

A Work Project presented as part of the requirements for the Award of a Master Degree in  
Economics from the Nova School of Business and Economics.

THE IMPACT OF TEACHER TURNOVER ON STUDENT PERFORMANCE:  
EVIDENCE FROM PORTUGAL

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31-05-2023

# The Impact of Teacher Turnover on Student Performance: Evidence from Portugal \*

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May 31, 2023

## Abstract

Teacher turnover is a much-discussed topic in education policy debates. Nevertheless, there is no study measuring its impacts on student achievement for the Portuguese context, characterized by a rigid and centralized teacher allocation model. We measure teacher turnover as the yearly share of new-to-school teachers and estimate its causal effects on 6<sup>th</sup> grade students' exam scores. A small, yet statistically significant negative effect is found, being stronger for students from lower socioeconomic backgrounds, females, and those with lower previous achievement. We also find that students in socially-disadvantaged schools suffer a double penalty from teacher turnover. No differences were detected for students who had the same teacher in the 5<sup>th</sup> and 6<sup>th</sup> grades and those who had not, suggesting organizational disruption as a main driver of teacher turnover effects.

**Keywords:** Education, Teacher turnover, Student achievement, Schools

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\*First and foremost, I would like to express my full gratitude to professor Luís Catela Nunes and Pedro Freitas for their invaluable guidance and patience. I also thank DGEEC (*Direção-Geral de Estatísticas da Educação e Ciência*) for providing access to the administrative data used in this paper. A special acknowledgment to Sara Cal for her suggestions and constant encouragement. Finally, I am extremely grateful to my family, for being always very supportive, and to my friends, who were crucial during my academic path.

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

# 1 Introduction

Teacher turnover is very frequently in the center of education policy debates. While there are potential benefits associated with it, since new teachers may bring new ideas, gain new experience, and be more motivated; the general assumption is that high turnover rates impose a cost on students' learning processes and create a barrier for high-quality education. Consistent with this view, the few empirical studies on this topic (for the U.S. and the U.K.) find a small, yet negative effect: a 10 percentage point increase in the teacher turnover rate is expected to decrease student point scores by 0.3% to 1.1% of one standard deviation, on average.

Between 2008/09 and 2017/18, in Portugal, the average share of new teachers per school in a particular year (i.e. average teacher turnover) ranged between 17% to 36%, being more prevalent in disadvantaged schools (Nunes et al., 2022). However, there is not yet any causal study measuring the effects of teacher turnover on student achievement for the Portuguese context, which due to its particularities may imply different conclusions from those found in studies on the American or English systems. In fact, Portugal is one of the nine European education systems with a candidate list type of recruitment, managed at a top-level authority<sup>1</sup>, which represents the most rigid and centralized method of teacher recruitment. In contrast, open recruitment, granting schools autonomy in teacher selection, prevails in 75% of European countries (Eurydice et al., 2018).

This study aims at finding a causal relationship between teacher turnover and student achievement with a fixed effects design and a rich set of student and school controls. Using data from four cohorts of 6<sup>th</sup> grade students in Portugal and their teachers, we measure the effects of teacher turnover (per subject and for the entire 2<sup>nd</sup> cycle) on students' Portuguese

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<sup>1</sup>The education systems with this type of model are: Germany, Cyprus, Luxembourg, Malta, Albania, Belgium (French and German-speaking Communities), Austria and Portugal. In countries with this system, teachers apply for employment at a top-level authority that will rank candidates according to some criteria (Eurydice et al., 2018).

and Mathematics exam scores. Defining teacher turnover as the fraction of teachers giving classes in a school in year  $t$  who were not there in year  $t - 1$  (i.e. the share of new-to-school teachers)<sup>2</sup>, we investigate whether students in schools with higher rotation of teachers have, on average, higher or lower exam scores, holding student's and school's characteristics constant. Further, we disentangle the heterogeneity in the results across students and schools with different characteristics. Ultimately, this work has two main goals: first, to better understand what are the predictors of student achievement; and second, to uncover teacher mobility dynamics and provide evidence on the efficacy of the current teacher allocation scheme.

The main finding of this paper is that an increase of one standard deviation in the teacher turnover rate is associated with a decrease of 0.38% of a standard deviation in exam scores. Essentially this means that when teacher turnover increases by 10 percentage points, students, on average, are expected to score around 0.25% of a standard deviation less in exams, which is a slightly smaller effect than the one found in the literature. Furthermore, we unveil several heterogeneous effects across students and schools. On the one hand, the student subset carrying the negative costs of teacher turnover are female students with low ability levels, who are beneficiary of school social support. On the other hand, the lower-achieving schools and those with higher shares of economically disadvantaged students seem to suffer a double penalty from teacher rotation. Moreover, no differences are detected between students who had the same teacher across the two grades of 2<sup>nd</sup> cycle and those who had not, suggesting that turnover impacts students through an organizational disruption effect.

The remainder of the paper is structured as follows. Section 2 reviews the existing literature on teacher turnover and its effect on students; Section 3 gives an overview of the Portuguese Educational System and the teacher allocation model; the data used in the analysis is described in Section 4; the methodology and empirical strategy are depicted in Section 5; and the results obtained are reported in Section 6 and discussed in Section 7.

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<sup>2</sup>Turnover within the same school or within the same year will not be considered.

## 2 Literature Review

The literature in the field of Economics of Education shows that within the school, teachers are the input with higher impact on students' achievements. Using the Teacher Value-Added<sup>3</sup> (TVA) model, the common method to assess teachers' quality, there is evidence that they are important not only for students' academic performance ([Rivkin et al., 2005](#); [Aaronson et al., 2007](#); [Kane and Staiger, 2008](#); [Chetty et al., 2014a](#); [Reis et al., 2021](#)), but also for their adult outcomes ([Rothstein, 2010](#); [Chetty et al., 2014b](#)). With the development of these methods, and knowing the relevance a teacher can have on a student's path, a new body of literature is emerging, focusing on how teacher turnover impacts students' achievements.

We identify both a direct and an indirect channel through which the teacher entry rate can affect students. On the one hand, students may be directly affected if they have two different teachers for the same subject in two consecutive years (within the same cycle of studies). In this case, turnover effects would be captured by comparing the scores of students whose teachers are new to the school with scores of students whose teachers stayed at the school from one year to another, holding other factors constant. This channel looks at the effectiveness of entering and exiting teachers and assumes the difference between both will determine the sign of the effect. In that regard, several studies identified that the teachers who leave are, on average, significantly less effective than the stayers, even for disadvantaged schools ([Hanushek and Rivkin, 2010](#); [Goldhaber et al., 2011](#); [Boyd et al., 2011](#)).

On the other hand, even the switching teachers being the least effective, turnover may still impose a cost on students. With the entering of new teachers, the organization of the school will suffer a disruption: previous interpersonal dynamics are altered; the cohesion of the staff may be affected ([Guin, 2004](#)); new teachers, lacking school-specific human capital, need to allocate time and effort to adjust to the new school environment; and the staying teachers

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<sup>3</sup>Teacher Value-Added models, introduced by [Hanushek \(1971\)](#), consider that if we have a big enough dataset of students' socioeconomic information and some measure of their prior test scores comparable between individuals, we are able to get unbiased metrics of teachers' value added to students' achievement.

may need to spend extra time to help new teachers integrate. One can argue that this broader organizational disruption caused by turnover will impact not only entering teachers and their students, but also the students of teachers that did not change schools (Ronfeldt et al., 2013).

Both channels are analyzed in the few existing studies investigating the causal impact of teacher turnover on students: Ronfeldt et al. (2013); Hanushek et al. (2016); Atteberry et al. (2017); Gibbons et al. (2021). All point towards a negative effect, stronger for more disadvantaged schools. Ronfeldt et al. (2013) looks at 4<sup>th</sup> and 5<sup>th</sup> grade New York students over 8 years and regress exam scores on two measures of teacher turnover (entry and exit rate). They test two models, using school-by-grade and school-by-year fixed effects and find that (i) students from grades with higher turnover have lower scores in both English language arts (ELA) and math; and (ii) students of teachers of the same grade and in the same school perform worse in years of higher turnover. Overall, a 10 p.p. increase in turnover leads to a decrease in scores of 0.5-1.0% of a standard deviation. This negative impact is particularly felt for students in schools with more low-performing and Black students. Further, they show that turnover has a disruptive effect beyond changing the distribution in teacher quality, meaning that even students who have the same teacher from one year to the other are affected by turnover.

Using a similar method, Hanushek et al. (2016) analyzes the effects of teacher turnover on the quality of instruction for students of the 4<sup>th</sup> to the 8<sup>th</sup> grades from Texas, over a period of 5 years. They point out that school-by-year and school-by-grade fixed effects alone may not be enough to isolate the causal effect of turnover, once there may be time-varying, grade-specific factors affecting both teacher turnover and students' achievement. Thus, a grade reassignments control<sup>4</sup> and a set of specifications that aggregate turnover at a school-year

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<sup>4</sup>The grade reassignments control included in Hanushek et al. (2016) is defined as the fraction of teachers who were lecturing a different grade in the same school in the previous year. They find a correlation of -0.17 between the share of teachers who moved from another grade and the share of new-to-school teachers, which suggests there may be some sorting into grades.

level<sup>5</sup> were introduced. The first conclusion is that teachers who exit Texas public schools are less effective than teachers who stay in the school. Furthermore, and similarly to [Ronfeldt et al. \(2013\)](#), they find that higher turnover rates decrease students' math scores in lower-achieving schools. The grade-specific knowledge and experience lost when teachers leave schools offset the potential gains from departing teachers being less effective than the staying, on average. In higher-achieving schools, the negative effect of turnover is not so evident.

With a slightly different approach, [Atteberry et al. \(2017\)](#) studies turnover both between and within schools. Using data from New York teachers, between 1974 and 2010, and their students (3<sup>rd</sup> to 8<sup>th</sup> grades), the authors analyze differences in average teacher quality by transition type (i.e. changes within and between districts, and within schools). They conclude that historically underserved students may have a higher probability of being paired with a churning teacher; and that teachers' ethnicity is a predictor of the propensity to be reassigned to another grade/subject. Regarding the impact on students, they find a more prevalent negative result of turnover for students who had a brand new teacher and a less strong effect on students assigned to teachers who are in the same school but new to their subject/grade.

Finally, using data on 18 subject groups of age-16 students (11<sup>th</sup> grade) and their teachers in England, over five years, [Gibbons et al. \(2021\)](#) measures the impact of turnover on exam scores of each school-subject-year group, using student and school controls and a range of fixed effects (i.e. school-subject, school-by-year and subject-by-year groups). With this design, the possible bias from the non-random allocation of teachers is smoothed since we are looking at subject-specific teachers within one grade of high school. The main finding of this paper is that students who experience higher rates of teacher entry in their subjects have lower exam scores than the rest. Specifically, an increase in the entry rate of 10 p.p. is expected to reduce attainment by around 0.4-0.5% of one standard deviation. As an additional step, the authors conclude that the primary mechanism through which turnover impacts student per-

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<sup>5</sup>Two specifications of the model are tested: one measuring turnover as an average of transitions at the school-grade-year level, and another at the school-year level.

formance is the absence of school-specific knowledge, such that new teachers are disruptive only in their first year in the new school.

When looking at the Portuguese case, there is not yet any study measuring the causal effects of teacher turnover on student attainment. Nevertheless, a recent correlational analysis by [Nunes et al. \(2022\)](#) shows that, on average, lower-achieving schools have a teacher turnover rate 3 p.p. above that of higher-achieving schools when the average exam scores from the 4<sup>th</sup> to the 12<sup>th</sup> grade are compared. Moreover, schools with a higher percentage of students receiving school social support or with low-educated mothers have, on average, teacher entry rates 5 p.p. higher. These results suggest that teacher turnover is more prevalent in disadvantaged schools and opens the door to empirically study its effects.

It is important to note that all the existing studies on the causal effects of teacher turnover are either for the U.S. or the U.K. contexts, which have several differences with the Portuguese one. For example, the U.K. has an open recruitment system, such that schools have autonomy to hire ([Eurydice et al., 2018](#)); and in the U.S. salaries are adjusted to the school context ([Allen et al., 2018](#)). In contrast, Portugal has one of the most rigid teacher recruitment models in Europe, which gives schools no autonomy in the hiring process (further explained in [Section 3](#)), and the salary scheme is the same for the entire country. Given these disparities, the results of previous studies may not extend to Portugal. It is thus important to understand whether the current model is benefiting students and teachers such that new policies can be designed towards a more efficient educational system. Specially in a context of teacher shortages<sup>6</sup>, where stability is a determinant factor to make the profession more attractive.

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<sup>6</sup>See [Nunes et al. \(2021\)](#) for an outline of the future teacher recruitment needs, and the characteristics of the current teaching staff in Portugal compared to other teaching systems.

### 3 Portuguese Educational System

Compulsory education in Portugal is organized into Basic and Secondary education. The first cycle of Basic education covers the 1<sup>st</sup> to 4<sup>th</sup> grades, the second cycle the 5<sup>th</sup> and 6<sup>th</sup> grades, and the third cycle the 7<sup>th</sup> to 9<sup>th</sup> grades. Accordingly, Secondary education corresponds to the 10<sup>th</sup> to 12<sup>th</sup> grades, where students can follow either the vocational track or four different scientific-humanistic courses: Languages and Humanities, Science and Technology, Socio-Economic Sciences and Visual Arts. At the end of the 4<sup>th</sup>, 6<sup>th</sup> and 9<sup>th</sup> grades, students have National Exams for Portuguese and Mathematics<sup>7</sup>. In the 12<sup>th</sup> grade, all students are required to do the Portuguese National Exam, while the Mathematics National Exam is mandatory for only the Socio-Economic Sciences and Science and Technology courses students.

Teachers are divided into three main recruitment groups, based on the grades in which they teach: (i) 1<sup>st</sup> cycle teachers, (ii) 2<sup>nd</sup> cycle teachers, and (iii) 3<sup>rd</sup> cycle/Secondary education teachers<sup>8</sup>. This means that a Math teacher in the 9<sup>th</sup> grade can also give Math classes to the 12<sup>th</sup> grade, for example. Although teachers are not restricted to their teaching group, it is not very common for them to be giving classes in two groups at the same time.

Allocation of teachers to public schools is based on a centralized model. Internationally, there are essentially three teacher recruitment schemes: open recruitment, competitive examination, and candidates list (Eurydice et al., 2018). Portugal adopted the most rigid one, in which employment is managed at the top-level education authority, giving no autonomy for schools to choose their teachers: the candidates lists. Teachers are allocated solely based on their preferences, final GPA after graduation, and years of experience. This means that a more experienced teacher, with a better graduation score will be given priority, having higher

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<sup>7</sup>The National Exams for the 4<sup>th</sup> and 6<sup>th</sup> grades were reintroduced in 2000 as an instrument for schools' supervision, after their abolition in 1974 (Eurydice and EACEA, 2011). For most years, these were low-stakes exams (*Provas de Aferição*), so did not count for the student's final grade, however in 2004/05 for the 9<sup>th</sup> grade, in 2011/12 for the 6<sup>th</sup> grade and in 2012/13 for the 4<sup>th</sup> grade, they became mandatory and part of students' evaluation. In 2015/16, the 4<sup>th</sup> and 6<sup>th</sup> grade National Exams disappeared.

<sup>8</sup>See Table A1 for the list of teacher recruitment groups by education level.

chances of being allocated to their first option. This model totally ignores the heterogeneity between schools and whether the candidate teacher has adequate skills for that school.

In more detail, this model is divided into an internal and external process. The internal process occurs every four years<sup>9</sup> and is directed towards (i) Permanent teachers (*professores de Quadro de Agrupamento ou Escola não Agrupada*), who are associated with a specific school cluster, and (ii) District teachers (*professores do Quadro de Zona Pedagógica*), who belong to one of the ten administrative zones of the Portuguese Educational System. While this internal process is of mandatory application for district teachers, that apply to schools within their administrative zone, a permanent teacher does not have to apply. On the other hand, the annual external process is applied to (iii) Temporary-contract teachers that do not have yet a permanent link with the Ministry of Education, so, generically, the external process is intended to bring more temporary-contract teachers into the career. Those that do not enter may not have a full-time contract and will be placed in a group of teachers able to answer emergency staff needs throughout the year.

## 4 Data and Descriptive Statistics

### 4.1 Sample

The data used for the analysis is based on anonymized administrative records of Portuguese students and teachers provided by *Júri Nacional de Exames* (JNE) and MISI, the information system of the Ministry of Education, managed by DGEEC<sup>10</sup>. These rich databases are available for the years between 2006/07 and 2017/18 and provide information on students' characteristics (e.g. gender, age, nationality, social support, family background, place of

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<sup>9</sup>Formally this process should occur every four years, however, there were some exceptions. Since 2008/09, there were internal processes in the following years: 2009/10, 2013/14, 2015/16, and 2017/18. Naturally, in these years teacher turnover spikes were observed.

<sup>10</sup>DGEEC - *Direção-Geral de Estatísticas da Educação e Ciência*.

residency), students' scores in all subjects (i.e. teacher grading and national exams scores) and teacher information (e.g. gender, age, type of contract, experience, school assignment, subjects, classrooms taught in each year).

We choose to focus our analysis on the 2<sup>nd</sup> cycle of studies to minimize the problem of sorting of teachers. As mentioned by both [Hanushek et al. \(2016\)](#) and [Gibbons et al. \(2021\)](#), one of the obstacles for measuring the causal impact of turnover is the non-random allocation of incoming teachers to higher or lower-performing student groups, such as specific grades. Since a teacher giving classes to the 2<sup>nd</sup> cycle of Basic Education can only teach two grades (as described in [Section 3](#)), the probability of less-effective teachers being allocated to lower-performing or "harder" grades may be reduced, contrarily to what can happen in the 3<sup>rd</sup> cycle/Secondary Education<sup>11</sup>.

Our variable of interest is 6<sup>th</sup> grade exam scores of Mathematics and Portuguese (measured on a 0-100 scale). We consider only the years between 2011/12 and 2014/15, when high-stakes exams were in place. We disregard the years before 2011/12, once the low-stakes exam scores are graded on a 1-5 scale, and the years after 2014/15 due to the elimination of 6<sup>th</sup> grade exams in 2015/16. The exam scores are standardized by year and by subject to account for possible effects of different difficulty levels, or score inflation each year. As a measure of the student's previous academic achievement, the model includes the score of the 4<sup>th</sup> grade Mathematics and Portuguese exams, which are concentrated (approximately 98%) in the years between 2009/10 and 2012/13.

Regarding teacher turnover, there are different ways to measure it. The most common in the literature, and also the one adopted in this paper, is the entry rate, defined as the share of teachers in a school in year  $t$  that were not there in year  $t - 1$ . We discard measuring turnover by the exit rate for two reasons. First, it is a noisier measure of turnover, once only

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<sup>11</sup>If we focused the analysis on the 3<sup>rd</sup> cycle of Basic Education or the Secondary Education, we would capture a much wider and diverse group of teachers. For example, a 3<sup>rd</sup> cycle teacher can give classes from the 7<sup>th</sup> to the 12<sup>th</sup> grades, across several subjects. In this case, the probability of selective allocation of teachers to higher or lower performing grades would, most likely, be higher.

a part of the departures it captures will be replaced by new teachers (Hanushek et al., 2016). Second, due to being a noisier measure, the exit rate will always be larger than the entry rate in a context of decline in the number of teachers, as Ronfeldt et al. (2013) pointed out. Attending to the demographic decline and consequent reduction in the number of Portuguese teachers during the last years, it is more reasonable to measure teacher turnover by the entry rate. In the analysis, our measure of turnover is standardized by year and by subject. This is mainly due to the fact that there are spikes in the turnover rate for years of internal process of teacher allocation (in our sample for 2013/14), and given that Mathematics teachers have, on average, higher turnover rates than Portuguese teachers (see Figure A1). Furthermore, within-year teacher turnover (i.e. teachers moving from one school to another in the same year) will not be considered.

Most schools in Portugal are grouped into school clusters. Each school cluster can contain schools of different education levels (e.g. from kindergarten to high school). In our sample, there are 617 school clusters, each with an average of 3 schools. In total, there are 863 schools, 434 of which are non-grouped. Since a teacher can give classes in several schools of the same cluster, at the same time, we only consider to be turnover the cases in which the teacher changed from one school cluster to another (or non-grouped schools)<sup>12</sup>. Turnover is measured as the share of 2<sup>nd</sup> cycle teachers of a particular subject giving classes in a school in year  $t$  who were not there in year  $t - 1$ , based on the first month the teacher appears in the system in each year.

Ultimately, we combine information on teachers and students of public schools from mainland Portugal<sup>13</sup> and end up with data on 322,224 students from the 6<sup>th</sup> grade, making a total of 642,687 exam-score observations, over a period of 4 school years (2011/12 to 2014/15).

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<sup>12</sup>From now on, when we mention *school(s)*, we are referring to school-clusters (and non-grouped schools).

<sup>13</sup>Açores and Madeira have independent teacher-allocation processes, thus will not be included in the sample.

## 4.2 Descriptive Statistics

Table A2 presents the summary statistics of the variables used in the paper. The average teacher turnover rate of all 2<sup>nd</sup> cycle teachers was of 17% to 29%, being the highest in 2013/14, a year of internal process of teacher allocation (see Figures A1). Teacher turnover is always higher for Mathematics (18%-30%) than for Portuguese (16%-28%). Table A3 presents the summary statistics of teacher turnover per subject for the different subject-year groups.

When analyzing the correlations between teacher turnover and school characteristics, we find that lower-achieving schools tend to have higher teacher turnover rates, with a correlation of -0.24 to -0.18 (Figure A2). For schools with higher shares of students with school social support, teacher turnover rates also seem to be higher (Figure A3), although the correlation is not very strong (0.04 to 0.06). Finally, the share of students with higher-educated mother has a very weak correlation with turnover (Figure A4), which oscillates between positive and negative for Mathematics and Portuguese (-0.04 to 0.00). One of the possible reasons for our correlations being considerably weaker than those found in Nunes et al. (2022) is the fact that we are considering a smaller sample, either in terms of the time period, as in terms of the grades included<sup>14</sup>.

## 5 Empirical Strategy

The first aim of this paper is to understand what is the average effect of teacher turnover on student academic performance. Detecting this causal link presents several empirical challenges due to potential endogeneity problems, such as the non-random allocation of teachers to schools and subjects. Although no autonomy is given to schools regarding the hiring and allocation process, their characteristics (i.e. socio-economic background of students, social

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<sup>14</sup>Table A4 displays the correlation coefficients mentioned.

composition of the stock of teachers, and the school conditions) will determine how attractive they are to applicant teachers. A consistent body of literature for the U.S. (Boyd et al., 2013; Jackson, 2009; Hanushek et al., 2004) has found that teachers typically prefer to teach in less disadvantaged schools (i.e. with lower percentages of poor, non-white, and low-achieving students). This means that the less attractive schools may experience higher turnover, as teachers tend to stay in more attractive ones. Nunes et al. (2022) hints on this, by showing that more disadvantaged schools, and presumably less attractive, tend to have higher teacher turnover rates. If this is not properly taken into account in the model, we face the risk of having omitted variable bias, because school characteristics may impact both teacher turnover and exam scores.

In order to surpass these limitations and isolate the effect of turnover, we regress students' 6<sup>th</sup> grade exam scores of Portuguese and Mathematics on teacher turnover per school-subject, using a fixed effects design and a set of student and school controls. The first specification of our model is the following:

$$S_{icst(g=6)} = \alpha + \beta T_{cst} + \gamma X'_{it} + \theta I_{icst} + \delta S_{icst(g=4)} + \zeta_{st} + \varepsilon_{icst}, \quad (1)$$

where  $S_{icst(g=6)}$  is the standardized score in the 6<sup>th</sup> grade national exam of student  $i$ , for subject  $c$ , in school  $s$ , in year  $t$ . Teacher turnover is represented by  $T_{cst}$ , being the share of new-to-school teachers from subject  $c$ , in school  $s$ , in year  $t$ .  $X'_{it}$  is a set of student controls: gender, age, nationality, school social support, access to a computer and internet at home, parents' education, nationality and job situation<sup>15</sup>.  $I_{icst}$  is a binary variable that takes the value of 1 if student  $i$  had a different teacher of subject  $c$  in the 5<sup>th</sup> and 6<sup>th</sup> grades<sup>16</sup>. As a measure of the student's prior achievement, and a proxy of their ability, we add  $S_{icst(g=4)}$ , the

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<sup>15</sup>Parent's education, nationality, and job situation are binary variables for each parent. If the parent has higher education, Portuguese nationality, and is unemployed, all variables will be equal to 1.

<sup>16</sup>Under the condition that the student remained in the same school from one grade to the other.

score in the 4<sup>th</sup> grade national exam (measured on a scale of 1 to 5) of student  $i$ , for subject  $c$ , in school  $s$ , in year  $t$ . Finally,  $\zeta_{st}$  are school-by-year fixed effects. These fixed effects capture time-varying characteristics of schools, either observed or not observed. Standard errors are clustered at a class level, once it is likely that scores of students from the same class are not independent from each other.

Overall, our coefficient of interest is  $\beta$ , which tells us what is the change in students' 6<sup>th</sup> grade exam scores from a standard deviation increase in teacher turnover in the year the student does the exam. After controlling for student-observed factors that may be correlated with both the dependent and independent variables, and for time-varying school characteristics, with the inclusion of school-by-year fixed effects, identification comes from the differences in teacher turnover between subjects, within school-year groups.

The baseline equation does not account for unobservable subject-specific factors that may be related with turnover rates. Hence, in our second specification of the model we use subject-by-year fixed effects and a set of school controls:

$$S_{icst(g=6)} = \alpha + \beta T_{cst} + \gamma X'_{it} + \theta I_{icst} + \delta S_{icst(g=4)} + \eta Z'_{st} + \lambda_{ct} + \varepsilon_{icst}, \quad (2)$$

where  $\lambda_{ct}$  are the subject-by-year fixed effects and  $Z'_{st}$  the set of school controls, including the share of female students, share of students with school social support, share of students with higher educated mothers, share of female teachers, share of teachers with a permanent contract, teachers' average age, teachers' average experience, number of teachers in the school and number of students in the school. In this case, identification comes from differences in teacher turnover between schools, controlling for time-varying school characteristics and unobserved time-varying factors specific to each subject (e.g. the difficulty of the exams). Once we take both subject and school factors into account, this is our most demanding, and thus preferred, specification.

Finally, and following the approach taken by [Gibbons et al. \(2021\)](#), we create a last specification of the model:

$$S_{icst(g=6)} = \alpha + \beta T_{cst} + \tau_t + \rho_i + \varepsilon_{icst}, \quad (3)$$

where  $\tau_t$  are year fixed effects and  $\rho_i$  student fixed effects. The student fixed effects control for student-specific observed and unobserved characteristics (e.g. ability, emotional skills, socioeconomic background). The year fixed effects control for yearly shocks that affected all schools (e.g. years of internal teacher allocation process, introduction of a new education policy, changes in the school calendar). This variation of the model is useful to understand whether a student in a school where the teacher turnover rate was different for Portuguese and Mathematics will have distinct scores in both subjects. Identification in this specification comes from differences in teacher turnover within student and across subjects. We are not able to include school-by-year nor subject-by-year fixed effects, once there is no variation within student. This specification constitutes a useful robustness check to the main model.

## 6 Results

We start by analyzing the main results of our model when using teacher turnover at school-subject-year level (Section [6.1](#)) and when using teacher turnover at school-year level (Section [6.2](#)). After looking at the average effects, we investigate potential sources of heterogeneity (Section [6.3](#)). Namely, we assess whether there are any non-linear patterns in the turnover effect; whether the effect is different for students with distinct characteristics; and if different kinds of schools are unequally affected.

## 6.1 Teacher Turnover per School-Subject Groups

In column 1 of Table 1, we estimate exam scores against teacher turnover without controlling for potential confounders. In column 2, we add student and school controls, and in column 3 year fixed effects. The results for the specification of eq. (1) are presented in column 4, with student controls and school-by-year fixed effects. Column 5 presents the results for the second specification (eq. 2), with subject-by-year fixed effects, and student and school controls. Finally, in column 6 we have the estimation results for our last model (eq. 3), with student and year fixed effects.

Table 1: Impact of Teacher Turnover per Subject on 6<sup>th</sup> grade Standardized Exam Scores

	(1)	(2)	(3)	(4)	(5)	(6)
Teacher turnover	-0.0316*** (0.0029)	-0.0082*** (0.0024)	-0.0040* (0.0023)	-0.0075** (0.0031)	-0.0038* (0.0022)	-0.0102*** (0.0033)
Observations	638,946	466,715	466,715	466,715	466,715	638,946
R <sup>2</sup>	0.001	0.437	0.454	0.478	0.464	0.836
Student Controls		✓	✓	✓	✓	
School Controls		✓	✓		✓	
Year FE			✓			✓
SchoolxYear FE				✓		
SubjectxYear FE					✓	
Student FE						✓

**Notes:** The table presents OLS regressions at the student level. The dependent variable is the standardized 6<sup>th</sup> grade exam score. Teacher turnover is measured as the share of teachers of subject  $c$  in a school  $s$  in year  $t$  that were not there in year  $t - 1$ , standardized per subject-year groups. Results for the specification of eq. 1 are presented in column 4, for eq. 2 in column 5, and for eq. 3 in column 6. All coefficients should be interpreted as standard deviation changes. Student controls include: gender, school social support, age, parents' education, nationality, and job situation, access to a computer and internet at home, 4<sup>th</sup> grade exam scores per subject, and whether the student had a different teacher in the 5<sup>th</sup> and 6<sup>th</sup> grades per subject. School controls include: share of female students, share of students with school social support, share of students with higher-educated mother, share of female teachers, share of teachers with a permanent contract, teachers' mean age, teachers' mean experience, number of teachers in the school and number of students in the school. Standard errors are clustered at class-level and presented in parentheses. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

The results suggest that higher teacher turnover rates are associated with lower exam scores, with the negative direction of the effect being consistent across all specifications of the

model. Without controlling for neither time-variant or time-invariant factors, the coefficient of column 1 implies that an increase of one standard deviation in the teacher turnover rate, for a specific year and subject, is associated with lower 6<sup>th</sup> grade exam scores by 3.16% of a standard deviation, on average. With the inclusion of student and school controls in column 2, and year fixed effects in column 3, the magnitude of the estimate decreases considerably but remains statistically significant for a 1% and 10% level, respectively. For the specification of eq. (1) in column 4, the coefficient (-0.0075) is statistically significant. It is to note that with this specification we can rule-out all school-level shocks, but are ignoring any variation between schools.

Regarding our preferred specification (eq. 2) in column 5, we find that for a standard deviation increase in the teacher turnover rate, the 6<sup>th</sup> grade exam score is expected to decrease by 0.38% of a standard deviation, on average. Given the standardization is made per year and subject, each subject-year group will have a different standard deviation value (see Table A3). This implies that a 10 p.p. increase in the teacher turnover rate (56% to 76% of a standard deviation) decreases exam scores by 0.21% to 0.29% of a standard deviation. Finally, on the student fixed effects specification (column 6), an increase of one standard deviation in the turnover rate decreases exam scores by 1.0% of a standard deviation, on average. Although the magnitude of the coefficient did not remain stable (increased), the sign of the effect remains in line with previous specifications.

Between our two main specifications (column 4 and 5) there is a variation in the magnitude of the effect. This is indicative that not accounting for subject-specific factors may be problematic. This way, in the rest of the analysis, we will focus on our most demanding specification (eq. 2). Overall, the results suggest that when teacher turnover increases by 10 p.p., 6<sup>th</sup> grade exam scores are expected to decrease, on average, by around 0.25% of a standard deviation. As expected, and following previous studies (Ronfeldt et al., 2013; Hanushek et al., 2016; Gibbons et al., 2021), this effect is small, but not negligible.

## 6.2 Teacher Turnover per School

In this Section, we focus on a broader measure of teacher turnover, by considering all 2<sup>nd</sup> cycle teachers jointly, and estimate our preferred specification (eq. 2). One should note that it is not possible to compare all three specifications of the model as in Section 6.1 given school-by-year and student fixed effects cannot be included. We are, this way, analyzing whether students in schools with higher turnover rates of 2<sup>nd</sup> cycle teachers have higher or lower exam scores in Mathematics and Portuguese, holding time-variant factors specific to each subject constant. The results are presented in Table 2.

Table 2: Impact of 2<sup>nd</sup> Cycle Teacher Turnover on 6<sup>th</sup> grade Standardized Exam Scores

	(1)	(2)	(3)	(4)
Teacher Turnover (2 <sup>nd</sup> cycle)	-0.0372*** (0.0034)	-0.0017*** (0.0032)	0.0007 (0.0030)	-0.0020 (0.0026)
Observations	642, 687	469, 310	469, 310	469, 310
R <sup>2</sup>	0.001	0.438	0.455	0.464
Student Controls		✓	✓	✓
School Controls		✓	✓	✓
Year FE			✓	
SubjectxYear FE				✓

**Notes:** The table presents OLS regressions at the student level. The dependent variable is the standardized 6<sup>th</sup> grade exam score. Teacher turnover is measured by the share of 2<sup>nd</sup> cycle teachers in a school  $s$  in year  $t$  that were not there in year  $t - 1$ , standardized per year. Results for the specification of eq. 2 are presented in column 4. All coefficients should be interpreted as standard deviation changes. Standard errors are clustered at class-level and presented in parentheses. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Contrarily to what happens when measuring teacher turnover at school-subject-year level, the estimates are not precise across specifications. The coefficient becomes positive and loses statistical significance upon the inclusion of controls and year fixed effects (column 3). For the main specification (column 4), we do not find any evidence of a turnover effect. These results indicate that when measuring turnover with a broader scope, no effects on exam scores of Portuguese and Mathematics are found. One might argue that scores of a particular subject are not impacted by high turnover rates in other subjects.

## 6.3 Heterogeneity Analysis

The average effects of higher teacher entry rates may hide substantial heterogeneity, given students and schools with different characteristics may be differently affected by turnover. In this Section we analyze potential non-linearities (Section 6.3.1), and disentangle the marginal effects of teacher turnover across student characteristics (Section 6.3.2), the social composition of the school (Section 6.3.3), and the teacher workforce characteristics (Section 6.3.4).

### 6.3.1 Non-Linear Effects

To capture possible non-linear effects of teacher turnover on students' exam scores, we add a quadratic term to each of our three main regression specifications (eq. 1 to 3). Results are presented in Table 3.

Table 3: Impact of Teacher Turnover per School-Subject on 6<sup>th</sup> grade Standardized Exam Scores: Quadratic Regressions

	(1)	(2)	(3)
Teacher turnover	-0.0079** (0.0034)	-0.0086*** (0.0025)	-0.0113*** (0.0035)
(Teacher turnover) <sup>2</sup>	0.0006 (0.0016)	0.0038*** (0.0010)	0.0015 (0.0017)
Observations	466, 715	466, 715	638, 946
R <sup>2</sup>	0.478	0.464	0.836
Student Controls	✓	✓	
School Controls		✓	
Year FE			✓
SchoolxYear FE	✓		
SubjectxYear FE		✓	
Student FE			✓

**Notes:** The table presents OLS quadratic regressions at the student level. The dependent variable is the standardized 6<sup>th</sup> grade exam score. Teacher turnover is measured as the share of teachers of subject  $c$  in a school  $s$  in year  $t$  that were not there in year  $t - 1$ , standardized per subject-year groups. Results for the specification of eq. 1 are presented in column 1, for eq. 2 in column 2, and for eq. 3 in column 3. All coefficients should be interpreted as standard deviation changes. Standard errors are clustered at class level and presented in parentheses. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

The quadratic term is significant for our preferred specification (column 2), which suggests that, although small, there might be some non-linearity. The analysis of the marginal effects of this quadratic regression tells the direction of the effect for each decile of the teacher turnover distribution (Figure A5b)<sup>17</sup>. We conclude that the turnover effect is always negative, being stronger for schools in the first four deciles of the teacher turnover distribution. For a student from a school of the 10<sup>th</sup> percentile, increasing teacher turnover by one standard deviation decreases exam scores by 1.7% of a standard deviation, but in a school of the 90<sup>th</sup> percentile the effect is not significant.

### 6.3.2 Student Characteristics

For the examination of student heterogeneity, we interact the main explanatory variable - standardized teacher turnover at a school-subject level - with the subject and several student characteristics, namely, mother education, school social support, gender, baseline exam score, and individual turnover. Figure 1 plots the coefficients and confidence intervals for each dimension. The same coefficients are also displayed in Table A5.

We find a stronger negative effect in Portuguese than in Mathematics. Further, more disadvantaged students (with school social support) tend to face heavier costs from higher teacher turnover rates, given the statistically significant effect is of larger magnitude for these students. Regarding gender, we also find relevant magnitude differences in the effects of teacher turnover, with females showing a stronger negative impact. Additionally, we find that lower-achieving students, specifically those with a score of 2 in the 4<sup>th</sup> grade exam, are the ones most adversely affected in their results at the end of 6<sup>th</sup> grade by teacher turnover<sup>18</sup>.

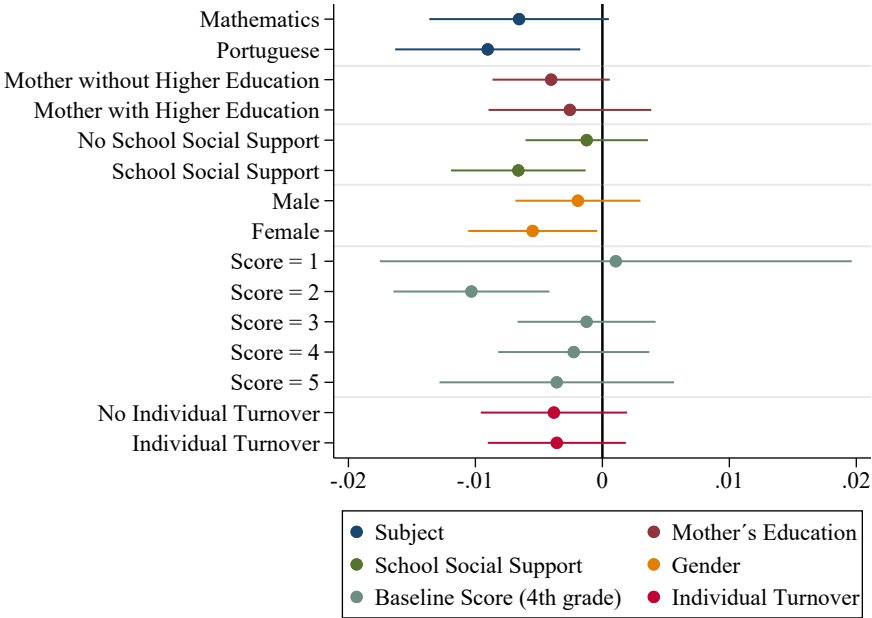
Concerning students with and without higher-educated mothers, no relevant different magnitudes were detected. Furthermore, in the last two rows of Figure 1 we also see similar

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<sup>17</sup>The same graphs are plotted for specifications 1 and 3 in Figures A5a and A5c, respectively.

<sup>18</sup>The large confidence interval for the coefficient on having a score of 1 is, most likely, due to a very low share of students with that score, approximately 1% of the total.

Figure 1: Heterogeneous Effects of Teacher Turnover on the Standardized 6<sup>th</sup> grade Exam Scores: Student Characteristics



**Notes:** This figure presents the estimated coefficients of OLS regressions when interacting the subject and student characteristics with the teacher turnover variable (Table A5). The confidence interval was of 95%.

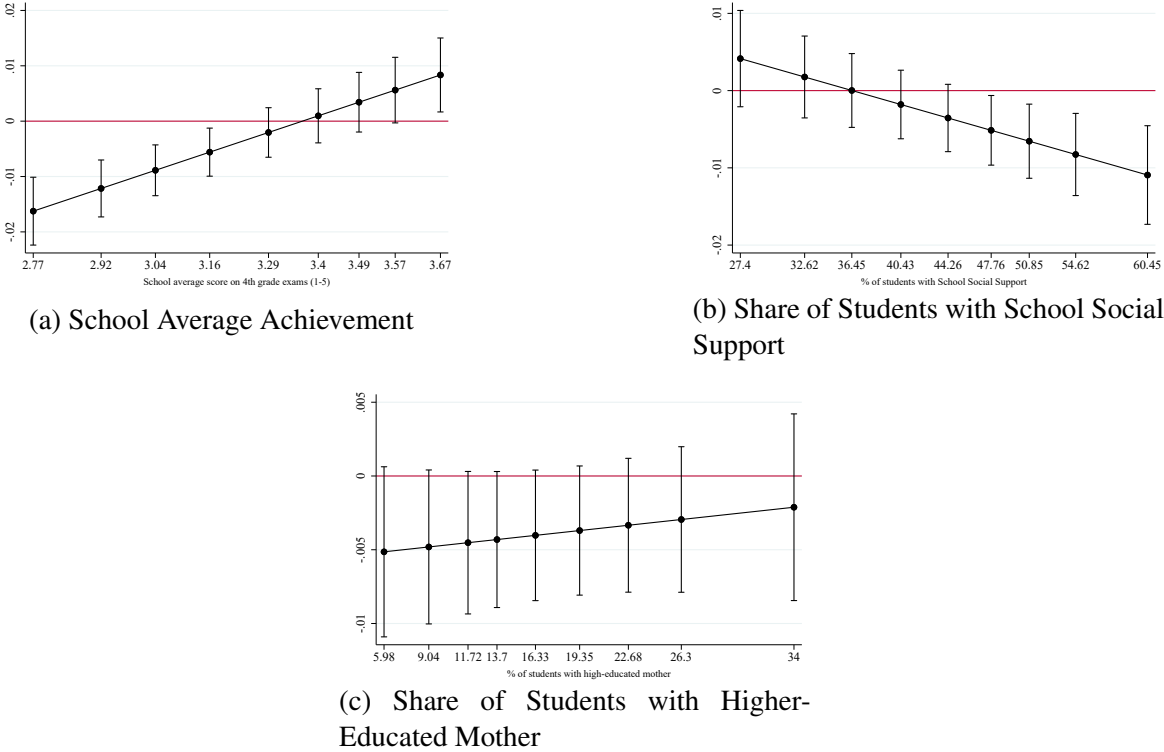
effects between students who had the same teacher in the 5<sup>th</sup> and 6<sup>th</sup> grades and those who had not. If students of both incumbent and new teachers are, on average, similarly impacted, this suggests that the teacher turnover effect is based on an organizational disruption mechanism.

**6.3.3 School Characteristics**

In this section we interact school characteristics, namely the average student achievement (measured by the mean scores of the 4<sup>th</sup> grade exams, per school and year), the share of students with school social support, and the share of students with higher-educated mothers, with our main explanatory variable, the standardized teacher turnover rate. The marginal effects at each decile of the distribution of the referred variables are presented in Figure 2.

As Figure 2a shows, the effects of turnover in schools performing below the median (first four deciles) are negative and statistically significant. For a school in the 10<sup>th</sup> percentile

Figure 2: Heterogeneous Effects of Teacher Turnover on the Standardized 6<sup>th</sup> grade Exam Scores: School Characteristics



**Notes:** This figure presents the estimated marginal effects of teacher turnover on the standardized 6<sup>th</sup> grade exam scores, across the distribution of the following variables: school average achievement, the share of students with school social support, and the share of students with high-educated mother. All other covariates are kept at their means. The results are obtained from the model with subject-by-year fixed effects (eq. 2). The horizontal axis corresponds to the 10 deciles of the distribution of the mentioned variables and the vertical axis the standardized effect. The confidence interval used was of 95%.

of the average achievement distribution (2.77 average score), a standard deviation increase in teacher turnover may decrease exam scores by 1.6% of a standard deviation, while for a school in the 90<sup>th</sup> percentile (3.67 average score) may increase by 0.8% of a standard deviation. This outcome is in accordance with the findings of [Ronfeldt et al. \(2013\)](#) and [Hanushek et al. \(2016\)](#) that students from lower-performing schools suffer more with turnover.

As expected, the magnitude of the effects is also different between more and less socially-disadvantaged schools. In Figure 2b we see that schools with a share of students with school social support above the median suffer a negative and statistically significant effect from

teacher turnover, while for those below the median no effect was detected. In particular for a school from the 90<sup>th</sup> percentile of the distribution (60.5% of students with school social support), an extra standard deviation in teacher turnover decreases exam scores by 1.1% of a standard deviation. This means that teacher turnover tends to impose higher costs on students in more disadvantaged schools. No statistically significant heterogeneity was found for schools with higher or lower concentrations of college-educated mothers (Figure 2c).

#### **6.3.4 Teacher Workforce Characteristics**

Schools may differ greatly in terms of the composition of the teacher workforce. For example, one would expect that a more experienced teacher workforce would have more tools and be better prepared to deal with the entrance of new teachers. Ultimately, this could also be reflected on how students are impacted by teacher mobility. With this in mind, we proceed to analyze whether the teacher turnover effect is different between schools with a higher and lower percentage of teachers with a permanent contract; and between schools with teachers with higher and lower average years of experience, by interacting those variables with the turnover variable. The results are provided in Figure A6.

We conclude that the effects of turnover are similar across schools with a higher or lower share of teachers with a permanent contract and across schools with a more or less experienced teacher workforce, as no significant differences are observed.

## **7 Discussion and Conclusions**

Due to the unique characteristics inherent to each educational system, the applicability of findings from previous studies on the impacts of teacher turnover may not directly extend to Portugal. We thus contribute to the limited literature on this topic and provide evidence for the Portuguese context. Our study draws a conclusion consistent with prior research:

increasing teacher turnover is associated with a decrease in students' exam scores, on average. By measuring turnover at subject- and 2<sup>nd</sup> cycle-level, we identified that the disruption effect occurs mainly within subject-specific teacher teams given that Mathematics (and Portuguese) exam scores do not seem to be impacted by the entrance of new teachers in other subjects. Furthermore, small non-linear effects were detected, indicating that an increase in teacher turnover has a stronger negative impact in schools with less prevalence of teacher rotation than in schools with already high shares of new teachers.

Teacher turnover does not impact all students equally. From the heterogeneity analysis across student characteristics, three main conclusions can be drawn. First, we detect a stronger negative effect in Portuguese than in Mathematics. Second, students who benefit from school social support, females, and those with lower ability levels are the student subset being negatively affected by teacher turnover<sup>19</sup>. In fact, previous research has shown that there is a strong association between teacher mobility and students' characteristics (Boyd et al., 2013; Allen et al., 2018; Jackson, 2009). Third, by investigating heterogeneous effects between students who had the same teacher in the 5<sup>th</sup> and 6<sup>th</sup> grades and those who had not, our aim is to understand if teacher turnover has a disruptive effect across all students, even those who remained with the same teacher from one year to another. Our results corroborate this mechanism, by showing no differences for both student groups<sup>20</sup>.

Analyzing heterogeneity at a more aggregated level, we find the low-achieving and socially-disadvantaged schools to be the most affected by teacher turnover. Beyond the negative effect found for lower-achieving schools, they also tend to face higher rates of teacher turnover, as mentioned in Section 4.2. This combination implies that these students face a double penalty. Not only do they experience higher turnover rates in their schools, on average, as the negative

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<sup>19</sup>Gibbons et al. (2021) also finds differences regarding students' ability, by showing that those with a medium baseline score were the most affected by turnover, but did not find any differences regarding gender.

<sup>20</sup>Similarly, Ronfeldt et al. (2013) also shows that turnover negatively affects students of teachers who stay in the school during two consecutive years, suggesting a disruptive effect of turnover beyond compositional changes in teacher quality.

consequences of a one standard deviation increase in turnover are also more pronounced for them. Regarding the characteristics of the teacher workforce, no differences in the effect of turnover were estimated for schools with more or less experienced teachers, nor with a higher or lower percentage of permanent-contract teachers<sup>21</sup>.

Our findings carry significant policy implications. Albeit the small magnitude, high teacher turnover rates have consistently shown detrimental effects on students. This highlights the importance of implementing targeted policies that promote continuity among school-subject-level teams over time as to ensure stability within the teacher workforce. Disadvantaged schools bear the greatest brunt of turnover, with low-achieving and economically disadvantaged students facing the highest costs. It is therefore imperative to develop policies specifically tailored to these schools, potentially through the establishment of incentive structures for teachers working in such contexts<sup>22</sup>.

In conclusion, our findings are very close to the literature but there are some limitations worth mentioning. First, the study is constrained by its narrow time frame. Due to the availability of data on 6<sup>th</sup> grade high-stakes exams for only four years, we may have not captured enough variation in turnover rates. Second, we are unable to explore the effects for other subjects, once this cycle of studies has national exams solely for Portuguese and Mathematics. Third, since we focus only on the 6<sup>th</sup> grade, we do not know if the impact of teacher turnover is the same for students of other ages. Finally, upon the entrance of new teachers, schools might adapt by sorting teachers into grades. For instance, incumbent teachers may be reassigned to grades where high-stakes exams are conducted, while new teachers could be allocated to grades without such exams. As further research, it would be interesting to explore this teacher reallocation mechanism and how it affects our conclusions.

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<sup>21</sup>This is in line with Rivkin et al. (2005), who found that little of the variation in teacher quality is explained by the teacher's education or experience.

<sup>22</sup>Clotfelter et al. (2008) studied the impacts of a policy intervention in North Carolina, where the state awarded a bonus to teachers working in high-poverty and/or low-achieving schools, and found that the mean teacher turnover (measured by the teacher exit rate) was reduced by 17%.

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## A Appendix of Section 3 - Portuguese Educational System

Table A1: Teacher Recruitment Groups within Education Levels

Education Level	Recruitment Groups
1 <sup>st</sup> Cycle of Basic Education	Basic Education - 1 <sup>st</sup> cycle
2 <sup>nd</sup> Cycle of Basic Education	Portuguese and Social Studies/History Portuguese and French Portuguese and English Mathematics and Natural Sciences Visual Technological Education Musical Education Physical Education Moral and Religious Education
3 <sup>rd</sup> Cycle of Basic Education and Secondary Education	Moral and Religious Education Portuguese Latin and Greek French English German Spanish History Philosophy Geography Economics and Accounting Mathematics Physicochemical Biology and Geology Technological Education Electrical Engineering Computing Agricultural Sciences Visual Arts Music Physical Education

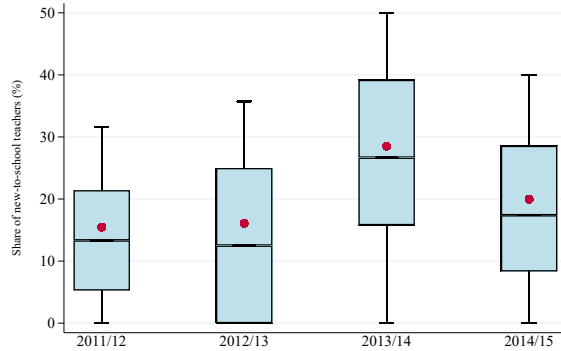
## B Appendix of Section 4 - Data and Descriptive Statistics

Table A2: Summary Statistics

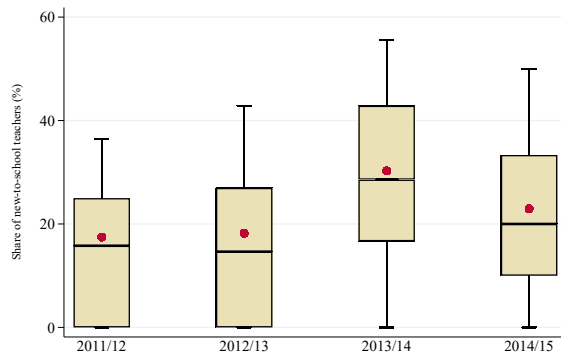
Variable	Mean	Std. Dev.	Min.	Max.	N
<b>Turnover measures at the school-year level</b>					
Teacher turnover rate of 2 <sup>nd</sup> cycle (%)	21.18	14.13	0	96.43	2,438
Standardized teacher turnover rate (2 <sup>nd</sup> cycle)	0.05	1.19	-2.31	7.33	2,438
Teacher turnover rate by subject (%)	21.04	18.64	0	100	2,409
Standardized teacher turnover rate (by subject)	0.01	1.20	-1.75	5.84	2,409
<b>School characteristics (2<sup>nd</sup> cycle)</b>					
% Female students	49.37	6.42	0	100	2,438
% Students with school social support	46.38	14.89	0	100	2,438
% Students with higher-educated mother	16.43	11.17	0	100	2,438
% Female teachers	72.31	10.68	0	100	2,438
% Teachers with permanent contract	71.72	16.70	0	100	2,438
Average teachers' age (years)	47.01	3.23	31.31	56.64	2,438
Average teachers' experience (years)	21.09	3.79	3.08	31.25	2,438
# Teachers per school	41.63	117.56	1	3352	2,438
# Students per school	132.17	101.17	1	863	2,438
<b>Student characteristics</b>					
6 <sup>th</sup> grade exam score (0-100)	53.80	20.34	0	100	642,687
Standardized 6 <sup>th</sup> grade exam score	0	1.00	-3.74	2.85	642,687
4 <sup>th</sup> grade exam score (1-5)	3.24	0.92	1	5	477,742
Female	0.49	0.50	0	1	642,687
Age	11.41	0.54	9.10	14.00	642,687
School social support (higher echelon)	0.23	0.42	0	1	642,687
School social support (lower echelon)	0.21	0.40	0	1	642,687
Portuguese nationality	0.98	0.15	0	1	642,687
Having a computer at home	0.70	0.46	0	1	642,687
Having access to internet at home	0.60	0.49	0	1	642,687
Mother with higher education	0.19	0.39	0	1	642,687
Father with higher education	0.12	0.33	0	1	642,687
Mother with Portuguese nationality	0.95	0.22	0	1	642,687
Father with Portuguese nationality	0.95	0.22	0	1	642,687
Mother is unemployed	0.13	0.34	0	1	642,687
Father is unemployed	0.08	0.27	0	1	642,687
Individual turnover	0.47	0.50	0	1	625,422

**Notes:** Standardization of the teacher turnover rate (by subject) and the 6<sup>th</sup> grade exam score is made by year and subject. Standardization of teacher turnover rate (2<sup>nd</sup> cycle) is made by year.

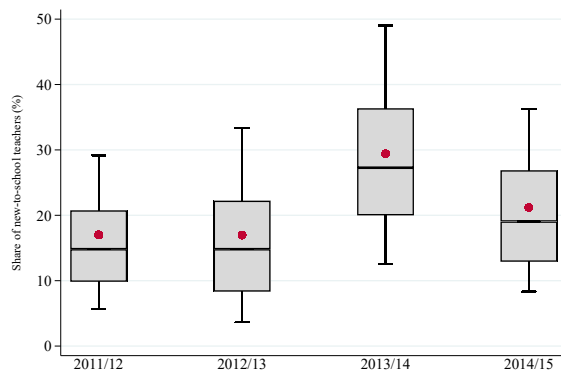
Figure A1: Annual Distribution of Teacher Turnover (2011/12 - 2014/15)



(a) Portuguese Teachers



(b) Mathematics Teachers



(c) 2<sup>nd</sup> cycle teachers

**Notes:** Teacher turnover is measured at a school level. The red dot represents the average rate in each year. The top line of each box represents the 90<sup>th</sup> percentile of the distribution. The following lines represent the 75<sup>th</sup>, the 50<sup>th</sup>, the 25<sup>th</sup> and the 10<sup>th</sup>, respectively. In 2013/14 there was internal process of teacher allocation.

Table A3: Summary statistics of Teacher Turnover per Subject

Year	Subject	Mean (p.p.)	Stand. Dev. (p.p.)	10 p.p of teacher turnover per Stand. Dev.	N
2011/12	Mathematics	18.03	14.05	71%	83,798
2012/13	Mathematics	17.76	15.14	66%	81,221
2013/14	Mathematics	29.59	17.98	56%	78,465
2014/15	Mathematics	21.43	14.79	68%	75,360
2011/12	Portuguese	16.43	13.17	76%	84,030
2012/13	Portuguese	15.78	14.63	68%	81,753
2013/14	Portuguese	28.44	16.22	62%	78,565
2014/15	Portuguese	19.72	14.25	70%	75,754

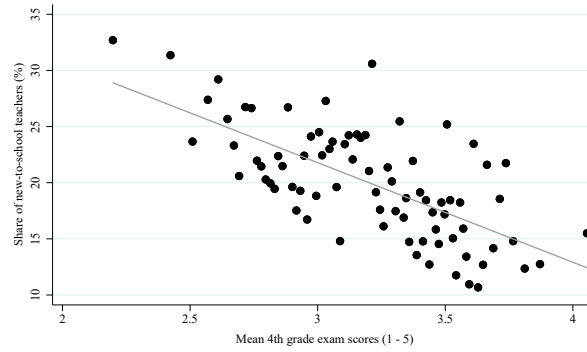
**Notes:** The table provides the mean and standard deviations of teacher turnover for each subject-year group and the share of the standard deviation corresponding to 10 p.p. of teacher turnover.

Table A4: Correlations Table

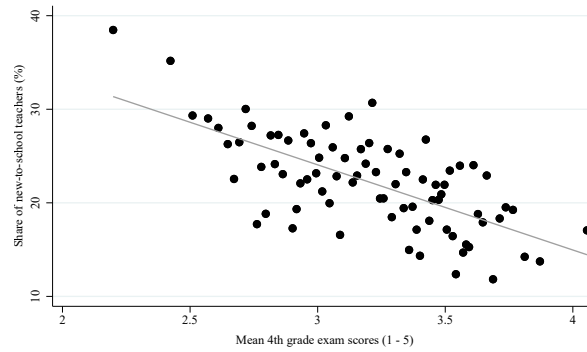
	Turnover (2 <sup>nd</sup> cycle)	Turnover (Math)	Turnover (Port.)	% SSS students	% High-educ. Mother	Mean Achiev.
Turnover (2 <sup>nd</sup> cycle)	1.000					
Turnover (Math)	0.715	1.000				
Turnover (Port.)	0.790	0.409	1.000			
% SSS students	0.057	0.054	0.041	1.000		
% High-educ. Mother	-0.014	-0.044	0.004	-0.662	1.000	
Mean Achiev.	-0.238	-0.176	-0.188	-0.184	0.103	1.000

**Notes:** Correlation coefficients table. The following variables included: turnover of 2<sup>nd</sup> cycle teachers, turnover of Mathematics teachers, turnover of Portuguese teachers, share of students with school social support per school, share of students with high-educated mother per school, and the average score in the 4<sup>th</sup> grade exam per school. Variables are measured at school-year level.

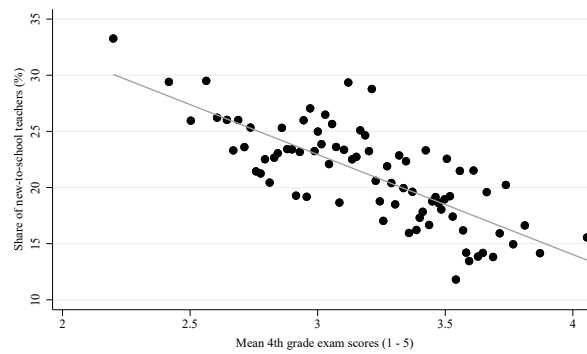
Figure A2: Correlation between Teacher Turnover and Average School Achievement



(a) Portuguese Teachers



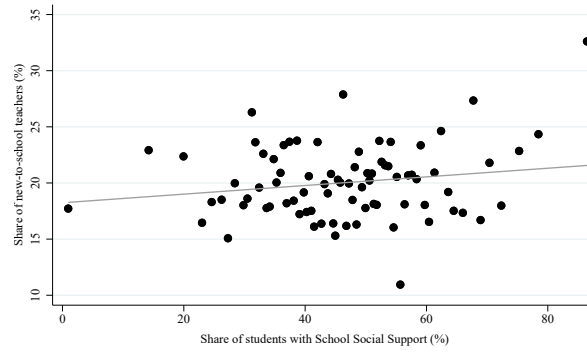
(b) Mathematics Teachers



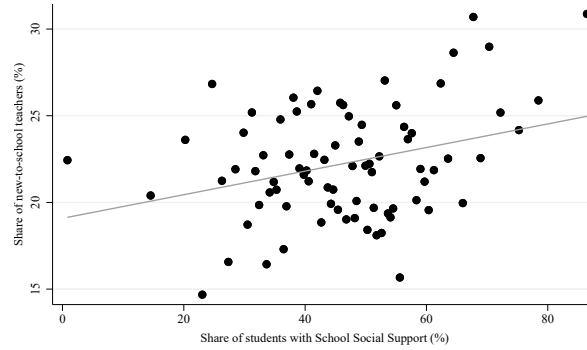
(c) 2<sup>nd</sup> Cycle Teachers

**Notes:** Correlations plot between teacher turnover and average achievement at school-year level. The horizontal axis corresponds to the mean 4<sup>th</sup> grade exam scores (1-5) and the vertical axis to the share of new-to-school teachers of Portuguese, Mathematics and entire 2<sup>nd</sup> cycle, respectively.

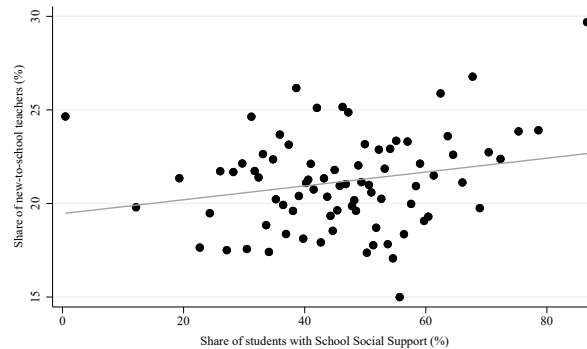
Figure A3: Correlation between Teacher Turnover and Share of Students with School Social Support



(a) Portuguese Teachers



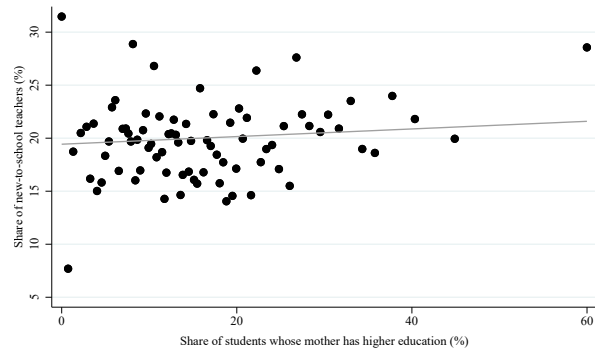
(b) Mathematics Teachers



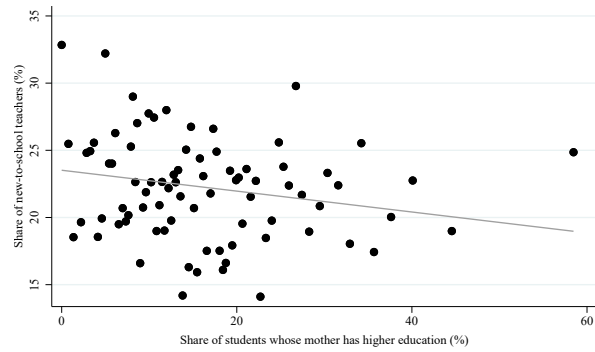
(c) 2<sup>nd</sup> Cycle Teachers

**Notes:** Correlations plot between teacher turnover and average achievement at school-year level. The horizontal axis corresponds to the share of students with school social support and the vertical axis to the share of new-to-school teachers of Portuguese, Mathematics and entire 2<sup>nd</sup> cycle, respectively.

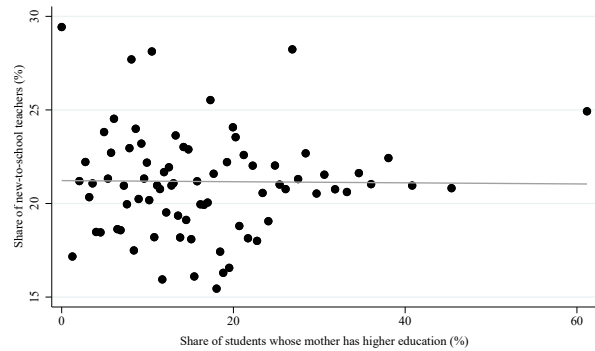
Figure A4: Correlation between Teacher Turnover and Share of Students with Higher-educated Mother



(a) Portuguese Teachers



(b) Mathematics Teachers

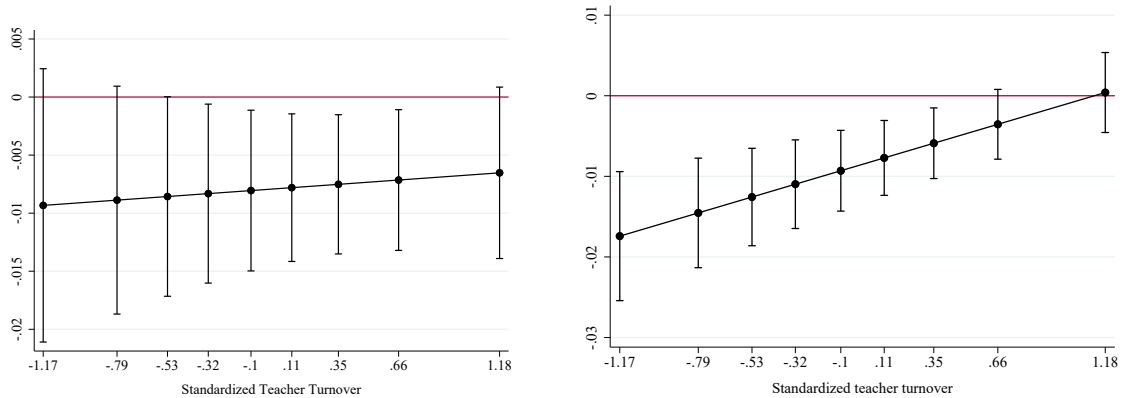


(c) 2<sup>nd</sup> Cycle Teachers

**Notes:** Correlations plot between teacher turnover and average achievement at school-year level. The horizontal axis corresponds to the share of students with higher-educated mother and the vertical axis to the share of new-to-school teachers of Portuguese, Mathematics and entire 2<sup>nd</sup> cycle, respectively.

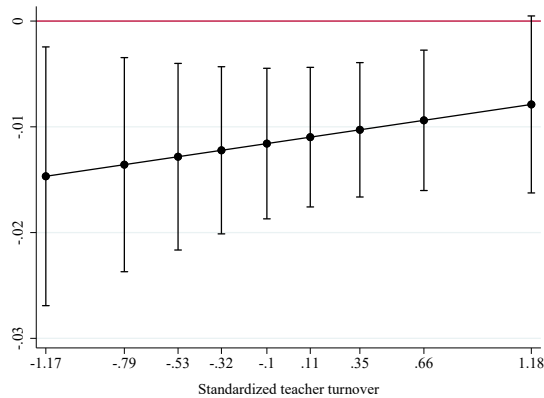
## C Appendix of Section 6 - Results

Figure A5: Non-linear Marginal Effects of Teacher Turnover on Standardized 6<sup>th</sup> grade Exam Scores



(a) School-by-Year FE model

(b) Subject-by-Year FE model



(c) Student and Year FE model

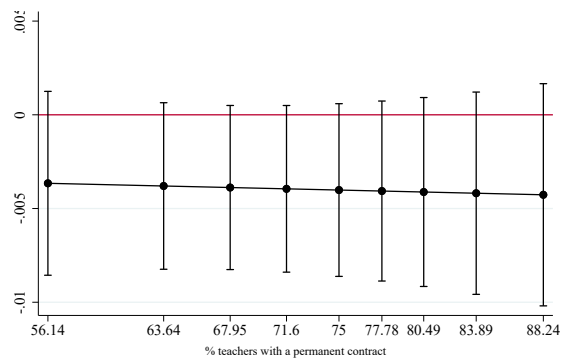
**Notes:** This figure presents the estimated marginal effects from each specification of Table 3. The horizontal axis corresponds to the 10 deciles of the standardized teacher turnover distribution and the vertical axis the standardized non-linear effect. All other covariates are kept at their means. The confidence interval used was of 95%.

Table A5: Heterogeneous Effects of Teacher Turnover on Standardized 6<sup>th</sup> grade Exam Scores: Student Characteristics

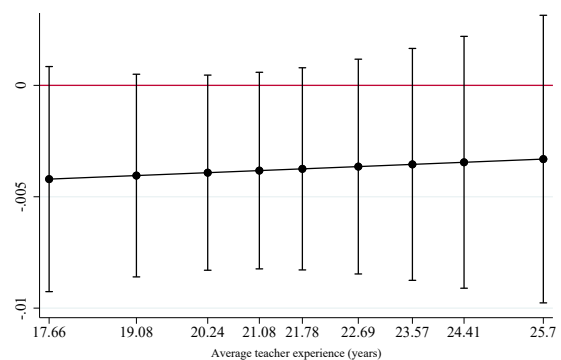
VARIABLES	Subject (1)	Mother Education (2)	SSS (3)	Female (4)	Baseline Score (5)	Individual Turnover (6)
Turnover X Mathematics	-0.0066* (0.0036)					
Turnover X Portuguese	-0.0090** 0.0037					
Turnover X No Higher Educ.		-0.0040* (0.0024)				
Turnover X Higher Educ.		-0.0026 (0.0033)				
Turnover X No-SSS			-0.0012 (0.0025)			
Turnover X SSS			-0.0066** (0.0027)			
Turnover X Male				-0.0019 (0.0025)		
Turnover X Female				-0.0055** (0.0026)		
Turnover X Score = 1					0.0011 (0.0095)	
Turnover X Score = 2					-0.0103*** (0.0031)	
Turnover X Score = 3					-0.0012 (0.0028)	
Turnover X Score = 4					-0.0023 (0.0030)	
Turnover X Score = 5					-0.0036 (0.0047)	
Turnover X No Indiv. Turn.						-0.0038 (0.0029)
Turnover X Indiv. Turn.						-0.0036 (0.0028)
Observations	466, 715	466, 715	466, 715	466, 715	466, 715	466, 715
R <sup>2</sup>	0.478	0.464	0.463	0.463	0.463	0.463
Student Controls	✓	✓	✓	✓	✓	✓
School Controls		✓	✓	✓	✓	✓
SchoolxYear FE	✓					
SubjectxYear FE		✓	✓	✓	✓	✓

**Notes:** The table presents OLS regressions at the student level. The dependent variable is the standardized 6<sup>th</sup> grade exam score. Teacher turnover is measured by the share of teachers of subject  $c$ , in school  $s$ , in year  $t$  that were not there in year  $t - 1$ , standardized per subject-year groups. Student controls include: gender, school social support (SSS), age, parents' education, nationality, and job situation, access to a computer and internet at home, 4<sup>th</sup> grade exam scores per subject, and whether the student had a different teacher in the 5<sup>th</sup> and 6<sup>th</sup> grades per subject. School controls include: share of female students, share of students with school social support, share of students with higher-educated mother, share of female teachers, share of teachers with a permanent contract, teachers' mean age, teachers' mean experience, number of teachers in the school and number of students in the school. Standard errors are clustered at class-level.

Figure A6: Heterogeneous Effects of Teacher Turnover on the Standardized 6<sup>th</sup> grade Exam Scores: Teacher Workforce Characteristics



(a) Share of teacher with a permanent contract



(b) Average teacher experience

**Notes:** This figure presents the estimated marginal effects of teacher turnover on the standardized 6<sup>th</sup> grade exam scores across the distribution of the following variables: share of teachers with a permanent contract and the average teacher experience in years. All other covariates are kept at their means. The results are obtained from the model with subject-by-year fixed effects (eq. 2). The horizontal axis corresponds to the 10 deciles of the distribution of the mentioned variables and the vertical axis the standardized effect. The confidence interval used was of 95%.