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FACULTY OF SOCIAL SCIENCES

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Bachelor thesis

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Examination of the impact of teacher's gender, age and experience on student achievement

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Abstract

The effectiveness of transferring knowledge to students is one of the key aspects of teacher quality. It is influenced by many factors, among others, by gender match. Even though the gender match itself has been recently a topic of many studies, little is known about the impact of other teacher characteristics on it. In this thesis, we extend the gender match theory by examining whether teacher experience and age influence the effect of gender match on student achievement in the Czech Republic, using the dataset from TIMSS 2007. We do not find any effect of experience on gender match. However, although small, we do find a significant positive effect of young female teachers on girls' achievement.

Abstrakt

Jednou z klíčových charakteristik učitelů je jejich úspěšnost při předávání znalostí studentům. Tato schopnost je ovlivněna mnoha faktory, mimo jiné i genderovou shodou mezi učiteli a žáky. Přestože samotný význam genderové shody byl v poslední době mnohokrát studován, o jejím ovlivnění dalšími vlastnostmi učitelů není mnoho známo. Tato práce zkoumá, zda zkušenosti a věk učitelů ovlivňují efekt genderové shody na žáky 8. tříd v České republice. Ačkoli jsme nenašli žádný významný vliv zkušeností učitelů na efekt genderové shody, našli jsme malý, ale signifikantní kladný vliv mladých učitelek na výsledky děvčat.

Keywords

gender match, role model, education, teacher-student interactions, academic achievement, TIMSS 2007

Klíčová slova

genderová shoda, vzor (role model), vzdělávání, vztah mezi učitelem a studentem, studijní výsledky, TIMSS 2007

Declaration of Authorship

I hereby proclaim that I wrote my bachelor thesis on my own under the leadership of my supervisor and that the references include all resources and literature I have used.

I grant a permission to reproduce and to distribute copies of this thesis document in whole or in part.

Prague, 18 May 2017

Signature

Acknowledgment

I would like to express my gratitude to the supervisor PhDr. Václav Korbel, especially for his guidance and constructive remarks that improved the quality of this thesis.

BACHELOR THESIS PROPOSAL

Author: Petra Aschermannová

Supervisor: PhDr. Václav Korbel

Proposed topic: Teachers as role models

Preliminary scope of work: The relationship between students and teachers is a very important determinant of student's school adjustment. Several studies have shown that the teacher-student relationship has positive effect on girls and that teachers have poorer relationship with boys (Baker, 2006). Theoretically, teachers of the same gender could improve student's achievement by serving as role models or because it is more likely that they will think positively about student's potential (Winters, Haight, Swaim and Pickering, 2013).

In my thesis, I am going to investigate the effect of teacher's gender on students' performance using the data from TIMSS on mathematics, biology, chemistry, physics and earth science test scores of 8^{th} grade students in the Czech Republic from 2007. Do girls perform better when they are taught by female teachers because female teachers are role models for them? Or is it because of good match - male teachers better understand boys and vice versa? Furthermore, I can examine whether other variables such as teacher's age and experience influence this as well.

Contribution: In Czech primary and secondary schools, most subjects are taught by female teachers rather than male teachers. This is true for most post-communist countries (e.g. Slovakia or Poland). The TIMSS 2007 dataset contains 73% of female teachers. I will examine whether this has a good impact on academic achievement of students, depending on their gender.

Methodology: As was already mentioned, I am going to use the data-

set from Trends in International Mathematics and Science Study (TIMSS) that was collected in the Czech Republic in 2007. The data contains students' scores on the achievement tests along with other characteristics of both the student (e.g. student's background, gender, age...) and the teacher (e.g. gender, age, years of experience...) that were gathered through questionnaires.

I am going to work with econometric models (OLS, Fixed effects model) and estimate them using the R software.

Outline:

1. Introduction
2. Literature Review & Theoretical Background
3. Methodology
4. Econometric Identification and Estimation
5. Data Analysis, Discussion of Results
6. Conclusion

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Contents

Introduction

Gender differences in student academic achievement are a concern for both parents and educators. Recent studies addressing the gender gaps in education often emphasize the important role of teachers and their characteristics, because no other attribute of school is nearly as important when it comes to student achievement. These studies focus on the impact of teacher's gender, depending on whether the student is a girl or boy. However, the results are mixed - while some studies claim that teachers of the same gender have a positive impact on student achievement (e.g. Dee, 2007), others claim that these effects are insignificant (Holmund and Sund, 2008; Neugebauer et al., 2011).

There are several reasons to believe that gender match may enhance student results. For instance, according to Thomas Dee (2007), teacher of the same gender may positively influence student results by serving as a role model, being more able to communicate with students, or having higher expectations for them. Nevertheless, other studies (Krieg, 2005) did not find any evidence of such effects. The problem of these studies might be the fact that there is a problem of self-selection (Dee, 2005), that is, teachers are not assigned randomly to classes, which biases the results.

In this study, we investigate the impact of teacher experience and age on the effect of gender match on 8^{th} grade student achievement in the Czech Republic, using the dataset from TIMSS 2007. This dataset contains student results in five subjects: mathematics, biology, chemistry, physics and earth science (geography). This allows us to analyze the data and still overcome the issue of teacher self selection by taking into account student fixed effects and using within-student between-subject estimation, even though we only have data for one year.

We find no evidence to support the hypothesis that student achievement is enhanced when he/she is assigned to a same gender teacher. However, when we examine the effect of age on gender match, we find evidence that young teacher of the same gender has a positive effect on student achieve-

ment, especially for girls.

The findings appear to be highly robust. Our estimation relies on the assumption that the effect of gender match is the same across all subjects and that teacher unobserved characteristics are not correlated with the gender match. We employ a mixed model to check our findings which supports the robustness of our results.

We contribute to current literature by extending the relationship between teachers and students and by examining other factors that may influence gender gaps in education. Until now, most studies have focused solely on the gender match. We extend this by adding teacher experience and age and examine whether there is possibly a match between students and young teachers, or maybe with older, more experienced ones. The rich dataset from TIMSS 2007 allows us to analyze these effects while controlling for various variables such as school background, student background and teacher characteristics.

The remainder of the thesis has the following structure: Section 1 discusses the related literature, Section 2 briefly describes the data, Section 3 describes the econometric approach, Section 4 reports on the findings and Section 5 contains the robustness check.

1 Literature review

1.1 Role of teachers

High quality education is very important for the whole society. It helps us to achieve sustainable economic development, raise people's productivity and creativity, and enrich their understanding of the world. However, education is a luxury that should not be taken for granted. Even today, according to UNICEF [1], there are over 60 million children who are denied the access to education. A crucial component of quality education are teachers because no other attribute of school affects student achievement in such a big manner. Even two parallel grades at the same school can achieve different gains in learning only because the teacher is different (Hanushek and Rivkin, 2010).

So what makes teachers so important? In primary schools, teachers serve as authorities that children look up to. They are role models for many students and serve as evaluators of student achievement. They are the leaders of the class and those who enforce the rules. They praise good behavior and punish bad manners. Without good teachers, quality education would be impossible to reach.

Besides that, teachers have an enormous economic value. In a study conducted by Hanushek (2011) in the USA, it has been found that in a class of 20 students, a teacher who is one standard deviation above the mean effectiveness produces over $400,000 in individual added earnings (annually). This shows that teachers have an important economic role and that the more effective they are, the more significant their economic impact is. Moreover, students taught by more effective teachers are more likely to go to college, earn higher salaries, save for retirement and live in higher SES (socioeconomic status) neighborhoods. They are also less likely to have children as teenagers (Chetty et al., 2014).

Regrettably, it is still not clear how to reliably identify an effective teacher based on measurable characteristics, mainly because learning is a cumulative process which relies on both current and past family, school and com-

[1] `https://www.unicef.org/education/bege_61657.html` [accessed 15-05-2017]

munity characteristics which are rarely all available. Therefore, studies in this field have to face the fact that frequently, teacher quality has little to do with observable characteristics such as education (certification), experience or salary (Rivkin et al., 2005; Hanushek, 2011). However, the unobservable characteristics such as teacher effort, character and authority are often quite important.

1.2 The impact of teacher experience and age

Teacher experience is one of the observable determinants of teacher quality. In general, employees with higher experience are more skilled, productive and effective. However, this is not completely true for teaching. In teaching, experience matters, but more is not always better (Rice, 2010).

Several studies have found that returns to experience in teaching increase during the first few years, but then remain relatively stable. In other words, teachers who have no experience are less effective than those with some experience. This is because in the first year or two, teachers are new to the job and they need to adjust and learn the craft of teaching. Nevertheless, the effectiveness of teachers with more than 20 years of experience and those with 5 years of experience is very similar (Ladd, 2008). What is more, some studies have found evidence that effectiveness even declines after some time, especially among high school teachers and in mathematics (Harris and Sass, 2011). In contrast, at the middle school level, Harris and Sass (2011) found that more experienced teachers are more effective in mathematics. Unfortunately, the effect of teacher experience is not so clear - while Aaronson, Barrow and Sander (2007) found no significant effect, Clotfelter, Ladd and Vigdor (2007) found completely opposite, positive effect of teacher experience on high school student outcomes.

Because teachers usually enter the profession when they are around 25 years old, the returns to experience increase (according to Ladd, 2008) only until they turn 30 and then, experience does not play a major role when examining teacher effectiveness. This is the reason why it is also useful to

examine the impact of age on student achievement, since the effect of experience becomes negligible after the first few years.

To our knowledge, not much has been found about the effect of teacher's age on student achievement. Although a few studies have examined this topic, their results are quite questionable. Kimberly and Lyle (1990) took a sample of 28 7^{th} grade science students and examined how they rate photographs of six teachers. They found that they perceived middle-aged teachers and females as more effective. At the college level, Arbuckle and Williams (2003) conducted a similar experiment on 350 students and found that young male professors were rated better than old male, young female and old female professors, concerning enthusiasm and voice tone during lectures.

1.3 The impact of teacher's gender

Current literature on gender differences in academic achievement often indicates that teaching in primary and secondary schools has become a female profession and that there is lack of male teachers, which could negatively influence especially boys' achievement. Indeed, in the Czech Republic, there are only about 30% of male teachers in the education system as a whole, and only 17% of male teachers in primary and secondary schools (MŠMT[2]). This is a common problem in many post-communist countries, such as Slovakia or Poland. Male teachers are necessary especially in kindergartens and primary and secondary schools where children develop themselves both psychologically and socially. Numerous studies have been conducted to examine the impact of teacher's gender on student academic achievement, but results of these studies are mixed, maybe because this varies by the country and the type of testing.

At the middle school level, Dee (2007) found that assignment to an opposite gender teacher negatively influences student outcome as well as teacher perceptions of student behavior. Nevertheless, Holmlund and Sund (2008) found no significant relationship between the gender match and student

[2] `http://toiler.uiv.cz/rocenka/rocenka.asp` [accessed 15-05-2017]

achievement when they used a within student and subject estimation on a sample of upper-secondary Swedish students.

Unbalanced share of male and female teachers is also an issue at universities, particularly at technical and mathematical fields that are mainly taught by male teachers. Bettinger and Long (2005) found that consequently, female students rarely choose these fields as their major and they are underrepresented in these professions. Unfortunately, the impact is even larger as it causes lower returns to education for women compared to men, and results in gender gaps in salaries (Loury, 1997). On the contrary, a more recent study by Hoffmann and Oreopoulos (2009) did not find any relationship between the teacher gender and choice of field at universities.

1.4 Gender gaps in education - why boys lack behind

Traditional literature on gender gaps indicates that boys outperform girls in mathematics and science while girls outperform boys in language related subjects. Even though these gender gaps are typical for primary and secondary schools, they have been decreasing over the last years (Neugebauer et al., 2011). What is more, girls are now outperforming boys, which is referred to as reversed gender gap (Mullis et al., 2012, Holmlund and Sund, 2008). These gender gaps in education seem concerning because of their lasting consequences - they might affect students in the future (e.g. their decision to continue in education and what field they choose to study) as well as the future labor market (Merrell and Tymms, 2011).

Gender gaps begin already in young age when boys are more likely to repeat kindergarten. In fact, in 2016, 67% of all kids who were retained in kindergarten in the Czech Republic were boys (MŠMT[3]). This is probably because many parents believe that if their son goes to school a year later, he will be more able to keep up with girls (Bellisimo et al., 1995). Likewise, during primary and secondary school education, boys are more likely to repeat a class (Entwisle et al., 2007). This is mainly caused by slower

[3] `http://toiler.uiv.cz/rocenka/rocenka.asp` [accessed 15-05-2017]

maturing of boys, compared to girls (Buchmann, DiPrete and McDaniel, 2008).

Part of the reason why boys are more often retained is that already in kindergarten, teachers approach boys and girls differently. While girls are supposed to sit at a table and cut papers, boys are boisterously running around and playing (Sadker and Sadker, 1994). Later at school, boys need more physical activity and they cannot get used to the lack of it, which results in disturbing and not paying attention. That is the reason why teachers' interactions with boys are often negative and disciplinary (Huston, 1983) which can negatively influence boys' attitude towards school and learning.

1.4.1 Lack of male role models

The main reason why male teachers are needed at schools is the lack of male role models. If students identify themselves more with a same-sex teacher, it is possible that their academic achievement will be enhanced if they are assigned to a teacher of the same gender (Basow and Howe, 1980). Boys, especially those from incomplete families, need someone to look up to, someone who could serve as a role model for them (Foster and Newman, 2005).

The hypothesis that boys would perform better with male teachers is suggested for several reasons. Firstly, boys usually have more difficulties concerning behavior at school, so they are more influenced by a good (or bad) relationship quality (Hamre and Pianta, 2001, Epstein, 1998). According to Cushman (2007), male teachers are more tolerant of boy-typical behavior such as liveliness or impulsiveness, and they can also better empathize with boys. They can promote positive behavioral attitudes towards school and serve as inspiration (role model). In contrast, Spilt, Koomen and Jak (2012) found that *all* teachers are closer to girls and have less conflicting relationships with them, which they state is due to their submissive behavior. They argue that the reason for this is that since education is being feminized, typical girl behavior is considered to be appropriate. As a result,

attentiveness and cooperation is valued more than the male-typical liveliness and disturbance (Fagot, 1981).

Secondly, some recent studies show that boys perform academically worse than girls at almost all levels, and the question is whether the reason behind this might be the dominance of female teachers in basic levels of education (Entwisle et al., 2007). If we assume that the theory of gender match is valid, boys' achievement will be improved if they are assigned to a male teacher. Additionally, assignment to a same gender teacher not only has a positive effect on student achievement, but also significantly improves student's engagement at class and teacher's perception of students (Dee, 2007). However, the idea that male teachers could inspire boys and handle them better has been criticized as an oversimplification of gender schema theory. For instance, Holmlund and Sund (2008) did not find any evidence of gender match when estimating the relationship using the student fixed effects in upper-secondary schools in Sweden.

It should also be noted that there are several reasons why there is lack of male role models in teaching. Firstly, the profession of teaching has long been perceived as predominantly female and low status, which affects men more than women (Hoyle, 2001). Secondly, teachers have low salaries and few benefits, which is also an issue because men are often perceived by society as those who should "feed the family".

1.4.2 Teacher expectations

Already in 1960s, Robert Rosenthal found through an experiment that higher expectations have positive effect on student achievement, which is known as the Pygmalion effect in literature (Rosenthal and Jacobson, 1968). Later, another experiment conducted by Chaiken, Sigler, and Derlega (1974) showed that if teachers believe that some students are more intelligent, they approach them differently. They make more eye-contact with them, respond more favorably to their comments and smile at them more often than at others. Consequently, those students enjoy going to school more and they

try harder to improve.

Unfortunately, expectations of teachers on girls and boys are not the same. Teachers expect more from girls which is given as another reason why boys lack behind. This is because girls are more diligent and hardworking, whereas boys are more careless about their school results (Entwisle et al., 1997).

Moreover, low expectations also negatively affect non-cognitive student outcomes such as self-esteem and motivation (Trouilloud et al., 2002). However, a more recent study by Jussim and Harber (2005) based on 35 years of empirical research indicates that self-fulfilling prophecies do occur, but they have small effects and they fade away over the years rather than accumulate. They also claim that teacher expectations predict student outcomes because they are accurate and not because they are self-fulfilling.

2 Data

The data used in this thesis contain both qualitative and quantitative information about 8th grade students, their teachers and schools in the Czech Republic from 2007. The project of international testing is organized by the International Association for the Evaluation of Educational Achievement (IEA) and more than 50 countries participated in TIMSS 2007. The main purpose of these testings is to provide data to teachers and politicians in order to help improve students' achievement in mathematics and science, and to provide crucial information for effective education policy-making.

TIMSS started in 1995 and data have been collected every 4 years for students in 4th and 8th grade. In this thesis, we only use the data for 8th graders because students in 4th are usually taught by a single teacher, which would not allow us to perform a within-student between-subject analysis.

2.1 Participants

In the Czech Republic, 291 schools with more than 9,000 students and more than 1300 teachers and headmasters participated in the TIMSS studies (National Report 2007, 2008[4]). In 8th grade, students were tested in mathematics and science and each of these subjects consists of four sections: in mathematics students were tested in numbers, algebra, geometry and data and chance. In science, students were tested in biology, chemistry, physics and earth ecience (geography). To compare the scores across countries, TIMSS identified 4 points on the achievement scales to serve as international benchmark scores (see Table 1). The results are then expressed as the percentage of students in each of these categories.

Concerning the 8th grade results in 2007, Czech students reached an average score in mathematics and an above average score in science. However, compared to the first testing in 1995 when Czech students performed very well in both sections, the scores in both science and mathematics are signi-

[4]http://www.csicr.cz/getattachment/cz/O-nas/Mezinarodni-setreni-archiv/TIMSS/TIMSS-2007/Narodni-zprava-2007.pdf [accessed 19-04-2017]

Table 1: **International Benchmarks** (TIMSS 2007 User Guide)

Scale Scores	International Benchmarks
400	Low International Benchmark
475	Intermediate International Benchmark
550	High International Benchmark
625	Advanced International Benchmark

ficantly lower (National Report 2007, 2008). For more details about student performance in the Czech Republic, see the plots in Appendix B.

In figure 1 and figure 2, we can see how the average score in mathematics and science evolved between the years 1995 and 2007 in the Czech Republic. Unfortunately, Czech Republic did not participate in testing in 2003, so we do not have data for this year, and since 2007, Czech Republic has been participating in testing for 4^{th} grades only.

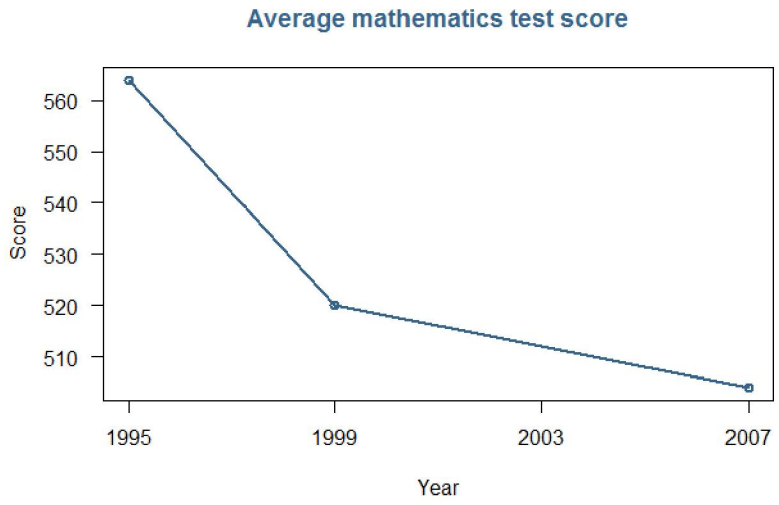

Figure 1: Average mathematics test score in the Czech Republic since 1995

One of the reasons why the average score dropped by such a large amount is the change of length of primary school. Before the academic year 1995/1996, there used to be only eight grades at Czech primary schools. However, some parts of curriculum were moved to a new, 9^{th} grade, so the

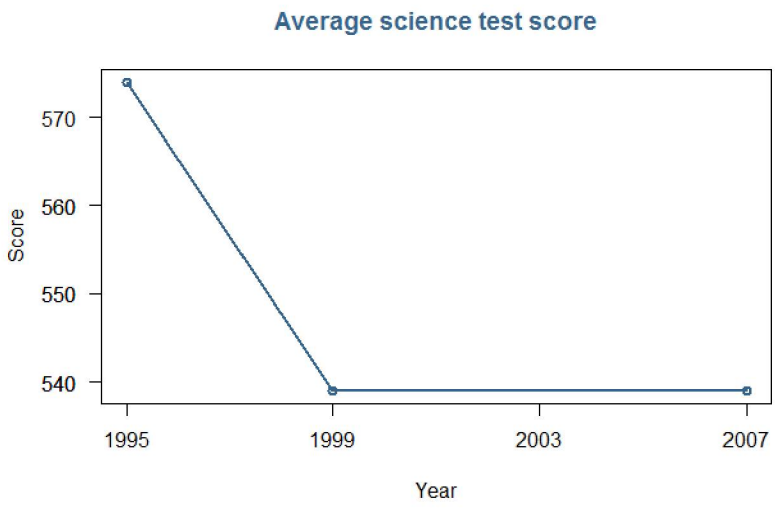

Figure 2: Average science test score in the Czech Republic since 1995

curriculum is now more spread out. In 2007/2008, a new curriculum reform was established to improve the situation, but since TIMSS 2011 is only available for the 4^{th} grade, we cannot observe the effect it has on 8^{th} grade students.

2.2 Data collection

The data were collected in the Czech Republic in spring 2007 and they are based on a representative sample of students. As was already mentioned in previous parts, the data contain information about students' background and their knowledge in five subjects as well as information about school environment, teachers and classrooms.

The student sampling selection is called *probability proportional-to-size* (PPS) sampling technique, where schools are first sampled and then classes within these participating schools are sampled. More information about this two-stage sampling technique is beyond the scope of this text and can be found in TIMSS 2007 Technical Report (chapter 5).

Through the method mentioned above, 147 schools with 4845 8^{th} grade students were randomly chosen. Each individual in the dataset is given a specific weight due to oversampling certain population. It is also important

to mention that even though students were chosen randomly, the teachers do not necessarily have to be a representative sample of Czech teachers (they just happened to teach a representative sample of students).

Students who participated in TIMSS 2007 were administered one of 14 booklets. 16 achievement scales were produced and for each achievement scale, five plausible values (estimates of the score on that scale) are available in the TIMSS 2007 database. The variability between these values reflects the uncertainty in the scale estimation process (TIMSS 2007 User Guide).

2.3 Data description

This part is dedicated to the description of the dataset in the Czech Republic. There were in total 147 primary schools that participated in the data collection, more than 4,800 students and over 1000 teachers and headmasters.

2.3.1 Teachers

There are altogether 200 mathematics teachers and 800 science teachers in the sample. Female teachers make up 79% of math teachers and 70% of science teachers. Most teachers in the sample are 40 - 59 years old, the average teacher's experience is 19 years and more than 95% of teachers studied at university.

2.3.2 Students

In the sample for the Czech Republic, half of the students (precisely 51.6%) are boys, the rest are girls. Students' age ranges between 13.5 to 17.5 years, and average 8^{th} grade student is 14.5 years old.

2.3.3 Schools and classes

There were altogether 147 schools with 90 to 1200 students. The amount of 8^{th} grade students at one school ranged from 12 to 138 students and an average class had 24 students.

2.4 Missing values and influential points

There are two types of missing values in the dataset: N/A and "Omitted". In this section, we describe what is the difference between these values and how do we handle them.

N/A was given to those items that were not administered, which means that they were either misprinted and a participant could not fill them, or he/she did not have these items in his/her booklet. Additionally, when a student was absent from a session, all variables relevant to that session were also coded as N/A. "Omitted" response code was given to items where students should have responded but did not.

In this paper, we treat these values differently depending on the type of variable. If the variable is continuous, we substitute it with its average across individuals. If it is a dummy variable, we treat it as zero. However, in order to know which values were originally N/A or "Omitted", we also construct dummy variables which take on value 1 if they were originally N/A or "Omitted" and 0 otherwise.

For the variables crucial for our analysis, namely teacher's gender, teacher's age and teacher's experience, we drop the observations that have N/A or "Omitted" in any of these three variables. This way we drop 32 science teachers (3.8%) and 5 mathematics teachers (2.4%).

Concerning students, the crucial variables are students' test scores and student's gender. None of these variables contains N/A or "Omitted", so we do not drop any students.

We also need to get rid of influential points (outliers) that might affect the analysis. This only concerns a few variables, for example teacher experience (which is crucial for our analysis) contains 17 teachers with experience 99 years. This is because the answer was not filled and should have been marked as "Omitted". We replace these values with the average teacher experience. Similarly, when class size is 999 students, we again replace this value with an average class size, and when minutes taught weekly to the TIMSS class are 999, we also replace this with an average.

2.5 Sampling weights and plausible values

An important characteristic of the TIMSS studies is that they use data from carefully drawn random samples of students, schools and classes and it is necessary for any analysis to take into account sampling weights in order to accurately reflect population attributes. All results of analyses reported in this thesis are computed with the use of these weights.

Another very important note is that as we already mentioned, each student's score has five plausible values. We compute each regression with all these values separately, however, for simplicity, we always report the results for the first plausible value. The results do not vary significantly between the plausible values, which is why it is not necessary to report them all.

3 Methodology

The main objective of this thesis is to study the effect of teacher's gender, age and experience on student achievement. Moreover, we are interested in examining whether the gender match is influenced by teacher's age and experience. These effects are studied using the TIMSS dataset which contains information about students, teachers and schools as well as student's test scores in five subjects, which lets us estimate the relationships while accounting for student fixed effects.

We first estimate the effect of teacher's characteristics by OLS while accounting for many other factors such as student background, class size and parents' education. By pooling the scores together across all subjects, we assume that the effect of teacher characteristics and other variables on student outcome is the same in all subjects (especially the variable $SAME$[5] that we are the most interested in). To let the effect change across subjects, we would also need to add interaction terms where we interact the variable $SAME$ with each subject. However, we do not take this approach in this thesis because it would lead to a very complicated interpretation of results if used along with other interaction terms which are the main object of this thesis.

The OLS approach, while controlling for many factors, does not take into account the selection problems that are common in teaching. The first problem is that teachers are not randomly assigned to schools or to classrooms within schools. Therefore, teacher effects could be confounded by unobserved student characteristics, such as motivation and ability. For example, if more effective teachers select themselves into classes with more able students, it would produce an upward bias. Alternatively, if principals or policy makers try to improve the performance of students that are lagging behind by assigning them to a teacher with strong credentials, this would lead to a downward bias. Secondly, students can choose to attend schools where they

[5] $SAME$ indicates whether there is a gender match between teacher and student (i.e. $SAME = 1$ if male teacher teaches male student, or if female teacher teaches female student, otherwise $SAME = 0$)

(or their parents) believe there are more able teachers, which would again bias the results. Thirdly, the OLS approach does not take into account that current achievement may be influenced by previous teacher characteristics. Although specifications like OLS that do not control for student fixed effects are likely to yield biased estimates, we include them in this thesis as a baseline. Equation 1 displays the baseline equation:

$$\begin{aligned} y_{ism} = \beta_0 + \beta_1 SAME_{ism} + \beta_2 EXPmedium_{sm} + \beta_3 EXPhigh_{sm} + \\ \beta_4 AGEmedium_{sm} + \beta_5 AGEhigh_{sm} + \nu_m + \lambda_m + \eta_c + \epsilon_{ism}, \end{aligned} \tag{1}$$

where y_{ism} is a test score for student i in school s, in subject m and $SAME$ represents the gender match mentioned above. ν_m represents student background information (e.g. number of books at home, whether the student has been bullied, his/her parents' education etc.), λ_m is an indicator variable for each subject and η_c is a variable capturing the class characteristics. ϵ_{ism} is the error term that we assume is normally distributed and iid. We keep experience below 3 years, age below 30 years and biology in the intercept. Therefore, the intercept can be interpreted as test score of student who had an opposite gender, low experienced teacher aged under 30 years. In case that β_1 is positive, we find an evidence of positive effect of gender match on test scores (girls benefit from being assigned to female teachers and boys benefit from being assigned to male teachers). We are also interested in estimating the coefficients on variables EXP and AGE.

To avoid the problems with selection issues mentioned above, we would need a panel dataset with information about teacher's gender from previous years. This would facilitate our analysis and we could very well examine whether the test scores were influenced by a teacher of the same gender or not. However, a similar effect can be obtained if we take advantage of the fact that we have five test scores for each student in the dataset. This lets us estimate the effect of teacher characteristics while accounting for the student fixed effects and allowing for correlation between the fixed effects and the explanatory variables in any subject. Since there is evidence that better trained and more experienced teachers are assigned to students of greater

ability and with fewer discipline problems (Clotfelter et al., 2006), inability to control for unobserved student characteristics such as motivation and ability would lead to an upward biased estimates of teacher characteristics. Therefore, preferred version of equation 1 takes into account the student fixed effects:

$$\begin{aligned} y_{ism} = \beta_0 + \beta_1 SAME_{ism} + \beta_2 EXPmedium_{sm} + \beta_3 EXPhigh_{sm} + \\ \beta_4 AGEmedium_{sm} + \beta_5 AGEhigh_{sm} + \nu_m + \lambda_m + \eta_c + a_i + \epsilon_{ism}, \end{aligned} \tag{2}$$

where a_i represents the student fixed effect. We estimate this model using the fixed effects estimation, which involves subtracting the averages across subjects from each variable and getting subject-demeaned data, which can be estimated by pooled OLS. This procedure gets rid of all variables that are fixed across subjects - namely the intercept and the student characteristics.

However, even when using the fixed effects, we still need to make several assumptions. The first assumption is that the marginal effect of teacher's characteristics on student outcome is constant across subjects and we suppose that the relationship is linear. Secondly, we assume that the student fixed effects influence the student results in the same way across subjects.

We now explain how we examine the effect of gender match, experience and age on student achievement. To facilitate the interpretation, we first divide *EXPERIENCE* and *AGE* into 3 dummies: experience below 3 years, experience 3 to 5 years and experience above 5 years and age below 30 years, age between 30 and 49 years and age above 50, respectively. We refer to these dummies as *EXPsmall*, *EXPmedium*, *EXPhigh*, *AGEsmall*, *AGEmedium* and *AGEhigh* respectively. Originally, teacher experience was a continuous variable. However, because current literature (e.g. Rivkin et al., 2005) suggests that the effect grows the first few years of teaching, but remains relatively unchanged when experience is above 5 years, it is better to divide this variable into these groups.

We show on a simplified equation (without other variables) how we can compare the effect of same gender teacher across different age groups and across different levels of teacher experience. Let's suppose that we have the

following equation:

$$y_{ism} = \beta_0 + \beta_1 SAME_{ism} + \beta_2 EXPmedium_{sm} + \beta_3 EXPhigh_{sm} + \beta_4 AGEmedium_{sm} + \beta_5 AGEhigh_{sm} + \beta_6 SAME_{ism} * EXPmedium_{sm} + \beta_7 SAME_{ism} * EXPhigh_{sm} + \beta_8 SAME_{ism} * AGEmedium_{sm} + \beta_9 SAME_{ism} * AGEhigh_{sm} + \epsilon_{ism}$$

After adding the interaction terms, the interpretation of the intercept and coefficient on β_1 changes. Now, the intercept represents the test score of a student who is taught by an opposite gender, low-experienced, young teacher. β_1 now represents the effect of gender match for a low-experienced, young teacher (that is, β_1 is the effect of having a same gender, low-experienced young teacher, compared to having an opposite gender, low-experienced young teacher). Below we write out the effects of different combinations of *SAME*, *EXPERIENCE* and *AGE*:

SAME = 0, EXPERIENCE $<$ 3 years: β_0
SAME = 1, EXPERIENCE $<$ 3 years: $\beta_0 + \beta_1$
SAME = 0, EXPERIENCE 3 - 5 years: $\beta_0 + \beta_2$
SAME = 1, EXPERIENCE 3 - 5 years: $\beta_0 + \beta_1 + \beta_2 + \beta_6$
SAME = 0, EXPERIENCE $>$ 5 years: $\beta_0 + \beta_3$
SAME = 1, EXPERIENCE $>$ 5 years: $\beta_0 + \beta_1 + \beta_3 + \beta_7$
SAME = 0, AGE $<$ 30 years: β_0
SAME = 1, AGE $<$ 30 years: $\beta_0 + \beta_1$
SAME = 0, AGE 30 - 49 years: $\beta_0 + \beta_4$
SAME = 1, AGE 30 - 49 years: $\beta_0 + \beta_1 + \beta_4 + \beta_8$
SAME = 0, AGE $>$ 50 years: $\beta_0 + \beta_5$
SAME = 1, AGE $>$ 50 years: $\beta_0 + \beta_1 + \beta_5 + \beta_9$

Now, we can easily compare the effects of each combination. We are the most interested in whether the effect of gender match varies across different years of teacher's experience and across different age groups. Table 2 shows the effect of gender match on student outcome for different levels of experi-

ence, compared to a young, low-experienced teacher. Table 3 show the effect of gender match on student achievement for different age groups, as opposed to having a low-experienced, young teacher.

Table 2: Effect of experience

Experience $3-5$ years	$\beta_2 + \beta_6$
Experience > 5 years	$\beta_3 + \beta_7$

Table 3: Effect of age

Age $30-49$ years	$\beta_4 + \beta_8$
Experience > 50 years	$\beta_5 + \beta_9$

The tables above show that the effect of being assigned to a medium-experienced teacher of the same gender, compared to a low-experienced, young teacher of the same gender, is $\beta_2 + \beta_6$. Similarly, we can see the effect for a well-experienced teacher and different teacher age groups.

Since the effects of teacher age and experience contain multiple terms, it is necessary to test the joint significance of $\beta_2 + \beta_6$, $\beta_3 + \beta_7$, $\beta_4 + \beta_8$ and $\beta_5 + \beta_9$. We use both the F test and LM test to test the following hypotheses:

$$H_1 : \beta_2 = \beta_6 = 0,$$
$$H_2 : \beta_3 = \beta_7 = 0,$$
$$H_3 : \beta_4 = \beta_8 = 0,$$
$$H_4 : \beta_5 = \beta_9 = 0$$

We include both teacher experience and teacher age in the regression for the following reason. Since, according to several studies, the effect of experience becomes negligible after the first few years, experience does not play a major role when teachers are above 35 years - by that point, most of them have gone through the first years of teaching and embraced the skills necessary to be a teacher. Therefore, for teachers above 35 years old, age may play a major role when it comes to the relationships between teachers and students.

4 Empirical results and discussion

4.1 OLS

The OLS method relies on the assumption that teacher-student assignment is random. In other words, the OLS estimates will be unbiased if we assume that high ability students do not choose to attend high ability schools and low ability students do not assign into low ability schools. However, if this assumption is not valid, the OLS estimation will produce biased estimates. Nevertheless, we still include the OLS model which serves as a baseline for the fixed effects model.

We estimate a model represented by equation 1 in previous section. We control for various variables which represent the student background, teacher background and other class characteristics. Table 4 summarizes our main findings. We find that the estimate on variable *SAME* is negative and significant. This would mean that gender match between teacher and student affects student outcome negatively, which is in stark contrast with what we expect. However, there can be several reasons why the coefficient is negative. Since this is an OLS estimation, it does not control for teacher self selection into classes, so the results can be biased. If, for example, teachers with stronger credentials select themselves into classes with more able students, this would produce an upward bias. Alternatively, which seems to be our case, if principals or policy makers try to improve the achievement of low-performing students by assigning them to a teacher with strong credentials, this would lead to a downward bias.

The last reason why the effect of *SAME* appears to be negative could be that the magnitude and sign of the coefficient is driven by females, because there are much more observations for the match girl-female teacher than for boy-male teacher. To see whether this is true, we perform another set of regressions where we divide the effect separately for girls and boys.

The results of these regressions confirm our expectations (see Table 4). The effect for girls is still negative but less significant, while the effect for boys is positive and statistically significant. This shows that we cannot

assume that the effect of *SAME* is identical for girls and boys - instead, we found that it has a different impact on boys and girls.

Table 4: Linear model

Dependent variable: test score			
Explanatory variable	ALL	GIRLS	BOYS
Intercept	659.864***	655.553***	704.153***
	(23.091)	(38.511)	(28.678)
SAME	-6.010***	-5.629**	8.031***
	(1.012)	(1.719)	(1.646)
Experience 3 - 5 years	-4.266+	-1.893	-3.521
	(2.492)	(3.578)	(3.394)
Experience $>$ 5 years	2.320	5.454	2.043
	(2.722)	(3.951)	(3.667)
Teacher age $30-50$	0.026	-4.396	3.801
	(2.346)	(3.308)	(3.247)
Teacher age $>$ 50	-3.350	-8.377*	-0.512
	(2.493)	(3.486)	(3.469)
Other controls	Yes	Yes	Yes
N	23 321	11 208	12 113
R^2	27.57	27.66	27.57

Notes: Heteroskedasticity robust standard errors are reported in parantheses. Other controls refers to number of books at home, parent education, parent support, student age, class size, whether the student has been bullied, how often he watches TV and whether he has camera at home (indicator of SES). +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Concerning the effects of these OLS estimates, we do not go into much detail here because this regression could be biased due to non random assignment of teachers into classes (evidence of this problem has been found by Clotfelter et al., 2006). Instead, we move on to another model with interactions which examines whether the gender match is affected by experience or age.

We estimate a similar model as previously, but we add interaction terms *SAME*EXPmedium*, *SAME*EXPhigh*, *SAME*AGEmedium* and *SAME*AGEhigh* because we want to test a hypothesis whether there is an effect of having a same gender, low-experienced teacher, as opposed to having

a same gender, medium- or high-experienced teacher on student outcome. Furthermore, we can test a hypothesis whether there is an effect of having a same gender, middle-aged or old teacher, compared to having a same gender, young teacher. In other words, girls/boys may benefit from being assigned to a same gender young, low-experienced teacher, or contrarily, students might benefit from being assigned to a same gender, old and high-experienced teacher. Results from this regression can be found in Table 5.

Table 5: OLS: Estimation with interaction terms

Dependent variable: test score			
Explanatory variable	ALL	GIRLS	BOYS
Intercept	653.960***	649.730***	699.339***
	(23.165)	(37.106)	(28.741)
SAME	9.619*	3.808	16.132**
	(3.746)	(5.493)	(5.111)
Experience 3-5 years	-0.430	-3.767	-0.857
	(3.537)	(6.475)	(4.365)
Experience $>$ 5 years	10.897**	6.031	10.048*
	(3.772)	(8.326)	(4.430)
Age 30-49 years	0.626	-0.245	-0.061
	(3.249)	(7.785)	(3.688)
Age $>$ 50 years	-2.870	0.751	-4.025
	(3.441)	(8.019)	(3.939)
Same*Experience 3-5 years	-7.535	0.812	-5.388
	(4.888)	(7.792)	(6.952)
Same*Experience $>$ 5 years	-16.790**	-2.440	-26.207**
	(5.296)	(9.460)	(8.263)
Same*Age 30-49 years	-1.424	-5.664	16.567*
	(4.504)	(8.573)	(7.665)
Same* Age $>$ 50 years	-1.154	-12.555	15.210+
	(4.813)	(8.907)	(8.168)
Other controls	Yes	Yes	Yes
N	23 321	11 208	12 113
R^2	25.36	27.47	27.41

Notes: Heteroskedasticity robust standard errors are reported in parantheses. +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

After adding the interaction terms, the interpretation of *SAME* changes. The coefficient on this variable now represents the effect of having a same

gender, low-experienced, young teacher, as opposed to having an opposite gender, low-experienced, young teacher. The effect of teacher experience on gender match is summarized in Table 6 and the effect of teacher age on gender match is summarized in Table 7.

Table 6: OLS: The effect of experience

	ALL	GIRLS	BOYS
$\beta_2 + \beta_6$ (experience 3 - 5 years)	-7.965*	-2.955	-6.245
$\beta_3 + \beta_7$ (experience $>$ 5 years)	-5.893**	3.591	-16.159**

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Table 7: OLS: The effect of age

	ALL	GIRLS	BOYS
$\beta_4 + \beta_8$ (age 30 - 49 years)	-0.798	-5.909	16.506*
$\beta_5 + \beta_9$ (age $>$ 50 years)	-2.487	-11.804**	11.185

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

From the signs and magnitudes in Table 6, it seems that it is beneficial for both boys and girls when they are assigned to a low-experienced teacher of the same gender. Results in Table 7 suggest that the effect of teacher age is different for boys and girls. While girls benefit from being assigned to a young female teacher, boys benefit from being assigned to a middle-aged or to an old male teacher. We return back to the interpretation of these interaction terms in the next section where we also include student fixed effects.

All OLS estimates reported in this part might be biased because we did not control for unobserved student characteristics such as motivation and ability. Inability to control for these characteristics leads to upward biased estimates if better trained and more experienced teachers are assigned to more able students (Clotfelter et al., 2006). Moreover, teachers choose their major depending on what they are good at and what they like, and we

believe that this also varies by the culture and stereotypes in a country. Female students are more likely to choose to study humanities while male students are more likely to study technical fields. This unobserved mechanism influences students and teachers across generations and causes positive correlation between the student achievement and having a same-sex teacher. Therefore, we conclude that the evidence of gender match found in these estimations is associated to teachers sorting themselves into specific subjects.

4.2 Fixed Effects model

Because of the issues mentioned above, we estimate the effect of teacher characteristics on student outcome using the within-student between-subject estimation. This estimation allows us to account for unobserved student fixed characteristics and also to get rid of the bias caused by nonrandom sorting of teachers into subjects. The crucial assumption for this estimation is that the fixed student characteristics are the same in all subjects. That is, we assume that the unobserved student characteristics affect the test score by the same amount in each subject. In case that the results of this estimation are the same as OLS, then we cannot explain the student outcome by unobserved student characteristics.

We first estimate equation 2 with fixed effects. The results are reported in Table 8. We can see that using the fixed effects estimation, the effect of having a same gender teacher is significantly positive when we consider the sample as a whole. This is in line with the role-model theory. However, when we estimate the model separately for girls and boys, we see that in fact, there is no evidence of role model effect neither for girls, nor for boys. The effect on girls has p-value = 0.23 and is slightly negative, while the effect on boys has p-value = 0.15 level and is slightly positive and both these effects are very small in magnitude. Concerning just the signs of the coefficients, it is a little surprising that the coefficient on *SAME* for girls is negative. The reason for this could be the fact that since there are not enough male teachers in education in general, even girls benefit from being assigned to a male teacher because he can have different approach to teaching compared to female teachers. The positive sign on *SAME* for boys confirms that the gender match has a positive effect on boys, but the effect is very small. These results are similar to those of Holmlund and Sund, who used a similar strategy. They first estimated their model by OLS which suggested that having a same gender teacher increases the test scores of both boys and girls. However, when they added fixed effects, the effect was no longer significant.

Table 8: Fixed effects estimation

Dependent variable: test score			
Explanatory variable	ALL	GIRLS	BOYS
SAME	3.568***	-1.364	1.698
	(0.771)	(1.145)	(1.169)
Experience 3 - 5 years	0.159	-3.048	3.543
	(1.637)	(2.269)	(2.309)
Experience > 5 years	2.092	1.522	2.658
	(1.795)	(2.552)	(2.471)
Teacher age 30 - 49 years	-2.371	-2.127	-2.511
	(1.530)	(2.161)	(2.139)
Teacher age > 50 years	-2.581	-2.755	-2.404
	(1.634)	(2.303)	(2.292)
Earth Science	4.345***	-4.489***	12.125***
	(0.869)	(1.238)	(1.243)
Chemistry	6.274***	5.461***	7.033***
	(0.860)	(1.187)	(1.233)
Math	-30.832***	-27.685***	-33.961***
	(0.917)	(1.287)	(1.274)
Physics	6.664***	-2.404*	14.318***
	(0.858)	(1.211)	(1.273)
Other controls	Yes	Yes	Yes
N	23 321	11 208	12 113
R^2	80.56	81.54	80.15

Notes: Heteroskedasticity robust standard errors are reported in parantheses. +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Concerning age and experience, the effects are all insignificant. Looking just at the signs, it seems like young teachers have a positive effect on student outcome when we compare them with teachers who are 30 to 49 or above 50 years old. We only observe increasing returns to experience when we take the sample as a whole. For both boys and girls, high experience has a positive effect on test scores, although it is again small in magnitude. It is also interesting to compare the effect of each subject - for example, mathematics is a hard subject and compared to biology, scores are lower by 28 points for girls and by 34 points for boys.

We now estimate a fixed effects model with interaction terms *SAME* EXPERIENCE* and *SAME*AGE* and test the hypothesis whether student

achievement will be enhanced if he/she is assigned to a same gender teacher with different levels of experience/age. The results are reported in Table 9 and the effects of interactions with experience and age are reported in Tables 10 and 11, respectively.

Table 9: Fixed effects with interaction terms

Dependent variable: test score			
Explanatory variable	ALL	GIRLS	BOYS
SAME	3.052	-2.054	4.128
	(2.482)	(3.434)	(3.540)
Experience 3 - 5 years	0.738	-1.589	3.304
	(2.359)	(3.702)	(2.999)
Experience $>$ 5 years	-0.429	-7.572	4.459
	(2.471)	(5.581)	(3.004)
Teacher age 30 - 49 years	-0.732	6.341	-3.557
	(2.108)	(4.211)	(2.481)
Teacher age $>$ 50 years	-0.076	4.890	-2.163
	(2.252)	(4.386)	(2.663)
Same*Experience 3 - 5 years	-1.103	-2.334	0.919
	(0.738)	(4.747)	(4.758)
Same*Experience $>$ 5 years	4.966	12.046*	-5.499
	(3.606)	(5.601)	(5.689)
Same*Teacher age 30 - 49 years	-3.160	-11.143*	4.586
	(2.992)	(4.927)	(4.917)
Same*Teacher age $>$ 50 years	-4.928	-9.992+	0.039
	(3.192)	(5.129)	(5.271)
Other controls	Yes	Yes	Yes
N	23 321	11 208	12 113
R^2	80.56	81.56	80.17

Notes: Heteroskedasticity robust standard errors are reported in parantheses. +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Results from Table 9 indicate that the effect of gender match is overall positive, but when we look at girls and boys separately, the effect is positive only for boys and negative for girls. Neither of these effects is statistically significant, though. Examining the effect of experience itself, the effects are different for boys and for girls: for boys, years of teacher experience have a positive effect which grows with more years, but for girls, the effect seems to be declining with years of experience. This seems strange, but the prob-

lem might be that it differs from one subject to another. For example, in mathematics, experience might play a major role because it is a subject which requires a lot of skills when the teacher explains new things to students. Nevertheless, these effects are again not significant. The reason for this might be the fact that in the Czech Republic, vast majority of teachers have completed university (in the dataset, 95% of teachers are certified). Therefore, they are ready to teach and experience does not play such a big role as it might be in other countries, e.g. in the USA where the situation is different.

Concerning the effect of age, it again varies for girls and boys. For girls, teachers above 30 in general have a positive effect on student outcome, while for boys, the effect is negative. This suggests that boys perform better with young teachers, regardless of their gender. However, all these effects mentioned above are small in magnitude and insignificant.

Table 10: FE: The effect of experience

	ALL	GIRLS	BOYS
$\beta_2 + \beta_6$ (experience 3 - 5 years)	-0.365	-3.923	4.223
$\beta_3 + \beta_7$ (experience $>$ 5 years)	4.567+	4.474*	-1.040

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Table 11: FE: The effect of age

	ALL	GIRLS	BOYS
$\beta_4 + \beta_8$ (age 30 - 49 years)	-3.892+	-4.802**	1.029
$\beta_5 + \beta_9$ (age $>$ 50 years)	-5.004**	-5.102*	-2.124

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

We now look at the effect of teacher experience and age on gender match. Results from Table 10 show that the effect of experience on gender match varies for girls and boys. The only significant effect is for girls and teachers with experience over 5 years. Precisely, for girls, having a same gender

teacher with experience over 5 years increases the test score by almost 5 points, compared to having a same gender, low-experienced young teacher. This effect, although significant, is quite small. It is still important though, because this can contribute to gender gaps, since there is majority of female teachers and sooner or later, they all get beyond the first few years of teaching.

Looking at the effect of age, it is again only significant for girls and it suggests that girls benefit from being assigned to a young female teacher. To be more specific, the negative effect of having a same gender teacher aged 30-49 years is -4.8 points, and the effect of having a same gender teacher above 50 years old is -5.1 points. These effects are again not large but they support our hypothesis that teacher-student match is more likely to occur between girls and young female teachers.

Concernig boys, the effects are not significant, but the signs suggest that boys benefit from being assigned to a male teacher aged 30 - 49 years, although the magnitude is very small in this case. However, being assigned to a male teacher aged over 50 years has negative impact on boys, but the magnitude is again small.

5 Robustness check

While the fixed effect estimates in Table 9 provide little evidence supporting a significant benefit of teacher-student gender match, they suggest that boys who are matched with a same gender teacher achieve slightly higher test scores than if they were matched with an opposite gender teacher. They also indicate that being assigned to a same gender young teacher has a positive effect on student outcome for both boys and girls. Inclusion of student fixed effects in this study aims to eliminate the potential bias in coefficients due to correlation between unobserved student characteristics and teacher selection into classes. Nevertheless, there are several reasons why the results might still be biased. For example, we were not able to control for unobservable teacher characteristics such as effectiveness, ability or motivation. Therefore, differences in teacher effectiveness may explain the observed positive correlation between teacher gender and student achievement.

This section examines whether the inclusion of random teacher effects explains the observed positive correlation between teacher age and gender and student achievement. In order to further control for differences in teacher characteristics, we employ a mixed model which allows for both fixed effects and random effects (RE) and estimates the coefficients through maximum likelihood. Including the RE allows each student with a teacher to have a different intercept (mean score). In other words, we assume variation in the test score due to individual differences in students and teachers. The results are presented in Table 12 in Appendix A. The column St.Dev. shows that there is variability of 65 points in the test score due to individual student characteristics and variability of 10 points due to individual teacher characteristics. There is still substantial variation in the test score which cannot be explained by neither the individual students, nor the teachers. This suggests that there are still other things that affect the student outcome which we could not control for.

Concerning the other variables in mixed model, the results are similar to those using the fixed effects, but they are larger in magnitude. The effects

of teacher experience and age on gender match are reported in Appendix B (see Tables 13 and 14). The results indicate that there is an evidence of gender match between students and young teachers. The negative effects of age on are especially significant between female teachers above 50 years old and girls.

Additionally, we assume throughout the thesis that the effects of teacher characteristics and student unobservable characteristics are the same across subjects. In other words, we assume that the effect of gender match is the same across subjects. However, this assumption may not be valid because in some subjects, there are more female teachers than in others. If this is true, having a male teacher might be beneficial for both boys and girls in those subjects, because male teachers can have different approach than females. However, this depends on the stereotypes in a given country and the degree of education. In the dataset for Czech 8^{th} grades used in this thesis, there are 71% of female teachers and 29% of male teachers.

In order to test this assumption, we estimate a model with student fixed effects where we interact $SAME$ with $SUBJECT$ and therefore let the gender match differ across subjects. The results can be found in Table 15 in Appendix A. For the effects of gender match across subjects, see Table 16. The results indicate that the effect of gender match differs significantly across subjects only when we take into account the full sample. When we divide it into boys and girls, the effect is no longer significant. Therefore, our assumption that gender match affects student results in the same way across subjects is valid.

Conclusion

In this thesis, we study the impact of teacher experience and age on gender match between teachers and students. Unexpectedly, we do not find any evidence of overall gender match. However, our findings are in accordance with a previous study by Holmlund and Sund (2008) who used a similar strategy.

Nevertheless, our aim was to extend the gender match theory by adding other teacher characteristics. To date, most studies have focused solely on the effect of gender match but to the best of our knowledge, no one has yet examined the effect of teacher experience and age on gender match. These are important attributes that might influence teacher effectiveness. In previous studies focusing only on experience, it has been found that marginal returns to experience increase during the first few years and then remain relatively constant. Even though we do not find any evidence to support this statement, we do find a significant impact of age on gender match. Specifically, we find that young female teachers have a significantly positive effect on girls' achievement, although the effect is quite small. On the basis of our findings, it is possible to state that simply employing more male teachers will probably not solve the current phenomenon of boys lacking behind. However, attracting more young teachers might have a positive effect on student achievement, because they may serve as role models to children.

To examine the relationship between teachers and students, we use data from TIMSS 2007 in Czech 8^{th} grades. Having a test score for each student in five subjects allows us to estimate the relationship using the within-student between-subject estimation. Although adding fixed effects helps to avoid many issues, it does not rule out that the effects are not driven by other unobserved variables. Additionally, only the data for mathematics and science were available, and the effects might differ in other subjects. In future research, the topic of this study could be extended by examining the effects in each subject separately or by analyzing the data from other countries.

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Appendix A

Table 12: Robustness check: Mixed model

Dependent variable: test score			
Random effects			
Groups	ALL	GIRLS	BOYS
STUDENT	63.48	64.78	64.87
TEACHER	12.00	10.54	8.62
Residual	190.14	183.23	192.20
Fixed effects			
Explanatory variable	ALL	GIRLS	BOYS
Intercept	465.588***	458.285***	479.126***
	(7.119)	(9.433)	(8.630)
SAME	3.716+	-2.432	5.551
	(2.152)	(4.559)	(4.161)
EXPERIENCE 3 – 5 years	-2.215	-3.404	0.652
	(3.314)	(5.151)	(3.633)
EXPERIENCE > 5 years	1.485	-4.210	6.018
	(3.647)	(6.609)	(3.801)
AGE 30 – 49 years	-2.630	2.463	-4.808
	(3.173)	(6.108)	(3.172)
AGE > 50 years	-4.033	0.895	-4.250
	(3.369)	(6.415)	(3.383)
Same*Experience 3 - 5 years	-1.969	-1.583	1.663
	(2.902)	(9.816)	(5.829)
Same*Experience > 5 years	3.618	9.816	-10.078
	(3.246)	(7.848)	(6.976)
SAME*Teacher age 30 – 49 years	-3.943	-8.923	7.936
	(2.792)	(7.018)	(3.683)
SAME*Teacher age > 50 years	-5.325	-9.091	3.135
	(2.967)	(7.374)	(6.536)
Other controls	Yes	Yes	Yes
N	23 321	11 208	12 113
R^2	81.27	82.49	80.91

Notes: Heteroskedasticity robust standard errors are reported in parantheses. +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Table 13: Mixed model: the effect of experience

	ALL	GIRLS	BOYS
$\beta_2 + \beta_6$ (experience 3 - 5 years)	-4.183	-4.987	2.315
$\beta_3 + \beta_7$ (experience $>$ 5 years)	5.103	5.606	-4.060

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Table 14: Mixed model: the effect of age

	ALL	GIRLS	BOYS
$\beta_4 + \beta_8$ (age 30 - 49 years)	-6.573+	-6.460	3.128
$\beta_5 + \beta_9$ (age $>$ 50 years)	-9.358*	-13.301*	-1.115

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Table 15: FE: Gender match across subjects

Dependent variable: test score			
Explanatory variable	ALL	GIRLS	BOYS
SAME	4.834***	-3.135	-2.539
	(1.325)	(2.340)	(3.555)
Experience 3 - 5 years	0.103	-3.329	3.448
	(1.635)	(2.282)	(2.320)
Experience > 5 years	2.123	1.514	2.386
	(1.790)	(2.569)	(2.478)
Teacher age 30 - 49 years	-2.434	-1.943	-2.222
	(1.529)	(2.177)	(2.141)
Teacher age > 50 years	-2.619	-2.764	-2.185
	(1.633)	(2.309)	(2.294)
Earth Science	7.416***	-6.959**	11.078***
	(1.374)	(2.551)	(1.504)
Chemistry	5.723***	3.026	6.012***
	(1.232)	(3.360)	(1.352)
Math	-33.379***	-30.755***	-34.396***
	(1.305)	(3.014)	(1.448)
Physics	8.936***	-2.358	12.806***
	(1.261)	(2.422)	(1.575)
Same*Earth Science	-6.113**	3.352	5.028
	(1.881)	(3.072)	(3.199)
Same*Chemistry	1.151	2.972	5.734
	(1.791)	(3.402)	(3.827)
Same*Math	5.197**	3.836	2.711
	(1.874)	(3.401)	(3.526)
Same*Physics	-4.592*	-1.008	5.864+
	(1.870)	(2.982)	(3.167)
Other controls	Yes	Yes	Yes
N	23 321	11 208	12 113
R^2	80.61	81.55	80.16

Notes: Heteroskedasticity robust standard errors are reported in parantheses. +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Table 16: Gender match across subjects

	ALL	GIRLS	BOYS
Biology	4.834***	-3.135	-2.539
Earth Science	-1.279***	0.217	2.489
Chemistry	5.985***	-0.163	3.195
Math	10.031***	0.701	0.172
Physics	0.242***	-4.143	3.325

Notes: +/*/**/*** refer to statistical significance at the 10, 5, 1 and 0.1 percent level, respectively.

Appendix B

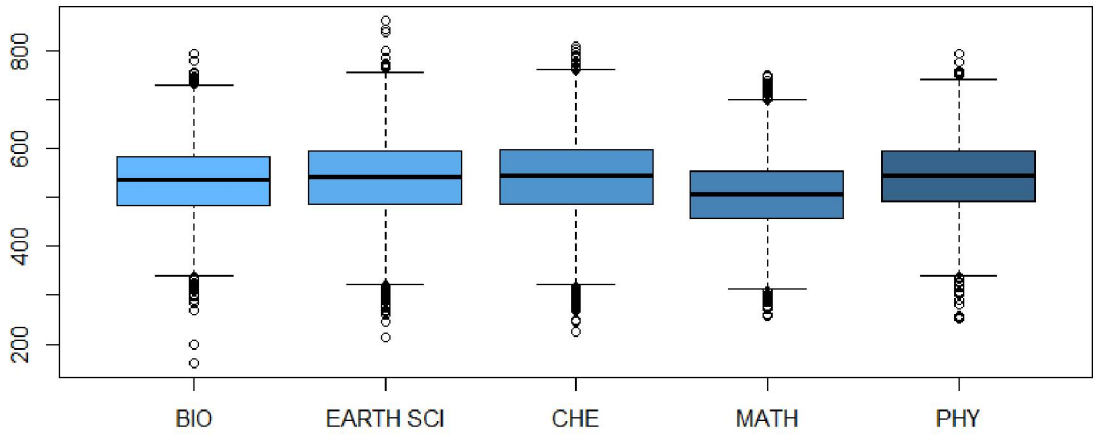

Figure 3: Overall scores in TIMSS 2007 (Czech Republic)

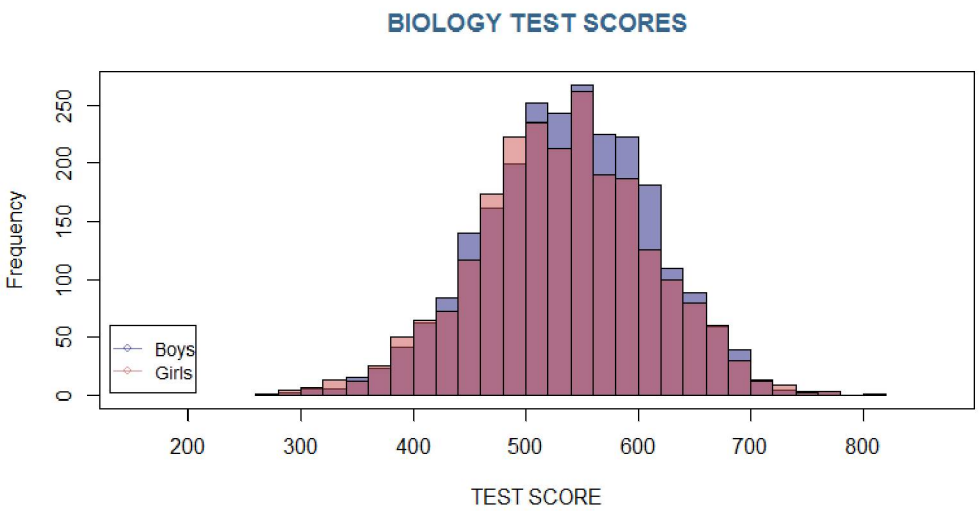

Figure 4: Boys vs. girls in biology

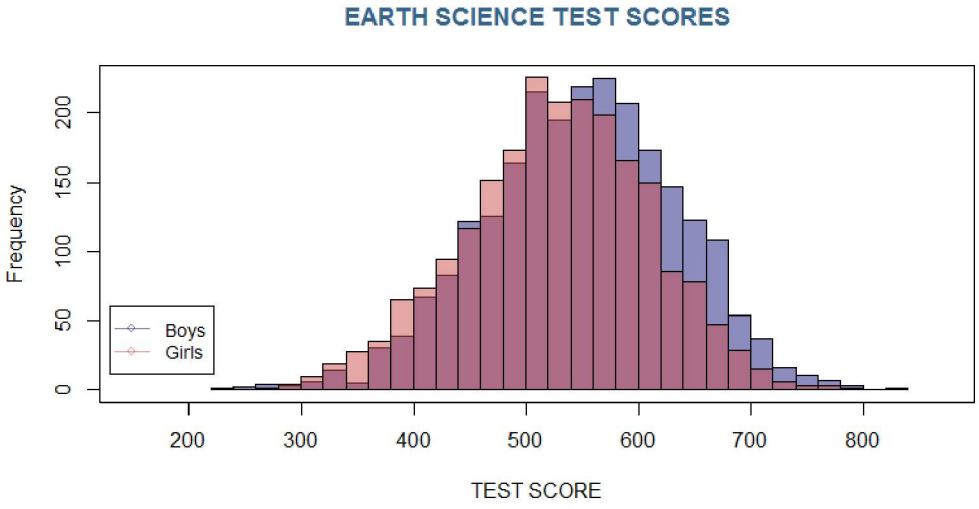

Figure 5: Boys vs. girls in geography

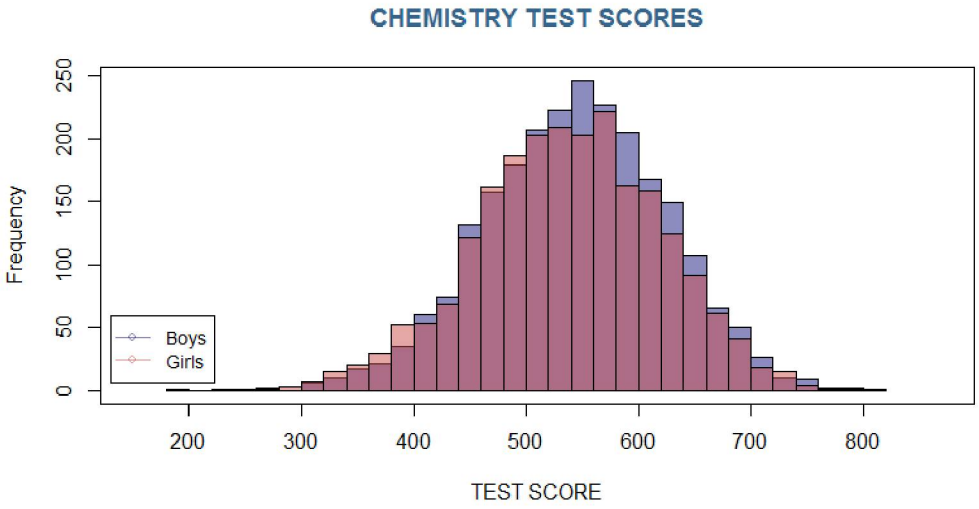

Figure 6: Boys vs. girls in chemistry

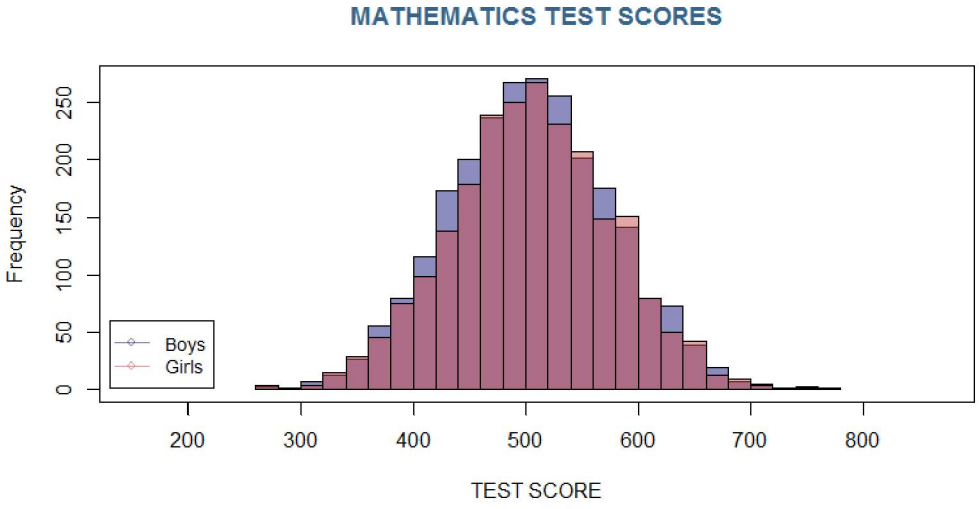

Figure 7: Boys vs. girls in mathematics

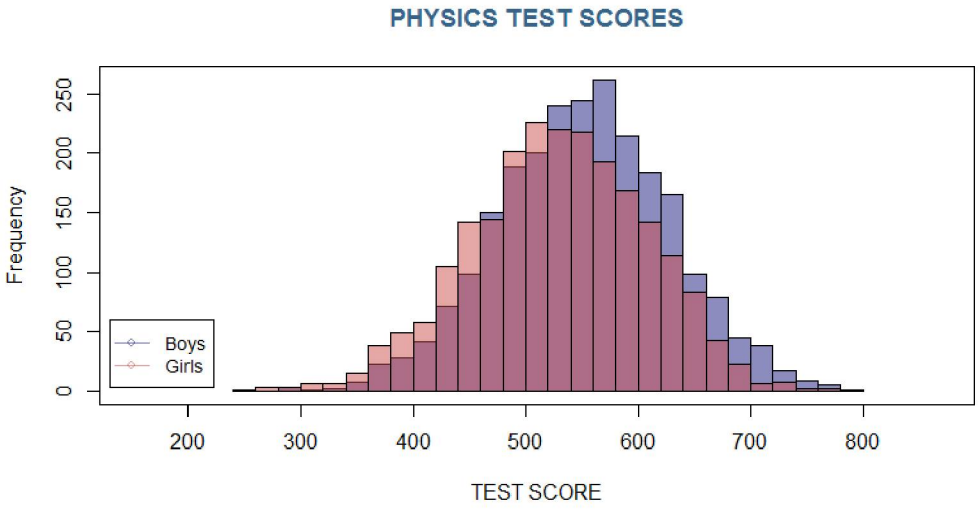

Figure 8: Boys vs. girls in physics

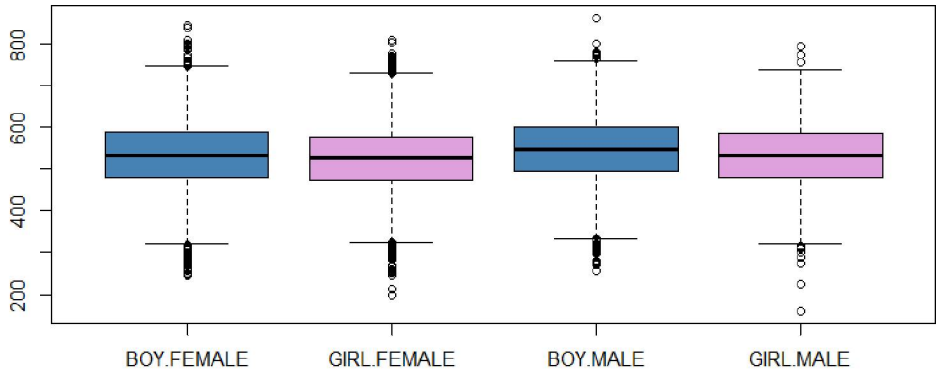

Figure 9: Gender match