Feng, 2012; Steele et al., 2015; Goldhaber et al., 2018). For equal availability of quality education for all students it is particularly important to know if teachers that move from disadvantaged schools are of different quality as compared to teachers moving from advantaged schools. A study by Sass et. al (2012) as well as a study by Steele et al. (2015) evidences that there are no distinct differences in the quality of teachers turning over in disadvantaged schools as

compared to advantaged schools. However, these studies on the relationship between teacher quality and turnover do not tell if teacher turnover is indeed detrimental to education quality, because they do not take into account who fills the vacancy that is left by a moving teacher. Ronfeldt, Loeb and Wyckoff (2013) study the effect of school-by-grade-by-year level turnover on student achievement using administrative data of 4th and 5th grade students in New York City elementary schools over 5 years. They control for student, classroom and school characteristics and they use fixed effects. They compare a model with school-by-grade fixed effects exploiting variation over years with a school-by-year fixed effects model exploiting variation across grades. For both models they find that teacher turnover has a negative effect on student achievement. The effect is larger for students in schools with many black students and schools with many low-performing students. Changes in teacher quality do explain part of the effect, but there are more factors contributing to the negative effect of turnover on student achievement. Hanushek et al. (2016) perform a similar analysis to Ronfeldt et al. (2013). They also account for the possibility that teachers from another grade can fill the vacancy of a leaving teacher and for the possibility that assignment of new teachers to a class with a vacancy is non-random. In both cases the analysis could be biased. Therefore, they aggregate turnover to school-year level, include school fixed effects and include a variable with the fraction of teachers who switch grades. Their results are similar to Ronfeldt et al. (2013), though smaller in magnitude. They conclude that in lower achievement schools turnover has a negative effect on education quality, because of the loss of general experience and grade-specific experience, not because they lose their highest quality teachers. For high achievement schools turnover has no effect on education quality.

Student achievement and student grade retention

Economists have found that student achievement and student grade retention are related. However, not much is known about the effect of teacher mobility on grade retention. The threat of grade retention can serve as an incentive for students to increase their efforts (Eide & Showalter, 2001; Corman, 2003). Besides, grade retention might be benificial in increasing the probability of success for some students and it might benefit their peers by reducing the variety of different ability students in one class. On the other hand, grade retention requires school resources to be spend on a student for an additional year. A well-known study by McCoy and Reynolds (1999) found a negative association between grade retention and student achievement, however it does not use a convincing identification strategy. Jacob and Lefgren (2004) analyse the effect of grade retention and student achievement in California using a regression discontinuity design (RDD). In California the decision to promote or retain a student is based on his or her performance on a standardized test, which provides a threshold that can be used in the RDD-analysis. The authors find a positive short term effect

of grade retention for retained third grade students. Sixth grade student retention seems to have little effect on students. Greene and Winters (2007) reach a similar conclusion for Florida. They also use RDD-analysis and find a positive effect of grade retention on reading achievement for retained grade three students relative to the control group of promoted students. The effect is bigger two years after retention than one year after being retained. In another study they provide evidence that the effect of retention is still present in later grades, but that it has been declining (Winters & Greene, 2012). Finally, Schwerdt, West and Winters (2017) find that retained students have better results than their promoted peers when tested in the same grade, on math till grade eight and on reading till grade ten. Considering the evidence found in the literature they then suggest that retention in low grades might be more beneficial than in higher grades.

Teacher mobility and the state of the labor market

Teacher labor markets tighten when the demand for teachers increases, the supply of teachers decreases or when both happen at the same time. Teacher supply decreases when the number of individuals that decide to quit teaching is larger than the number of individuals that decide to become a teacher. Even so, the tightening of the teacher labor market can impact teacher supply decisions when teaching jobs with more preferable characteristics become available to (prospective) teachers. A lot is written about teacher labor supply decisions, however research on the effects of a tightening teacher labor markets is limited. According to Falch, Johansen and Strøm (2009) teacher shortages are procyclical. They find a negative relationship between teacher shortages and the regional unemployment rate. Also Nagler, Piopiunik and West (2015) find that business cycle conditions influence teacher supply. They use a valued-added framework to determine teacher quality and show that teachers who start their career in a recession are more effective in raising the test scores of their students. In a recession potential teachers have less alternative job opportunities, therefore they are more likely to apply for a teaching job, which loosens the teacher labor market. In this case more high quality individuals enter teaching. Sorensen and Ladd (2018) examined the consequences of teacher turnover using administrative data on middle school math and English language teachers in North Carolina in regression analysis with school and year fixed effects. They also interacted their teacher turnover variable with dummy variables indicating periods before, in and after the economic recession of 2009-2012. Their evidence suggests that schools with higher turnover have more inexperienced teachers, have more teachers without certification and that teachers in schools with high turnover are more likely to have lower licensure test scores. The effects are found to be larger in high poverty schools and in times with growing student enrollment. During the recession, turnover decreased and this seemed to dampen the negative effects associated with turnover.

Teacher mobility and the state of the teacher labor market

The above studies explore the impact of a loose or tight labor market on teacher labor supply. Goldhaber, Strunk, Brown and Knight (2016) study the impact of a loosening teacher labor market on teacher labor supply. Education budget cuts in the Great Recession lead schools to send layoff notices to teachers that might be laid off for the next year. According to Goldhaber and Theobald (2013) layoff notices are mainly based on teacher seniority. Besides, math, science and special education teachers as well as teachers with a masters degree are less likely to receive a notice. They suggest to base layoff notices on teacher effectiveness. Goldhaber et al. (2016) find that teachers whose job is at risk are more likely to chose to move to another school in the district. The turnover is higher than necessary to reach the budget saving targets. They do find no evidence that teachers are more likely to leave the district or that the response of teachers to a layoff notice differs by their effectiveness. Jackson published a paper in 2012 which is also closer related to the issues of a tightening teacher labor market as compared to a tightening labor market in general. He studies the effects of charter school entry on public schools in North Carolina. Charter school entry might make it harder for public schools to attract or retain teachers. Using a difference-in-difference framework he finds that mainly low-qualified teachers leave public schools for charter schools. There are no signs of a long-run rise of teacher turnover in public schools. The number of new teachers hired in public schools declines however. The effects are bigger for schools with more minority or low-income students, which might already have staffing problems, and also the teacher quality is found to decrease in those schools after charter school entry. Lastly, demand for teachers increases when policies are implemented to reduce class-size. Dieterle (2015) provides some evidence that the quality of newly hired teachers falls temporarily in both treated and untreated schools. These low-quality teachers are likely to leave teaching in the next years.

Hypotheses

A lot has been written about the determinants of teacher mobility and on the relationship between education quality and teacher mobility. Most of this literature is based on American data. Less literature is based on different contexts and almost no research has been done on the Dutch situation. This paper provides more insights in the determinants of teacher mobility and the impact of teacher mobility on the quality of education in The Netherlands. The main contribution of the paper to the current literature however is its study of the effects of a tightening teacher labor market on teacher mobility and subsequently on the quality of education. Such research is currently non-existent.

The literature on the state of the (teacher) labor market unequivocally finds that the state of the market influences teacher labor supply decisions. The change in the availability of alternative teacher job opportunities seems to be the main mechanism. Combining this with the literature on the determinants of teacher mobility the first two hypotheses are:

Hypothesis 1: Teacher mobility will increase in a tightening teacher labor market.
Hypothesis 2: The effects of teacher mobility determinants on teacher mobility will be bigger in a tightening teacher labor market.

The literature on education quality and teacher mobility suggests that teacher turnover is detrimental to the quality of education. The literature on the state of the (teacher) labor market suggests that teacher quality decreases when the demand for teachers increases or when the supply of teachers decreases. Therefore the third hypothesis is:

Hypothesis 3: The decrease in education quality when teacher mobility increases is bigger in a tightening teacher labor market.

3. Data

Most of the data used in this paper are provided by The Education Implementation Service of the Ministry of Education (DUO). Every year they receive information from all schools in The Netherlands about all teachers and students registered on October 1, which is at the beginning of the school year. The data cover the school years 2006/2007 to 2018/2019. This paper refers to the year 2006/2007 as 2006, to the year 2007/2008 as 2007 and so forth. Schools have a legal obligation to provide DUO with reliable and complete data, so it may be assumed that the data are of high quality. The DUO data are linked to restricted-use administrative microdata from Statistics Netherlands. Data on neighborhood characteristics of schools are also obtained from Statistics Netherlands, as well as countrywide vacancy information. Other vacancy information is accessed through the Ministry of Education. This creates a teacher-school-year panel with 1,324,163 observations.

Teacher data

The main data for the analyses come from DUO and contain information on all teacher contracts with primary schools in The Netherlands. Primary schools in the Netherlands serve children from age four till approximately twelve years old. Students leave after grade 8 for secondary education. A test in grade 8 indicates which secondary education level will be most appropriate. Teachers must hold a certificate to be eligible to teach. Teacher wages are set at national level in a collective labor agreement. Schools receive funding from the national government and schools are free to have their own policies within boundaries set by the Ministry of Education. The DUO teacher contract data contain information on teacher age, teacher gender, if the teacher has a temporary or a permanent contract, the size of the teacher contract and the identification number of the school a teacher teaches in. This information is necessary for all analyses. If teachers teach in multiple schools, the teacher data for the school with the biggest teacher contract size are kept.

Next, for every school year *t* teachers are believed to turnover when they are not teaching in the same school the following year *t+1*. Teacher turnover can be broken down in teachers who are leaving the primary education sector and in teachers who are moving to a different school in primary education in the following year. If a teacher is found in the same school the following year *t+1* it means that the teacher has stayed. Teachers in schools with more than 50% turnover in a particular year are removed from the dataset to make sure the analyses are not affected by administrative deficiencies. Teachers who are teaching less than 4 hours per week are also dropped from the dataset. Teachers are on average 42.92 years old,

87.4% is female, 6.57% has a temporary contract and they work 0.73 FTE on average (Appendix A, Table 1 and 3).

The DUO teacher data are linked to restricted-use microdata from Statistics Netherlands containing information on every individual registered in the Dutch Personal Records Database or filing tax returns with the Tax and Customs Administration. Information on the teacher's migration background, place of the teacher within a household compared to the main breadwinner, number of individuals in a household, household composition, household gross income and household home ownership will be used in the analyses, because these might influence teacher mobility decisions. For instance a single teacher residing in a rented property is likely to be more mobile than a couple with young children that owns a property. Household information is available from 2011 to 2017.

School data

Much of the school-level data come from DUO too. Because the teacher data are supplied at primary school institution level (BRIN-level) the numerical data for schools with multiple locations are aggregated. Data of the school location with most students is kept when data is categorical. To be able to look for heterogeneities in the effect of a tightening labor market on teacher mobility DUO provided information on school denomination, teaching concept, number of students in a school and the number of students with a particular student weight. The Ministry of Education provides extra resources to schools to support the education of disadvantaged students. To determine the amount of additional resources, a weight is assigned to every student based on the educational attainment of its parents. A weight of 1.2 is assigned when one parent has only primary education and the other parent completed at most level 3 in pre-vocational education (VMBO-KB), a weight of 0.3 is assigned when both parents completed at most level 3 in pre-vocational education. In all other cases a weight of 0.0 is assigned. From DUO's online open data, information on staff composition and student-teacher ratios (which can proxy class size) at primary school institution level are used. The open data also contain information on the number of (disadvantaged) students in a school which are used to fill in previously missing values. A school has on average 235 students and they are taught by 13 teachers (Appendix A, Table 2). The share of disadvantaged students weighted by their corresponding student weights relative to the total number of students in a school is on average 7.7%. It does not vary a lot over the years, but it does differ by region. Urban areas have a higher number of disadvantaged students. Student-teacher ratios are approximately 18, but are lower in highly urban areas. More than 45% of the teachers teach in urban areas.

Characteristics of the municipality or neighborhood of a school are added to the data using the postcode of the school. Statistics Netherlands publishes open data on the total population of a municipality. Data for 2018 was not yet available. Statistics Netherlands also publishes data on the urbanity of a municipality based on the number of addresses per square kilometer. Both sets of data should be corrected for municipality mergers.

Student data

Student enrollment data from 2008 to 2018 for students in primary education are accessible through Statistics Netherlands' restricted-use microdata. Since 2010 complete data for all students in primary education are available. The data is appended with information on student's migration background from Statistics Netherlands' dataset containing information on every individual registered in the Dutch Personal Records Database. Next, the data is aggregated to BRIN-level to be able to calculate the shares of western and non-western migrants in a school. The student enrollment data is also used in the analysis of the effects of teacher mobility in a tightening labor market on education quality, because it holds information on student's grade 8 test scores.

State of the teacher labor market

There are three forces that have been influencing the teacher labor market over the past years. Teachers have postponed their retirement (Adriaens, Fontein, & De Vos, 2018), which means that the proportion of old teachers has grown over the years (Figure 1). However, those teachers are currently starting to leave the teacher labor market contributing to the teacher shortage. Thereby, the amount of students graduating with a teaching certificate has been declining. Figure 2 shows that the proportion of young teachers has declined over the years.

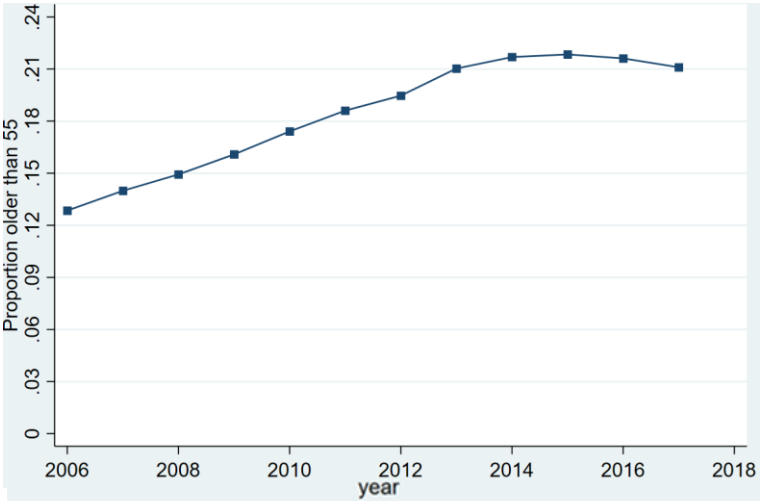

Figure 1: Proportion of teacher older than 55 years over time.

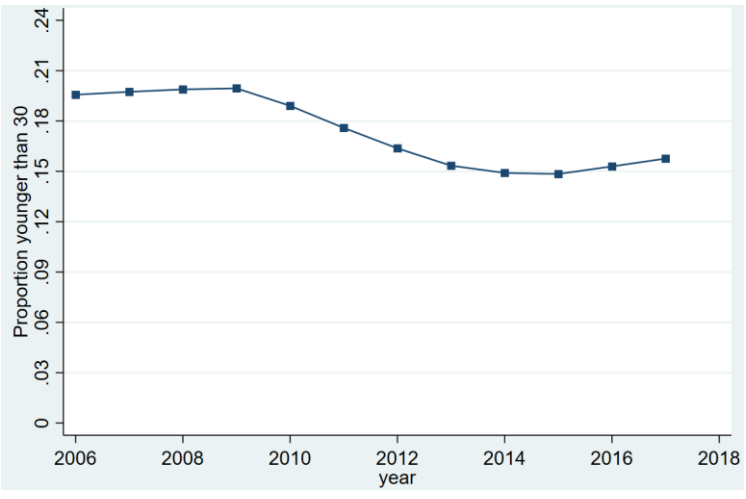

Figure 2: Proportion of teacher younger than 30 years over time.

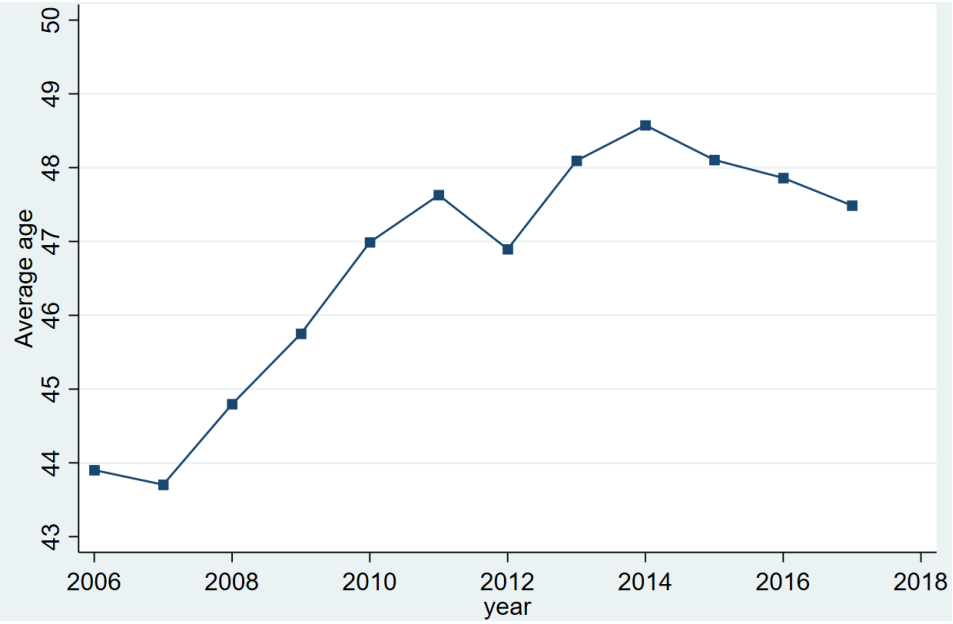

Figure 3: The average age of teachers that leave the primary education sector

Note: Teachers that leave in year t are teachers that are not found in the data in year t+1

Also the state of the national labor market has an impact on the state of the teacher labor market. Figure 3 shows that the average age of the leaving teachers has mostly been rising, which is line with the finding that teachers are retiring later. However, in the last years the average age of leaving teachers has gone down a little bit, which might be related to the state of the national labor market.

Countrywide vacancy data for the primary education sector covering all years to be analyzed are obtained from Statistics Netherlands. These are supplemented by data on the employed labor force of primary education teachers. Relative vacancy rates can be calculated by dividing the number of vacancies by the number of employed individuals. There are on average 4 open vacancies per 1000 employed individuals. The relative vacancy rates are standardized before being used in the analyses.

Dialogic compiled a dataset for the Ministry of Education with all vacancies in education that were published online from the third quarter of 2016 to the fourth quarter of 2018. This means that they provide a lower bound for the number of vacancies in a particular year, since they do not include vacancies that are published offline or vacancies spread through school networks. For this paper the vacancy data for primary education have been aggregated to regional level, distinguishing teaching staff from management and support staff. The aggregated data are not a perfect measure of the actual shortages in a region, but the number of advertised vacancies should increase when a region faces a shortage in the teacher labor market. The total number of teacher vacancies in FTE is 969, 2923 and 4108

for the years 2016, 2017 and 2018 respectively, varying widely by region. Dialogic had to make some judgements to clean and classify their data and to remove duplicate vacancies. This might introduce some noise in the measurement of the regional number of vacancies. Therefore this data will be used as a robustness check.

Descriptive patterns

Figure 4 shows the development of teacher mobility over time. Till 2014 approximately 90% of the teachers in year *t+1* are in the same school as they were in year *t.* From 2014 onwards mobility is increasing and it is highest in the year 2017. The figure indicates that almost 15% of the teachers are not teaching in the same school in 2018 as in 2017. This is mainly caused by a sharp increase of teachers that move from one school to another in year *t+1,* from 4.26% in 2013 to 7.46% in 2017. The relative vacancy rate over time is also shown to be increasing from 0.24% in 2012 to 0.58% in 2017 (figure 5). Thus the increase in teacher mobility seems to coincide with a tightening of the teacher labor market.

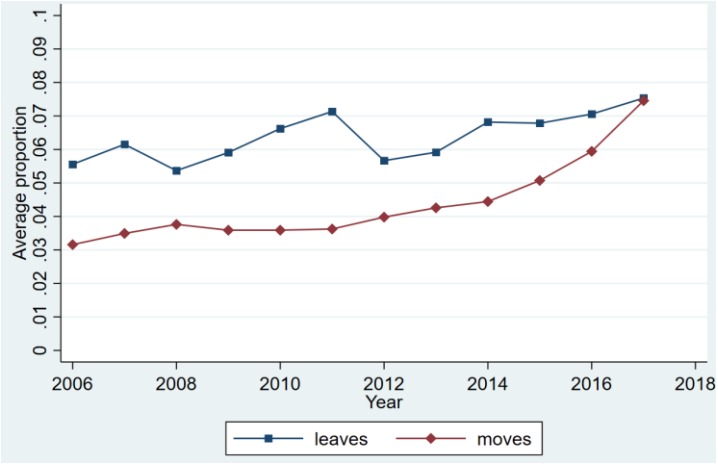

Figure 4: Teacher mobility over time broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed.

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1.

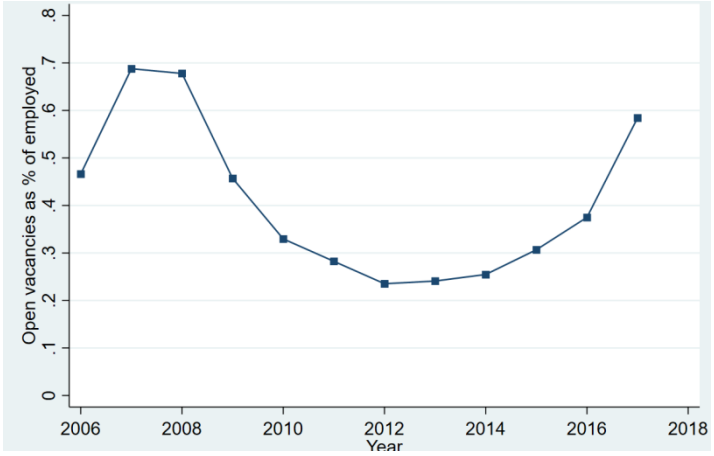

Figure 5: Relative vacancy rate over time

Note: The relative vacancy rate is the number of open vacancies in year t in primary education divided by the number of employed individuals in year t in primary education

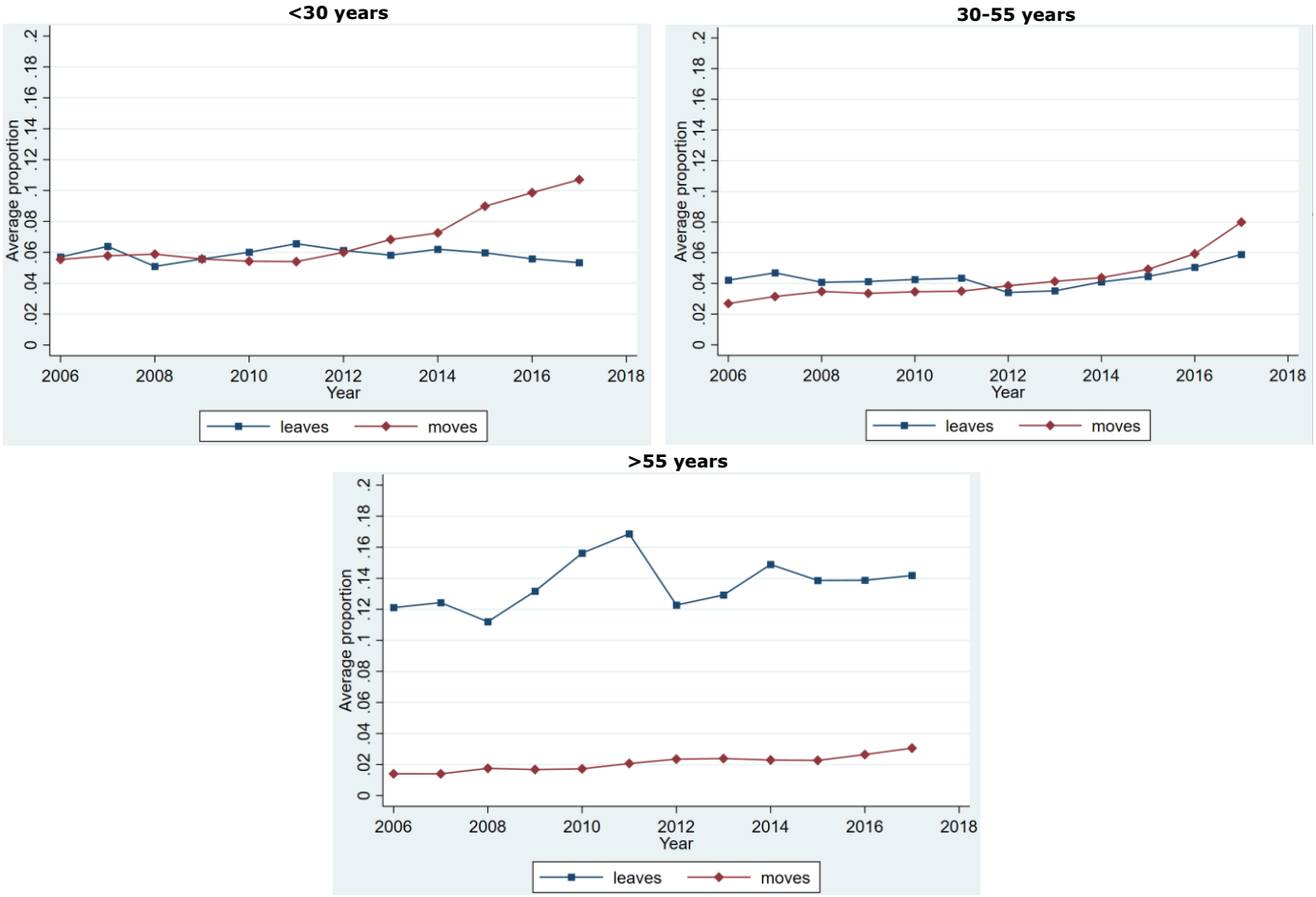

Figure 6: Teacher mobility over time for teachers in different age brackets. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed.

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1.

Figure 6 shows teacher mobility for three age brackets. Little seems to have changed for the age bracket 55+ in recent years. On the contrary, teachers in the lowest age bracket have started to be increasingly mobile in recent years. Also teachers in the middle age bracket show increasing mobility. Again this is mainly caused by a rise in the proportion of teachers that move from one school to another. Teacher mobility in schools characterized as high Socioeconomic Status (SES) as well as in schools characterized as low SES by their respective shares of disadvantaged students has been increasing over the past few years (figure 7).

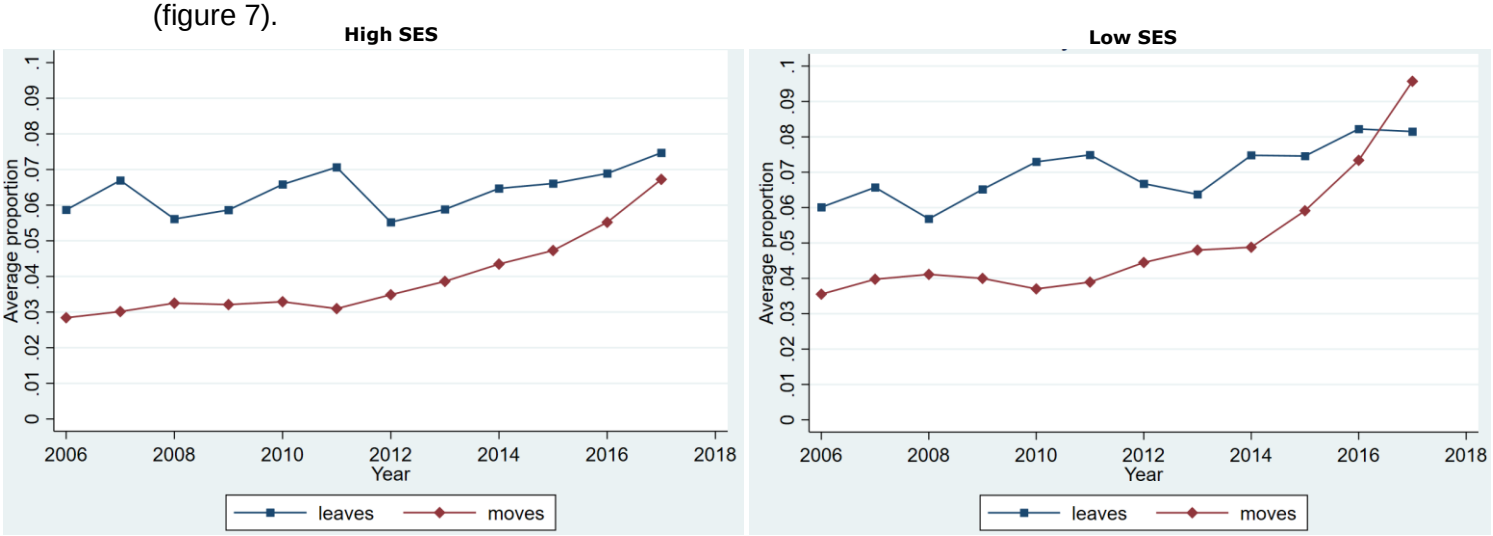

Figure 7: Teacher mobility over time for high Socioeconomics Status (SES) and low SES schools. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed.

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1. High SES schools are schools in the quartile with least disadvantaged students measured by student weights. Low SES schools are schools in the quartile with most disadvantaged students.

However, the increase in mobility has been larger for low SES schools than for high SES schools. Finally, figure 8 shows how the average teacher age at school-year level decreases when turnover increases. This is in line with hypotheses three. More experienced teachers provide higher quality education, thus when the average teacher age decreases it is expected that the quality of education decreases. Higher turnover seems to reduce education quality.

Additional figures and tables with descriptive statistics on teachers, schools and students for the years 2009, 2011, 2017 and for the full period can be found in the Appendix A.

.

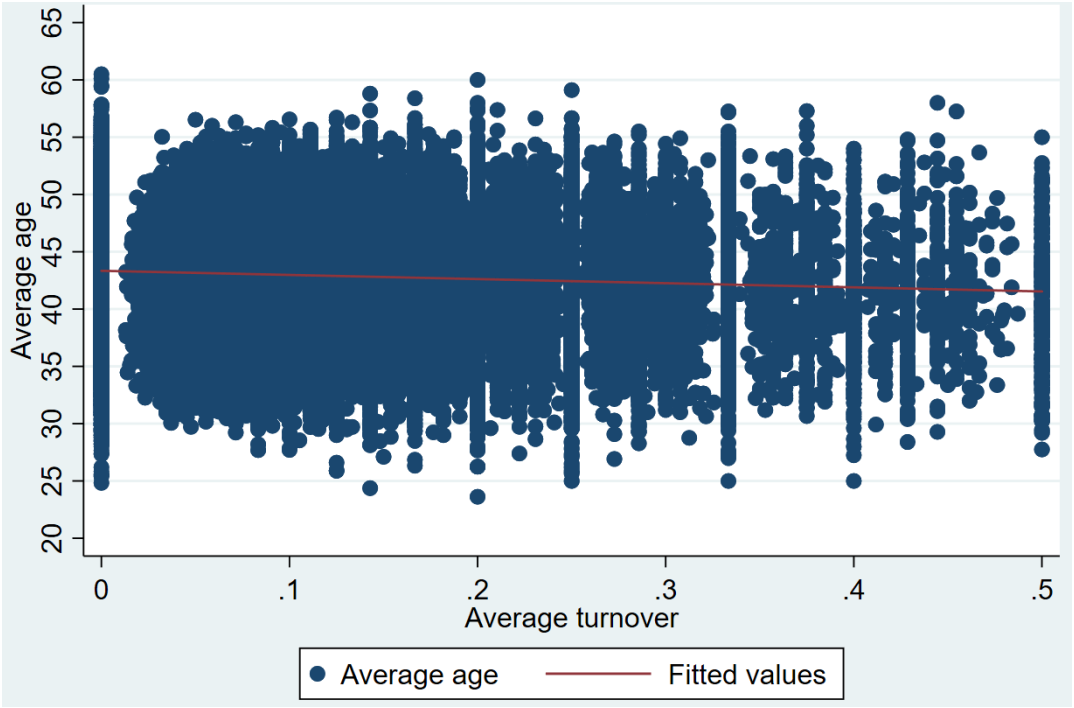

Figure 8: Average age and average turnover at school-year level

Note: Every dot represents the mean age of the teacher staff in school j in year t and the proportion of teachers that were teaching in school j in year t-1, but that are not teaching in school j in year t

4. Empirical strategy

The determinants of teacher mobility

The first analyses will be descriptive in nature and study the determinants of teacher mobility in The Netherlands. For this, Ordinary Least Squares (OLS) regressions with school fixed effects will be used. Teachers select themselves into schools based on observed and unobserved school characteristics. The analyses will be biased if these school characteristics are (a) correlated to the outcome variable, (b) correlated to regressor of interest and (c) not included in the regression models. School fixed effects account for unobserved omitted school-level variables that do not vary over time.

Estimation of equation 1 will provide insights in the factors determining teacher turnover in The Netherlands.

$$T_{is\,t+1} = \alpha + \gamma\, Z_{ist} + \delta\, S_{st} + \lambda_s + \tau_t + \eta_{ist} \qquad (1)$$

Turnover ***T*=1** when teacher ***i*** working in school ***s*** in year ***t*** is not working in school ***s*** in year ***t+1***, ***T=0*** otherwise. ***Z*** is a vector of teacher characteristics that might determine teacher turnover according to the literature. It includes age, gender, migration background, contract size and contract type in all analyses and household composition, family home ownership and the logarithm of gross family income for analyses using data from 2011 and onwards. ***S*** is a vector of school characteristics that might determine teacher turnover. It includes school size, the share of disadvantaged students, urbanity indicators and student-teacher ratios. ***λ*** denotes the school fixed effects and ***τ*** denotes year fixed effects, accounting for time-varying country-wide policies or other country-wide shocks that might impact turnover. ***η*** is the error term. Standard errors are clustered at school-level because the error terms of teachers are likely to be correlated, since they are exposed to the same environment. Standard errors might increase when clustering is not applied.

To causally interpret the results it would be necessary to assume that unobserved time-varying and time-fixed teacher-level variables and unobserved time-varying school-level variables are unrelated to the outcome variable and the regressors of interest. Including school-by-year fixed effects or teacher fixed effects could bring causal interpretation nearer, but their inclusion would preclude the estimation of the effects of school factors that do not change across teachers within schools or the effects of fixed teacher characteristics. Thereby, the inclusion of teacher fixed effects would only allow for examination of the set of teachers who turned over at least once in the period under examination and not of the set of teachers who always stayed in the same school in that period.

Next, the standardized vacancy rate ***V*** is added to equation 1 to determine the impact of a tightening teacher labor market on teacher turnover. The vacancy rate is calculated by dividing the number of open unfilled vacancies in primary education in year ***t*** by the number of employed primary education teachers in year ***t***. Thus, it measures the relative teacher shortage in the teacher labor market. It is therefore different from teacher turnover, firstly because turnover not necessarily leads to an increase of unfilled vacancies, secondly because it measures the relative number of vacancies in the year before the teacher decides to turnover. Because vacancy rates are only available at national level each year, year fixed effects cannot be added to the analysis anymore. This may introduce bias from factors that are changing over time at national level and that are correlated to turnover and the vacancy rate. Robustness checks will be performed to determine the consequences of the lack of inclusion of year fixed effects by using an alternative labor market tightening indicator from Dialogic that varies at region-by-year level.

Mobility outcomes are binary, but OLS regressions assume that the values of the outcome variable can be negative or greater than one. Therefore, equation 1 is also estimated with a multinomial logit model. Teacher stay is used as the reference outcome, while teacher movement to another school and teachers leaving the primary education sector are the other outcomes. This analysis will also include the standardized vacancy rate ***V.*** Since school fixed effects cannot be used in the multinomial logit model, additional covariates with school characteristics are used to control for time-fixed school-level variables that might bias the results. These covariates include school type, school denomination, teaching concept and if the school is situated in the 'Randstad'.

The determinants of teacher mobility in a tightening teacher labor market

Standardized vacancy rate ***V*** is interacted with school and teacher characteristics to find the effects of teacher mobility determinants on teacher mobility in a tightening teacher labor market. This gives rise to equation 2.

$$M_{is\,t+1} = \alpha + \beta\, V_t + \gamma\, Z_{ist} + \delta\, S_{st} + \theta\, Z_{ist} * V_t + \pi\, S_{st} * V_t + \lambda_s + \eta_{it} \qquad (2)$$

Equation 2 is analyzed for three mobility outcomes (***M***).

- The first outcome is 'turnover' as defined in equation 1. ***M*=1** when teacher ***i*** working in school ***s*** in year ***t*** is not working in school ***s*** in year ***t+1***, ***M=0*** otherwise.
- The second outcome is teacher movement from one school to another. In this case ***M*=1** when teacher ***i*** working in school ***s*** in year ***t*** is working in another school in year ***t+1***, ***M=0*** otherwise.

- The third outcome is if a teacher leaves the primary education sector. In that case ***M*=1** when teacher ***i*** working in school ***s*** in year ***t*** is not working in the primary education sector anymore in year ***t+1***, ***M=0*** otherwise.

Again results should be interpreted cautiously for reasons mentioned before: the lack of inclusion of year fixed effects, not accounting for factors that change by school year and for omitted teacher-level variables that might be correlated with the regressors of interest and teacher mobility.

Teacher mobility, tightening teacher labor markets and education quality

After determining the relationship between teacher and school characteristics and teacher mobility in a tightening teacher labor market, hypothesis 3 about the effects of teacher mobility in a tightening teacher labor market on education quality will be examined for three outcomes: the average teacher age in a school, standardized grade 8 test scores of students and student grade retention.

From the literature it is known that education quality increases when teacher experience increases. This effect is particularly strong for teachers with little experience. Therefore equation 3 uses the average teacher age as a proxy for education quality, assuming that a low average teacher age signifies a low quality of education.

$$A_{st} = \alpha + \beta\, V_t + \delta\, S_{st} + \theta\, T_{s\,t-1} + \pi\, T_{s\,t-1} * V_t + \lambda_s + \eta_{it} \qquad (3)$$

A is the average teacher age at school ***s*** in year ***t***. Again ***V*** denotes the state of the teacher labor market. ***T*** is an indicator of teacher turnover aggregated at school level equaling the proportion of previous year teachers that were teaching in school ***s*** in year ***t-1***, but are not teaching in school ***s*** in year ***t***. ***S*** is a covariate of school characteristics including the proportion of female teachers, the proportion of temporary teachers, the average teacher contract size, teacher household characteristics, school size, share of disadvantaged students, urbanity and student-teacher ratios. All these tend to be correlated with turnover and are likely to be correlated with the average teacher age as well. School fixed effects (***λ)*** are included and standard errors are clustered at school-level. To allow for a causal interpretation, time-varying school unobservables and country-wide shocks should be unrelated to the average teacher age, the relative vacancy rate and the aggregate turnover at school level.

Equation 4 will be estimated using OLS regressions with school fixed effects as well.

$$A_{ist} = \alpha + \beta\, V_t + \gamma\, Z_{ist} + \delta\, S_{st} + \theta\, T_{s\,t-1} + \mu P_{st} + \pi\, T_{s\,t-1} * V_t + \lambda_s + \eta_{it} \qquad (4)$$

A is the standardized grade 8 test score for student ***i*** in school ***s*** in year ***t***. ***Z*** is a vector of student characteristics such as gender, disadvantaged student's school weight, migration background, family home ownership, household composition and disposable household income. ***S*** comprises the school characteristics: school size, urbanity and student-teacher ratio. Grade 8 peer effects (***P***) accounting for shares of migrants, shares of disadvantaged students and the share of students from the lowest quartile of the disposable income distribution are also included. Turnover aggregated at school level ***T*** equals the proportion of previous year teachers that were teaching in school ***s*** in year ***t-1***, but are not teaching in school ***s*** in year ***t***. ***V*** is the standardized vacancy rate denoting the state of the labor market, ***λ*** denotes the school fixed effects and ***η*** is the error term, which is clustered at school-level.

This analysis resembles the analysis of Hanushek, Rivkin and Schiman (2016) who estimate the effect of teacher turnover on student test scores in Texas using two methods to account for non-random sorting of students and teachers among grades. In the first case they include grade-by-year level fixed effects, in the second case they aggregate teacher turnover to school-by-year level. Both methods find the same effect of turnover on student test scores. Hanushek et al. (2016) also investigate the bias that could be introduced by not accounting for unobserved school policies that change over time or other unobserved school-wide shocks. Wherefore, they include school-by-year fixed effects to the model that has grade-by-year fixed effects already. They find that the coefficients hardly change, which indicates that the bias might be small. Since, the student test score data from Statistics Netherlands are only available for the final grade the present analysis builds upon the second method of Hanushek, Rivkin and Schiman assuming that unobserved time-varying school factors are also not significantly biasing coefficients in the Netherlands. Hanushek et al. (2016) could also access student's test scores from previous years and information on the number of teachers that switched grades, which cannot be included in the analysis for the Dutch case.

Finally, equation 4 will be estimated using student grade retention instead of student test scores as the outcome variable.

5. Teacher mobility determinants in The Netherlands

The determinants of teacher turnover

There are several factors significantly associated with teacher mobility in The Netherlands. The first is teacher age. Table 1 shows that teachers who are 55 years or older are more likely to turnover than teachers between 36 and 40 with and without additional covariates containing household characteristics (column (1) & (2)). For teachers under 30 the coefficient shrinks when adding covariates. Table 1 column 1 shows the probability of turnover to be 2.6 percentage points higher for a teacher between 21 and 25 than for a teacher aged between 36 and 40. By adding covariates with household information to the regression model, young age no longer significantly determines turnover (Table 1, column (2)). This means that household characteristics such as having a partner or owning a house are negatively correlated with this age bracket and negatively correlated with turnover. Also contract type is strongly correlated with the young age bracket. When not controlling for contract type the coefficient for teachers between 21 and 25 is almost four times larger (Appendix B, Table 1; column (1)). This indicates that a large part of young teacher turnover could be explained by their possession of a temporary contract. In general, teachers with a temporary contract have an approximately 19 percentage point higher probability of turnover than teachers with a permanent contract.

Furthermore, female teachers are consistently less likely to turnover than male teachers. Contract size is also significantly associated with turnover. Teachers with bigger contracts are less likely to turnover. Holding all else equal teachers seem to prefer bigger schools over smaller schools, though the coefficients are never statistically significant.

Two surprising results are found when looking at teacher preferences about the share of disadvantaged students and student-teacher ratios. Contrary to expectations, teachers seem to be less likely to turnover in schools with a high share of disadvantaged students and in schools with higher student-teacher ratios. This could be explained by the effect that the attributes of the current job might have on turnover. Bonhomme et al. (2016) found that a high share of disadvantaged students in a school limits the opportunities of a teacher to move to another school. If this is true such teachers should be more likely to move in a tight teacher labor market. This will indeed be shown in the next section.

TABLE 1

Estimated effects of teacher and school characteristics on teacher turnover, moving to another school and leaving primary education

	Turnover			**Move**		**Leave**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Relative vacancy rate (standardized)			0.018 ***	0.016 ***	0.016 ***	0.002 ***	0.003 ***
			(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Age (ref. 36-40)							
age 21-25	0.026 ***	-0.002	-0.002	0.031 ***	0.022 ***	-0.005 **	-0.025 ***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
age 26-30	0.011 ***	-0.005 **	-0.005 **	0.010 ***	0.007 ***	0.002 *	-0.012 ***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
age 31-35	0.007 ***	0.003 **	0.003 **	0.006 ***	0.005 ***	0.002 **	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
age 41-45	-0.004 **	-0.003 **	-0.003 **	-0.003 **	-0.003 **	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
age46-50	-0.007 ***	-0.005 ***	-0.006 ***	-0.007 ***	-0.007 ***	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
age 51-55	-0.010 ***	-0.011 ***	-0.012 ***	-0.015 ***	-0.015 ***	0.004 ***	0.003 **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
age 56-60	0.015 ***	0.007 ***	0.006 ***	-0.023 ***	-0.024 ***	0.039 ***	0.030 ***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
age 61-65	0.226 ***	0.211 ***	0.212 ***	-0.030 ***	-0.032 ***	0.263 ***	0.249 ***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
age 65+	0.167 ***	0.146 ***	0.146 ***	-0.077 ***	-0.081 ***	0.251 ***	0.231 ***
	(0.032)	(0.033)	(0.033)	(0.019)	(0.019)	(0.031)	(0.032)
Female	-0.045 ***	-0.046 ***	-0.046 ***	-0.017 ***	-0.017 ***	-0.031 ***	-0.032 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Contract size (ref. <0.5)							
0.5-0.8 FTE	-0.058 ***	-0.059 ***	-0.059 ***	-0.016 ***	-0.017 ***	-0.047 ***	-0.048 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
0.8+ FTE	-0.082 ***	-0.094 ***	-0.094 ***	-0.026 ***	-0.030 ***	-0.064 ***	-0.073 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Temporary contract	0.197 ***	0.190 ***	0.191 ***	0.105 ***	0.103 ***	0.119 ***	0.115 ***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
School size (ref. 300-400)							
0-100 students	0.001	0.001	0.002	0.011 **	0.011 **	-0.010 *	-0.010 *
	(0.007)	(0.007)	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)
100-200 students	0.008 **	0.008 **	0.008 **	0.011 ***	0.011 ***	-0.002	-0.002
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
200-300 students	0.003	0.003	0.003	0.006 **	0.006 **	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
400-500 students	-0.008 **	-0.008 **	-0.008 **	-0.006 **	-0.006 **	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
>500 students	-0.001	-0.001	-0.001	0.001	0.001	-0.002	-0.002
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.003)	(0.003)
Share of disadvantaged students							
2nd quartile	0.001	0.001	-0.001	-0.002	-0.002	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
3rd quartile	0.000	0.000	-0.003	-0.001	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
4th quartile	-0.001	-0.001	-0.006	-0.005	-0.005	-0.001	-0.001
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Urbanity (ref. Very Urban)							
Urban	0.003	0.002	-0.001	-0.001	-0.001	0.000	0.000
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.003)	(0.003)
Moderately Urban	-0.003	-0.003	-0.011	-0.013 **	-0.013 **	0.003	0.002
	(0.007)	(0.007)	(0.007)	(0.005)	(0.005)	(0.004)	(0.004)
Little Urban	-0.011	-0.011	-0.023 **	-0.023 ***	-0.023 ***	0.000	0.000
	(0.008)	(0.008)	(0.008)	(0.007)	(0.006)	(0.006)	(0.006)
Rural	-0.005	-0.005	-0.021 **	-0.018 **	-0.018 **	-0.002	-0.003
	(0.011)	(0.011)	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)
Student-teacher ratio	-0.008 ***	-0.008 ***	-0.008 ***	-0.004 ***	-0.004 ***	-0.004 ***	-0.004 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Position in household (ref. Breadwinner without Partner)							
Main breadwinner with Partner		-0.019 **	-0.020 **		-0.016 **		-0.005
		(0.006)	(0.006)		(0.005)		(0.005)
Partner		-0.024 ***	-0.025 ***		-0.020 ***		-0.007
		(0.006)	(0.006)		(0.005)		(0.005)
Child		0.026 ***	0.026 ***		0.003		0.025 ***
		(0.006)	(0.006)		(0.005)		(0.004)
Home ownership (ref. Home owner)							
Rented property without housing benefits		0.005 ***	0.006 ***		0.003 **		0.003 **
		(0.001)	(0.001)		(0.001)		(0.001)
Rented property with housing benefits		0.029 ***	0.029 ***		0.014 ***		0.020 ***
		(0.005)	(0.005)		(0.004)		(0.004)
Household composition (ref. Other)							
Couple with children		-0.013	-0.012		0.007		-0.021 ***
		(0.008)	(0.008)		(0.006)		(0.006)
Single parent		-0.020 **	-0.020 **		0.001		-0.023 ***
		(0.006)	(0.006)		(0.005)		(0.005)
Single person		-0.004	-0.004		-0.001		-0.004
		(0.006)	(0.006)		(0.005)		(0.005)
Couple without children		0.014 *	0.014 *		0.010		0.005
		(0.008)	(0.008)		(0.006)		(0.006)
Adjusted r2	0.068	0.070	0.070	0.027	0.028	0.083	0.085
Number of observations	748,759	748,759	748,759	698,700	698,700	748,759	748,759
Additional teacher level covariates	No	Yes	Yes	No	Yes	No	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No	No	No	No
Years	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of teacher and school characteristics on teacher turnover in column 1-3 (teacher in year *t* turnsover if he or she is not found in the same school in *t+1)* teacher movement to another school in column 4 and 5 (teacher *i* in year *t* moves to another school if he or she is found in another school in year *t+1)* and teachers leaving the primary education sector in column 6 and 7 (teacher *i* in year *t* leaves primary education if he or she is not found in the data in year *t+1).* Additional covariates include migration background, family gross income, independant school and the number of staff. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

The household characteristics determining teacher turnover are showing the expected signs. Teachers are less likely to turnover when they have a partner, when they have children and when they own a house compared to renting a property.

Column 3 of table 1 displays the impact of a tightening teacher labor market on turnover. A one standard deviation increase in the relative vacancy rate leads to a 1.8 percentage point higher probability of turnover holding all else equal. The coefficient is statistically significant. By including the country-level relative vacancy rate, year-fixed effects can no longer be accounted for. This might introduce bias from factors at country-level that are changing over time which are correlated with turnover and with the variable of interest. This should not be too much of a concern, because coefficients do not change much when estimating the model in column 2 without year-fixed effects (Appendix B; Table 1, column (3)).

Turnover broken down by moving and leaving teachers

Columns 4-7 in Table 1, break down the effects of the determinants of teacher turnover by the effects on the probability that a teacher moves to another school and the effects on the probability that a teacher leaves the primary education sector entirely. For most variables the signs of the determinants of these two outcomes and the turnover outcome in the first columns are the same, but the magnitude differs between moving and leaving teachers. However, there are also cases where the sign of a mobility determinant is opposite between the two outcomes.

The impact of a one standard deviation change in the relative vacancy rate is almost 7 times larger on moving than on leaving. The results also show that teachers aged between 21 and 25 are significantly more likely to move to another school than teachers between 36 and 40 (Table 1, column (4)). The coefficient is smaller though still significantly positive when adding covariates containing household characteristics to the model (Table 1, column (5)). In contrast, young age is negatively related to the probability of leaving the primary education sector and the additional covariates lower the coefficient substantially (Table 1, column (6) & (7)). Teachers who are 55 years or older are less likely to move to another school, but more likely to leave the primary education sector.

Contract size is associated more strongly with a teacher's decision to leave than with his or her decision to move. School characteristics such as school size, share of disadvantaged students and urbanity of the area seem to be important in the determination of movement, but not so much in the determination of leaving. Teachers are less likely to move when they

are in a school in a rural area and they are more likely to move when they are in a smaller school.

The position of a teacher in a household seems to determine teacher movement, whereas household composition seems to determine teacher leaving, except when the position of a teacher in the household is ‘child’. When a teacher is still living with his or her parents he or she is more likely to leave the primary education sector, while he or she is not more likely to move to another school.

The same patterns can be seen in the multinomial logit models which accounts for the binary nature of the outcome variables, the models cannot control for school-fixed effects however (Appendix B, table 2). Younger teachers are more likely to move between schools, while older teachers are more likely to leave the primary education sector. School-level variables are more important in determining teacher movement, whereas teacher level variables are more important in determining teacher leaving the primary education sector. Also the tightening of the labor market has a stronger impact on teacher movement than on the decision of a teacher to leave the primary education sector.

6. Main results

The determinants of teacher mobility in a tightening teacher labor market

Teacher labor market tightening seems to significantly influence teacher mobility, but it is not yet clear how teacher labor market tightening influences the relationship between teacher mobility and its determinants. In a teacher labor market with an average relative vacancy rate of 4 open vacancies per 1000 employed individuals the relationships between teacher and school characteristics and teacher mobility are as described in the previous chapter. Besides, the effects of several determinants of teacher mobility differ over the state of the teacher labor market. Table 2 indicates that teachers aged 21 to 30 are significantly less likely than teachers who are between 36 and 40 years old to move to another school or leave the primary education sector when the teacher labor market tightens. If the teacher labor market becomes one standard deviation tighter (an increase of approximately 1.5 open vacancies per 1000 employed individuals) those teachers are 0.7 percentage points less likely to move to another school, though they are still 1.2 percentage points more likely to move to another school than teachers between 36 and 40 (Table 2, column (2)). Another way of interpreting this result is by noting that teachers in almost all age categories are less likely to move or leave teaching when the teacher labor market tightens. This implies that teachers between 36 and 40 are increasingly likely to move to another school or leave the primary education sector when the teacher labor market tightens. Another significant finding is that also older teacher are less likely to leave the primary education sector when there is an increased demand for teachers. A one standard deviation rise of the relative vacancy rate increases the probability that a 61-65 year old teacher stays in teaching by 4.2 percentage points (Table 2, column (3)). Teachers with more FTE are even less likely to turnover in a tightening teacher labor market. Another interesting result is that teachers with a temporary contract are more than 5 percentage points less likely to leave teaching in a one standard deviation tighter teacher labor market. Those teachers might get a permanent contract more easily in those times and might therefore chose to stay in primary education. The net effect of the possession of a temporary contract on teacher leave is still positive.

Lesser urban schools become even more attractive to teachers in a tight teacher labor market. Lastly, table 2 displays that teachers prefer not to teach in schools with a higher share of disadvantaged students. After interacting the relative vacancy rate with the quartiles of disadvantaged students shares, the 4^{th} quartile coefficient becomes positive, though not significant. The interaction term indicates that teachers who are teaching in a school which is in the 4^{th} quartile of the share of disadvantaged students have a 1 percentage point higher

probability to move to another school when the relative vacancy rate increases by one standard deviation than teachers who are teaching in a school which is in the 1st quartile of the share of disadvantaged students (Table 2, column (2)). This is in line with the hypothesis that the attributes of the current job of these individuals might limit their opportunities to move to another school in a loose labor market, but if they get the opportunity teachers still prefer to teach in a school with less disadvantaged students.

All analyses in this paragraph use a measure of teacher labor market tightening that is set at national level. Yet, tightness of the teacher labor market can also vary over regions. Therefore, the models from Table 2 are rerun with the number of advertised vacancies per region compiled by Dialogic as an indicator of teacher labor market tightening that varies over regions. The results (Appendix B, Table 3) show that the signs of the coefficients of the determinants of teacher mobility are robust to this different measure of teacher labor market tightening. The tightening of the labor market still has a positive relationship with teacher turnover (Appendix B, Table 3; column (1)). Thereby, significant results are still found for older teachers and teachers with a temporary contract who are both less likely to leave the primary education sector when the teacher labor market tightens (Appendix B, Table 3; column (7)). There is also still significant evidence that rural schools are more attractive to teachers in a tight teacher labor market and that teachers who are teaching in a school which is in the 4th quartile of the share of disadvantaged students have a higher probability to move to another school. Not all coefficients are still statistically significant. This might have two reasons. Firstly, the alternative vacancy variable is only available for the years 2016 and 2017, which leads to an increase of the standard errors, because there is less variation in the variables in the models. Secondly, the alternative vacancy variable might be measured imprecisely, which would bias the coefficients towards zero.

The analyses with the alternative measure of teacher labor market tightening also addresses the concern of biased coefficients caused by the lack of inclusion of year-fixed effects. The coefficients in the models estimated with and the models estimated without fixed-effects do not differ considerably, except for the coefficient on the number of advertised vacancies per region. Therefore, conclusions about the magnitude of the impact of a tightening teacher labor market on turnover should be drawn cautiously. Also the other results should be interpreted cautiously, since there might still be unobserved time-varying school-level variables or unobserved teacher-level variables that are correlated with teacher mobility and the determinants of teacher mobility.

TABLE 2

Estimated effects of teacher and school characteristics on turnover, moving to another school and leaving primary educationin a tightening teacher labor market

	Turnover	Move	Leave
	(1)	(2)	(3)
Relative vacancy rate (standardized)	0.058 ***	0.035 ***	0.028 ***
	0.004	0.003	0.003
Age (ref. 36-40)			
age 21-25	-0.012 ***	0.019 ***	-0.033 ***
	0.003	0.003	0.002
age 26-30	-0.009 ***	0.005 **	-0.015 ***
	0.002	0.002	0.001
age 31-35	0.007 ***	0.008 ***	0.000
	0.002	0.002	0.001
age 41-45	-0.006 **	-0.005 **	-0.001
	0.002	0.002	0.001
age46-50	-0.008 ***	-0.009 ***	0.001
	0.002	0.002	0.001
age 51-55	-0.016 ***	-0.018 ***	0.002
	0.002	0.002	0.001
age 56-60	-0.007 ***	-0.032 ***	0.024 ***
	0.002	0.001	0.001
age 61-65	0.186 ***	-0.040 ***	0.231 ***
	0.003	0.002	0.002
age 65+	0.140 ***	-0.081 ***	0.228 ***
	0.034	0.021	0.032
Contract size (ref. <0.5)			
0.5-0.8 FTE	-0.062 ***	-0.018 ***	-0.051 ***
	0.002	0.001	0.001
0.8+ FTE	-0.099 ***	-0.033 ***	-0.076 ***
	0.002	0.001	0.002
Temporary contract	0.170 ***	0.100 ***	0.093 ***
	0.003	0.003	0.002
Share of disadvantaged students			
2nd quartile	-0.001	-0.001	0.001
	0.002	0.002	0.002
3rd quartile	-0.002	-0.001	-0.001
	0.003	0.002	0.002
4th quartile	0.003	0.003	0.001
	0.004	0.003	0.003
Urbanity (ref. Very Urban)			
Urban	0.002	0.001	0.001
	0.005	0.004	0.003
Moderately Urban	-0.011	-0.013 **	0.002
	0.007	0.005	0.004
Little Urban	-0.029 ***	-0.028 ***	-0.001
	0.008	0.007	0.006
Rural	-0.037 ***	-0.034 ***	-0.004
	0.010	0.008	0.008

TABLE 2 (continued)

Interactions with the relative vacancy rate			
Age (ref. 36-40)			
age 21-25	-0.018 ***	-0.007 **	-0.014 ***
	0.003	0.003	0.002
age 26-30	-0.010 ***	-0.004 **	-0.007 ***
	0.002	0.002	0.001
age 31-35	0.006 **	0.005 **	0.001
	0.002	0.002	0.001
age 41-45	-0.005 **	-0.004 **	-0.001
	0.002	0.002	0.002
age46-50	-0.006 **	-0.004 **	-0.002
	0.002	0.002	0.002
age 51-55	-0.009 ***	-0.007 ***	-0.003 **
	0.002	0.002	0.001
age 56-60	-0.026 ***	-0.015 ***	-0.013 ***
	0.002	0.002	0.002
age 61-65	-0.059 ***	-0.020 ***	-0.042 ***
	0.003	0.002	0.003
age 65+	-0.033	0.008	-0.029
	0.030	0.020	0.030
Contract size (ref. <0.5)			
0.5-0.8 FTE	-0.005 **	-0.001	-0.006 ***
	0.002	0.001	0.001
0.8+ FTE	-0.009 ***	-0.005 ***	-0.006 ***
	0.002	0.001	0.001
Urbanity (ref. Very Urban)			
Urban	-0.015 ***	-0.013 ***	-0.003 **
	0.002	0.002	0.001
Moderately Urban	-0.019 ***	-0.015 ***	-0.006 ***
	0.003	0.002	0.002
Little Urban	-0.022 ***	-0.018 ***	-0.006 ***
	0.002	0.002	0.001
Rural	-0.026 ***	-0.024 ***	-0.005 **
	0.003	0.002	0.002
Temporary contract	-0.047 ***	-0.004	-0.051 ***
	0.003	0.003	0.002
Share of disadvantaged students			
2nd quartile	0.000	0.001	-0.001
	0.002	0.001	0.001
3rd quartile	0.000	0.001	-0.001
	0.002	0.001	0.001
4th quartile	0.010 ***	0.010 ***	0.001
	0.002	0.002	0.001
Adjusted r2	0.072	0.029	0.088
N	748,759	698,700	748,759
Additional teacher level covariates	Yes	Yes	Yes
School FE	Yes	Yes	Yes
Year FE	No	No	No
Years	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of teacher and school characteristics on teacher turnover in column 1, teacher movement to another school in column 2 and teachers leaving the primary education sector in column 3 (for definitions see Table 1). Additional covariates include gender, migration background, position in household, home ownership, household composition, family gross income, independant school, school size, student-teacher ratio and the number of staff. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

Lastly, the model of Table 1 column 2 is estimated for teachers in the 4 biggest cities of The Netherlands (Amsterdam, Rotterdam, The Hague and Utrecht) and teachers in the surrounding areas respectively (Appendix B, Table 4). The findings for the different determinants of teacher mobility are in several cases similar to the findings for the determinants of teacher mobility in a tightening teacher labor market assuming that the teacher labor market is tighter in the 4 cities than in the surrounding areas. For example older teachers and teachers with a temporary contract are both less likely to leave the primary education sector in the big cities comparing them to teachers in the surrounding areas. Gerritsen, Kuijpers and van der Steeg (2015) mention that the costs of living might be higher in those cities and there could be more alternative job opportunities, this might lead to teacher shortages. Thereby, the Ministry of Education, Culture and Science (2019) points out that Amsterdam and Rotterdam are the cities that are most likely to face high teacher shortages in a tightening labor market. In this context it is interesting to notice that gross family income has a significantly negative effect on the probability on teacher movement in the big cities, but not in the surrounding areas. It should be noted however that there might be mobility between the cities and the surrounding areas which keeps the composition of the teacher labor force changing.

Turnover and the effects on average teacher age

Several teacher and school characteristics seem to be significantly related to teacher turnover (in a tightening teacher labor market). To study how turnover impacts education quality, a model is estimated with average teacher age at school-level as the dependent variable. The model also includes variables which are significantly related to teacher age and have been found to be correlated with turnover in the previous section. Average teacher age serves as a proxy for teacher experience.

According to Table 3 column 1, the average teacher age decreases by 0.25 years ceteris paribus when turnover in a school increases by 10 percentage points. The coefficient is statistically significant. Column 2 shows that the coefficient of the turnover variable decreases slightly when excluding year-fixed effects. The year-fixed effects cannot be included in the analysis of Table 3 column 3, because of the inclusion of the yearly relative vacancy rate. Column 3 shows that a 10 percentage point increase of turnover, in a teacher labor market with an average relative vacancy rate of 3 open vacancies per 1000 employed individuals[1], reduces the average teacher age in a school by 0.37 years. If the teacher labor

[1] The relative vacancy rate is standardized for a different period in the paragraph on the determinants of teacher mobility in a tightening teacher labor market than in the other paragraphs, which means that the means and standard deviations of the relative vacancy rate differ between the chapters.

TABLE 3

Estimated effects of turnover on average teacher age and proportion of novice teachers

	Average teacher age			Proportion young teachers
	(1)	(2)	(3)	(4)
Turnover	-2.521 ***	-2.658 ***	-3.783 ***	0.092 ***
	(0.157)	(0.159)	(0.207)	(0.007)
Relative vacancy rate (standardized)			0.270 ***	-0.012 ***
			(0.031)	(0.001)
Relative vacancy rate * Turnover			-2.228 ***	0.061 ***
			(0.212)	(0.008)
Adjusted r2	0.156	0.145	0.151	0.143
Number of observations	42,918	42,918	42,918	42,918
Additional teacher level covariates	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	No
Years	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of school-level turnover and the standardized vacancy rate on the average teacher age in column 1-3 and the proportion of teachers under 30 in column 4. Additional covariates include share of female teachers, average contract size, share of teachers with a temporary contract, school size, share of disadvantaged students, urbanity, student-teacher ratio, share of couples with children, share of couples without children, share of single parents and the share of single teachers. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

market becomes tighter the effect of turnover on teacher age is even bigger, though the separate effect of the tightening of the teacher labor market on the average teacher age is positive. Figure 9 shows that in a one standard deviation tighter teacher labor market the net impact of turnover on teacher age is positive in schools with turnover below 5 percent, but the total impact of turnover is negative in schools with higher turnover. This means that approximately 75% of the schools face a decrease in the average teacher age in a one standard deviation tighter teacher labor market.

Table 5 column 1 in Appendix B shows that the signs of the coefficients are robust to the use of the alternative vacancy indicator compiled by Dialogic which also varies by region, but the coefficients are not statistically significant anymore. The inclusion of year-fixed effects in this alternative model increases the coefficient on teacher labor market tightening substantially and it decreases the coefficient of the interaction term slightly. This suggests that turnover has an even stronger impact on the average teacher age than shown in Table 3 column 3, but that the net effect of turnover and teacher labor market tightening is positive for a larger share of schools.

According to the literature the effect of teacher experience on the quality of education is particularly strong for the least experienced teachers. Therefore, the impact of turnover on the proportion of teachers younger than 30 years are estimated. Column 4 of table 3 displays that the proportion of young teachers increases with 0.92 percentage points when turnover increases with 10 percentage points and the relative vacancy rate is average. When the

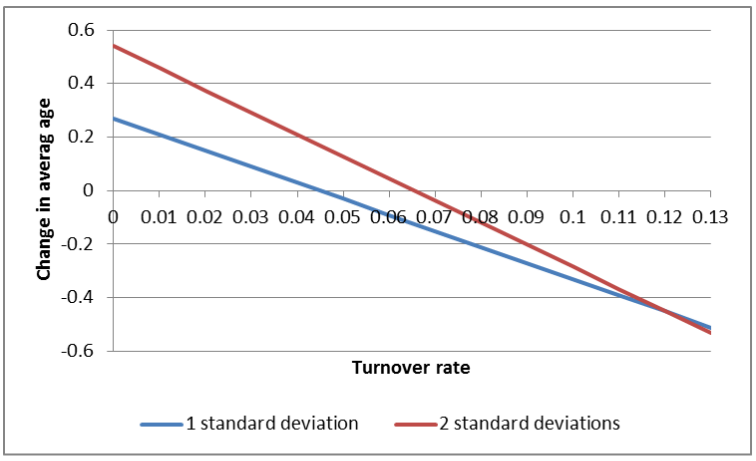

Figure 9: The impact of the rate of turnover on the change in the average age of teachers in a school for different states of the teacher labor market

Note: Turnover rate aggregated at school level equals the proportion of previous year teachers that were teaching in school s in year t-1, but are not teaching in school s in year t. The figure shows results for one and two standard deviations tightening of the teacher labor market.

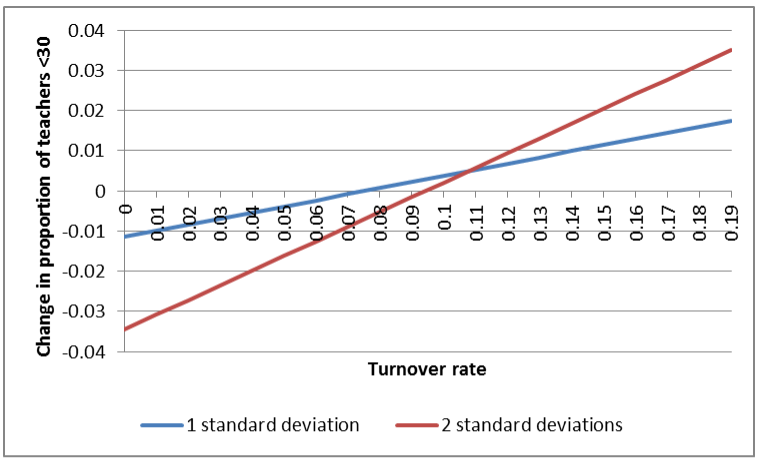

Figure 10: The impact of the rate of turnover on the change in the proportion of teachers under 30 years old in a school for different states of the teacher labor market

Note: Turnover rate aggregated at school level equals the proportion of previous year teachers that were teaching in school s in year t-1, but are not teaching in school s in year t. The figure shows results for one and two standard deviations tightening of the teacher labor market.

teacher labor market tightens with one standard deviation a 10 percentage point increase in turnover increases the proportion of young teachers with another 0.6 percentage points. The net effect however of a one standard deviation higher relative vacancy rate for a school with 10% turnover is a 0.5 percentage points increase of the share of teachers younger than 30. Figure 10 shows that in a one standard deviation tighter teacher labor market the net impact of turnover on the proportion of young teachers is negative in schools with turnover below 8 percent, but the total impact of turnover is positive in schools with higher turnover. Also when using the alternative indicator for teacher labor market tightening the results are comparable and statistically significant (Appendix B, Table 5). Though school fixed effects have been used in all analyses, it is important to realize that results could be biased by changing school policies that are related to teacher age and turnover.

Turnover and the effects on student test scores

From the last paragraphs, it seems that teacher turnover negatively influences teacher experience proxied by teacher age and positively influences the proportion of young teachers. This paragraph studies the impact of teacher turnover (in a tightening teacher labor market) on student test scores, which is another measure of education quality. The analysis resembles the analysis of Hanushek et al. (2016). The first two columns of table 4 show that teacher turnover has a negative impact on student test scores for all students in the years 2011 up to and including 2017, who took the national grade 8 test developed by Cito. The effect is only significant at 5%-level when year fixed effects are included. Column 3 reveals that the negative effect of turnover on test scores is attenuated in a tighter teacher labor market. When the teacher labor market tightens by one standard deviation the impact of an increase in teacher turnover is approximately zero. However, since 2015 students do no longer take the same grade 8 tests, but schools can chose between several tests.

TABLE 4

Estimated effects of turnover on standardized student test scores

	(1)	(2)	(3)	(4)	(5)	(6)
Turnover	-0.038 *	-0.048 **	-0.035 *	-0.058 **	-0.063 **	-0.057 **
	(0.021)	(0.021)	(0.021)	(0.025)	(0.025)	(0.025)
Relative vacancy rate (standardized)			-0.005 *			-0.005
			(0.003)			(0.003)
Relative vacancy rate * Turnover			0.036 *			0.024
			(0.017)			(0.019)
Adjusted R2	0.053	0.054	0.053	0.054	0.055	0.054
Number of observations	912,351	912,351	912,351	610,675	610,675	610,675
Additional studentlevel covariates	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	No	Yes	No
Balanced	No	No	No	Yes	Yes	Yes
Years	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of school-level turnover and relative vacancy rates on standardized student test scores for an unbalanced sample in column 1-3 and a balanced sample in column 4-6. Additional covariates include gender, student weights, migration background, family disposable income, family home ownership, household composition, number of persons in the household, shares of migrants in grade 8, shares of low-income peers, share of disadvantaged students in grade 8, school size, urbanity and student-teacher ratio. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

Swart, Van den Berge and Visser (2019) found evidence that schools with low test scores on the test developed by Cito are more likely to switch to an alternative grade 8 test. This will introduce sample selection bias when turnover in those schools also differs from turnover in schools that do not change tests. Therefore, the analyses are repeated for the set of schools which do take the Cito test in all years. This leads to a loss of one third of the grade 8 students available for analyses and hence the next analyses includes only a little more than half of the schools in the Netherlands. The negative effect of turnover on student test scores is stronger for the balanced set of schools, while the effect of teacher labor market tightening is not statistically significant anymore. This would indeed be expected when excluding switching schools with higher turnover and lower student test scores from the analyses. The sign and size of the turnover coefficient are in line with the findings of Hanushek et al. (2016) who find a negative coefficient between 0.04 and 0.06 in similar analyses. An increase of turnover at school level with 10 percentage points would change student test scores with approximately 0.006 standard deviations which is approximately 0.27 points on the Cito test.[2] The results are robust to exclusion of schools with 10 or less students that take the Cito test and to an imputed Cito score of 517 for students who don't have a reported test result (Appendix B, Table 6; column (1) & (2)). Again, the analyses using the alternative labor market tightening indicator show the same signs for the estimated coefficients, but the coefficients are not found to be significant. The inclusion of year fixed effects changes the coefficients only little (Appendix B, Table 6).

The impact of aggregate turnover on tests scores is only estimated on a sample of grade 8 students. They might be affected by the turnover of a teacher that taught grade 8, by the

[2] This is also in line with analysis by Bolhaar and Scheer (2019) from CPB Netherlands Bureau of Economic Policy Analysis who find a decrease of 0.4 Cito points for schools with a turnover rate of 15 percent or more.

switching of grades between teachers when a teacher in another grade turns over or they might be affected by the general disturbance in the teacher team when teachers leave or move to another school. However, it might also be the case that the estimate of the effect of aggregate turnover in a school is too small when students were confronted with teacher turnover in a lower grade. Using the average teacher turnover of the last 3 years instead of the turnover of the previous year might account for that. Table 6 in Appendix B shows that the impact of the average teacher turnover of the last 3 years on student test scores is still negative, though not significant. One reason could be that the standard errors of the model have increased, because the teacher turnover of the last 3 years has less variation. Another reason could be that the 3-year average of teacher turnover is a more imprecise measure of the impact of turnover which would bias the coefficient towards zero.

The relationship between student test scores and teacher turnover differs between the four big cities of The Netherlands and their surrounding areas (Appendix B, table 7, column (1)). There is no evidence that teacher turnover significantly impacts student test scores in the region around the cities, but turnover seems to significantly reduce student test scores in the big cities. This suggests that the effect of teacher turnover might be heterogeneous across regions. Though it might also be caused by other factors that are not accounted for which differ across regions and are related to turnover and student test scores. There is also some evidence that the effect of teacher turnover on the average teacher age and the proportion of young teacher differs by region (Appendix B, table 7; column (2)). An increase of the rate of turnover would decrease the average teacher age less in the 4 cities than in the surrounding areas.

Turnover and the effects on grade retention

Grade retention is another student outcome measure that can shed light on the relationship between teacher turnover and education quality. According to the literature it is positively related to student test scores. The specification of the models in the grade retention analyses is identical to the specification used in the test score analyses. The models can be estimated on the full set of schools in The Netherlands. Turnover has a minimally negative effect on grade retention which is significant at the 10%-level when a student is believed to be retaking a grade if he or she is found in the same grade in year *t* and in year *t+1* (Table 5, column (1)). The coefficient of the interaction effect between turnover and teacher labor market tightening is not significantly different from zero (Table 5, column (3)).

TABLE 5
Estimated effects of turnover on grade retention

	Repeat grade			>8 year primary school			Age-at-test
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Turnover	-0.006 *	-0.010 ***	-0.007 *	0.001	-0.002	0.001	-0.002
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.008)
Relative vacancy rate (standardized)			-0.004 ***			-0.004 ***	-0.043 ***
			(0.001)			(0.001)	(0.002)
Relative vacancy rate * Turnover			0.004			-0.002	-0.004
			(0.004)			(0.007)	(0.011)
Adjusted R2	0.002	0.001	0.002	0.012	0.011	0.012	0.036
Number of observations	7,298,402	7,298,402	7,298,402	1,214,998	1,214,998	1,214,998	1,181,488
Additional studentlevel covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	Yes	No	No	No
Years	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of school-level turnover and relative vacancy rates on grade retention indicators. In column 1-3 a student repeates a grade when he or she is found in the same grade in year *t* and in year *t+1*. In column 4-6 is students is believed to have repeated a grade when he or she is in the 8th grade and has been observed in primary school for more than 8 years. Column 7 has age-at-test as outcome. Additional covariates include gender, student weights, migration background, family disposable income, family home ownership, household composition, number of persons in the household, shares of migrants in grade 8, shares of low-income peers, share of disadvantaged students in grade 8, school size, urbanity and student-teacher ratio. Standard errors clustered at school-level are in parentheses.
* p<0.10 ** P<0.05 *** p<0.001

However, the grade indicator used to determine grade retention is not fully reliable. Therefore, an alternative outcome variable is used to study the effect of turnover on student retention. In this case students are believed to have repeated a class when they are in the 8th grade and have been observed in primary school for more than 8 years. In these analyses no significant effect of turnover nor a significant effect of turnover in a tightening labor market is found (Table 5, column (4) & column (6)).

However, school-level turnover of the year that students are in grade 8 might not be a good indicator of the effect of turnover on student retention, because students are usually not being retained in grade 8, but in previous years. Using the average teacher turnover of the last three years instead, provides some evidence that turnover is significantly negatively related to grade retention. The effect seems to be stronger in a tightening teacher labor market, though the coefficients are not statistically significant (Appendix B, Table 8). Similar results are found when using age-at-test as outcome variable, though the effect of teacher turnover in a tightening teacher labor market now turns out to be statistically significant for the 3-year average turnover measure. A 25 percentage point increase of the average turnover rate of the last three years decreases the age-at-test with approximately a quarter of a month. In a one standard deviation tighter labor market it decreases with an approximate other quarter of a month, which means that the total effect of a 25 percentage point increase of the 3-year average turnover in a one standard deviation tighter teacher labor market is about half a month on average. Notice that the analyses do not account for year or school-by-year fixed effects, which might bias the estimates.

7. Discussion and conclusion

In this paper the impact of teacher labor market tightening on teacher mobility determinants and subsequently on education quality in primary education in The Netherlands has been studied. Two sets of microdata provided by DUO have been used: one holds contract information for all primary school teachers and the other has information on school characteristics for all primary schools. Statistics Netherlands provided microdata containing information on all enrolled primary school students. The sets have been appended with other (micro)data from Statistics Netherlands. The methods used in the analyses are predominantly OLS regressions with school fixed effects. Evidence has been found that teacher labor market tightening is positively related to teacher mobility, its impact is particularly strong on a teacher's decision to move to another school. Hence, hypothesis 1 should be accepted. On hypothesis 2, results indicate that the relationship between teacher mobility and its determinants does indeed differ by the state of the teacher labor market. Teachers who are in their 30s seem to be more likely than other teachers to move to another school when the teacher labor market tightens. These are usually the teachers that have gained some years of teaching experience, which implies that the quality of education might be affected when schools replace them with younger teachers with less experience. At the same time teachers between 61 and 65 years old are less likely to leave the primary education sector when the teacher labor market tightens. Those teachers are about to retire, but they might chose to postpone retirement when they see the teacher shortages growing. However, this doesn't solve the teacher shortages problem, it might only delay the issue from becoming more pressing. In line with the literature, teachers are found to be more likely to move from schools with many disadvantaged students or schools in very urban areas when they have the opportunity to do so. Those opportunities emerge when the teacher labor market tightens. This means that teachers shortages might be exacerbated in very urban areas and schools with many disadvantaged students. The analyses intend to provide a clearer picture of teacher mobility in a tighter teacher labor market, though the discovered relationships should not be interpreted causally. The outcomes tell policy makers that they should take teacher shortages seriously and particularly focus on very urban areas and disadvantaged schools, where the impact of teacher labor market tightening seems to be felt most strongly. The results also suggest that policy makers should causally research the potential presence of, impact of and solutions to the high costs of living in the four big cities of The Netherlands. Teachers in the four biggest cities of The Netherlands are less likely to move to another school the higher their gross family income. This relationship is not found for teachers in the surrounding areas, which might imply that teachers have issues with the high

living costs in the city. Maybe those teachers could be kept from moving to another school by increasing their reward. The data show that teachers with bigger contracts and permanent contracts are less likely to move. Yet, this might also be caused by unobserved individual or family characteristics related to these contracts features and teacher mobility decisions. Therefore, causal research is necessary to validate this hypothesis.

The current study has not found conclusive evidence concerning the impact of teacher mobility in a tightening teacher labor market on the quality of education, wherefore the third hypothesis cannot be accepted. Teacher turnover seems to have a detrimental effect on education quality for all outcomes studied, but teacher turnover does not seem to have a bigger negative effect on all studied education quality outcomes when the teacher labor market is tighter. In a tighter teacher labor market, turnover has a stronger negative effect on the average teacher age in a school and it leads to a bigger increase of the proportion of young teachers in a school than in the average state of the teacher labor market, although the net effect of labor market tightening might decrease the proportion of young teachers in schools with relatively low turnover. Schools with above average turnover face a statistically significant increase in the proportion of young teachers when turnover increases and the labor market is one standard deviation tighter. In that situation, every 10-percentage point increase of teacher turnover increases the proportion of young teachers in such a school with 1.5 percentage points. In an average school with 13 teachers this equals approximately 0.2 teachers. Since young teachers are believed to be less experienced than older teachers and therefore provide a lower quality education, it implies that education quality deteriorates. However, the analysis might be biased by not accounting for time-varying school characteristics or other time-varying shocks.

Turnover has a negative effect on student test scores, nevertheless the interaction effect between turnover and the state of the labor market is statistically insignificantly positive. Robustness checks do not contradict these findings. The student test score analyses are performed on a subset of schools using a test developed by Cito throughout the entire period 2011-2017. After 2015 schools could chose to use an alternative test, so schools that switched from the Cito test to another test are not included in this subset. There is some evidence that the subset includes schools with higher average test scores and lower average turnover (See also Table 6). It could be the case that test scores in times of teacher shortages do not suffer very much from turnover in such schools, because those schools are attractive to teachers and are therefore able to find high quality replacement teachers. Whereas schools not included in the subset might have trouble replacing their teachers in a tight labor market, which could amplify the negative effect of turnover for those schools. This

TABLE 6

Average turnover and student test scores in schools taking the Cito test and schools switching to another test

	Cito Schools			Switching schools		
	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.
Cito test score	11,686	535.275	4.054	8,573	534.207	4.480
Turnover	11,686	0.110	0.094	8,573	0.123	0.105

Notes: Means and standard deviations are from the period 2011-2014 when all schools were obliged to take the Cito test. Cito schools are schools that took the Cito test in all years of the period 2011-2017. Switching schools are schools that didn't take the Cito test the whole period.

hypothesis is supported by the finding that schools with relatively low turnover see the proportion of young teachers decrease in a tight labor market. Currently, there is not enough student test score panel data available for schools that switched from the Cito test to an alternative test to verify if a tightening of the teacher labor market leads to a bigger negative effect of turnover on test scores for the sample with switching schools, but such data should be available in the near future.

Teacher turnover seems to have a significantly bigger negative impact on student test scores in the four biggest cities of The Netherlands when compared to its surrounding areas. Yet, the proportion of young teachers seems to be smaller in the cities. This might indicate that schools in bigger cities are not able to replace their leaving teachers. Another explanation could be that schools in the cities can only attract low quality teachers even though they might have some experience. If student test scores would be available for every grade and students could be matched to their teachers, this hypothesis could be examined by determining the added value of each teacher. Such data would also make it possible to determine the effect of teacher turnover at grade level instead of at school level, which allows for the inclusion of school-by-year fixed effects. Even though this paper builds on the analyses of Hanushek et al. (2016) who find that including school-by-year fixed effects do not change the results very much, it is not clear if this also applies to The Netherlands. Another suggestion for future research is finding a labor market tightening indicator with more variation. The main models in this paper use the yearly relative vacancy rate to signify labor market tightening, but vacancy rates available for a longer period of time varying both over time and region would be preferred and would allow for the inclusion of year fixed effects.

Student grade retention is the last outcome studied in this paper, providing evidence on the relationship between teacher mobility and education quality in a tightening teacher labor market. The probability of student grade retention is found to be lower when teacher turnover increases. It might be the case that schools have less information to decide about student grade retention when turnover increases, wherefore they are less likely to decide in favor of

retention. Alternatively, schools might be more likely to decide against student grade retention when they are facing higher turnover, because they do not want to spend their resources on a student for an additional year. An increase of turnover in a tight teacher labor market seems to decrease the probability of retention even more, though the effect is not statistically significant. Only the average turnover of the last three years is found to significantly decrease the age-at-test of a student in a tight teacher labor market. The literature provides evidence that grade retention can be beneficial for student test scores. Thus the findings that turnover decreases student test scores and decreases the probability of grade retention are in line with each other. Because the analyses are very similar they might also suffer from the same biases however.

Though the current study doesn't find conclusive evidence for the impact of teacher mobility on education quality in a tightening teacher market, the impact will most likely not be positive. Several education quality outcomes even point towards a negative effect of turnover on education quality in a tighter teacher labor market. This underlines that policy makers should not tarry in a tightening teacher labor market as to prevent a potential deterioration of the quality of education. Since the effects of turnover in a tightening teacher labor market seem to be heterogeneous over schools and regions, policy makers could consider setting targeted policies.

References

Adriaens, H., Fontein, P., & De Vos, K. (2018). *De toekomstige arbeidsmarkt voor onderwijspersoneel po, vo en mbo 2018-2028.* Tilburg: Centerdata.

Barbieri, G., Rossetti, C., & Sestito, P. (2011). The determinants of teacher mobility: Evidence using Italian teachers' transfer applications. *Economics of Education Review, 30*(6), 1430-1444.

Bolhaar, J., & Scheer, B. (2019). Verschillen in leerresultaten tussen basisscholen. The Hague: CPB

Netherland Bureau for Economic Policy Analysis

Bonhomme, S., Jolivet, G., & Leuven, E. (2016). School characteristics and teacher turnover: Assessing the role of preferences and opportunities. *The Economic Journal*(126), 1342-1371.

Borman, G. D., & Dowling, N. M. (2008). Teacher attrition and retention: A meta-analytic and narrative review of the research. *Review of educational research, 78*(3), 367-409.

Bouma, K. (2018, August 19). *Is er een lerarentekort, of toch niet? 'Hier in de Achterhoek is de concurrentie groot'*. Retrieved October 1, 2019, from de Volkskrant: https://www.volkskrant.nl/nieuws-achtergrond/is-er-een-lerarentekort-of-toch-niet-hier-in-de-achterhoek-is-de-concurrentie-groot~ba1d40a6/

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2008). *Who leaves? Teacher attrition and student achievement.* National Bureau of Economic Research.

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2013). Analyzing the determinants of the matching of public school teachers to jobs: Disentangling the preferences of teachers and employers. *Journal of Labor Economics, 31*(1), 83-117.

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. (2005). Who teaches whom? Race and the distribution of novice teachers. *Economics of Education review, 24*(4), 377-392.

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2011). Teacher mobility, school segregation, and pay-based policies to level the playing field. *Education Finance and Policy, 6*(3), 399-438.

Clotfelter, C., Glennie, E., Ladd, H., & Vigdor, J. (2008). Would higher salaries keep teachers in high-poverty schools? Evidence from a policy intervention in North Carolina. *Journal of Public Economics*(92), 1352-1370.

Commissie Leraren. (2007). *LeerKracht! advies van de Commissie Leraren.* Den Haag: Ministerie van OCW.

Corman, H. (2003). The effects of state policies, individual characteristics, family characteristics, and neighbourhood characteristics on grade repetition in the United States. *Economics of Education Review, 22*(4), 409-420.

CPB. (2013). *CPB notitie: Arbeidsmarkt leraren: aanpassingsmechanismen en aangrijpingspunten voor beleid.* Den Haag: CPB.

Den Brok, P., Wubbels, T., & Van Tartwijk, J. (2017). Exploring beginning teachers' attrition in the Netherlands. *Teachers and teaching, 23*(8), 881-895.

Dieterle, S. (2015). Class-size reduction policies and the quality of entering teachers. *Labour Economics*(36), 35-47.

Dolton, P., & Van der Klaauw, W. (1999). The turnover of teachers: A competing risks explanation. *Review of Economics and Statistics, 81*(3), 543-550.

Eide, E. R., & Showalter, M. H. (2001). The effect of grade retention on educational and labor market outcomes. *Economics of Education review, 20*(6), 563-576.

Falch, T., & Strøm, B. (2005). Teacher turnover and non-pecuniary factors. *Economics of Education Review, 24*(6), 611-631.

Falch, T., Johansen, K., & Strøm, B. (2009). Teacher shortages and the business cycle. *Labour Economics, 16*(6), 648-658.

Feng, L., & Sass, T. R. (2017). Teacher quality and teacher mobility. *Education Finance and Policy, 12*(3), 396-418.

Gerritsen, S., Plug, E., & Webbink, D. (2017). Teacher quality and student achievement: evidence from a sample of Dutch twins. *Journal of applied econometrics, 32*(3), 643-660.

Goldhaber, D., & Theobald, R. (2013). Managing the teacher workforce in austere times: The determinants and implications of teacher layoffs. *Education Finance and Policy, 8*(4), 494-527.

Goldhaber, D., Gross, B., & Player, D. (2011). Teacher career paths, teacher quality, and persistence in the classroom: Are public schools keeping their best? *Journal of Policy Analysis and Management, 30*(1), 57-87.

Goldhaber, D., Quince, V., & Theobald, R. (2018). Has it always been this way? Tracing the evolution of teacher quality gaps in US public schools. *American Educational Research Journal, 55*(1), 171-201.

Goldhaber, D., Strunk, K. O., Brown, N., & Knight, D. S. (2016). Lessons Learned From the Great Recession: Layoffs and the RIF-Induced Teacher Shuffle. *Educational Evaluation and Policy Analysis, 38*(3), 517-548.

Greene, J. P., & Winters, M. A. (2007). Revisiting grade retention: An evaluation of Florida's test-based promotion policy. *Education Finance and Policy, 2*(4), 319-340.

Guarino, C. M., Brown, A. B., & Wyse, A. E. (2011). Can districts keep good teachers in the schools that need them most? *Economics of Education Review, 30*(5), 962-979.

Hanushek, E. A. (1986). The economics of schooling: Production and efficiency in public schools. *Journal of economic literature, 24*(3), 1141-1177.

Hanushek, E. A., Kain, J. F., & Rivkin, S. G. (2004). Why public schools lose teachers. *Journal of human resources, 39*(2), 326-354.

Hanushek, E. A., Rivkin, S. G., & Schiman, J. C. (2016). Dynamic effects of teacher turnover on the quality of instruction. *Economics of Education Review*(55), 132-148.

Harris, D. N., & Sass, T. R. (2011). Teacher training, teacher quality and student achievement. *Journal of public economics*(95), 798-812.

Hendricks, M. D. (2014). Does it pay to pay teachers more? Evidence from Texas. *Journal of Public Economics*(109), 50-63.

Inspectie van het Onderwijs. (2019). *De Staat van het Onderwijs 2019.* Utrecht: Inspectie van het Onderwijs.

Jackson, C. K. (2009). Student demographics, teacher sorting, and teacher quality: Evidence from the end of school desegregation. *Journal of Labor Economics, 27*(2), 213-256.

Jackson, C. K. (2012). School competition and teacher labor markets: Evidence from charter school entry in North Carolina. *Journal of Public Economics, 5-6*, 431-448.

Jacob, B. A., & Lefgren, L. (2004). Remedial education and student achievement: A regression-discontinuity analysis. *Review of economics and statistics, 86*(1), 226-244.

Kalogrides, D., & Loeb, S. (2013). Different teachers, different peers: The magnitude of student sorting within schools. *Educational Researcher, 42*(6), 304-316.

Kane, T. J., & Staiger, D. O. (2008). *Estimating teacher impacts on student achievement: An experimental evaluation.* National Bureau of Economic Research.

Krieg, J. M. (2006). Teacher quality and attrition. *Economics of Education Review, 25*(1), 13-27.

Lankford, H., Loeb, S., & Wyckoff, J. (2002). Teacher sorting and the plight of urban schools: A descriptive analysis. *Educational evaluation and policy analysis, 24*(1), 37-62.

McCoy, A. R., & Reynolds, A. J. (1999). Grade retention and school performance:: An extended investigation. *Journal of school psychology, 37*(3), 273-298.

Ministry of Education, Culture and Science. (2019). *Arbeidsmarkt Leraren 2018.* The Hague: Ministry of Education, Culture and Science.

Murnane, R. (1981). Teacher mobility revisited. *Journal of Human Resources, 16*(1), 3-19.

Murnane, R. J., & Olsen, R. J. (1989). The effect of salaries and opportunity costs on duration in teaching: Evidence from Michigan. *The Review of Economics and Statistics, 71*(2), 347-352.

Musch, S. (2019, September 14). *'Prestaties leerlingen gaan achteruit door lerarentekort'*. Retrieved October 1, 2019, from nrc.nl: https://www.nrc.nl/nieuws/2019/09/14/prestaties-leerlingen-gaan-achteruit-door-lerarentekort-a3973388

Nagler, M., Piopiunik, M., & West, M. R. (2015). *Weak markets, strong teachers: Recession at career start and teacher effectiveness.* National Bureau of Economic Research.

NOS Nieuws. (2019, September 7). *Scholen in grote steden vragen om crisisaanpak lerarentekort*. Retrieved October 1, 2019, from NOS: https://nos.nl/artikel/2300718-scholen-in-grote-steden-vragen-om-crisisaanpak-lerarentekort.html

Papay, J. P., & Kraft, M. A. (2015). Productivity returns to experience in the teacher labor market: Methodological challenges and new evidence on long-term career improvement. *Journal of Public Economics*(130), 105-119.

Reininger, M. (2012). Hometown disadvantage? It depends on where you're from: Teachers' location preferences and the implications for staffing schools. *Educational Evaluation and Policy Analysis, 34*(2), 127-145.

Rockoff, J. (2004). The impact of individual teachers on student achievement: Evidence from panel data. *American economic review, 94*(2), 247-252.

Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal, 50*(1), 4-36.

Sass, T. R., Hannaway, J., Xu, Z., Figlio, D. N., & Feng, L. (2012). Value added of teachers in high-poverty schools and lower poverty schools. *Journal of Urban Economics, 72*(2-3), 104-122.

Scafidi, B., Sjoquist, D. L., & Stinebrickner, T. R. (2007). Race, poverty, and teacher mobility. *Economics of Education Review, 26*(2), 145-159.

Schwerdt, G., West, M. R., & Winters, M. A. (2017). The effects of test-based retention on student outcomes over time: Regression discontinuity evidence from Florida. *Journal of Public Economics*(152), 154-169.

Sorensen, L. C., & Ladd, H. (2018). *The Hidden Costs of Teacher Turnover.* National Center for Analysis of Longitudinal Data in Education Research (CALDER).

Steele, J. L., Pepper, M. J., Springer, M. G., & Lockwood, J. R. (2015). The distribution and mobility of effective teachers: Evidence from a large, urban school district. *Economics of Education Review*(48), 86-101.

Stinebrickner, T. R. (1998). An empirical investigation of teacher attrition. *Economics of education review, 17*(2), 127-136.

Swart, L., Van den Berge, W., & Visser, D. (2019). *De waarde van eindtoetsen in het primair onderwijs.* The Hague: CPB Netherlands Bureau for Economic Policy Analysis.

Theobald, N. D. (1990). An examination of the influence of personal, professional, and school district characteristics on public school teacher retention. *Economics of education review, 9*(3), 241-250.

Winters, M. A., & Greene, J. P. (2012). The medium-run effects of Florida's test-based promotion policy. *Education Finance and Policy, 7*(3), 305-330.

Wiswall, M. (2013). The dynamics of teacher quality. *Journal of Public Economics*(100), 61-78.

Appendix A

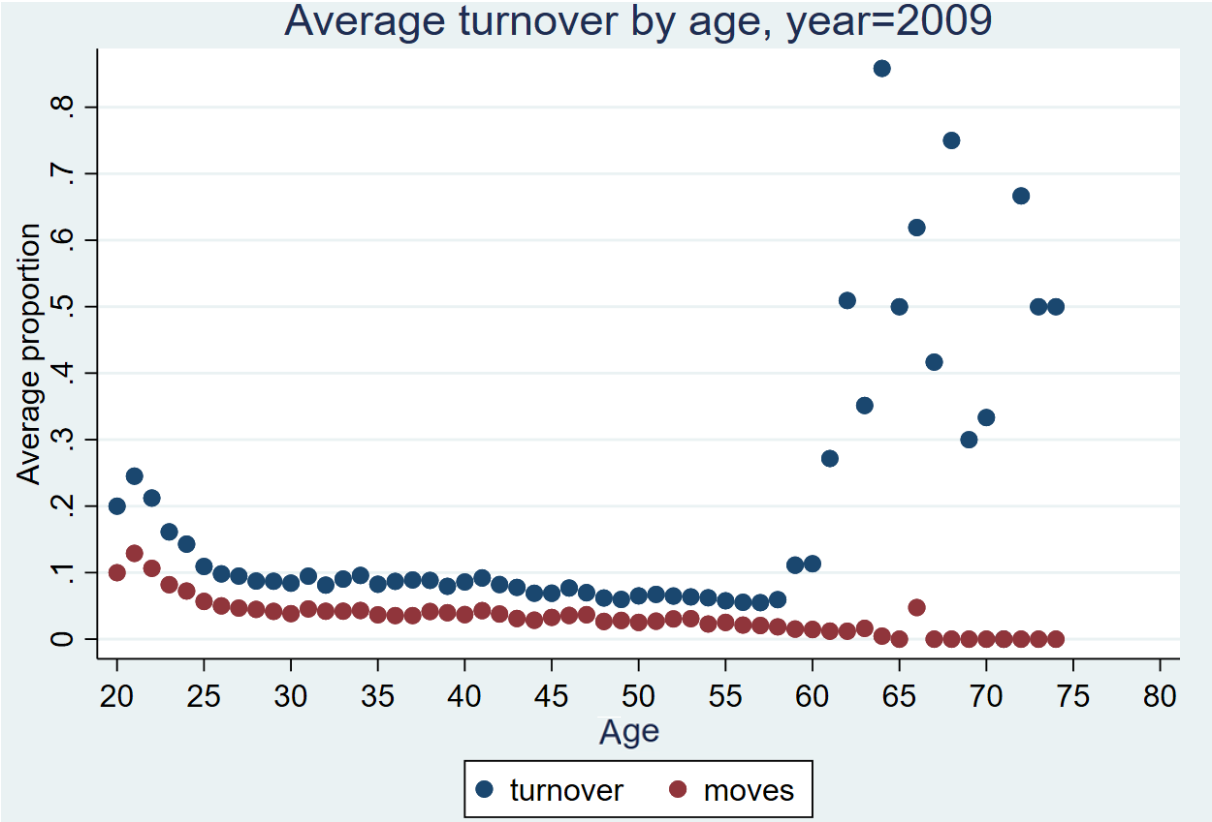

Figure 1: Teacher mobility by age in 2009. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed.

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1.

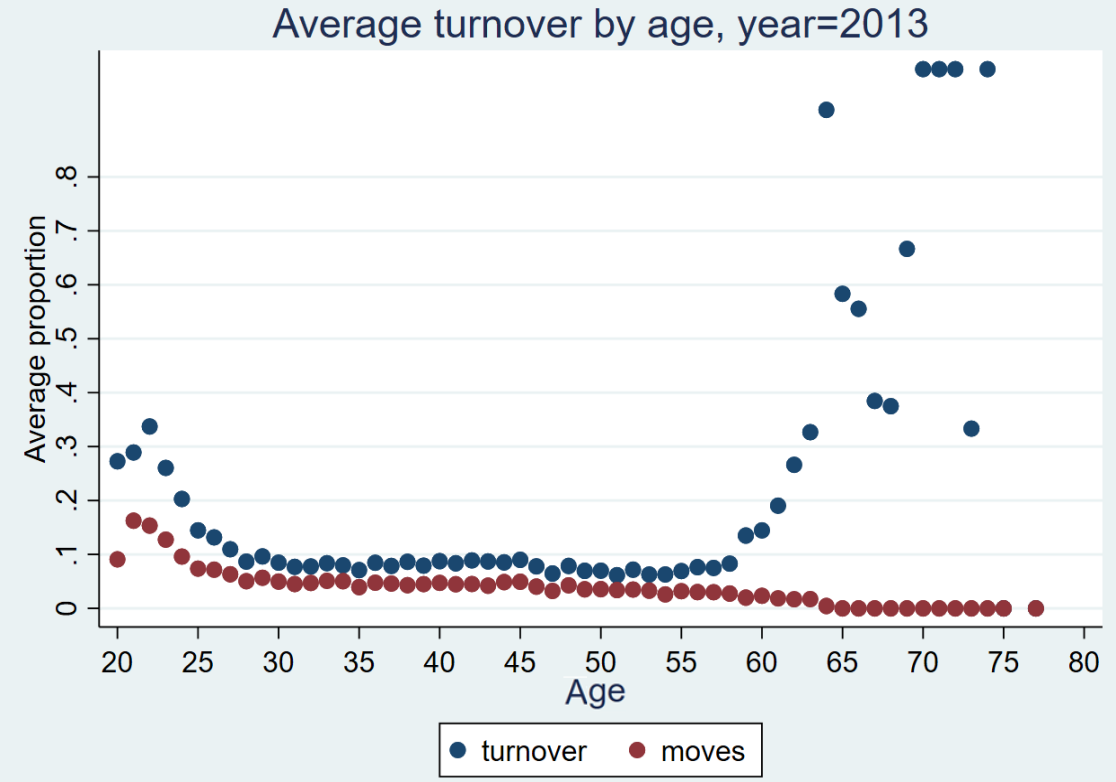

Figure 2: Teacher mobility by age in 2013. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed.

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1.

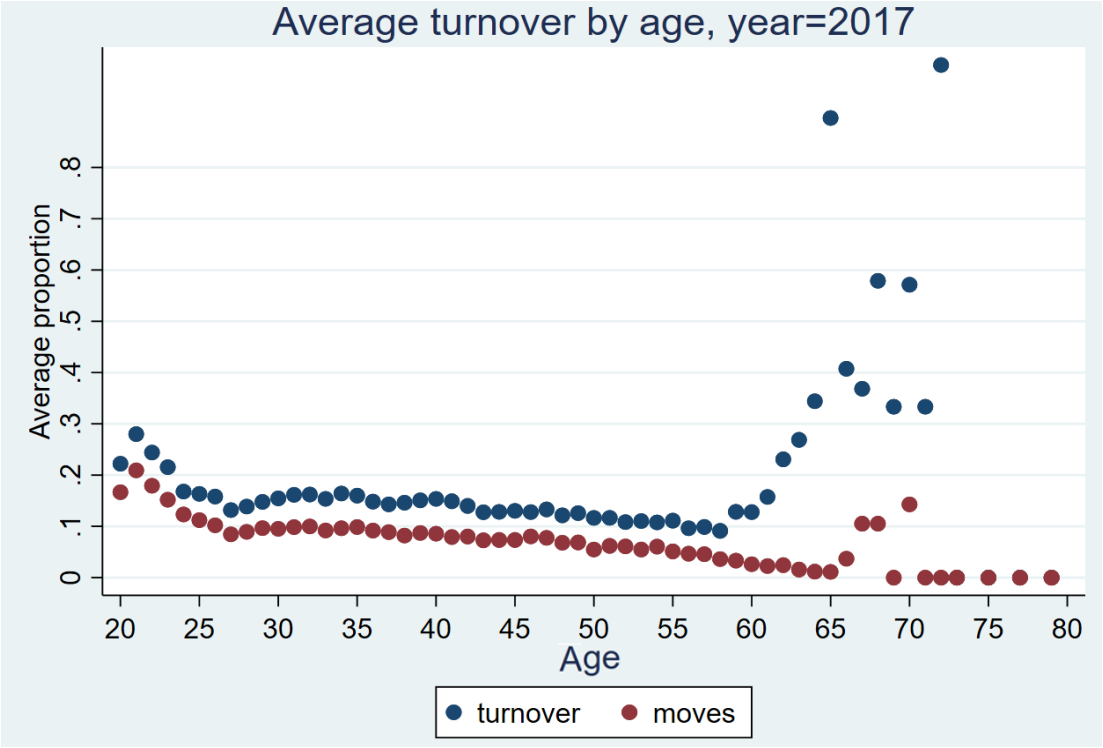

Figure 3: Teacher mobility by age in 2017. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed.

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1.

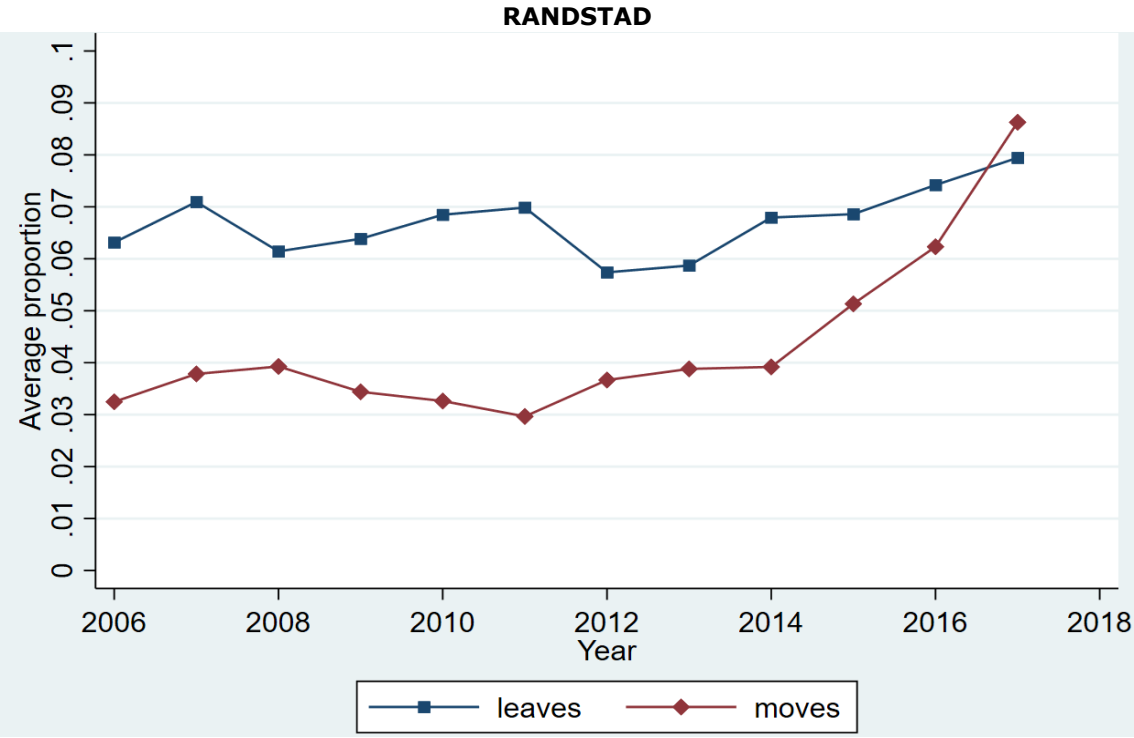

***Figure 4: Teacher mobility over time for teachers in the 'Randstad'. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed**..*

Note: Teachers that are shown to turnover in year t are teachers that are not found in the same school in year t+1.

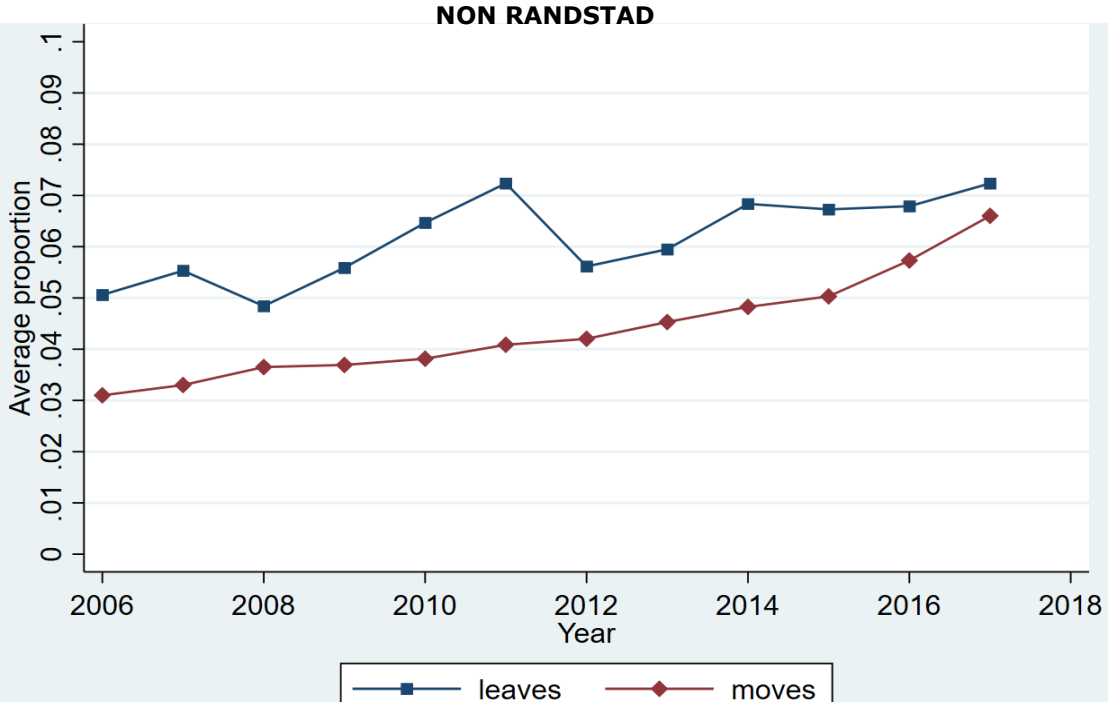

***Figure 5: Teacher mobility over time for teachers not in the 'Randstad'. Teacher mobility is broken down by teachers who are moving to another school or leaving the primary education sector as a share of the total number of teachers employed**.*

Note: Teachers that are shown to turnover in vear t are teachers that are not found in the same school in vear t+1.

TABLE 1

Descriptive statistics on teachers

	2009-2017			2009			2011			2017		
	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.
Age	985,952	42.921	11.855	117,954	42.406	11.839	110,941	42.857	11.812	103,754	42.759	12.003
Contract size	985,952	0.734	0.230	117,954	0.755	0.236	110,941	0.739	0.235	103,754	0.728	0.227
Gross household income	749,072	100,275.40	53,889.58				110,473	95,666.85	49,541.78	103,290	106,052.50	55,842.01
Female	985,952	0.874	0.332	117,954	0.859	0.348	110,941	0.867	0.339	103,754	0.887	0.316

TABLE 2

Descriptive statistics on schools

	2009-2017			2009			2011			2017		
	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.	**Obs**	Mean	Std.Dev.
Randstad	55,760	0.349	0.477	6,252	0.349	0.477	6,163	0.351	0.477	6,044	0.348	0.476
Special education	55,760	0.031	0.174	6,252	0.032	0.176	6,163	0.032	0.175	6,044	0.030	0.172
School size	55,760	235.280	139.341	6,252	246.367	139.768	6,163	241.404	139.674	6,044	225.737	138.606
Staff size	55,760	15.908	9.278	6,252	17.562	9.774	6,163	16.422	9.382	6,044	15.243	9.228
Number of teachers	55,760	12.978	7.537	6,252	14.243	7.914	6,163	13.343	7.609	6,044	12.468	7.485
Number of support staff	55,760	1.605	2.220	6,252	1.747	2.246	6,163	1.656	2.258	6,044	1.647	2.297
Student-teacher ratio	55,760	18.260	3.738	6,252	17.402	3.361	6,163	18.263	3.747	6,044	18.150	3.789
Share disadvantaged students	55,760	0.077	0.119	6,252	0.089	0.140	6,163	0.086	0.133	6,044	0.062	0.092
Share of teachers moving to another school	55,760	0.054	0.078	6,252	0.041	0.062	6,163	0.043	0.068	6,044	0.082	0.095
Share of teachers leaving the primary education sector	55,760	0.067	0.074	6,252	0.060	0.065	6,163	0.073	0.081	6,044	0.076	0.077
Share of teachers turning over	55,760	0.117	0.101	6,252	0.098	0.086	6,163	0.113	0.099	6,044	0.151	0.115

TABLE 3

Frequencies of several teacher characterististics

	2009-2017			2009			2011			2017		
	Observations	Percent	Cumulative	Observations	Percent	Cumulative	Observations	Percent	Cumulative	Observations	Percent	Cumulative
Contract type												
Permanent	921,166	93.43	93.43	110,077	93.32	93.32	104,741	94.41	94.41	94,778	91.35	91.35
Temporary	64,786	6.57	100	7,877	6.68	100	6,200	5.59	100	8,976	8.65	100
Migration background												
Dutch	908,868	92.18	92.18	108,444	91.94	91.94	102,071	92.00	92	95,771	92.31	92.31
Western Migrant	47,757	4.84	97.03	6,046	5.13	97.06	5,550	5.00	97.01	4,759	4.59	96.89
Non-Western Migrant	28,773	2.92	99.94	3,391	2.87	99.94	3,257	2.94	99.94	3,170	3.06	99.95
Unknown	554	0.06	100	73	0.06	100	63	0.06	100	54	0.05	100
Familiy type												
Other	240,942	24.44	24.44				1,096	0.99	0.99	1,083	1.04	1.04
Couple with Children	425,806	43.19	67.62				61,039	55.02	56.01	59,965	57.8	58.84
Single Parent	40,023	4.06	71.68				5,722	5.16	61.16	5,820	5.61	64.45
Single	88,518	8.98	80.66				13,399	12.08	73.24	11,834	11.41	75.85
Couple without Children	190,663	19.34	100				29,685	26.76	100	25,052	24.15	100
Position in household												
Main breadwinner without partner	126,949	16.95	16.95				18,870	17.08	17.08	17,309	16.76	16.76
Main breadwinner with partner	168,003	22.43	39.38				24,980	22.61	39.69	22,549	21.83	38.59
Partner	422,049	56.34	95.72				61,837	55.97	95.67	57,849	56.01	94.59
Child	28,915	3.86	99.58				4,338	3.93	99.59	5,006	4.85	99.44
Other	3,156	0.42	100				448	0.41	100	577	0.56	100
Home ownership												
Homeowner	647,549	86.45	86.45				95,304	86.27	86.27	89,038	86.20	86.2
Rented property without housing benefits	94,898	12.67	99.12				14,265	12.91	99.18	13,075	12.66	98.86
Rented property with housing benefits	6,353	0.85	99.96				854	0.77	99.95	1,135	1.10	99.96
Institutional household	272	0.04	100				50	0.05	100	42	0.04	100
Urbanity												
Very urban	185,000	18.76	18.76	19,638	16.65	16.65	19,306	17.4	17.4	22,849	22.02	22.02
Urban	274,840	27.88	46.64	31,424	26.64	43.29	29,674	26.75	44.15	31,558	30.42	52.44
Moderately Urban	201,834	20.47	67.11	25,162	21.33	64.62	23,615	21.29	65.44	17,911	17.26	69.7
Little Urban	226,322	22.95	90.06	28,393	24.07	88.69	26,697	24.06	89.5	22,605	21.79	91.49
Rural	97,956	9.94	100	13,337	11.31	100	11,649	10.5	100	8,831	8.51	100

TABLE 4

Descriptive statistics on students

	2009-2017			2009			2011			2017		
	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.	Observations	Mean	Std.Dev.
Family size	35,495	4.646	2.239				5682	4.578	1.785	3722	4.796	3.765
Share of male students	44,785	0.500	0.127	3734	0.498	0.127	5683	0.499	0.128	3733	0.500	0.129
Share students Western Migrants	44,785	0.062	0.068	3734	0.059	0.067	5683	0.059	0.065	3733	0.069	0.071
Share students Non-Western Migrants	44,785	0.159	0.23	3734	0.159	0.237	5683	0.155	0.231	3733	0.174	0.229
Proportion poor students	35,534	0.241	0.178				5683	0.243	0.178	3733	0.232	0.178
Proportion students with weight 0.3	44,785	0.077	0.094	3734	0.097	0.112	5683	0.09	0.104	3733	0.052	0.073
Proportion students with weight 1.2	44,785	0.056	0.118	3734	0.066	0.139	5683	0.06	0.125	3733	0.048	0.099
Test score	44,571	534.825	4.455	3728	535.15	4.639	5683	535.12	4.04	3640	535.08	4.49
Number of students in grade 8	35,534	28.917	18.043				5683	28.209	17.629	3733	29.500	17.898

TABLE 5

Frequencies of several student characterististics

	2009-2017			2009			2011			2017		
	Observations	Percent	Cumulative	Observations	Percent	Cumulative	Observations	Percent	Cumulative	Observations	Percent	Cumulative
Familiy type												
Other	249,446	20.47	20.47				1,500	0.98	0.98	1,371	1.34	1.34
Couple with Children	821,838	67.44	87.9				129,251	84.72	85.7	84,834	82.95	84.29
Single Parent	147,400	12.10	100				21,819	14.3	100	16,071	15.71	100
Home ownership												
Homeowner	745,711	76.43	76.43				116,287	76.52	76.52	76,784	75.49	75.49
Rented property without housing benefits	107,839	11.05	87.49				17,269	11.36	87.89	10,858	10.68	86.17
Rented property with housing benefits	118,564	12.15	99.64				17,941	11.81	99.69	13,616	13.39	99.55
Institutional household	1,026	0.11	99.75				149	0.1	99.79	170	0.17	99.72
Unkown	2,484	0.25	100				316	0.21	100	286	0.28	100

Appendix B

TABLE 1

Estimated effects of teacher and school characteristics on teacher turnover

	(1)	(2)	(3)
Age (ref. 36-40)			
age 21-25	0.106 ***	0.026 ***	-0.003
	0.002	0.002	0.003
age 26-30	0.029 ***	0.011 ***	-0.006 ***
	0.001	0.001	0.002
age 31-35	0.010 ***	0.007 ***	0.003 **
	0.001	0.001	0.001
age 41-45	-0.004 ***	-0.005 ***	-0.004 **
	0.001	0.001	0.001
age46-50	-0.008 ***	-0.007 ***	-0.008 ***
	0.001	0.001	0.001
age 51-55	-0.013 ***	-0.010 ***	-0.015 ***
	0.001	0.001	0.001
age 56-60	0.009 ***	0.014 ***	0.004 **
	0.001	0.001	0.002
age 61-65	0.239 ***	0.244 ***	0.212 ***
	0.002	0.002	0.002
age 65+	0.336 ***	0.192 ***	0.148 ***
	0.029	0.028	0.033
Female	-0.050 ***	-0.043 ***	-0.045 ***
	0.001	0.001	0.001
Contract size (ref. <0.5)			
0.5-0.8 FTE	-0.072 ***	-0.057 ***	-0.058 ***
	0.001	0.001	0.001
0.8+ FTE	-0.101 ***	-0.079 ***	-0.094 ***
	0.001	0.001	0.001
Temporary contract		0.200 ***	0.193 ***
		0.003	0.003
School size (ref. 300-400)			
0-100 students	-0.009 **	-0.009 *	0.007
	0.005	0.005	0.007
100-200 students	-0.001	0.000	0.012 **
	0.003	0.003	0.004
200-300 students	-0.001	0.000	0.004
	0.002	0.002	0.003
400-500 students	-0.002	-0.003	-0.007 **
	0.002	0.002	0.003
500-600 students	0.005	0.005	0.002
	0.004	0.004	0.005

TABLE 1 (Continued)

Share of disadvantaged students			
2nd quartile	0.001	0.001	-0.004 **
	0.002	0.002	0.002
3rd quartile	0.002	0.001	-0.011 ***
	0.002	0.002	0.003
4th quartile	0.001	0.000	-0.019 ***
	0.003	0.003	0.004
Urbanity (ref. Very Urban)			
Urban	0.000	-0.001	-0.018 ***
	0.005	0.005	0.005
Moderately Urban	-0.003	-0.006	-0.045 ***
	0.006	0.006	0.006
Little Urban	-0.006	-0.010	-0.072 ***
	0.008	0.008	0.008
Rural	-0.004	-0.007	-0.086 ***
	0.009	0.009	0.010
Student-teacher ratio	-0.010 ***	-0.009 ***	-0.009 ***
	0.000	0.000	0.000
Position in household (ref. Breadwinner without Partner)			
Main breadwinner with Partner			-0.019 **
			0.006
Partner			-0.026 ***
			0.006
Child			0.024 ***
			0.006
Home ownership (ref. Home owner)			
Rented property without housing benefits			0.006 ***
			0.001
Rented property with housing benefits			0.032 ***
			0.005
Household composition (ref. Other)			
Couple with children			-0.013
			0.008
Single parent			-0.018 **
			0.006
Single person			-0.003
			0.006
Couple without children			0.014 *
			0.008
Adjusted r2	0.053	0.072	0.068
N	985,952	985,952	748,759
Additional teacher level covariates	No	No	Yes
School FE	Yes	Yes	Yes
Year FE	Yes	Yes	No
Years	2009-2017	2009-2017	2011-2017

Notes: Coefficients come from regressions of teacher and school characteristics on teacher turnover (teacher in year *t* turnsover if he or she is not found in the same school in *t+1).* Additional covariates include migration background, family gross income, independant school and the number of staff. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 2

Multinomial logit regression determinants of teacher mobility

	Move	**Leave**
	(1)	(2)
Relative vacancy rate (standardized)	0.281 ***	0.058 ***
	(0.009)	(0.008)
Age (ref. 36-40)		
age 21-25	0.262 ***	-0.338 ***
	(0.032)	(0.033)
age 26-30	0.111 ***	-0.220 ***
	(0.023)	(0.024)
age 31-35	0.095 ***	-0.017
	(0.020)	(0.022)
age 41-45	-0.074 **	-0.038
	(0.023)	(0.024)
age46-50	-0.156 ***	-0.066 **
	(0.023)	(0.025)
age 51-55	-0.361 ***	-0.036
	(0.024)	(0.024)
age 56-60	-0.637 ***	0.506 ***
	(0.026)	(0.023)
age 61-65	-0.890 ***	2.110 ***
	(0.043)	(0.022)
age 65+	-0.898 **	0.728 ***
	(0.286)	(0.154)
Female	-0.285 ***	-0.458 ***
	(0.019)	(0.015)
Contract size (ref. <0.5)		
0.5-0.8 FTE	-0.271 ***	-0.689 ***
	(0.016)	(0.014)
0.8+ FTE	-0.488 ***	-1.048 ***
	(0.019)	(0.016)
Temporary contract	1.095 ***	1.523 ***
	(0.020)	(0.022)
School size (ref. 300-400)		
0-100 students	0.459 ***	0.138 **
	(0.071)	(0.056)
100-200 students	0.394 ***	0.176 ***
	(0.042)	(0.032)
200-300 students	0.131 ***	0.056 **
	(0.029)	(0.021)
400-500 students	-0.124 ***	-0.062 **
	(0.037)	(0.025)
500-600 students	-0.123 **	-0.086 **
	(0.048)	(0.031)
Share of disadvantaged students		
2nd quartile	0.011	0.044 **
	(0.024)	(0.018)
3rd quartile	0.021	0.015
	(0.026)	(0.019)
4th quartile	-0.064 **	-0.020
	(0.031)	(0.022)

TABLE 2 (Continued)

Urbanity (ref. Very Urban)		
Urban	0.176 ***	0.027
	(0.032)	(0.021)
Moderately Urban	0.118 ***	0.021
	(0.034)	(0.025)
Little Urban	0.085 **	0.010
	(0.037)	(0.026)
Rural	0.093 **	0.059 *
	(0.042)	(0.031)
Student-teacher ratio	-0.062 ***	-0.038 ***
	(0.004)	(0.003)
Position in household (ref. Breadwinner without Partner)		
Main breadwinner with Partner	-0.262 ***	-0.102
	(0.065)	(0.065)
Partner	-0.334 ***	-0.122 *
	(0.064)	(0.065)
Child	-0.044	0.404 ***
	(0.063)	(0.063)
Home ownership (ref. Home owner)		
Rented property without housing benefits	0.054 **	0.082 ***
	(0.018)	(0.016)
Rented property with housing benefits	0.112 **	0.284 ***
	(0.049)	(0.048)
Household composition (ref. Other)		
Couple with children	0.143	-0.327 ***
	(0.095)	(0.084)
Single parent	0.085	-0.342 ***
	(0.086)	(0.072)
Single person	-0.006	-0.078
	(0.085)	(0.070)
Couple without children	0.184 *	0.048
	(0.096)	(0.085)
Number of observations	748,759	748,759
Additional teacher level covariates	Yes	Yes
School FE	No	No
Year FE	No	No
Years	2011-2017	2011-2017

Notes: Coefficients come from multinomial logit regressions of teacher and school characteristics on teacher movement to another school in column 1 (teacher *i* in year *t* moves to another school if he or she is found in another school in year *t+1)* and teachers leaving the primary education sector in column 2 (teacher *i* in year *t* leaves primary education if he or she is not found in the data in year *t+1).* Additional covariates include migration background, family gross income, independant school , school denomination, school method, Randstad, school type and the number of staff. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 3

Estimated effects of teacher and school characteristics on turnover, moving to another school and leaving primary education in a tightening teacher labor market for two labor market tightening indicators

	Turnover			**Move**			**Leave**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Relative vacancy rate (standardized)	0.015 ***					0.031 ***			0.012 **
	(0.001)					(0.005)			(0.005)
Regional vacancy rate (standardized)		0.031 ***	0.015 ***	0.009	0.020 **		0.009	0.012 **	
		(0.003)	(0.004)	(0.008)	(0.008)		(0.006)	(0.006)	
Age (ref. 36-40)									
age 21-25	-0.010 **	-0.010 *	-0.010 *	0.019 ***	0.019 ***	0.026 ***	-0.032 ***	-0.032 ***	-0.031 ***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)
age 26-30	-0.012 ***	-0.013 ***	-0.012 ***	0.003	0.003	0.008 **	-0.017 ***	-0.018 ***	-0.016 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
age 31-35	0.009 **	0.009 **	0.009 **	0.009 ***	0.009 ***	0.010 ***	0.000	0.000	-0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
age 41-45	-0.007 **	-0.007 **	-0.007 **	-0.006 **	-0.006 **	-0.002	-0.002	-0.002	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
age46-50	-0.010 **	-0.010 **	-0.010 **	-0.010 ***	-0.010 ***	-0.006 *	0.000	0.000	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
age 51-55	-0.020 ***	-0.020 ***	-0.020 ***	-0.019 ***	-0.019 ***	-0.015 ***	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
age 56-60	-0.022 ***	-0.023 ***	-0.022 ***	-0.038 ***	-0.038 ***	-0.031 ***	0.014 ***	0.014 ***	0.015 ***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
age 61-65	0.149 ***	0.149 ***	0.149 ***	-0.046 ***	-0.046 ***	-0.035 ***	0.199 ***	0.199 ***	0.205 ***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)
age 65+	0.103 **	0.103 **	0.103 **	-0.077 **	-0.077 **	-0.067	0.174 ***	0.174 ***	0.176 **
	(0.045)	(0.045)	(0.045)	(0.033)	(0.033)	(0.042)	(0.044)	(0.044)	(0.054)
Contract size (ref. <0.5)									
0.5-0.8 FTE	-0.064 ***	-0.064 ***	-0.064 ***	-0.017 ***	-0.017 ***	-0.018 ***	-0.055 ***	-0.055 ***	-0.053 ***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
0.8+ FTE	-0.104 ***	-0.104 ***	-0.104 ***	-0.034 ***	-0.034 ***	-0.035 ***	-0.081 ***	-0.081 ***	-0.079 ***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Temporary contract	0.144 ***	0.144 ***	0.144 ***	0.103 ***	0.103 ***	0.106 ***	0.067 ***	0.067 ***	0.077 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)
Share of disadvantaged students									
2nd quartile	-0.003	-0.003	-0.002	0.000	0.000	-0.001	-0.003	-0.003	-0.002
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
3rd quartile	0.003	0.004	0.004	0.002	0.002	0.003	0.002	0.002	0.003
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
4th quartile	0.006	0.009	0.008	0.003	0.004	0.000	0.005	0.005	0.008
	(0.014)	(0.014)	(0.014)	(0.012)	(0.012)	(0.012)	(0.009)	(0.009)	(0.009)
Urbanity (ref. Very Urban)									
Urban	-0.013	-0.016	-0.012	-0.024 *	-0.028 **	-0.017	0.009	0.008	0.010
	(0.017)	(0.017)	(0.017)	(0.013)	(0.013)	(0.014)	(0.010)	(0.010)	(0.010)
Moderately Urban	-0.014	-0.032	-0.017	-0.052 **	-0.063 **	-0.036	0.030 *	0.027 *	0.030 *
	(0.026)	(0.026)	(0.026)	(0.023)	(0.024)	(0.023)	(0.016)	(0.016)	(0.016)
Little Urban	-0.014	-0.030	-0.017	-0.061 **	-0.070 **	-0.040	0.038 *	0.035 *	0.039 *
	(0.032)	(0.031)	(0.032)	(0.028)	(0.027)	(0.027)	(0.020)	(0.020)	(0.020)
Rural	0.020	0.001	0.016	-0.061 *	-0.059 *	-0.003	0.041	0.042	0.035
	(0.036)	(0.037)	(0.036)	(0.034)	(0.034)	(0.030)	(0.031)	(0.031)	(0.025)

TABLE 3 (continued)

Interactions with the relative vacancy rate									
Age (ref. 36-40)									
age 21-25				-0.021 ***	-0.020 ***	-0.016 **	0.004	0.004	-0.001
				(0.005)	(0.005)	(0.006)	(0.003)	(0.003)	(0.004)
age 26-30				-0.005	-0.005	-0.011 **	0.009 ***	0.009 ***	-0.002
				(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
age 31-35				0.000	0.000	-0.001	0.005 **	0.005 **	0.002
				(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
age 41-45				0.000	0.000	-0.008 **	-0.002	-0.002	0.003
				(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
age46-50				-0.007 **	-0.007 **	-0.009 **	0.003	0.003	-0.002
				(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
age 51-55				-0.006 **	-0.006 **	-0.010 **	0.003	0.003	0.000
				(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
age 56-60				-0.012 ***	-0.012 ***	-0.016 ***	-0.006 **	-0.006 **	-0.003
				(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
age 61-65				-0.016 ***	-0.016 ***	-0.025 ***	-0.017 ***	-0.017 ***	-0.014 **
				(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.006)
age 65+				0.014	0.014	-0.014	0.038	0.038	0.033
				(0.031)	(0.031)	(0.044)	(0.037)	(0.037)	(0.055)
Contract size (ref. <0.5)									
0.5-0.8 FTE				0.003	0.003	0.000	-0.008 ***	-0.009 ***	-0.002
				(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
0.8+ FTE				0.002	0.002	0.001	-0.011 ***	-0.011 ***	-0.003
				(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Urbanity (ref. Very Urban)									
Urban				0.007	0.012 *	-0.007 **	0.001	0.003	0.001
				(0.007)	(0.007)	(0.003)	(0.005)	(0.005)	(0.002)
Moderately Urban				-0.003	0.006	-0.011 **	0.006	0.009	-0.002
				(0.009)	(0.009)	(0.004)	(0.007)	(0.007)	(0.003)
Little Urban				-0.007	0.004	-0.016 ***	0.002	0.005	-0.002
				(0.013)	(0.012)	(0.003)	(0.009)	(0.009)	(0.003)
Rural				-0.064 **	-0.035	-0.016 ***	0.009	0.018	0.006
				(0.024)	(0.024)	(0.004)	(0.025)	(0.025)	(0.004)
Temporary contract				-0.022 ***	-0.023 ***	-0.018 **	-0.012 ***	-0.012 ***	-0.026 ***
				(0.003)	(0.003)	(0.006)	(0.003)	(0.003)	(0.004)
Share of disadvantaged students									
2nd quartile				0.001	0.001	0.002	-0.002	-0.002	0.000
				(0.006)	(0.006)	(0.003)	(0.005)	(0.005)	(0.002)
3rd quartile				0.002	0.002	0.000	-0.003	-0.003	0.000
				(0.007)	(0.007)	(0.003)	(0.005)	(0.005)	(0.002)
4th quartile				0.018 **	0.018 **	0.008 **	-0.008	-0.008	-0.003
				(0.008)	(0.008)	(0.003)	(0.006)	(0.006)	(0.003)
Adjusted r2	0.072	0.029	0.088	0.027	0.026	0.025	0.064	0.064	0.063
N	204,789	204,789	204,789	189,836	189,836	189,836	204,789	204,789	204,789
Additional teacher level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	No	No	Yes	No	No
Years	2016-2017	2016-2017	2016-2017	2016-2017	2016-2017	2016-2017	2016-2017	2016-2017	2016-2017

Notes: Coefficients come from regressions of teacher and school characteristics on teacher turnover in column 1-3, teacher movement to another school in column 4-6 and teachers leaving the primary education sector in column 7-9 (for definitions see Table 2). Additional covariates include gender, migration background, position in houshold, home ownership, household composition, family gross income, independant school, school size and the number of staff. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 4

Estimated effects of teacher and school characteristics on teacher turnover, moving to another school and leaving primary education for Netherlands biggest cities and their surrounding areas

	Turnover		**Move**		**Leave**	
	(1)	(2)	(3)	(4)	(5)	(6)
Age (ref. 36-40)						
age 21-25	-0.008	-0.022 ***	0.022 ***	0.004	-0.031 ***	-0.027 ***
	(0.006)	(0.007)	(0.005)	(0.006)	(0.004)	(0.004)
age 26-30	-0.004	-0.007	0.007 **	0.002	-0.011 ***	-0.009 **
	(0.003)	(0.005)	(0.003)	(0.004)	(0.002)	(0.003)
age 31-35	0.002	0.003	0.005 **	0.002	-0.002	0.002
	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.003)
age 41-45	0.001	-0.011 **	0.003	-0.009 **	-0.002	-0.002
	(0.003)	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)
age46-50	-0.004	-0.015 ***	-0.004	-0.015 ***	0.000	-0.001
	(0.003)	(0.005)	(0.002)	(0.004)	(0.002)	(0.003)
age 51-55	-0.015 ***	-0.030 ***	-0.011 ***	-0.026 ***	-0.004	-0.005
	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.003)
age 56-60	-0.003	-0.023 ***	-0.022 ***	-0.037 ***	0.019 ***	0.012 ***
	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)
age 61-65	0.191 ***	0.164 ***	-0.033 ***	-0.050 ***	0.227 ***	0.215 ***
	(0.005)	(0.006)	(0.003)	(0.004)	(0.005)	(0.006)
age 65+	0.183 **	0.158 **	-0.047	-0.028	0.252 ***	0.203 **
	(0.060)	(0.066)	(0.040)	(0.039)	(0.059)	(0.063)
Female	-0.044 ***	-0.029 ***	-0.015 ***	-0.007 **	-0.032 ***	-0.024 ***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
Contract size (ref. <0.5)						
0.5-0.8 FTE	-0.057 ***	-0.066 ***	-0.016 ***	-0.014 ***	-0.047 ***	-0.058 ***
	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.004)
0.8+ FTE	-0.095 ***	-0.094 ***	-0.029 ***	-0.020 ***	-0.075 ***	-0.083 ***
	(0.003)	(0.005)	(0.002)	(0.003)	(0.003)	(0.004)
Temporary contract	0.168 ***	0.121 ***	0.096 ***	0.057 ***	0.093 ***	0.077 ***
	(0.006)	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)
School size (ref. 300-400)						
0-100 students	0.015	0.032	0.021	0.032	-0.004	0.002
	(0.017)	(0.028)	(0.014)	(0.026)	(0.012)	(0.015)
100-200 students	0.014	0.006	0.018 **	0.014	-0.001	-0.007
	(0.010)	(0.012)	(0.008)	(0.011)	(0.007)	(0.008)
200-300 students	0.002	0.000	0.008	0.002	-0.006	-0.003
	(0.007)	(0.008)	(0.005)	(0.006)	(0.004)	(0.005)
400-500 students	-0.002	-0.012	-0.004	-0.010	0.001	-0.003
	(0.006)	(0.009)	(0.005)	(0.007)	(0.004)	(0.006)
>500 students	-0.002	-0.007	-0.004	-0.007	0.002	-0.002
	(0.009)	(0.012)	(0.008)	(0.011)	(0.006)	(0.008)
Share of disadvantaged students						
2nd quartile	-0.003	0.004	-0.001	0.002	-0.001	0.003
	(0.005)	(0.010)	(0.003)	(0.009)	(0.003)	(0.005)
3rd quartile	0.001	0.009	0.004	0.005	-0.002	0.006
	(0.006)	(0.012)	(0.005)	(0.011)	(0.005)	(0.007)
4th quartile	0.014	0.012	0.009	0.004	0.005	0.009
	(0.008)	(0.015)	(0.007)	(0.014)	(0.006)	(0.009)

TABLE 4 (Continued)

Urbanity (ref. Very Urban)						
Urban	0.002		0.001		0.002	
	(0.008)		(0.006)		(0.005)	
Moderately Urban	-0.021 *		-0.022 **		0.000	
	(0.012)		(0.010)		(0.007)	
Little Urban	-0.037 **		-0.035 **		-0.004	
	(0.018)		(0.014)		(0.012)	
Rural	-0.050 **		-0.029 *		-0.022	
	(0.022)		(0.016)		(0.016)	
Student-teacher ratio	-0.008 ***	-0.008 ***	-0.004 ***	-0.003 **	-0.004 ***	-0.006 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Position in household (ref. Breadwinner without Partner)						
Main breadwinner with Partner	-0.003	-0.024 *	-0.004	-0.008	0.003	-0.019 *
	(0.013)	(0.015)	(0.011)	(0.012)	(0.009)	(0.010)
Partner	-0.010	-0.024 *	-0.009	-0.008	0.001	-0.019 *
	(0.013)	(0.014)	(0.011)	(0.012)	(0.009)	(0.010)
Child	0.033 **	-0.002	0.007	-0.005	0.031 ***	0.000
	(0.012)	(0.014)	(0.010)	(0.011)	(0.009)	(0.010)
Home ownership (ref. Home owner)						
Rented property without housing benefits	0.008 **	0.001	0.002	-0.001	0.007 **	0.002
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Rented property with housing benefits	0.046 ***	0.021 *	0.013	0.012	0.040 ***	0.012
	(0.012)	(0.011)	(0.010)	(0.008)	(0.010)	(0.009)
Household composition (ref. Other)						
Couple with children	-0.036 **	-0.002	-0.014	0.014	-0.026 *	-0.015
	(0.018)	(0.017)	(0.014)	(0.014)	(0.014)	(0.013)
Single parent	-0.026 *	-0.019	-0.010	0.006	-0.018	-0.027 *
	(0.015)	(0.013)	(0.012)	(0.010)	(0.011)	(0.011)
Single person	-0.006	-0.009	-0.010	0.006	0.004	-0.015
	(0.015)	(0.013)	(0.012)	(0.010)	(0.011)	(0.010)
Couple without children	-0.009	0.017	-0.014	0.012	0.002	0.006
	(0.018)	(0.018)	(0.014)	(0.014)	(0.014)	(0.013)
Gross family income	-0.005	-0.018 ***	-0.002	-0.008 **	-0.003	-0.012 ***
	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)
Adjusted r2	0.063858	0.05249	0.030664	0.0295	0.074075	0.06272
Number of observations	148,049	99,810	138,342	92,605	148,049	99,810
Additional teacher level covariates	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Years	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of teacher and school characteristics on teacher turnover in column 1-2, teacher movement to another school in column 3-4 and teachers leaving the primary education sector in column 5-6 (for definitions see Table 1). Even columns have estimates for the 4 biggest cities of The Netherlands (Amsterdam, Rotterdam, The Hague, Utrecht), uneven column have estimates for their surrounding areas. Additional covariates include migration background, independant school and the number of staff. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 5

Estimated effects of turnover on average teacher age and proportion of novice teachers

	Average teacher age			Proportion young teachers	
	(1)	(2)	(3)	(4)	(5)
Turnover	-2.752 ***	-2.763 ***	-1.344 ***	0.083 ***	0.047 ***
	(0.297)	(0.297)	(0.293)	(0.011)	(0.012)
Regional vacancy rate (standardized)	0.047	0.171 **		-0.007 **	
	(0.060)	(0.070)		(0.003)	
Regional vacancy rate * turnover	-0.276	-0.319		0.019 **	
	(0.270)	(0.271)		(0.009)	
Relative vacancy rate (standardized)			0.421 ***		-0.011 ***
			(0.038)		(0.002)
Relative vacancy rate * Turnover			-3.710 ***		0.090 ***
			(0.334)		(0.013)
Adjusted r2	0.151	0.153	0.184	0.126	0.137
Number of observations	11,786	11,786	11,786	11,786	11,786
Additional teacher level covariates	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No
Years	2016-2017	2016-2017	2016-2017	2016-2017	2016-2017

Notes: Coefficients come from regressions of school-level turnover and two different labor market tightening indicators on the average teacher age in column 1-3 and the proportion of teachers under 30 in column 4 and 5. Additional covariates include share of female teachers, average contract size, share of teachers with a temporary contract, school size, share of disadvantaged students, urbanity, student-teacher ratio, share of couples with children, share of couples without children, share of single parents and the share of single teachers. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 6

Robustness checks: Estimated effects of turnover on standardized student test scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Turnover	-0.061 **	-0.058 **	-0.074	-0.068	-0.245 **		
	(0.025)	(0.029)	(0.061)	(0.061)	(0.093)		
Relative vacancy rate (standardized)	-0.009 **	-0.003			-0.019 **		
	(0.003)	(0.003)			(0.006)		
Relative vacancy rate * Turnover	0.019	0.010			0.117 **		
	(0.019)	(0.022)			(0.046)		
Regional vacancy rate (standardized)			-0.011	0.007			
			(0.018)	(0.021)			
Regional vacancy rate * turnover			0.062	0.054			
			(0.068)	(0.068)			
Turnover (3-year average)						-0.014	-0.023
						(0.053)	(0.056)
Relative vacancy rate							0.010
							(0.007)
Relative vacancy rate * Turnover (3-year average)							0.064
							(0.060)
Adjusted R2	0.055	0.055	0.049	0.049	0.049	0.054	0.054
Number of observations	616,736	543,393	166,049	166,049	166,049	613,524	613,524
Additional studentlevel covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	No	No	No
Balanced	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Years	2011-2017	2011-2017	2016-2017	2016-2017	2016-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of two measures of school-level turnover and two different teacher labor market tightening indicators. For column 1 missing student test scores have been imputed at 517. Column 2 only includes schools with more than 10 students taking the Cito test. Column 4 and 5 have the regional vacancy rate from Dialogic as alternative teacher labor market tightening indicator. For the columns 6 and 7 turnover and the relative vacancy rate are averaged over the past three years. Additional covariates include gender, student weights, migration background, family disposable income, family home ownership, household composition, number of persons in the household, shares of migrants in grade 8, shares of low-income peers, share of disadvantaged students in grade 8, school size, urbanity and student-teacher ratio. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 7

Estimated effects of turnover on student test scores, average teacher age and proportion of young teachers for Netherlands biggest cities and their surrounding areas

	(1)	(2)	(3)
Turnover	-0.023	-2.296 ***	0.059 ***
	(0.066)	(0.370)	(0.014)
Turnover*big 4 cities	-0.176 **	1.3421 **	-0.054 **
	(0.103)	(0.601)	(0.022)
Adjusted r2	0.059	0.158	0.147
Number of observations	196,221	11,650	11,650
Additional teacher level covariates	Yes	Yes	Yes
School FE	Yes	Yes	Yes
Year FE	Yes	No	No
Years	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of teacher turnover on education quality outcomes. The interaction term has the coefficient for the 4 biggest cities of The Netherlands (Amsterdam, Rotterdam, The Hague, Utrecht). For covariates see Table 3 and 4. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001

TABLE 8

Estimated effects of 3-year average turnover on student grade retention

	>8 years primary school		**Age-at-test**
	(1)	(2)	(3)
Turnover (3-year average)	-0.025 **	-0.024 **	-0.094 ***
	(0.009)	(0.010)	(0.016)
Relative vacancy rate		-(0.002)	-(0.007) **
		0.001	0.002
Relative vacancy rate * Turnover (3-year average)		-(0.007)	-(0.071) ***
		0.011	0.017
Adjusted R2	0.011	0.012	0.034
Number of observations	1,221,419	1,221,419	1,187,528
Additional studentlevel covariates	Yes	Yes	Yes
School FE	Yes	Yes	Yes
Year FE	No	No	No
Years	2011-2017	2011-2017	2011-2017

Notes: Coefficients come from regressions of 3-year average school-level turnover and relative vacancy rates on grade retention indicators. In column 1-2 a student is believed to have repeated a grade when he or she is in the 8th grade and has been observed in primary school for more than 8 years. Column 3 has age-at-test as outcome. Additional covariates include gender, student weights, migration background, family disposable income, family home ownership, household composition, number of persons in the household, shares of migrants in grade 8, shares of low-income peers, share of disadvantaged students in grade 8, school size, urbanity and student-teacher ratio. Standard errors clustered at school-level are in parentheses.

* p<0.10 ** P<0.05 *** p<0.001