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Teachers' Wages on Students' Performance**

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The Effects of Policies Concerning Teachers' Wages on Students' Performance

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Abstract

Using country panel data of student achievement from PISA, 2003-2012 combined with national-level teacher salary data from the OECD; this study investigates if relatively short term -5-years - changes in the level and structure of statutory teacher salaries affect student performance in the European countries. Our results show that there are marked differences between subjects and by the experience of teachers. Higher statutory teacher salaries and larger growth of teacher salaries at the first part of teachers' career increase students' maths and science performance, while the effect was less pronounced on reading performance and at the second part of teacher career. Nevertheless, the reason for the lack of the effect of teacher salaries at the second part of teachers' career may be the result of the lack of data on teachers' actual salaries.

Keywords: teacher salaries, student performance, international, PISA, random effect, two-step method

JEL codes: I20, J31, J45, C23

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A tanári bérek alakulásának hatása a tanulói teljesítményekre

Varga Júlia

Összefoglaló

A tanulmány a 2003 és 2012 közötti PISA tanulói teljesítmésmérések adataiból országszinten összekapcsolt panel adatbázis és OECD tanári bérekre vonatkozó adatgyűjtéseinek adatai segítségével azt vizsgálja, hogy a tanári bérek színjének, és a tanári bérpálya alakjának viszonylag rövid távú (5 éves) változásai befolyásolják-e a tanulók teljesítményét az európai országokban. Az eredmények azt mutatják, hogy a hatás szignifikánsan különbözik kompetencia területek (olvasás-szövegértés, matematika, természettudomány) és a tanárok gyakorlati ideje szerint. A pályakezdő tanárok magasabb besorolás szerinti bére, és a tanári pálya első felében a besorolási bérek gyorsabb emelkedése a tanulók szignifikánsan jobb eredményeihez vezetnek matematikából és természettudományokból, míg nem találtunk szignifikáns hatást az olvasás-szövegértés eredményekre. Ugyancsaknem hatott szignifikánsan a tanulói teljesítményekre egyetlen kompetenciaterületen sem a tanárok besorolási bérének gyorsabb emelkedése a tanári életpálya második felében. A tanulmányban azt is bemutatjuk, hogy annak, hogy az életpálya második felében megfigyelhető bérnövekedésnek nincs hatása az lehet, hogy annak a következménye, hogy a bér adatok a besorolási bérekre vonatkoznak, és nem állnak rendelkezésre a tanárok tényleges keresetére vonatkozó adatok.

Tárgyszavak: tanári bérek, tanulói teljesítmények, PISA mérések, véletlen hatás modell, két lépcsős modell

JEL kódok: I20, J31, J45, C23

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INTRODUCTION

Improving students' performance is an important objective in most countries. Although measurable information concerning teachers (gender, educational level, experience) does not correlate closely with students' performance (Hanushek and Rivkin, 2006), a number of national level studies (e.g. Chetty, Friedman and Rokoff, 2014; Darling-Hammond, 2000; Rivkin, Hanushek and Kain, 2005) conducted using value-added models to evaluate teachers based on their impact on their students' test scores suggest that teacher quality is one of the major determinants of student achievement. Many countries are facing teacher quality problems (Barbieri, Cipollone and Sestito 2008; Corcoran, Evans and Schwab, 2002; Lakdawalla, 2001; Leigh and Ryan, 2008; Neugebauer, 2015), and a common proposal is that teacher quality might be increased by means of teacher wage reforms. Higher pay is assumed to attract higher quality teachers to teaching and assist in retaining them.

However, the results of national level studies on how teachers' salaries are associated with students' performance are mixed. On the one hand, some of the research findings suggest that evidence for salaries having an effect on students' performance is lacking. For example, Hanushek and Rivkin (2006) summarize the results of more than a hundred studies on the effect of teacher salaries on student performance and find that only a minority of studies has found statistically significant results; nevertheless, the studies do show that salaries are more likely to be positively related to student achievement than negatively. Other studies claim that paying teachers more will not improve the quality of teachers very much, because a pay rise operates as a kind of negative feedback, helping to ensure that teachers of lower quality will stay on in the job longer after a salary increase (Ballou and Podgursky, 1995), or stress that teacher responses to alternative wages are less pronounced than the response in other jobs (Hanushek and Rivkin, 2006). Using a sharp geographical discontinuity in teacher salary scales in England, Greaves and Sibieta (2014) find little evidence that higher teacher salaries have a positive impact on pupil attainment. Ree, Muralidharan, Pradhan and Rogers (2015) present experimental evidence from Indonesian schools that the doubling in teachers' pay led, in the following two or three years, to no improvements in student learning outcomes.

Another section of the research suggests that the quality of education can be improved by raising teacher salaries (e.g. Loeb and Page, 2000; Murnane and Olsen, 1990). These studies show that teachers with high opportunity costs, that is, those who have better labour market opportunities outside of teaching, stay in teaching for a

shorter time (Dolton 2010; Dolton and van der Klaauw 1999; Murnane and Olsen, 1990), as also that wage differentials between those professions outside of teaching and teachers' wages affect teachers' decisions to exit teaching (Gilpin, 2011; Imazeki, 2005; Krieg, 2006; Ondrich, Pas and Yinger, 2008). It has also been shown that higher teacher salaries retain and attract more effective teachers (Hendricks, 2014). Results also suggest that novice teachers are most responsive to changes in salary, both in terms of retention and selection effects (e.g. Gilpin, 2011). The main difficulty of national level studies is that on a country level there is limited exogenous variation in teacher salaries as teachers' pay is usually set by national agreements, and the variation in salaries tend to reflect differences in teachers' education, experience or costs in the local area (see Hanushek and Rivkin, 2006). Using international variation for the identification of effects of teacher salaries can help alleviate this problem, although there are concerns about the use of cross-country data, too, such as omitted variables bias and other constraints (see Hanushek and Woessmann, 2010). In fact, there are very few studies concerning the question of how international differences in educational achievement are related to teacher salaries.

In a study that investigates the role of teacher cognitive skills on students' performance, comparing different countries, Hanushek, Piopiunik and Wiederhold (2014) attempt to estimate whether teachers' cognitive skills are higher in countries that pay teachers relatively better wages. Their results indicate that higher relative teacher pay is systematically related to higher teacher skills; nevertheless, they emphasize that the estimates are not causal estimates of how the quality of teachers would change if teacher salaries were raised. Carnoy, Beteille, Brodziak, Loyalka and Luschei (2009) compared the salaries of primary and secondary school teachers with the salaries of people in mathematics-oriented professions, such as engineering and various scientific fields, and found that in countries where teachers are paid more relative to salaries in competing professions, students do better in mathematics knowledge tests. Based on Programme for International Student Assessment (PISA) 2006 data on student science performance and OECD teacher salary data, Boarini and Lüdemann (2009) employed a multi-level analysis on the sample of OECD countries, and found that teachers' wages are associated with higher PISA performance. Woessmann (2011) combined country performance-pay measurements with PISA-2003 achievement data, and estimated international education production functions at the student level using alternative measures of the control variable for teacher salary levels. He found that teacher performance pay is significantly positively related to achievement in maths, science, and reading achievement between countries. Employing Trends in International Mathematics and Science Study (TIMSS) and PISA

assessment test data, Dolton and Marcenaro-Gutierrez (2011) constructed a composite measure of students' performance for 8th grade students (a standardised score for each type of assessment) and, merging the data with OECD data for teacher salaries between 1995 and 2006, constructed a country panel data-set. Based on this panel data-set they then investigated the determinants of teachers' salaries across countries, and also whether absolute and relative teacher pay in a given country had an impact on pupil performance. They found that both absolute and relative levels of teacher salaries exert an important influence on pupil performance. Unlike most other studies, which relate current teacher salaries to current student performance, Dolton and Marcenaro-Gutierrez use average salaries of primary, lower secondary and upper secondary teachers between 1995 and 2006 and their overall wage growth in the same period. As the quality distribution of the current stock of teachers is the result of both past and current salaries, this method might be more reliable than just using current salaries for measuring teachers' quality. Nevertheless, a 12-year period might mask different periods of growth and decline in teacher salaries which might, in turn, have an impact on the decision to become a teacher and on the rate of teacher attrition. Dolton and Marcenaro-Gutierrez also emphasize that not only average relative wages in teaching are important in the question of teacher supply, but that both the pattern of teacher salaries and the age-earning profile of teachers also play important roles. They use average teacher starting salaries, the salaries of those with 15 years' experience, and maximum salaries separately in different models in their attempt to capture this effect.

This study investigates how relatively short term changes in the level and structure of teacher salaries affect student performance. Our work is closely related to the Dolton and Marcenaro-Gutierrez study; it differs, however, in several respects. First, in this study, it is the relatively short-term (5 years) implications of changes in relative earnings or changes in the shape of the age-earning profiles of teachers that are at the centre of the investigation. This may be of interest from a policy-making perspective, as it is usually assumed that it takes a very long time to change the overall quality of the whole stock of teachers completely, because in the case of a salary increase, the quality of new recruits would rise, but the quality of existing teachers would not change, and the rise would act as an incentive for the latter group to stay in the job longer. Second, the analysis only considers European countries, assuming that the effect of teacher wages will be relatively homogenous for countries at a similar stage of economic development and with similar traditions of education. Finally, we analyze the wage-effect separately for reading, maths and science performance, in order to investigate if there are differences between subjects.

Between 1999 and 2013 there were great differences between countries in the changes of relative earnings of teachers (Figure A1). In some countries, there were distinct periods of salary increase and decrease (e.g. Czech Republic, Hungary, Germany) while in other countries the relative salary of teachers declined continuously (e.g. Greece, Spain), or was constant over the whole period (e.g. Italy, Slovak Republic, Sweden). Furthermore, the shape of the age-earnings profile remained constant in some countries (e.g. Belgium, Denmark), while in others it changed (e.g. Portugal, Poland) (Figure 2). This already might also have an effect in the short run, because as a consequence of these changes teachers at different points on the age-experience profile could receive different incentives to stay in teaching or leave the profession. Our study analyzes the wage-effect separately in different subjects (literacy, mathematics, and science). Many national-level studies have demonstrated that in some subject areas there is an over-supply of teachers while in others, there is a lack of qualified teachers (e.g. Boyd, Grossman, Lankford, Loeb and Wyckoff 2006; Hanushek, 2007). With regard to teaching labour market opportunities, opportunity wages are different for teachers in different subject areas. Usually, teacher shortages are most pronounced in maths and the sciences, in those subjects where alternative wages are usually higher. As salary scales do not differ according to teachers' subject-specialisation, changes in teacher salaries might have different effects in subject areas.

DATA

For the analysis, data from four waves of the Programme for International Student Assessment (PISA) and 14 waves (1999-2012) of the OECD Educational at a Glance (EAG) data were used. PISA measures three different types of literacy: reading, mathematics, and science at the age of 15 every 3 years since 2000. A two-step sampling procedure ensures that student samples are representative of the relevant populations. First, schools in which 15-year-olds are studying are selected (schools are sampled with probabilities proportional to the number of 15-year-olds enrolled), then, a subset of students is sampled in each selected school. PISA data include students' test scores and also provide information on students' family background, and on the characteristics of schools. The school questionnaire is filled in by school principals, so the answers reflect these principals' views on different features of school functioning. The EAG data provide detailed information on the education systems of the OECD and partner countries. It contains information on teacher salaries too. Since 1999, the OECD has collected comparable data on statutory salaries at three points in time: starting salary, salary with 15 years' experience and top salary by ISCED (International

Standard Classification of Education) levels. We also know from EAG data how many years it takes to reach the top statutory salary. It worth emphasizing that our salary data refer to the statutory salaries of teachers, and not the actual salaries. Although the OECD has also recently begun collecting data on actual teacher salaries, these data are available only for the most recent years and on only for a few, although growing number of countries. That's why – similar to all previous studies – analyzing the effect of teachers' salaries on student performance with the help of EAG data - we could not use data on actual salaries. In the conclusion section, we return to this question and summarize how this might affect our results. Furthermore, EAG data provide information on the proportion of women teachers and the age distribution of teachers. We also used EAG data for per capita GDP of the countries in the sample.

In order to construct our data-set we first combined students' test scores in maths, science, and reading literacy with individual students' characteristics, family background information, and school-level data for each of the four PISA waves. We then constructed a country-level panel dataset from the four waves (2003, 2006, 2009, and 2012) of the PISA data. These data were then merged with country-level variables for teacher salaries and teacher characteristics. Finally, data from the full PISA sample were completed with countries' GDP per capita, based on EAG data.

For the country level variables we used 5-year averages, that is, we merged the t year PISA data with the averages of the given year and the preceding 4 years' EAG country level data. The reason for this method was rooted in the concept that behind teacher salaries potentially having an effect on students' performance lies the fact that salaries have an effect on teacher quality, via the mechanism of teachers' self-selection into teaching. Nevertheless, teachers' or potential teachers' response to salaries and salary changes requires time to become apparent. The current stock of teachers at any time is shaped by the effects of both past and current salaries. Teacher pay exhibits a cyclical pattern in many countries (e.g. Chevalier, Dolton, McIntosh, 2007; Varga, 2014; Wolter and Denzler, 2004) where a period of decline of teachers' relative salaries is followed by a large increase, which is then followed by a fresh decline in teachers' relative salaries. So relative salaries for a longer period, and not just for a single year may better reflect the real position of teachers.

In order to minimize differences in economic development, the group of countries in the sample was restricted to EU countries, and only selected observations from countries which participated in at least three of the five waves of PISA. Our final sample consists of 708,856 individuals, 23 countries and 75 country/year observations (countries in the sample are presented in Appendix Table A1).

METHODS

The analysis is based on an education production function framework. In their simplest form, the models estimated can be represented as follows:

$$Y_{ict} = \beta_1 T_{ct} + \beta_2 F_{cti} + \varepsilon_{cti} + u_{ct} \quad (1)$$

Where Y_{ict} is the test score of an individual i in a country c at a time t . F contains variables that summarise individual level characteristics, while T_{ct} contains variables summarising country-level teacher salaries and other country-level characteristics. There are also unobserved individual effects ε_{cti} and country effects u_{ct} .

Our database is of a hierarchical nature, the individual level observations are embedded in the higher, country level, and so multilevel modeling methods were used to analyze the effect of teachers' salary structure on students' performance. Nevertheless, our data contains a very large sample of individuals within each country, though from a small number of countries, so the main difficulty in this analysis was to provide robust conclusions about the effects of country-level characteristics on students' performance. A large number of individual-level observations and a small number of countries is a common problem of studies which try to explain differences in socio-economic outcomes across countries (Bryan and Jenkins, 2015). To deal with this problem, we used different model specifications for the analysis.

For reference purposes, first, we pooled the data of the four waves and used OLS regressions. This approach ignores the fact that individuals within a country share unobserved characteristics, so cluster-robust (country) standard errors were used to allow for a more general correlation structure between individuals within countries.

The second specification used country random effect models because our focus is on the effects of country-level predictors and we put in our models time-invariant country-level variables too.

Finally a two-step method was used, in which the first step is a regression at the individual level and the second another regression at the country/year level. In the first step we estimate:

$$Y_{ict} = v_{ct} + \beta_2 F_{cti} + \varepsilon_{cti} \quad (2)$$

Where, v is the regression intercept, which combines both observed and unobserved country characteristics. Then, with the help of the second step OLS regression we analysed the country-specific components:

$$\hat{v}_{ct} = \alpha + \beta_1 T_{ct} + \eta_{ct} \quad (3)$$

Where, \hat{v}_{ct} are the intercepts from the first-step country/year separate regressions and η_{ct} is a residual error term. The effects of country-level characteristics are estimated from only C observations, so their standard errors will typically be relatively large.

First our models were estimated using only individual and country level variables, then we repeated the estimations, complementing the models with school-level variables too. A large body of literature confirms that teachers are not randomly assigned to schools (e.g. Rivkin, Hanushek, Kain, 2005; Rockoff, 2004). School-level characteristics were chosen that may have an effect on the sorting of teacher quality between schools and thus may alter student performance so that it is above or below average.

The models were estimated separately for the performance of the students in mathematics, reading and science because outside of teaching, salaries and the labour market opportunities for teachers of different subjects are heterogeneous, and thus may have differing impacts on teacher selection and quality.

Our individual level variables include gender, age, a variable indicating if the individual student is an immigrant (was born in another county), another variable indicating if one or both parents of the student are immigrants, dummy variables indicating the highest educational attainment of the student's mother and father. To describe teacher sorting at the school-level the following covariates were used: whether the school the student was studying in was a private school; the proportion of fully qualified teachers in the school; if there was a teacher shortage at school in the opinion of the school principal; the type of settlement the school was operating in (large city, city, town, small town versus village); the proportion of immigrant students at school; the proportion of girls at school; whether the school had responsibility for the determination of salaries (beginning salaries, salary increases, or both); and whether the school had responsibility for the hiring or firing of teachers, or both.

In order to analyze the effect of teachers' salaries, four variables describing the age-earning profile of teachers were used: starting salary as proportion of GDP per capita, the growth of salaries from starting to 15th year of experience, the growth of salaries from 15th year of experience to the top salary, and the number of years needed to reach the top salary year. For all variables describing relative salaries of teachers and teachers' age-earnings profiles, 5-year averages were used, for the reasons summarized in the previous section. Although the salaries of teachers relative to other graduate

salaries would have been a better measure of teachers' relative position and outside teaching opportunities than salaries as a proportion of per capita GDP, the latter measure was used because of the lack of available, longitudinal data for the first measure. However, salaries as a proportion of per capita GDP can illustrate how teacher salaries stand relative to the country's economic wealth. We also controlled for country level GDP per capita in equivalent US dollars (using PPP). The proportion of women teachers was a further country level variable in our models. We also put a dummy variable in our models indicating whether the country is a central or eastern European country (CEE) or not in order to analyze whether there were systematic differences between CEE and non-CEE countries. The reason why there might have been systematic differences between the two groups was that in the countries of the former Soviet Bloc, selection into teaching –for the older age cohorts who graduated under the old regime – was very different from that found in non-CEE countries. In the CEE countries, until the end of the 90s the number of higher education places was very restricted, and higher education – including teacher training – was more competitive than in the non-CEE countries, in spite of the relatively low salaries of teachers in the CEE countries (Kogan, 2008). That's why we expect systematic differences in teacher quality for the older age cohorts between these two groups of countries.

RESULTS

The Effect of Statutory Teachers' Salaries on Student performance

Table 1 summarizes the results of the models for the performance of students in mathematics /according to different model specifications; Table 2 shows the results for science performance and Table 3 reading performance. (Summary statistics are presented in the (Appendix, Table A1).

Marked differences in the effect of salaries on student performance are to be found in different subjects. Higher starting salaries increase maths and science performance but not literacy performance. Statutory starting salaries for teachers have a significant positive effect on students' maths and science performance with all model specifications. As for reading performance, the results are mixed; there are some specifications in which a positive relationship between teachers' starting salaries and students' reading performance could be found, but in the case of the majority of specifications, no effect was to be found.

Table 1.

Determinants of student performance in maths

MATHS						
Variable	Pooled sample OLS	Panel Random	Two-Step Method	Pooled sample OLS	Panel Random Effect	Two-Step Method
<i>Individual level variables</i>			<i>1st step Country/Year</i>			<i>1st step Country/Year</i>
Gender (Male)	11.77* (1.266)	11.27* (1.190)	Yes	16.06* (2.096)	14.94* (1.529)	Yes
Age	18.13* (1.916)	16.28* (1.257)	Yes	16.82* (2.419)	14.87* (1.777)	Yes
Immigrant student	-36.98* (7.155)	-38.61* (8.306)	Yes	-35.35* (7.054)	-38.10* (8.248)	Yes
One or both parents immigrant	-13.85 (5.491)	-11.51 (6.070)	Yes	-14.85 (6.936)	-11.51 (6.012)	Yes
Mother's educational attainment upper secondary (ISCED 3/4)	29.03* (2.518)	24.77* (1.872)	Yes	27.09* (2.532)	23.85* (1.901)	Yes
Mother's educational attainment tertiary (ISCED 5/6)	43.87* (3.531)	39.03* (3.296)	Yes	41.53* (3.844)	36.85* (3.391)	Yes
Father's educational attainment upper secondary (ISCED 3/4)	24.33* (1.608)	20.83* (1.542)	Yes	23.65* (1.872)	20.61* (1.537)	Yes
Father's educational attainment tertiary (ISCED 5/6)	44.05* (2.862)	39.26* (3.728)	Yes	41.99* (3.117)	37.60* (3.546)	Yes
<i>School-level variables</i>						
Private school	-	-	No	13.16** (3.790)	12.96 (5.426)	Yes
Proportion of fully certified teachers	-	-	No	15.20 (6.734)	6.83 (7.569)	Yes
Teacher shortage at school	-	-	No	-5.96 (2.208)	-4.31 (2.474)	Yes
School in small town	-	-	No	12.90* (3.416)	9.33** (3.132)	Yes
School in town	-	-	No	20.01* (5.146)	15.34* (4.170)	Yes
School in city	-	-	No	21.55* (4.285)	17.12* (3.941)	Yes
School in large city	-	-	No	21.60 (9.096)	21.49** (7.083)	Yes
School has responsibility for determining salaries	-	-	No	-0.72 (2.420)	0.31 (3.808)	Yes
School has responsibility for	-	-	No	0.07 (2.893)	1.94 (3.357)	Yes

hiring/firing						
Proportion of immigrant students at school	-	-	No	-79.84 (44.18)	-22.72 (39.563)	Yes
Proportion of girls at school	-	-	No	36.57 (16.81)	27.99 (9.349)	Yes
<i>Country-level variables</i>			2nd step			2nd step
Proportion of women teachers	-0.24 (0.323)	0.09 (0.927)	-0.26 (0.257)	-0.23 (0.341)	0.20 (0.448)	-0.45 (0.348)
GDP per capita in equivalent US dollars (using PPP)	0.00 (0.000)	-0.00 (0.001)	0.00 (0.000)	0.00*** (0.000)	0.00 (0.000)	0.00 (0.000)
Starting salary as proportion of GDP per capita	49.23* (11.067)	34.09** (12.257)	36.14* (9.62)	49.39* (13.016)	39.34** (13.172)	38.61** (12.753)
Years to top salary	-0.60 (0.256)	0.27 (1.113)	-0.55 (0.216)	-0.81 (0.292)	-0.46 (0.269)	-0.70 (0.282)
Growth of salaries from starting to 15 years' experience	45.59* (10.334)	14.24 (23.665)	28.07*** (10.800)	32.26*** (11.011)	16.34 (14.642)	36.51*** (14.491)
Growth of salaries from 15 years' experience to top	63.62* (17.111)	0.94 (27.092)	0.50 (0.516)	60.04* (16.221)	33.06 (13.727)	-0.14 (0.701)
CEE country	32.84** (9.572)	-9.72 (22.300)	11.110 (8.091)	41.17** (12.275)	31.53 (12.666)	36.20* (10.23)
Year 2006	-11.67** (3.375)	-2.01 (3.563)	No	-10.30 (4.357)	-11.42*** (4.422)	No
Year 2009	-16.92 (6.744)	1.09 (8.468)	No	-13.31 (9.619)	-21.15*** (7.966)	No
Year 2012	-17.84 (8.870)	3.44 (12.304)	No	-19.47 (10.787)	-27.10*** (10.400)	No
Constant	-41.96 (72.426)	169.93 (106.712)	-56.48 (31.732)	-53.35 (85.640)	47.45 (71.542)	-74.45 (45.373)

*Significant at the 1 per cent level; **Significant at the 5 per cent level; ***Significant at the 10 per cent level

Table 2.

Determinants of students' science performance

SCIENCE						
Variable	Pooled sample OLS	Panel Random Effect	Two – Step Method	Pooled sample OLS	Panel Random Effect	Two – Step Method
			<i>1st step Country/Year</i>			<i>1st step Country/Year</i>
<i>Individual level variables</i>						
Gender (Male)	3.04 (1.349)	1.83*** (1.008)	Yes	8.06* (1.876)	6.37* (1.466)	Yes
Age	18.75* (1.519)	17.17* (1.337)	Yes	17.56* (1.789)	15.01* (1.945)	Yes
Immigrant student	-42.57* (7.486)	-41.21* (7.092)	Yes	-41.55* (7.598)	-41.65* (7.201)	Yes
One or both parents immigrant	-16.54 (6.585)	-12.47 (5.823)	Yes	-18.70 (8.417)	-13.48 (6.278)	Yes
Mother's educational attainment upper secondary (ISCED 3/4)	32.16* (2.517)	26.83* (2.172)	Yes	30.42* (2.638)	26.48* (2.058)	Yes
Mother's educational attainment tertiary (ISCED 5/6)	48.22* (3.608)	41.89* (3.290)	Yes	45.73* (4.039)	40.32* (3.639)	Yes
Father's educational attainment upper secondary (ISCED 3/4)	26.71* (2.237)	22.05* (1.873)	Yes	25.93* (2.508)	21.47* (1.793)	Yes
Father's educational attainment tertiary (ISCED 5/6)	47.52* (3.282)	40.64* (3.964)	Yes	44.83* (3.676)	38.16* (3.858)	Yes
<i>School-level variables</i>						
Private school	-	-	No	10.07 (4.231)	10.62* (3.104)	Yes
Proportion of fully certified teachers	-	-	No	22.41*** (7.687)	14.84 (6.052)	Yes
Teacher shortage at school	-	-	No	-5.29 (2.088)	-4.24 (2.414)	Yes
School in small town	-	-	No	12.44** (3.552)	7.94** (2.924)	Yes
School in town	-	-	No	18.81** (5.666)	14.26* (4.093)	Yes
School in city	-	-	No	22.03* (4.907)	18.55* (4.065)	Yes

School in large city	-	-	No	23.36 (9.733)	24.40* (6.044)	Yes
School has responsibility for determining salaries	-	-	No	4.20 (2.335)	5.30 (2.647)	Yes
School has responsibility for hiring/firing	-	-	No	-2.60 (2.934)	-1.81 (3.204)	Yes
Proportion of immigrant students at school	-	-	No	-46.06 (30.458)	-12.17 (29.401)	Yes
Proportion of girls at school	-	-	No	46.65*** (16.202)	37.84* (8.619)	Yes
<i>Country-level variables</i>			2nd step			2nd step
Proportion of women teachers	0.44 (0.383)	-0.27 (0.787)	0.61 (0.299)	0.32 (0.394)	0.69 (0.464)	0.53 (0.421)
GDP per capita in equivalent US dollars (using PPP)	0.00 (0.000)	0.00 (0.000)	0.00 (0.000)	0.00 (0.000)	0.00 (0.000)	0.00* (0.000)
Starting salary as proportion of GDP per capita	52.02** (14.156)	44.81*** (26.774)	45.81* (9.519)	49.75** (15.638)	30.34** (13.95)	50.80* (13.253)
Years to top salary	-0.62 (0.282)	-0.05 (0.771)	-0.32 (0.251)	-0.83*** (0.289)	-0.45 (0.309)	-0.47 (0.351)
Growth of salaries from starting to 15 years' experience	36.41** (11.976)	22.95 (23.541)	31.22** (10.851)	24.91*** (11.884)	14.62 (14.855)	40.50*** (15.800)
Growth of salaries from 15 years' experience to top	48.38 (21.644)	10.45 (24.934)	0.39 (0.502)	48.14 (22.519)	34.75 (19.106)	-0.36 (0.798)
CEE country	24.34 (10.300)	26.90 (21.281)	13.31 (7.623)	31.25*** (11.036)	20.39 (11.445)	38.93* (10.609)
Year 2006	-7.78 (3.125)	-2.11 (5.328)	No	-5.54 (3.477)	-5.39 (4.580)	No
Year 2009	-13.70 (5.981)	-4.20 (7.322)	No	-10.47 (6.707)	-15.34 (6.670)	No
Year 2012	-13.33 (8.130)	-1.91 (9.479)	No	-14.23 (8.290)	-17.88 (8.768)	No
Constant	-50.33 (77.560)	110.30 (109.676)	-159.47 (31.95)	-70.65 (76.627)	27.41 (71.870)	-193.64 (48.754)

*Significant at the 1 per cent level; **Significant at the 5 per cent level; ***Significant at the 10 per cent level

The shape of the age-earnings profile, the growth of teachers' salaries at the beginning of their career, that is, from starting to the 15th year of experience, seems to have an effect on students' maths and science performance, although the effect was not significant at all model specifications. In the course of the second part of teachers' careers (from the 15th years of experience to the top), the shape of the age-earnings profile seems to have no significant effect on students' maths performance. The effect is positive on students' science performance, but again, we could not find a significant

effect in the course of the second part of teachers' careers. The years from the 15th year up to the top salary does not seem to influence students' science performance, either.

Table 3.

Determinants of students' reading performance

READING						
Variable	Pooled sample OLS	Panel Random Effect	Two – Step Method	Pooled sample OLS	Panel Random Effect	Two – Step Method
			<i>1st step Country/Year</i>			<i>1st step Country/Year</i>
<i>Individual level variables</i>						
Gender (Male)	-37.63* (2.075)	-38.52* (1.626)	Yes	-32.31* (2.032)	-33.35* (1.768)	Yes
Age	17.68* (1.33)	16.04* (1.134)	Yes	17.78* (1.923)	14.49* (1.599)	Yes
Immigrant student	-39.48* (7.070)	-39.16* (7.206)	Yes	-39.43* (7.156)	-39.67* (7.119)	Yes
One or both parents immigrant	-11.38 (5.317)	-8.69 (5.253)	Yes	-13.67 (6.632)	-10.52 (5.333)	Yes
Mother's educational attainment upper secondary (ISCED 3/4)	31.75* (2.892)	25.98* (2.166)	Yes	29.85* (3.015)	25.03* (1.868)	Yes
Mother's educational attainment tertiary (ISCED 5/6)	46.44* (3.563)	39.90* (3.030)	Yes	43.75* (3.814)	37.67* (3.036)	Yes
Father's educational attainment upper secondary (ISCED 3/4)	25.46* (1.920)	21.83* (1.544)	Yes	24.93* (2.110)	21.08* (1.503)	Yes
Father's educational attainment tertiary (ISCED 5/6)	43.74* (2.691)	39.41* (3.384)	Yes	41.38* (3.031)	36.60* (3.374)	Yes
<i>School-level variables</i>						
Private school	-	-	No	12.64** (3.689)	13.82* (3.701)	Yes
Proportion of fully certified teachers	-	-	No	23.31*** (8.009)	18.35*** (7.065)	Yes
Teacher shortage at school	-	-	No	-6.36 (2.343)	-4.85 (2.504)	Yes
School in small town	-	-	No	12.59* (3.110)	8.25* (2.591)	Yes
School in town	-	-	No	20.62* (5.315)	16.03* (3.820)	Yes
School in city	-	-	No	24.65* (4.556)	20.74* (3.858)	Yes
School in large city	-	-	No	26.94 (9.665)	29.27* (6.056)	Yes

School has responsibility for determining salaries	-	-	No	-4.30 (1.976)	-1.58 (3.253)	Yes
School has responsibility for hiring/firing	-	-	No	-2.78 (2.693)	-0.75 (3.003)	Yes
Proportion of immigrant students at school	-	-	No	-54.77 (35.836)	-0.96 (28.368)	Yes
Proportion of girls at school	-	-	No	51.47** (15.219)	44.55* (11.066)	Yes
<i>Country-level variables</i>			2nd step			2nd step
Proportion of women teachers	-0.12 (0.257)	0.43 (0.639)	0.44 (0.198)	-0.21 (0.288)	0.38 (0.321)	0.41 (0.316)
GDP per capita in equivalent US dollars (using PPP)	0.00 (0.000)	-0.00 (0.000)	0.00 (0.000)	0.00 (0.000)	0.00 (0.000)	0.00* (0.000)
Starting salary as proportion of GDP per capita	27.63*** (10.12)	13.20 (17.205)	22.96** (7.802)	23.89 (12.690)	14.22 (9.061)	28.71 (11.317)
Years to top salary	-0.67 (0.255)	-0.59 (0.608)	-0.25 (0.191)	-0.97* (0.265)	-0.41 (0.227)	-0.36 (0.303)
Growth of salaries from starting to 15 years' experience	31.56 (8.888)	3.19 (15.971)	30.74* (8.534)	19.20 (8.265)	17.52 (9.803)	35.19*** (13.878)
Growth of salaries from 15 years' experience to top	50.52*** (16.171)	-12.74 (24.106)	0.68 (0.492)	53.25** (16.03)	23.99 (11.826)	-0.022 (0.699)
CEE country	5.31 (9.308)	-34.49 (16.156)	-4.08 (6.265)	12.83 (10.651)	3.328 (9.149)	17.66 (9.82)
Year 2006	-7.13 (3.504)	-3.96 (3.203)	No	-6.09 (3.976)	-9.57** (3.424)	No
Year 2009	-5.79 (4.680)	3.79 (5.491)	No	-5.99 (7.124)	-15.67** (5.649)	No
Year 2012	2.43 (6.452)	11.79 (7.452)	No	-2.53 (8.191)	-14.49 (6.910)	No
Constant	68.90 (58.543)	262.15* (67.279)	-110.94 (23.851)	24.31 (74.203)	98.17 (48.333)	-140.68 (38.294)

*Significant at the 1 per cent level; **Significant at the 5 per cent level; ***Significant at the 10 per cent level

Not only did statutory starting salaries prove to have no impact on students' reading performance, but neither did the other three indicators describing teachers' age-earning profile (even though some estimations resulted in significant effects).

Depending on the model specification, the level of GDP per capita either does not have a significant effect on students' performance or has a significant zero effect. The results of the estimations of some model specifications show that students in Central and Eastern European countries display better performance in maths and science, but the results are not consistent across model specifications.

Nearly all student-level variables are significant, with some exceptions. There are gender differences in students' performance by subjects, while in general older students perform better, and the higher the educational level of the student's parents the better the student's performance is. The first generation immigrant students (those born in another country) do worse than their schoolmates who were born in the same country, though there is no difference between the performance of students whose mother or father or both were born in another country and students whose parents are not immigrants. Many of the school-level variables are insignificant, but there are some notable exceptions. Private school students do better as well as students in schools located in larger settlements. The maths and reading performance of the students is better if the proportion of girls is larger in the school. The reading performance of students increases as the proportion of fully certified teachers increases in their school. Variables indicating whether the school has responsibility for the hiring/firing of teachers or for determining teachers' salaries proved to be insignificant if controlled for the level and growth of teacher salaries and other variables.

In view of the aims of this analysis, the most important result would have been if teachers' statutory starting salaries had been higher in the preceding five years and students' performance in maths and science had also been higher, but no such effect was to be observed on reading performance. The another important finding of the analysis is that the shape of the earnings profile in the preceding five years has no effect on students' performance. There might be different reasons for the variation of results across subjects. The most plausible explanation is that the differences reflect the differences in the labour market options for maths, science, and other teachers. Several studies have proved that the average wage return on a mathematics degree is higher than for many other subjects (e.g. Walker and Zhu, 2001), that quantitative fields (e.g. science, maths) increase employment probability and earnings (e.g. Buonanno and Pozzoli, 2009). Science and maths teachers seem to adapt to relative salary changes more flexibly than other teachers, thanks to better labour market opportunities.

A further explanation might be that as students' performance at any point in time reflects not only current and recent teacher quality, but also the effect of past teachers, current performance reflects the accumulated knowledge of students over the years. There might be differences between different skills in relation to how much time is needed to achieve improvements in student skills. If an improvement in the maths and science knowledge of students can be achieved within a shorter period than the improvement in literacy skills, then the effects of increasing teacher quality will only be observed after a longer period.

The next section summarises possible reasons for the analysis failing to find any effect due to the age-earning profile of teachers, particularly in the second part of their careers.

Statutory and Actual Salaries

Our results concerning starting salaries and the growth of salaries in the first part of teachers' careers (from their starting salary to that of teachers with 15 years' experience) were in line with those of previous research findings (e.g. Dolton and Marcenaro-Gutierrez, 2011). We found that the larger teachers' starting salaries and the larger the growth of their salaries at the beginning of their careers are, the better students' maths and science performance is. Nevertheless, we could not find a significant effect of the salary growth of teachers from the 15th year of experience to the top, nor did the number of years required to reach top salaries seem to have any effect.

These results may reflect the differences in the likelihood of attrition by experience. Studies of teacher attrition have found that salaries and outside teaching opportunities have differing impacts on teachers depending on their experience. There is a lower probability of experienced teachers exiting the profession than those at the beginning of their careers (e.g. Murnane and Olsen 1990; Gilpin, 2011). This explanation leads to the conclusion that from a wage-policy perspective raising teacher starting salaries is pivotal in increasing teacher quality, while salaries in the subsequent periods of teachers' careers it does not have a decisive impact.

Nevertheless, the drawing of this inference might be incautious. Our wage data concerns the statutory salaries of teachers as well as data of previous studies based on OECD data because the OECD has only recently begun to collect data on teachers' actual salaries. In addition to statutory salaries, many countries use schemes that offer additional payments or other rewards for teachers. Together with the starting salary, these payments may influence teachers' decisions to enter or remain in the teaching profession. Nevertheless, not all countries make additional payments over and above the statutory salaries, and the scale of additional payments can vary considerably across countries.

Figure 1

Statutory and actual salaries of teachers to salaries of workers with higher education, 2014

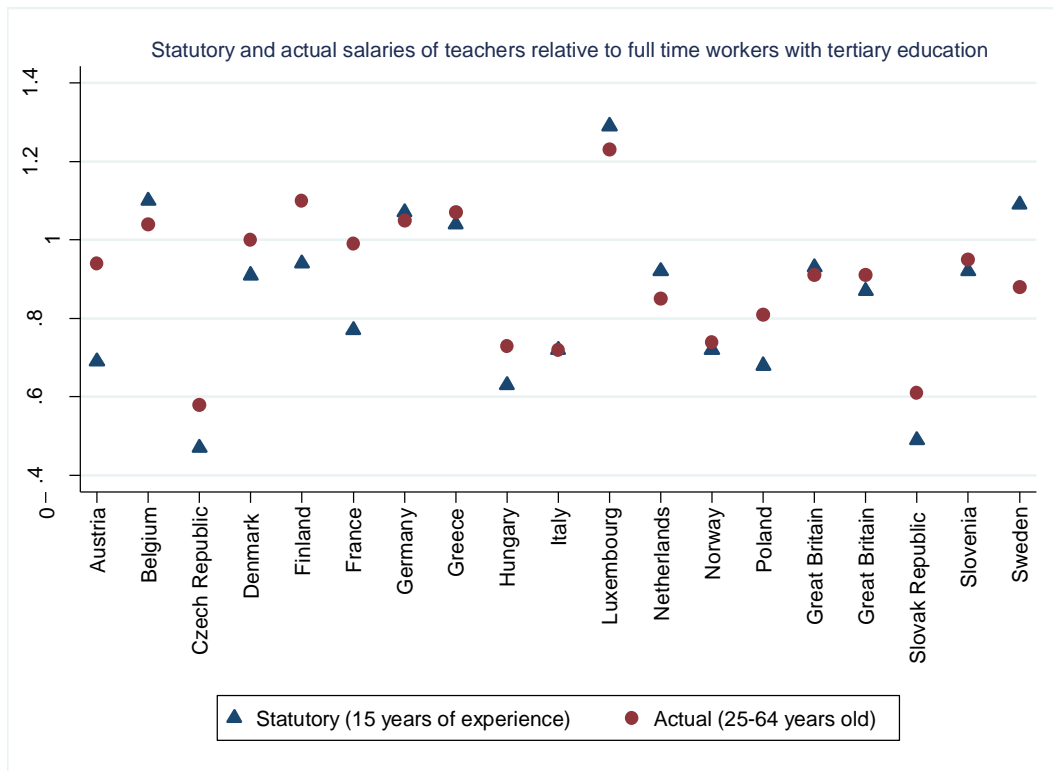


Figure 1 shows the relationship between the statutory salaries of teachers with 15 years' experience and the actual salaries of teachers between 25 and 64 to the salaries of other employees with a higher education in 2014 for various countries where data were available. In some countries statutory and actual) salaries do not differ (e.g. Norway, Germany, Slovenia); in other countries, the difference between statutory and actual salaries are small (e.g. Great Britain, Belgium, Netherlands) or large (Austria, France, Finland). In Finland, for example, relative statutory teacher salaries are not very high, but relative actual teacher salaries are the second highest in Europe.

The difference between actual and statutory salaries may vary according to the experience of teachers; older teachers may get more additional payments than younger teachers. In such cases, using statutory salaries, we measure the salaries that influence teachers' decisions to enter and exit the profession with different errors by age group. Here, the measurement error in teachers' relative starting salaries is smaller than that in the relative salaries of older teachers. These systematic differences in the real relative salaries of teachers might influence our results in the question of the effect of teacher age-earnings profiles.

CONCLUSIONS

This study investigates how teachers' relative salaries and the shape of their age-earning profiles over the preceding 5 years influence students' internationally comparable performance in European countries. Our results show that higher statutory teacher salaries and a larger growth in teacher salaries in the first part of teachers' careers increases students' maths and science performance, while we could not find a significant effect on reading performance.

Teacher salaries may influence teacher quality and thus students' performance through various mechanisms. First, higher wages may have a selection effect at the beginning of teachers' careers, (both in the choice to undertake teacher training in the first place, and later in finding employment as a teacher after finishing higher education); higher wages may also have an effect on the attrition of teachers. Second, higher wages may also have an incentive effect, in as much as higher paid teachers may make more effort to increase students' performance. Although selection and incentive effects could not be separated in this study, it seems a reasonable assumption that the differences between subjects are the results of the different outside labour market opportunities for teachers according to the different subjects taught. The results also show that an increase in teachers' wages lasting five years at the beginning of their career may have an immediate positive effect on students' maths and science performance. Nevertheless, based on the available data we cannot draw conclusions as to how wage increases in the second part of teachers' careers influence students' performance over the same period of time. As discussed in the previous section, the apparent lack of a significant effect of teachers' salaries in the second part of their career may be an artefact of the lack of data on teachers' actual salaries.

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APPENDIX*Table A1.***Countries/waves in the sample**

Austria	2003,2006,2009,2012
Belgium	2003,2006,2009,2012
Czech Republic	2003,2006,2009,2012
Denmark	2003,2006,2009,2012
Estonia	2006,2009,2012
Finland	2003,2006,2009,2012
France	2003,2006,2009,2012
Germany	2003,2006,2009,2012
Greece	2003,2006,2009,2012
Hungary	2003,2006,2009,2012
Iceland	2003,2006,2009,2012
Ireland	2003,2006,2009,2012
Italy	2003,2006,2009,2012
Luxembourg	2003,2006,2009,2012
Netherlands	2003,2006,2009,2012
Norway	2003,2006,2009,2012
Poland	2003,2006,2009,2012
Portugal	2003,2006,2009,2012
Great Britain	2003,2006,2009,2012
Slovak Republic	2003,2006,2009,2012
Spain	2003,2006,2009,2012
Sweden	2003,2006,2009,2012
Switzerland	2003,2006,2009,2012

Table A2.

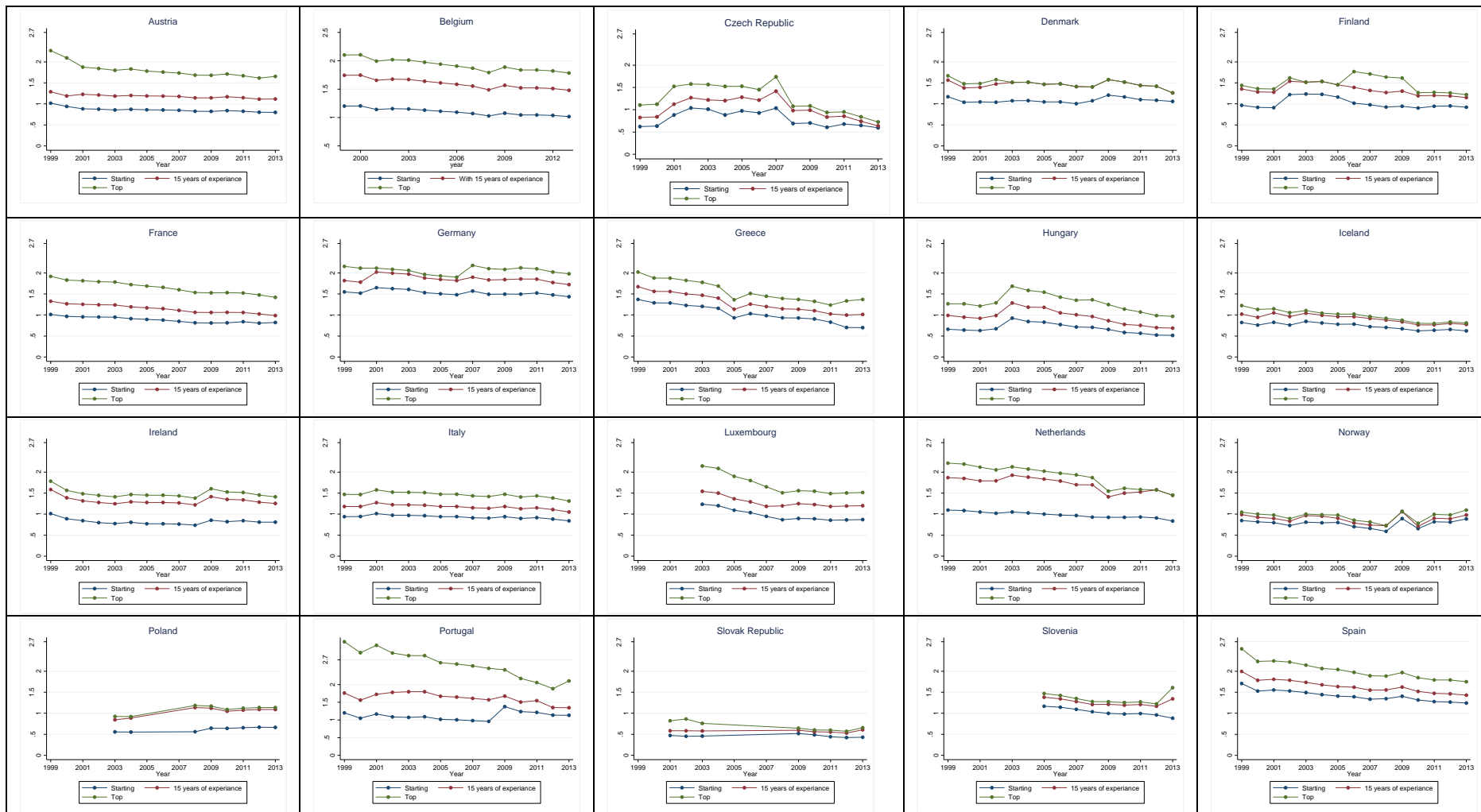
Summary statistics

Variable	Mean	Standard deviation
Gender (Male)	0.501	0.499
Age	15.775	0.290
Immigrant student	0.072	0.258
One or both parents immigrant	0.130	0.337
Mother's educational attainment less than upper secondary (ISCED1/2)	0.203	0.402
Mother's educational attainment upper secondary (ISCED 3/4)	0.396	0.489
Mother's educational attainment tertiary (ISCED 5/6)	0.355	0.479
Father's educational attainment less than upper secondary (ISCED1/2)	0.208	0.406
Father's educational attainment upper secondary (ISCED 3/4)	0.380	0.485
Father's educational attainment tertiary (ISCED 5/6)	0.339	0.473
Private school	0.174	0.379
Proportion of fully certified teachers	0.911	0.912
Teacher shortage at school	0.069	0.941
School in village	0.086	0.280
School in small town	0.241	0.428
School in town	0.357	0.479
School in city	0.204	0.403
School in large city	0.070	0.255
School has responsibility for determining salaries	0.202	0.401
School has responsibility for hiring/firing	0.591	0.492
Proportion of immigrant students at school	0.017	0.030
Proportion of girls at school	0.495	0.161

Proportion of women teachers	53.989	8.578
GDP per capita in equivalent US dollars (using PPP)	30299.72	10203.39
Starting salary as proportion of GDP per capita	1.011	.277
Years to top salary	27.415	9.925
Growth of salaries from starting to 15 years' experience	1.327	0.154
Growth of salaries from 15 years' experience to top	1.222	0.155
CEE country	0.173	0.379
Year 2003	0.201	0.401
Year 2006	0.250	0.433
Year 2009	0.271	0.445
Year 2012	0.278	0.448

Figure A1

Statutory salaries of teachers as a % of GDP per capita 1999-2013



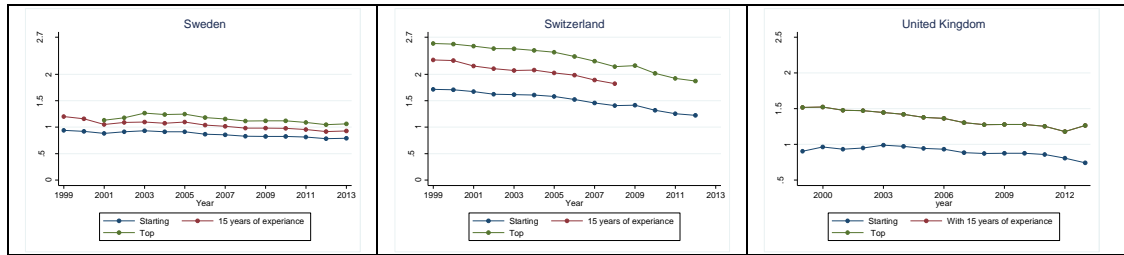


Figure A2

Age-earnings profile of teachers in the European countries 2003, 2006, 2009, 2012

