Master thesis

Secondary school teacher pay and pupil performance in the Netherlands

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Abstract:

This thesis investigates whether teachers' pay affects pupil performance. It focuses on Dutch general secondary education. It covers all VWO and HAVO schools for the time-period of 2010-2014. On the one hand, secondary school teacher pay is essentially fixed across the Netherlands; on the other hand, average regional wages vary across the country, resulting in variation in relative teacher wages. I exploit this exogenous variation to reveal the causal impact of teacher pay on pupil performance. I regress pupil performance on average regional wages by controlling for pupil-teacher ratio, school fixed effects, year fixed effects, and other variables. Overall, my research shows that secondary education teacher pay does not affect pupil performance. However, there is a strong statistical and economic relationship for technical VWO tracks. A 10% increase in outside wage leads to a 2.7% drop in the average state exam GPA for technical VWO tracks. The impact is most poignant specifically for the Nature and Technology VWO track, where a 10% increase in outside wage leads to a 4.8% decrease in the average state exam GPA and to a 12.4 percentage point decrease in pass rate.

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All remaining errors are my own.

Contents

1. Introduction

1.1. Pay-performance link in the public sector

Pay is an important tool to attract the best talent, which is crucial to improve performance both in the private and public sectors. However, empirical testing should be used on a case-by-case basis to determine whether a wage increase would have a meaningful impact on performance. In the public sector, pay is often set centrally and is therefore fixed. As a result, it is not possible to empirically determine the pay-performance link by simply regressing performance on remuneration. Due to a lack of pay variation it would show that there is no link between pay and performance.[1] Propper & Van Reenen (2010) have introduced an alternative approach to estimate this link. They exploit the fact that salary levels in private sectors vary substantially across the regions of a country, while public sector pay is fixed. This leads to a situation where the relative wage of public sector employees is actually different across various areas in the country. This variation is exogenous, since the labour market for a specific public sector position like a teacher, nurse or policeman is only a small fraction of the overall labour market in a given region. Propper & Van Reenen (2010) have focused specifically on nurses in public hospitals in England and found that a lower relative nurse pay in a given region increases death rates from heart attacks. Britton & Propper (2016) have used a similar approach and focused on secondary school teachers in England and found that a smaller relative wage of teachers has a negative impact on pupil performance.

This paper uses a similar approach, focusing on the general secondary education in the Netherlands. As mentioned in the 2013 OECD Teaching and Learning International Survey (TALIS), one of the key challenges of the Dutch educational system is to attract the best teachers. In particular, there is a shortage of well-qualified language, maths and science teachers (European Commission, 2015). Thus, it is very helpful to investigate whether teacher pay could be an effective tool to improve pupil performance in Dutch general secondary schools.

Policy makers in the Netherlands have already acknowledged the problem that there is not enough flexibility in teacher salaries. This is why in 2009 they introduced a policy that

[1] Often there is some variation in public sector pay, when pay is gradually increased according to the number of years worked. In this case, regressing performance on pay would yield biased estimates, as pay is not exogenous and is determined only by the number of years worked.

allowed an increase in the salaries of secondary school teachers in Randstad.[2] [3] This paper takes into account the effect of this policy, since the analysed time-period is from 2010 to 2014.

1.2. Main findings

This paper covers all general secondary educational establishments in the Netherlands for the time-period 2010-2014.[4] The first finding is that, overall, pay does not affect pupil performance. The second finding is that the average regional wage (outside wage) has a strong negative impact on pupil performance specifically in technical tracks of VWO. A 10% increase in outside wage leads to a 2.7% drop in the average state exam GPA for the technical VWO tracks, which is statistically and economically very significant. The magnitude is even higher for the VWO Nature and Technology track, where a 10% increase in outside wage leads to a 4.8% decrease in the average state exam GPA and to a 12.4 percentage point decrease in pass rate, which is very significant economically. The third finding is derived from the second, and it shows that, in specific cases, teacher pay can be used as a tool to improve educational outcomes.

1.3. Contribution to the existing literature and policy implications

While there have been many papers investigating the pay-performance relationship in the public sector, few have used a credible approach that is able to reveal a causal relationship. This paper uses a robust identification strategy, which allows it to estimate the impact of pay on performance in public schools. Britton & Propper (2016) showed that the flat teacher pay in England has an adverse impact on pupil performance; this paper shows that this is also the case in the Netherlands. The overall conclusions of the literature on the pay-performance relationship in the public sector become more credible when the findings are consistent across different countries.

A valuable policy implication is that, in the Netherlands, secondary school pupil performance in technical VWO tracks could be improved by making teacher salaries more flexible.

[2] For details see subsection **3.2.2.**
[3] Randstad is an agglomeration consisting of the 4 biggest Dutch cities, namely Amsterdam, Rotterdam, the Hague, Utrecht, and their surrounding areas.
[4] Namely, HAVO and VWO.

1.4. Structure of the paper

The paper proceeds as follows. Section 2 summarizes the main findings of the current literature on the topic. Section 3 describes the Dutch secondary education and the situation with teacher salaries. Section 4 explains the methodology used. Section 5 describes the data. Section 6 presents the main analysis and empirical findings. Section 7 presents robustness checks and sensitivity analysis. Section 8 gives some policy recommendations and discusses key findings. Section 9 presents limitations of this paper and advises on further research. Finally, section 10 concludes.

2. Literature review

Recently there have been an increased interest in investigating the teacher quality and teacher remuneration from both academics and policy makers. The main motivation is that there is a desire to attract the best talent to the teaching profession, which, hopefully, would improve the quality of education (Clotfelter, Glennie, Ladd, & Vigdor, 2008). In this section, I present studies which are relevant to this thesis. They cover such topics as teacher pay, teacher turnover, pupil performance and a more general topic of evaluating pay-performance link in the public sector.

2.1. Estimating pay-performance link in the public sector

In the situation with unregulated labour markets, where pay is determined by the markets, it is very hard to investigate the effect of pay on performance. The reason is that pay is likely to be determined by performance, hence it is endogenous. As a result, one cannot simply regress performance on pay, because it would yield biased estimates. In contrast, pay in the public sector is often determined centrally and it is fixed across heterogeneous labour markets. Public sector employees can switch their jobs and move to the private sector, where wage is determined by markets (outside wage). This creates a situation that outside wage can affect public employee performance, even though centralized public sector wage is fixed.[5] If outside wage is relatively small, then more people would want to work in the public sector, which would lead to a selection of better workers. Also the current public sector employees would put more effort to keep their employment. Thus,

[5] The situation in private industries can be similar to the public sector. This is the case in places with strong labour unions, which emphasize centralized wage setting.

performance would be higher. On the contrary, if outside wage is relatively high, then the opposite would hold, which would adversely affect performance. Propper & Van Reenen (2010) exploit such institutional setting when evaluating the link between pay and performance of public hospitals in England. They focus on nurses, whose pay in public hospitals is fixed across the country.[6] In contrast, the outside wage varies significantly across English regions. As a performance measure they use an in-hospital mortality-rate from 'heart-attacks' within 30 days after admission to a hospital. Their panel dataset consists of short-term general hospitals. These hospitals are homogenous across the country and the majority of 'heart-attacks' are treated exactly in such hospitals. The authors cover 1997-2005 time-period. There are 209 hospitals for the pooled-OLS analysis, with 1164 observations, and 149 hospitals for 3 year long-differenced analysis, with 598 observations. As the main outside wage metric they use the average non-manual female wage within a 20-km radius around a given hospital.[7] They regress performance on outside wage. They control for year fixed effects, hospital fixed effects, mortality-rate in the area of a hospital, age and gender distribution of patients. They find that a 10% increase in the outside wage is associated with a 7% increase in the mortality-rate. Given that the variation in outside wages is exogenous to performance in public hospitals, their estimates are unbiased and reveal a causal-relationship that runs from pay to performance. Their results are robust to a battery of tests.

The paper by Britton & Propper (2016) is the most relevant for this thesis. They use a similar identification strategy as Propper & Van Reenen (2010), but focus on education in England. They exploit the fact that secondary school teacher pay is almost fixed in England. There are only four pay bands, which correspond to four regions – 'Inner London', 'Outer London', 'The Fringe' and 'The rest of England'. The variation in wages in other than teacher occupations is much higher, which creates big differences in teacher relative wages across the country. They define relative wage as a gap between the average regional wage and a fixed teacher pay in a given school. This variation in relative wages is exogenous, because teacher pay is fixed, but the average wage is exogenous, since teachers are only a small fraction of the total labour market. This allows them to establish a causal relationship

[6] Their salaries are only slightly higher in London, while the average regional outside wage in London is much higher than in other places in England.

[7] In robustness checks they use different radii. As the second measure of outside wage they estimate a wage given education level, work-experience, age and other observables. And the third metric for pay is nurse wage at private nursing houses, which is a very good proxy for nurse salary, however, it could be endogenous. Their findings are robust to these different specifications.

by regressing pupil performance on the wage gap, while controlling for some school, pupil and teacher characteristics. They find that a 10% increase in the wage gap leads to a 2% decrease in pupil performance. It implies that not only pay matters, but also that some England's regions due to the fixed teacher pay might find it more difficult to attract good teachers.

2.2. Other studies on teacher pay and pupil performance

Dolton and Marcenaro-Gutierrez (2011) have investigated whether higher teacher pay improves teacher quality. They have conducted an international study by analysing a panel data of 39 OECD member states for the time-period that covers years 1995, 1996, and 1998-2007. As teacher quality is unobservable, they have looked at educational outcomes as a proxy for teacher quality. More precisely, they have used results in international tests PISA and TIMSS. These tests focus on math, science and reading. The fact that these tests are the same across countries allow them to compare performance of different countries. One limitation of their study is that they do not control for family background, even though this could be a very important determinant of educational outcomes. On the other hand, the big advantage of their study is that they use a panel dataset. This allows them to control for time fixed effects and country fixed effects, and the latter is unlikely to change significantly across short periods of time. Therefore, it allows them to mitigate the effect of some unobservable factors like family background, which likely to vary across countries, but its variation across time in one country is likely to be small. The authors have used different measures of teacher salaries: 1) purchasing power of teacher salary in a given country in $, 2) the percentile of a teacher pay from country's salary distribution, 3) normalized hourly teacher wage in real terms, 4) teacher salary as a proportion of the GDP per capita in a respective country. They control for other factors like state's expenditure on education as a fraction of GDP, the average teacher/pupil ratio, and the number of teachers as a fraction of labour force. They find that teacher pay is a statistically and economically significant determinant of pupil performance: a 10% increase in real pay leads to a 10% increase in test results. However, the authors did not fully address the fact that better performance of pupils can affect teacher salaries. Thus, they show correlation, but not necessarily causation. The latter can go from teacher pay to pupil performance, or from pupil performance to teacher pay, or either way.

Greavesyand & Sibieta (2014) have conducted another research on teacher wages and pupil attainment. Similarly to Britton & Propper, they also cover England. However, instead of

focussing on external salaries, they look at actual (inside) teacher wages. Instead of the secondary education they look at the primary education. They exploit geographical variation of official fixed teacher pay in England. There are only four pay bands, which correspond to four regions – 'Inner London', 'Outer London', 'The Fringe' and 'The rest of England'. The official fixed salary is higher in 'the Fringe' than in the neighbouring 'The rest of England'. This allows them to employ sharp regression discontinuity approach by looking at schools that are located near the outside border of 'the Fringe' from both sides.[8] They show that the difference in pay levels near the border is significant and that the difference amount is in-line with the requirement. When it comes to pupil performance, which is measured by leaving exam grades in Math and English, they find that there is no significant difference. They conclude that a higher teacher wage does not translate into better pupil performance. The authors explain that this is because teacher pay is only by 5% higher in high-pay zone schools near the border compared to similar nearby schools from the other side of the border. They argue that such a small difference in pay levels is not enough to affect pupil performance. Another explanation why they find insignificant results is that in contrast to Britton & Propper (2016) they focus on the primary education, which can be different from the secondary education.

2.3. Teacher pay and teacher turnover

Hendricks (2014) has investigated the relationship between teacher pay and teacher retention rate in Texas. He finds that teacher turnover is negatively related to teacher remuneration. In terms of elasticity, a 1% increase in teacher salary leads to a 1.4% decline in teacher turnover. He argues that if higher pay can retain teachers longer, then it allows them to accumulate more experience, which is directly and positively related to pupil performance. This positive link between teacher experience and pupil performance is well-established (Papay & Kraft, 2015; Harris & Sass, 2011; Rockoff, 2004). Thus, one can conclude that higher teacher pay indeed leads to better pupil performance. In his research, Hendricks uses a panel data of Texas teachers for the time-period from 1996 to 2012, which in total has a substantial 5 million observations. The unit of observation is a district per year per number of experience years. This allows him to control for district-by-year, experience-by-year and district-by-experience fixed effects. Ability to control district time

[8] They focus on the border between 'the Fringe' and 'the rest of England', because only for this border there are no discontinuities in observable control variables. For other borders, namely between 'Inner London' and 'Outer London', and 'Outer London' and 'The Fringe' there are discontinuities. Therefore, regression discontinuity is not a credible approach in these cases.

varying effects is a big advantage of this study. It is prohibited in Texas for teachers to collectively bargain for salary levels, thus teachers are not likely to affect pay level. Still, there is one limitation of this study - officials in districts facing higher teacher turnover are likely to set higher teacher salaries to reduce the turnover. But even if it is true, then this would bias results downwards, implying that the significant results found by the author are near the lower bound and in reality the link between teacher pay and turnover could be even stronger.

Gerritsen, Kuijpers, & van der Steeg (2015) have conducted a similar study. They have researched whether higher teacher pay affects teacher turnover in the Netherlands. They have exploited variation in teacher pay that occurred due to a new teacher wage policy introduced in 2009. The policy allowed schools in Randstad region, the most urbanized area in the Netherlands, to increase teacher wages by putting more teachers to a higher salary scale. Their sample consists of all teachers in the Netherlands during the period 1995-2014. Their approach is to instrument teacher salary scale with this policy. In their model, the main dependent variable, the retention rate, is a dummy variable which takes a value of 1 when a given teacher stays in a given school in a given year, otherwise it is 0. They regress this retention rate metric on the salary scale of the given teacher and control for other factors. It is likely that the salary scale is endogenous, as schools try to put the best teachers in higher scale levels in order to keep them. That is why the authors instrument the pay scale with policy dummy.

For this strategy to work, four conditions should be met. 1) First stage condition: the instrument should be strong. The policy should have a significant effect on increasing the chance that a treated teacher is placed to a higher salary band. 2) Independence condition: the instrument should be like a lottery – treated and non-treated areas should be similar. 3) Exclusion condition: the policy should affect the retention rate only via the higher scale level. 4) There should be no defiers. There should be no teachers that if treated choose not to be moved to a higher pay scale, but if not treated, then they are moved to a higher pay scale. The authors show that policy has a statistically and economically significant effect on teacher salary, thus the first condition is met. They show that a retention rate trend is similar for treated and non-treated areas in the period before the policy and that the trend is similar in these areas in the period after the policy was implemented. Thus, there is a change only at the moment when the policy was introduced. They also show that employment rate trend before the introduction of the policy is the same in Randstad and

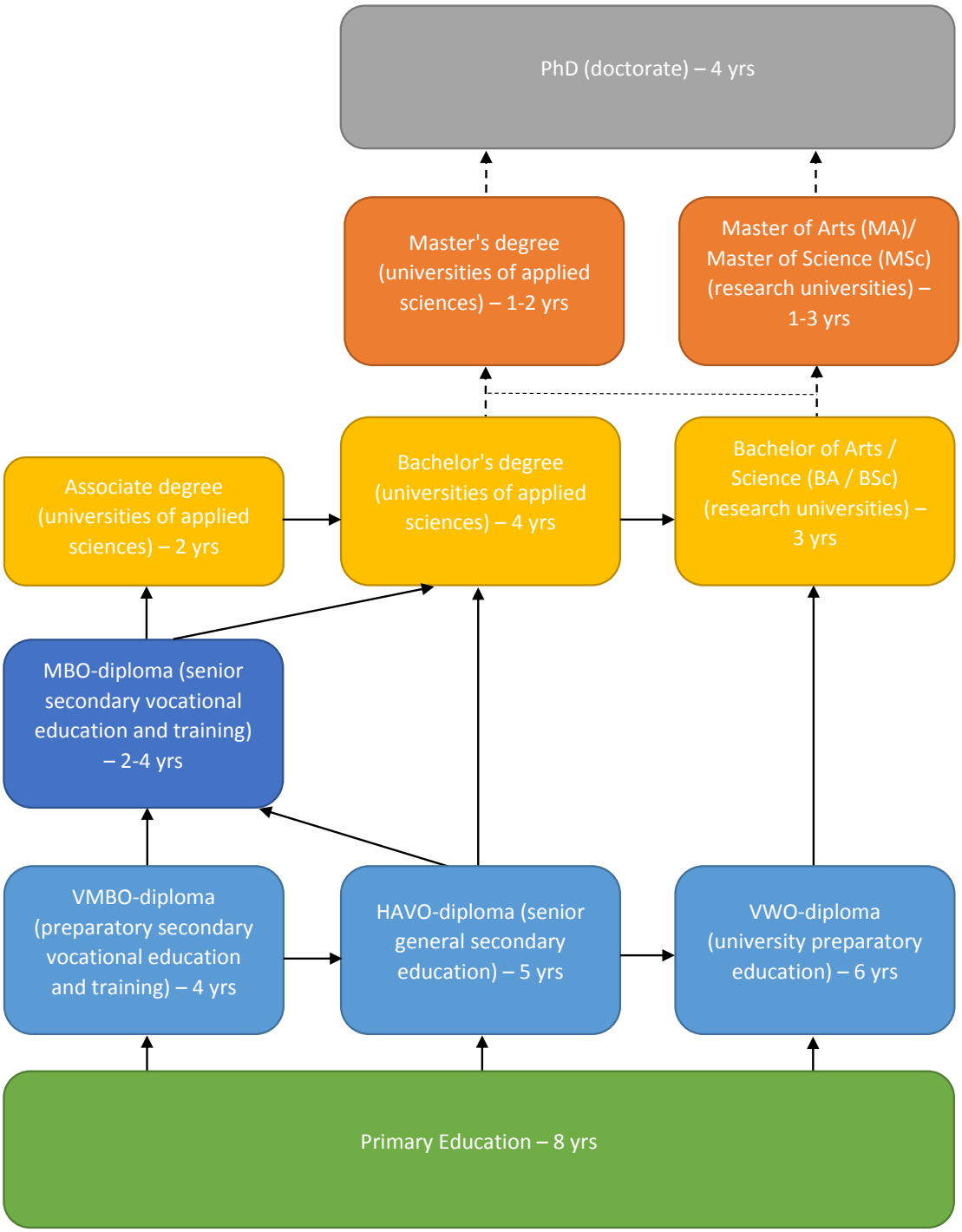
other regions, and that this trend is the same across two groups also after the policy introduction. Therefore, they show that the common trend assumption holds and that the second (independence) condition is met. The authors try to test whether the third condition holds as well. They argue that some Randstad schools can use additional funds for other purposes, for example to hire more teachers and thus to decrease pupil-teacher ratio. They show that pupil-teacher ratio, the proportion of non-teaching employees, the amount of saved funds and the proportion of non-personnel expenses of total costs were not affected by the policy. Therefore, the condition number three should hold. However, they have not discussed the fact that the policy also increased the teacher enrolment for degree programs. If the educational level of the treated teachers increases relatively to non-treated, then they could see more employment opportunities in other professions. Or on the contrary, after they become more qualified as teachers, they might be more entrenched in this particular profession. It implies that the authors investigate the effect of the combined policy – both the effect of a higher pay-level and of a higher educational level, but they cannot really distinguish separately the effect of a higher pay only. The authors do not discuss the fourth condition (no defiers). However, it is very unlikely that there are teachers who would choose not to be moved to a higher pay scale if they are treated and, at the same time, if they are not treated they would move to a higher pay scale. Thus, overall, it seems that their identification strategy is credible and that the policy indeed creates an exogenous variation in teacher pay scale, which allows them to obtain unbiased estimates of the effect of teacher pay on teacher turnover.

On the one hand, they find that higher teacher pay does not increase the overall teacher retention rate. On the other hand, they find that teachers from the treated regions have become less likely to switch to non-treated regions after the policy implementation. Thus, this policy was able to reduce teacher turnover in the targeted areas. Also, they find that teacher enrolment in higher education has increased from 2.3% to 3.2%. This is in line with the policy setting, where in order to be moved to a higher salary scale teachers were required to enrol in degree programmes. They conclude that, overall, the policy was not effective in reducing turnover in the teacher profession. However, the policy was effective in reducing teacher turnover and increasing teacher enrolment in degree programs specifically in Randstad.

3. Institutional framework

3.1. Educational system in the Netherlands

Figure 1 *- The structure of the Dutch educational system*



Source: created by the author based on information from EP-Nuffic (2015).

Note: dashed arrows indicate that there might be additional selection requirements. Otherwise, there is a direct access.

This subsection describes the educational system of the Netherlands. It briefly mentions all educational levels, however, it focuses more on the secondary education, because it is more relevant for this paper. **Figure 1** shows the general structure of the system with all the available pathways from primary education to PhD studies.

3.1.1. Primary Education

Primary education lasts for 8 years and it is the same for all pupils. At the end of primary education pupils take final exams (Citotoets). Pupils choose the type of secondary education based on the results of the exams, based on recommendations from their school, and based on their own preferences (EP-Nuffic, 2015).

3.1.2. Secondary Education

There are 2 types of secondary education: preparatory secondary vocational education (VMBO), and general secondary education (HAVO and VWO). The first one, as the name suggests, is vocationally oriented. The second is more theoretical and is aimed to prepare pupils for higher education.

3.1.2.1. VMBO

The duration in VMBO is 4 years. It has 4 pathways: 1) Theoretical learning pathway. It would allow pupils after graduation to go to the job market directly, to move to MBO (senior secondary vocational education and training) or to move to HAVO, which is a part of general secondary education that would allow them later to move to universities. 2) Combined learning pathway. Compared to the first pathway it is more vocationally oriented, but future track choices are similar. 3) Higher level of pre-vocational studying pathway. This option is tailored to prepare pupils for MBO (upper level secondary education). 4) Lower level of pre-vocational studying pathway. This is similar to the third pathway, but it prepares for lower levels of MBO studies (UNESCO-UNEVOC, 2012; EP-Nuffic, 2015).[9]

There are 4 sectors VMBO students can choose: 1) technology, 2) health, personal care and welfare, 3) agriculture, and 4) economics. Each sector has several learning tracks. For example, technology sector consists of transport and logistics, construction, graphics

[9] The four pathways in Dutch: 1) Theoretische Leerweg (VMBO-TL); 2) Gemengde Leerweg (VMBO-GL); 3) Laderberoepsgerichte Leerweg (VMBO-BL); 4) Basisberoepsgerichte Leerweg (VMBO-BL).

technology and others (UNESCO-UNEVOC, 2012; EP-Nuffic, 2015). In total there are 107 unique combinations of VMBO pathways, sectors and learning tracks (see **Table A** in Appendix).

3.1.2.2. HAVO and VWO

The general secondary education consists of two types. The first-type is pre-university education, or VWO, which lasts for 6 years. The second type is senior general secondary education, or HAVO, which lasts for 5 years. Both types prepare pupils for higher education. The key difference is that VWO prepares for research universities, but HAVO for universities of applied sciences (**see Figure 1**). Research universities are more academic and theoretical, while universities of applied sciences are more practice-oriented (EP-Nuffic, 2015).

The first 3 years of studies in the general secondary education offer a broad subject range. Afterwards, pupils should choose their profile. Both HAVO and VWO have 4 main profiles: 1) Economics and Society, 2) Culture and Society, 3) Nature and Technology, and 4) Nature and Health.[10] There are also combinations of these profiles, the most popular two are: 1) Economics and Society / Culture and Society, and 2) Nature and Technology / Nature and Health. Subjects in the following years will be based on the chosen profiles (years 4 and 5 for HAVO, and years 4, 5, and 6 for VWO). The studies will end with centralized state examinations in 6 subjects for HAVO and 7 for VWO. Admission to higher education (for Bachelor programs) is based on the successful completion of the chosen profiles (EP-Nuffic, 2015).

3.1.2.3. MBO

Senior secondary vocational education, or MBO, is a continuation of VMBO. It is more advanced than VMBO, but otherwise it is similar to it. It is practice-oriented with options to work after graduation or to move to universities of applied sciences (Associate degree or Bachelor degree, see **Figure 1**).

3.1.3. Higher education

There are two types of higher education in the Netherlands. The first one is research-oriented education, which is taught at research universities (universiteiten). The second one

[10] In dutch: 1) economie en maatschappij, 2) cultuur en maatschappij, 3) natuur en techniek, and 4) natuur en gezondheid.

is higher professional education (HBO), which is taught mainly at universities of applied sciences (hogescholen) (EP-Nuffic, 2015).

Research-oriented education's goal is "independent academic participation or the professional use of academic knowledge". It consists of 3 cycles: a bacherlor's programme (3 years), a master's programme (1-3 years), and a doctor's programme (4 years) (EP-Nuffic, 2015).

Higher professional education is more practice oriented. It's goal is "the transfer of theoretical knowledge and the development of skills that are closely linked to professional practice". It consists of 2 cycles: a bacherlor's programme (4 years) and a master's programme (1-2 years). There is also a short cycle – an associate degree programme (2 years), which is a part of a bachelor's programme and corresponds to its first 2 years. An HBO master's degree can grant admission to a doctor's programme at a research university (EP-Nuffic, 2015).

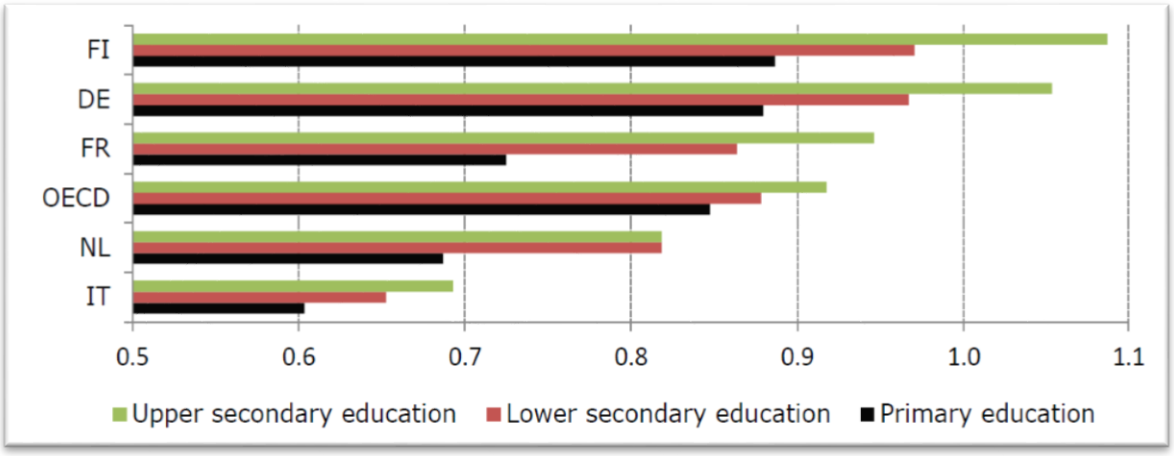
3.2. Teacher salaries in the Netherlands

3.2.1. Teacher salary levels in the Netherlands

In the Netherlands the average secondary school teacher salary is about 81% of the average salary of a full-time worker with tertiary education (European Commission, 2015). This is below the OECD average and below such countries like Finland, Germany and France (see **Figure 2**). It implies that Dutch teachers might have financial incentives to seek employment outside of public schools. This paper will indirectly investigate if this is the case.[11]

[11] In this paper the main variable of interest is pupil performance, not teacher retention rate. But the main dependent variable is exactly outside wage.

Figure 2 *– Ratio of teachers' salaries to earnings for full-time workers with tertiary education (as in 2012)*



Source: European Commission (2015).

Secondary school teacher salary is divided in three levels (scales): LB (low-level), LC (middle-level), and LD (high-level). As indicated in **Figure 3**, the maximum gross salaries per month as of 01.01.2011 are EUR 3739, EUR 4361, and EUR 4962 respectively (Gerritsen, Kuijpers, & van der Steeg, 2015; Ministry of Education, Culture and Science, 2011). Even though a higher proportion of teachers tend to be in LC and LD scales in Randstad, this variation is very small compared to the variation in private sector wages and in living costs across the country.

Figure 3 *- Secondary school teacher salary levels (as of 1-1-2011)*

Secondary education	Teacher			Director				Chair of central administration[1]			
Salary scale	LB	LC	LD	12	13	14	15	13	14	15	16
Starting salary	2445	2460	2470	3177	3856	4419	4640	3856	4419	4640	5032
Maximum salary	3739	4361	4962	4962	5381	5913	6495	5381	5913	6495	7137
Salary line in years	15	15	15	16	13	11	12	13	12	12	12

[1] *The highest applicable salary scale is scale 17. The maximum salary is € 7842.*

Source: Ministry of Education, Culture and Science (2011).

3.2.2. Teacher pay reform in 2009

In 2009 the Dutch government introduced a policy which allowed an increase in teacher salaries in highly urbanized areas (Gerritsen, Kuijpers, & van der Steeg, 2015). It was done by allowing to move more teachers to a higher salary scale. This policy targeted Randstad region, the most urbanized area of the Netherlands that includes the 4 biggest cities, Amsterdam, Rotterdam, the Hague and Utrecht, and their surrounding territories. The living costs and salary levels in the private sector are higher in Ranstad than in other areas, while the fixed state-determined teacher wages were the same across the whole country. This situation made the teacher job relatively less attractive in Randstad than in other areas. The idea of the policy was to tackle this problem and to reduce teacher turnover in the region. It is important to note that the analysis of this paper covers the period from 2010 to 2014, thus, the analysis will show the effect of regional outside wages on pupil performance already given this policy.

4. Methodology

4.1. Identification strategy

The main goal of the empirical analysis of this thesis is to investigate how teacher pay affects pupil performance. Teacher pay (inside wage) in the Netherlands is set at the state level and is essentially fixed across the country.[12] Variation in teacher pay, for the most part, comes from differences in experience. Regressions of pupil performance on inside pay are not able to reveal the causal effect of teacher pay on pupil performance, because of the earlier described lack of variation in teacher wages that is not driven by differences in teacher experience. Such regressions would just show how teacher experience is associated with pupil performance. However, Britton & Propper (2016) have found an alternative approach.[13] They exploit the fact that the inside teacher wage is fixed across the regions in England, while the average regional wage (outside wage) varies substantially across the country. Thus, schools in higher-paying regions can find it more difficult to attract and retain good teachers, because teachers have more employment options outside of schools, which, as a result, can have an adverse impact on pupil performance. Teachers are only a small part of regional labour markets, thus the average wage in a region is 'given' to them.

[12] Randstad is an exception, teacher pay is higher there. For details refer to subsection **3.2.2**.
[13] For the description of their paper, which covered England, refer to subsection **2.1**.

In other words, it is exogenous to schools. This implies that regressing pupil performance on exogenous outside wage would allow us to obtain unbiased and causal estimates of the impact of pay on pupil performance. This thesis uses this approach to determine the effect of teacher pay on pupil performance in the context of the Netherlands.

4.2. Econometric models

4.2.1. Main specification

The previous subsection has described how the identification strategy works. I will now present the econometric models that I use. To establish a causal relationship, I regress pupil performance on the outside wage, while controlling for school, pupil and teacher characteristics. More specifically, I estimate the following equation:

$$(1)\ pupil\ performance_{i,k,t} = \alpha + \beta * outside\ wage_{i,t} + year\ dummies_t + school\ dummies_i + track\ dummies_k + \gamma * controls_{i,t} + error\ term_{i,k,t}$$

Where *t* is a year, *i* is a school, and *k* is a track.[14] I run regression (1) separately for VWO and HAVO, as these education types differ and the relationships could be different as well.[15] Pupil performance is measured by state exam GPA. An alternative measure of performance is pass rate (graduation rate), which is calculated by dividing the number of exam-takers who obtained all passing grades on the total number of exam takers.

It is likely that teachers consider salary levels for a couple of years before making the decision to change their jobs. However, average regional salaries are likely to correlate across years. To deal with this correlation and to be able to obtain a single impact estimate, in line with Britton & Propper (2016), I use the average outside wage of the last 5 years. In mathematical terms,

$$outside\ wage_{i,t} = \frac{1}{5} * \sum_{j=1}^{5} \ln average\ regional\ salary_{i,t-j}$$

School dummies allow to control for important factors like school quality and regional specifics that are unlikely to vary during a 5-year period. Unfortunately, I am not able to control for student ability directly, but it is likely that the best pupils self-select to the best schools, and that the lower-ability pupils go to lower quality schools. Therefore, school

[14] A school is identified by its establishment number. Refer to subsection **3.1.2.2** for track (profile) descriptions.
[15] However, I also estimate regressions where I pool VWO and HAVO together.

fixed effects are crucial to make the analysis more credible. Year dummies allow to control for time fixed effects, and track dummies allow to control for track fixed effects.

The existing literature identified pupil-teacher ratio (or class size) to be an important determinant of pupil performance (Krueger, 1999; Chetty et al., 2011). I use pupil-teacher ratio in controls. In the Netherlands, there is a tendency to have smaller classes in schools where there are many disadvantaged pupils and/or pupils from ethnic minorities (The Center on International Education Benchmarking, 2016).[16] Such pupils tend to perform worse on exams. Therefore, pupil-teacher ratio can, to some extent, help to control for pupil background and ability. Other control variables are female pupil percent, female teacher percent, and the average teacher age in a given school.

The identifying assumption of equation (1) is

$$cov(outside\ wage,\ error\ term \mid year,\ school\ and\ track\ fixed\ effects) = 0$$

In other words, outside wage is not correlated with any unobserved factors.[17] Teachers are a small fraction of the regional labour markets, thus outside wage variation should be exogenous to schools. Therefore, this identifying assumption is reasonable.

In all regression specifications I use robust standard errors (White standard errors), which are robust to heteroskedasticity (Verbeek, 2004).

4.2.2. Other specifications

The relationship between outside wage and performance could also differ for different tracks. Therefore, I estimate a regression for each track separately. This corresponds to the following equation:

$$(2)\ pupil\ performance_{i,t} = \alpha + \beta * outside\ wage_{i,t} + year\ dummies_t + school\ dummies_i + \gamma * controls_{i,t} + error\ term_{i,t}$$

Where *t* is a year and *i* is a school.

4.2.3. Coefficient of interest and expectations

The β coefficient in equations (1) and (2) is of primary interest. If it were negative and statistically significant, then it would imply that teachers are attracted by outside wages. It

[16] The state provides more funding for such pupils, which allows schools to have smaller classes.
[17] If outside wage is truly exogenous, except for school, year and track fixed effects, any other controls should be irrelevant for obtaining an unbiased β estimate. I show results both with controls and without. School fixed effects are important, since they allow to separate the effect of outside wage from regional fixed factors.

would mean that, all other things being equal, it is harder for schools in higher-paying regions to get and retain well-qualified teachers. Worse teacher quality would then result in worse pupil performance. Given the findings of Britton & Propper (2016), I expect that there will be a negative link between the outside wage level and pupil performance, which would be indicated by a negative and statistically significant β coefficient.[18]

5. Data

5.1. Data types and sources

There are two types of data that are used in this paper. The first type concerns all data related to schools: pupil performance, the number of teachers and pupils (also by gender), school location, the average teacher age, the type of study tracks, school ID number, and others. The second type concerns outside of school wage data (henceforth called *outside wage*). For the full list of variables and their examples, refer to **Table B** in Appendix.

5.1.1. Outside wage data

The main dependent variable in this paper is the average wage in a given region. COROP typology is used to define regions, which corresponds to NUTS 3 EU regional typology (Eurostat, 2016; Encyclo.nl, 2016; Statistics Netherlands, 2016). In total, there are 40 COROP regions in the Netherlands (for the detailed list of 40 regions and respective mean salaries, see **Table C** in Appendix). I use publicly available data from Statistics Netherlands to construct the average wage data. Two tables are used – 'Regional accounts; key figures 1995-2011' for 1995-2009 data and 'Regional key figures; national accounts' for 2010-2013 data (Statistics Netherlands, 2016a; Statistics Netherlands, 2016b). In these tables I choose 2 variables: 1) 'Compensation of employees', which is the total remuneration paid to employees, and 2) the full-time equivalent number of employees. By dividing the total remuneration on the number of employees I obtain the average annual salary per COROP-region per year. Further, I divide it by 12 to get the mean monthly salary for each year for time-period 1995-2013. Later, I am able to link outside wage data with schools, as DUO provides COROP-region location of each school (see the next subsection).

[18] For the description of their paper, which covered England, refer to subsection **2.1**.

5.1.2. School data

I use publicly available data provided by DUO on their website to obtain all school data (DUO, 2016).[19] I use data only for secondary education. At the moment of writing this paper, data was available only for the time period 2010-2014. On DUO website there are several sections. The most important datasets are average exam marks per institution ('07.Geslaagden, gezakten en gemiddelde examencijfers per instelling') in 'pupils' ('Leerlingen') subsection. Key variables are already there: school ID (Brin number), establishment number (Vestigingsnummer), school name, information on education type and on tracks, the number of exam takers, the number of graduates, average exam grades per track, and other variables. I consolidate data for all the years. Further, I complement it with datasets on exam taker gender per track ('06. Examenkandidaten en geslaagden'). I add information on the number of teachers, teacher gender statistics, and the average teacher age per school from respective datasets ('02. Onderwijspersoneel in aantal fte') from subsection 'staff' ('Personeel'). To obtain teacher-pupil ratio I add information on the pupil amount per school from other datasets ('03. Leerlingen per vestiging en bevoegd gezag (vavo apart)') from 'pupils' ('Leerlingen') subsection. Finally, to link school data with outside wage data I add information on school COROP-region location from 'addresses' ('Adressen') subsection (dataset '02. Alle vestigingen vo').

5.2. Sample size and data limitations

After all consolidations and transformations I obtain a dataset of all VWO and HAVO secondary school tracks for the time-period 2010-2014.[20] The unit of observation is a track per school per year. For example, Visser t Hooft Lyceum in Leiden, year 2012, the Nature and Technology track. For the full list of variables and their examples, refer to **Table B** in Appendix. I analyse VWO and HAVO separately, therefore it could be said that there are two datasets – one for VWO with 14 342 unique observations and another for HAVO with 13 644 unique observations. There are 548 VWO establishments and 545 HAVO establishments. The majority of schools provide both VWO and HAVO type secondary education: in total there are 598 establishments that provide HAVO-type, VWO-type or both types. The fact that I cover all VWO and HAVO schools in the Netherlands is a big

[19] https://duo.nl/open_onderwijsdata/databestanden/vo/

[20] I exclude VMBO for two reasons. Firstly, it contains 107 unique tracks. Therefore, there is so much heterogeneity that it is hard to combine and analyse by these tracks in a reasonable way. Secondly, VMBO is much more practice oriented, not theoretical as VWO and HAVO, hence state exam grade is not the best indicator for performance (for details about VWO, HAVO and VMBO refer to section **3.1**).

advantage of this study, as this is the whole population of general secondary education. The sample sizes are big enough to implement econometric analysis. However, the fact that I have only 5-year time-span is a limitation. Such time-period might be not long enough to employ robust fixed effect regression analysis. I was not able to overcome this limitation - data on earlier years is not publicly available and I have not been able to obtain more data directly from DUO and/or the Ministry of Education.

5.3. Descriptive statistics

In this subsection I briefly present the descriptive statistics of the main variables.

5.3.1. Outside wage

Table 1 shows the Dutch regions with the highest, lowest and average salaries and how these change over time. Not surprisingly, Amsterdam agglomeration (Groot-Amsterdam) is consistently the highest paying region in the Netherlands. Utrecht has followed Amsterdam in 2005 and 2009, but in 2013 it has been overtaken by the Hague agglomeration (Aggl. 's-Gravenhage). Rotterdam agglomeration (Groot-Rijnmond) closes the top-5 of the most paying regions. Other regions with top salary-levels are IJmond and Het Gooi en Vechtstreek. The composition of the regions paying average salaries change over time, with the only exception of Noord-Overijssel that is in the middle of outside wage distribution across time. There is some variation across time among regions with the lowest salaries. Zuidwest-Friesland has been the lowest paying region in 2005 and 2009; it has improved in 2013, but still remained one of the least paying regions. Ooost-Groningen has been the second in the bottom and in 2013 it has become the least paying region. Other regions with low salaries are Zuidoost-Friesland, Achterhoek, Noord-Limburg, Midden-Limburg, and Zuidoost-Drenthe.[21]

The most important observation is that, while there is a variation of outside wages across regions, it is not that substantial. For all the observed years, the difference between the average salaries of the lowest and highest paying regions is around 1000 EUR. This implies that salary levels across different regions of the Netherlands are not economically very different. Another observation is that, while the average salary is increasing over time for most regions, the relative position of regions in the salary rank tend to remain the same over time.

[21] **Table C** in Appendix shows the full list of mean gross salaries by years per 40 regions.

Table 1 – Outside wage distribution across regions and time

Position	Region	2005	Region	2009	Region	2013
top	Groot-Amsterdam	4 226	Groot-Amsterdam	4 685	Groot-Amsterdam	5 049
	Utrecht	3 960	Utrecht	4 398	Aggl. 's-Gravenhage	4 869
	Aggl. 's-Gravenhage	3 928	Aggl. 's-Gravenhage	4 383	Utrecht	4 841
	IJmond	3 909	Groot-Rijnmond	4 310	Het Gooi en Vechtstreek	4 742
	Groot-Rijnmond	3 856	Zeeuwsch-Vlaanderen	4 309	Groot-Rijnmond	4 733
middle	West-Noord-Brabant	3 596	Veluwe	4 071	Zuid-Limburg	4 524
	Noord-Overijssel	3 583	Aggl. Haarlem	4 070	Overig Groningen	4 520
	Veluwe	3 576	Noord-Friesland	4 046	Noord-Friesland	4 520
	Zuidwest-Overijssel	3 568	Alkmaar en omgeving	4 036	Noord-Overijssel	4 492
	Flevoland	3 567	Noord-Overijssel	4 009	Zaanstreek	4 489
bottom	Zuidoost-Drenthe	3 410	Noord-Limburg	3 878	Midden-Limburg	4 334
	Zuidoost-Friesland	3 390	Zuidoost-Friesland	3 838	Zuidwest-Friesland	4 276
	Achterhoek	3 352	Achterhoek	3 828	Achterhoek	4 267
	Oost-Groningen	3 340	Oost-Groningen	3 779	Noord-Limburg	4 237
	Zuidwest-Friesland	3 280	Zuidwest-Friesland	3 759	Oost-Groningen	4 087

Source: created by the author based on the data from Statistics Netherlands (2016a; 2016b).
Note: Outside wage is defined as the annual average gross salary per month.

5.3.2. School characteristics

Table 2 summarizes the statistics on the number of teachers and pupils per school.[22] Panel A shows the statistics for HAVO and Panel B for VWO. It is noticeable that there is a big variation in school sizes in terms of pupil and teacher amounts. Relative variation in pupil-teacher ratio is smaller, but still substantial.

[22] All these descriptive statistics are after one school was excluded (brin number= 23HC). It had 12.3 FTE permanent employees in 2014, while in other 4 years it had around 230. It is certain that there is an error in the data, therefore I have excluded this observation for this school for 2014.

Table 2 – Pupil and teacher amount summary statistics

Variable	Mean	St.Dev.	Min	Max
Panel A - Havo				
Pupil Amount	2272	1114	37	5637
Teacher Amount	203	104	9	581
Pupil-teacher ratio	11.6	1.3	3.9	16.2
Panel B - VWO				
Pupil Amount	2140	1130	63	5637
Teacher Amount	190	106	9	581
Pupil-teacher ratio	11.7	1.5	2.6	16.2

Source: created by the author based on the data from DUO (2016).
Note: the full-time-equivalent amount of teachers is shown. The amounts of teachers and pupils are per educational institution (per BRIN number).

Table 3 summarizes pupil performance across different VWO and HAVO schools. It shows two key indicators – pass rate and state exam grade point average (GPA). Panel A shows the statistics for HAVO and Panel B for VWO. The mean performance results and their distributions are similar for HAVO and VWO. It is clearly seen that for both secondary education types pass rates are quite high, with means around 89%. The distribution of state exam grades is not that high: 98% of HAVO pupils end up with state examination scores in the range from 5.5 to 7.3, even though a 10-point grading system is used (EP-Nuffic, 2015). For VWO this range is from 5.4 to 7.6. The mean state exam GPAs have values around 6.4, which is quite low given that the minimum passing grade is 6.0 (EP-Nuffic, 2015).

Table 3 – Pass rate and state exam GPA summary statistics

Panel A - HAVO

Pass rate				State exam GPA			
Percentiles		Mean	0.877	Percentiles		Mean	6.363
1%	0.5	Std. Dev.	0.131	1%	5.5	Std. Dev.	0.360
5%	0.66	Min	0	5%	5.8	Min	2.7
10%	0.72	Max	1	10%	5.9	Max	8.7
25%	0.81	N	13 644	25%	6.1	N	13 644
50%	0.9			50%	6.4		
75%	1			75%	6.6		
90%	1			90%	6.8		
95%	1			95%	7		
99%	1			99%	7.3		

Panel B - VWO

Pass rate				State exam GPA			
Percentiles		Mean	0.898	Percentiles		Mean	6.411
1%	0.33	Std. Dev.	0.142	1%	5.4	Std. Dev.	0.435
5%	0.67	Min	0	5%	5.7	Min	4.0
10%	0.74	Max	1	10%	5.9	Max	8.9
25%	0.84	N	14 342	25%	6.1	N	14 342
50%	0.94			50%	6.4		
75%	1			75%	6.7		
90%	1			90%	6.9		
95%	1			95%	7.1		
99%	1			99%	7.6		

Source: created by the author based on the data from DUO (2016).
Note: For pass rate 1=100%, 0.94=94%, 0.5=50%, 0.33=33%, etc.

Table 4 shows state exam GPA distribution across regions for the VWO track Nature and Technology.[23] [24] In 2010 three regions with highest salary levels appeared to have below average GPA. These are Utrecht, Amsterdam and Rotterdam agglomerations (Utrecht, Groot-Amsterdam, and Groot-Rijnmond). From high paying regions only Hague agglomeration (Aggl. 's-Gravenhage) was close to top exam performers in 2010. In 2014 Utrecht was close to top exam performers, while Amsterdam, Rotterdam and Hague

[23] I sort regions from highest GPA to lowest and then I show 5 regions that are in the top, 5 in the middle and 5 in the bottom. In additions to that, I add regions that were in top 5, bottom 5 or middle 5 according to salary level (as shown in **Table 1**).
[24] I show per track GPAs for the results per regions to be comparable, since different tracks have different difficulty and track composition might differ across regions.

agglomerations were in the middle of GPA distribution. In 2010 most of the lowest paying regions had also the lowest state exam GPAs. These regions are Zuidoost-Friesland, Noord-Limburg, Achterhoek, Oost-Groningen and Zuidoost-Drenthe. In 2014 the situation changed. While Zuidoost-Drenthe, Noord-Limburg remained closer to the bottom of the GPA distribution, Achterhoek, and Oost-Groningen managed to get very high grades. Therefore, one can conclude that the GPA distribution changes across time over regions and that there is no pronounced link between outside wage and state exam GPA.

Table 4 – State exam GPA regional distribution for the VWO track Nature and Technology

Position	Region	2010	Region	2014
top	Zaanstreek	6.85	Achterhoek	6.93
	Oost-Zuid-Holland	6.75	Zuidoost-Noord-Brabant	6.92
	Zeeuwsch-Vlaanderen	6.75	Midden-Noord-Brabant	6.92
	Aggl. Leiden en Bollenstr	6.70	Zuidwest-Overijssel	6.90
	Overig Zeeland	6.68	Midden-Limburg	6.87
	Aggl. 's-Gravenhage	6.65	Oost-Groningen	6.87
	West-Noord-Brabant	6.54	Utrecht	6.79
	Veluwe	6.52	Veluwe	6.76
	Zuidwest-Friesland	6.47	West-Noord-Brabant	6.74
	Noord-Overijssel	6.46	Aggl. Arnhem/Nijmegen	6.73
middle	Het Gooi en Vechtstreek	6.45	Alkmaar en omgeving	6.70
	Kop van Noord-Holland	6.44	Delfzijl e.o.	6.70
	Flevoland	6.43	Aggl. Haarlem	6.69
	Aggl. Haarlem	6.43	Aggl. 's-Gravenhage	6.68
	Zuidoost-Noord-Brabant	6.41	Groot-Amsterdam	6.68
	Utrecht	6.40	Noordoost-Noord-Brabant	6.65
	Groot-Rijnmond	6.36	Het Gooi en Vechtstreek	6.59
	Zuidoost-Friesland	6.36	Groot-Rijnmond	6.59
	Noord-Limburg	6.32	Noord-Overijssel	6.56
	Groot-Amsterdam	6.31	Zuidoost-Drenthe	6.55
	Achterhoek	6.26	Zuidwest-Drenthe	6.53
bottom	Zuidwest-Drenthe	6.18	Zuidoost-Zuid-Holland	6.52
	Twente	6.17	Noord-Limburg	6.50
	Zuidwest-Overijssel	6.15	Twente	6.49
	Oost-Groningen	6.00	Zuidwest-Friesland	6.45
	Zuidoost-Drenthe	5.98	Noord-Friesland	6.20

Source: created by the author based on the data from DUO (2016).

Table 5 shows average state exam GPA distribution across regions for the VWO track Culture and Society. Rotterdam Agglomeration had the second lowest state exam GPA in

2010. Oost-Groningen had the highest grade in 2010, but its relative performance dropped substantially in 2014. Otherwise, the overall picture is not that different from the Nature and Technology track.[25]

Table 5 – State exam GPA regional distribution for the VWO track Culture and Society

Position	Region	2010	Region	2014
top	Oost-Groningen	6.43	Aggl. Haarlem	6.59
	Zeeuwsch-Vlaanderen	6.40	Aggl. Leiden en Bollenstr	6.57
	Zuidwest-Overijssel	6.40	Het Gooi en Vechtstreek	6.55
	Zuidoost-Zuid-Holland	6.33	Zuidoost-Zuid-Holland	6.53
	Aggl. Haarlem	6.32	Alkmaar en omgeving	6.51
	Noord-Overijssel	6.31	Utrecht	6.49
	IJmond	6.30	Noord-Overijssel	6.48
	Zuidwest-Friesland	6.20	Aggl. 's-Gravenhage	6.44
	Veluwe	6.16	Noord-Limburg	6.40
	Utrecht	6.15	Zuidoost-Friesland	6.40
middle	Zaanstreek	6.15	Noord-Drenthe	6.40
	Kop van Noord-Holland	6.14	Zuidwest-Overijssel	6.35
	West-Noord-Brabant	6.14	Achterhoek	6.34
	Het Gooi en Vechtstreek	6.13	Oost-Zuid-Holland	6.34
	Overig Groningen	6.11	Overig Groningen	6.34
	Groot-Amsterdam	6.10	Groot-Rijnmond	6.34
	Achterhoek	6.08	Veluwe	6.33
	Zuidwest-Gelderland	6.07	West-Noord-Brabant	6.32
	Zuid-Limburg	6.06	Zuidwest-Friesland	6.30
	Aggl. 's-Gravenhage	6.05	Groot-Amsterdam	6.28
	Noord-Limburg	6.03	Oost-Groningen	6.25
bottom	Zuidoost-Friesland	6.02	Midden-Noord-Brabant	6.18
	Midden-Noord-Brabant	5.98	Twente	6.18
	Oost-Zuid-Holland	5.97	Midden-Limburg	6.15
	Groot-Rijnmond	5.95	Delfzijl e.o.	6.00
	Zuidoost-Drenthe	5.93	Zuidoost-Drenthe	5.98

Source: created by the author based on the data from DUO (2016).

[25] Overall, regional GPA distribution for HAVO tracks is similar to VWO tracks. These are not reported in order to save space. They are available from the author upon request.

6. Analysis and findings

6.1. Main specification – all tracks together

In this subsection I present results separately for VWO and HAVO. I then show combined HAVO and VWO results. These results correspond to equation (1), where I pool all tracks together.[26]

Table 6 summarizes the output from regressions that cover VWO. Regressions (1) and (3) are without controls, and regressions (2) and (4) are with controls. All 4 regressions are with school, track and year fixed effects. In regressions (1) and (2) the dependent variable is state exam GPA, while in regressions (3) and (4) – pass rate. As expected, in all 4 regressions outside wage is negatively associated with pupil performance. However, the coefficients are not statistically significant, except for regression (3). In regression (1), a 10% increase in outside wage is associated with a 0.053 point decrease in state exam GPA, which corresponds to a 0.8% decrease in the average state exam GPA. Thus, the economic effect is not that strong. In regression (3), a 10% increase in the outside wage is associated with a 2.8 percentage point decrease in pass rate, which is 20% of the standard deviation. Thus, the economic effect here is not that high as well. The fact that the coefficients from regressions without controls (regressions 1 and 3) are similar to the ones with controls (regressions 2 and 4) might indicate that the identification strategy works.[27] If outside wage is exogenous, then additional controls should not change its coefficient. This is exactly observed in **Table 6** (this will hold also for all other specifications). In line with existing literature, I also find that pupil-teacher ratio is negatively associated with pupil performance (Krueger, 1999; Chetty et al., 2011).

[26] I have excluded few outliers with the pass rate of 0%. Without them pass rate is distributed smoothly from 17% to 100%. I have also dropped one school with a measurement error. It had 12.3 FTE permanent employees in 2014, while in other 4 years it had around 230. In sensitivity analysis I show that my findings are robust to these exclusions.

[27] Pupil-teacher ratio, the average teacher age and female-teacher % were not available for 2010. These 3 specific control variables are unlikely to change significantly from 2010 to 2011, therefore I replaced missing values for 2010 with available values for 2011. This allowed me to save substantial amount of observations. There were still few schools that missed these values in 2011, 2012, 2013 or 2014. I have dropped them from the analysis. As a result, I was able to use the same sample for regressions with and without controls. In robustness checks section I show that the exclusion of observations with missing values does not affect my overall findings.

Table 6 – Regression estimates of the effect of regional outside wages on pupil performance in VWO

Edu type: VWO Tracks: all				
#	(1)	(2)	(3)	(4)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-0.557	-0.563	-0.297*	-0.283
	(0.544)	(0.550)	(0.180)	(0.182)
Controls	no	yes	no	yes
Female pupil %		-0.0582***		-0.00679
		(0.0192)		(0.00527)
Pupil-teacher ratio		-0.0301***		-0.00805***
		(0.00637)		(0.00222)
Teacher age		0.000767		-0.00147
		(0.00622)		(0.00224)
Female teacher %		-0.0320		-0.0690
		(0.295)		(0.0956)
constant	10.81**	11.19**	3.357**	3.427**
	(4.536)	(4.576)	(1.505)	(1.520)
School, year, track FE	yes	yes	yes	yes
N	13 734	13 734	13 734	13 734
Adj. R2	0.377	0.378	0.129	0.129
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 7 is equivalent to **Table 6** with the only difference being that it focuses on HAVO. Here outside wages do not have any pronounced association with pupil performance. In some cases point estimators are negative, in others they are positive. However, in all cases their magnitude is small and they are not statistically different from zero. Thus, it appears that the outside pay and pupil performance link is weaker for HAVO than for VWO. It could imply that for HAVO teacher pay is of a smaller concern that for VWO. By looking at control variables we can see that, on average, female pupils perform worse than male pupils. This effect is statistically significant as indicated in regressions (6) and (8). Pupil-teacher ratio has a negative and statistically significant association with pupil performance.

Table 7 – Regression estimates of the effect of regional outside wages on pupil performance in HAVO

Edu type: HAVO Tracks: all				
#	(5)	(6)	(7)	(8)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	0.119	0.0782	-0.166	-0.186
	(0.502)	(0.501)	(0.195)	(0.196)
Controls	no	yes	no	yes
Female pupil %		-0.139***		-0.0145**
		(0.0219)		(0.00689)
Pupil-teacher ratio		-0.0273***		-0.00569**
		(0.00613)		(0.00230)
Teacher age		0.00631		0.00426**
		(0.00567)		(0.00216)
Female teacher %		0.349		0.135
		(0.255)		(0.1000)
constant	5.063	5.328	2.196	2.164
	(4.185)	(4.168)	(1.623)	(1.628)
School, year, track FE	yes	yes	yes	yes
N	13 068	13 068	13 068	13 068
Adj. R2	0.336	0.342	0.124	0.124
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 8 shows results for both HAVO and VWO combined. The statistical power of such analysis is higher with more observations. As expected, the coefficient sizes are between the ones found for VWO and HAVO separately. All coefficients are negative, implying a negative association between outside wage and pupil performance. The results are statistically significant only in regressions (11) and (12) at the 10% significance level. These results are not yet conclusive, therefore the results of a more detailed analysis are shown in the next subsection.

Table 8 – Regression estimates of the effect of regional outside wages on pupil performance in VWO and HAVO

Edu type: VWO & HAVO Tracks: all				
#	(9)	(10)	(11)	(12)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-0.273	-0.307	-0.236*	-0.242*
	(0.381)	(0.383)	(0.134)	(0.135)
HAVO dummy	-0.0110***	-0.0122***	-0.0186***	-0.0188***
	(0.00400)	(0.00399)	(0.00146)	(0.00146)
Controls	no	yes	no	yes
School, year, track FE	yes	yes	yes	yes
N	26 802	26 802	26 802	26 802
Adj. R2	0.336	0.338	0.114	0.115
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

6.2. Analysis per tracks

In this subsection, I present results that correspond to equation (2), where I perform econometric analysis for individual tracks. I also pool some tracks together, which correspond to equation (1), but for different combinations of tracks. Firstly I present results for VWO, and then for HAVO.

6.2.1. VWO

Table 9 summarizes results for the VWO track Nature and Technology. The key finding is that outside wage is negatively associated with pupil performance. This association is also statistically significant in all specifications, with a 10% significance level in regression (13) and (14), and a 1% significance level in regression (15) and (16). Regression (13) reveals that a 10% increase in outside wage leads to a 0.32 point decrease in state exam GPA, which corresponds to a 4.8% decrease in the average state exam GPA. This is economically very significant. Regression (15) reveals that a 10% increase in outside wage leads to a 12.4 percentage point decrease in pass rate, which is also very significant in economic terms. Similarly to regressions in subsection **6.1**, the fact that regressions with and without controls give similar estimates of outside wage coefficient might indicate that outside wage is exogenous and that it could reveal an unbiased and causal relationship.

Table 9 – Regression estimates of the effect of regional outside wages on pupil performance in the VWO track Nature & Technology

Edu type: VWO Track: Nature & Technology				
#	(13)	(14)	(15)	(16)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-3.341* (1.704)	-3.326* (1.725)	-1.305*** (0.493)	-1.431*** (0.494)
Controls	no	yes	no	yes
Female pupil %		0.0388 (0.0626)		0.0312** (0.0143)
Pupil-teacher ratio		-0.0484*** (0.0176)		-0.00396 (0.00516)
Teacher age		-0.000891 (0.0192)		-0.00883 (0.00552)
Female teacher %		-0. 313 (0.919)		0.189 (0.267)
constant	34.51** (14.20)	35.05** (14.40)	11.87*** (4.112)	13.31*** (4.136)
School, year FE	yes	yes	yes	yes
N	2131	2131	2131	2131
Adj. R2	0.276	0.277	0.078	0.081
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 10 shows regression results specifically for the VWO track Culture and Society. In contrast to the Nature and Technology track, all coefficients are statistically insignificant. This implies either a weak or absence of association between outside wage and pupil performance. Point estimators are positive in specifications when state exam GPA is the dependent variable, while they are negative when pass rate is the dependent variable. This might imply that there is a stronger demand for well-qualified 'hard' subject teachers from the Nature and Technology track rather than for 'soft' subject teachers from the Culture and Society track.

Table 10 – Regression estimates of the effect of regional outside wages on pupil performance in the VWO track Culture & Society

Edu type: VWO Track: Culture & Society				
#	(17)	(18)	(19)	(20)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	1.013	1.044	-0.513	-0.430
	(1.277)	(1.303)	(0.456)	(0.459)
Controls	no	yes	no	yes
Female pupil %		-0.0201		-0.00603
		(0.0502)		(0.0188)
Pupil-teacher ratio		-0.0219		-0.0126**
		(0.0154)		(0.00552)
Teacher age		-0.0101		-0.00423
		(0.0148)		(0.00569)
Female teacher %		-0.152		-0.291
		(0.746)		(0.250)
constant	-2.383	-1.840	5.119	4.904
	(10.65)	(10.83)	(3.802)	(3.841)
School, year FE	yes	yes	yes	yes
N	2316	2316	2316	2316
Adj. R2	0.238	0.238	0.105	0.106
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 10a in Appendix shows regression analysis results for other VWO tracks, namely Nature and Health, Economy and Society, a combined track Economy and Society / Culture and Society, and another combined track Nature and Technology / Nature and Health. On the one hand, the outside wage coefficient is statistically insignificant in the majority of cases. On the other hand, if we look at coefficient sizes and signs, there is some evidence that a negative link between outside wage and state exam GPA is more pronounced for more technical tracks, like Nature and Health, and Nature and Technology / Nature and Health.

One problem is that each regression at track level has only around 2300 observations. I perform separate analysis for 'hard' and for 'soft' tracks to overcome this limitation and to further test the theory that outside wage is more important for teachers of more technical subjects. I define Nature and Technology, Nature and Health, and their combination Nature and Technology / Nature and Health as 'hard' tracks. I define Economy and Society,

Culture and Society, and their combination Economy and Society / Culture and Society as 'soft' tracks. **Table 11** shows the results from this analysis. It is clear that for 'hard' tracks there is a strong negative link between outside wage and pupil performance, which is also statistically significant. Regression (21) indicates that a 10% increase in outside wage leads to a 0.17 point decrease in state exam GPA, which corresponds to a 2.7% drop in the average state exam GPA. Thus, it is significant not only statistically (at the 5% significance level), but also economically. The situation is different with 'soft' tracks, where the coefficients are smaller in magnitude and statistically not different from zero. This analysis supports the theory that there is a higher demand in labour markets for well-qualified teachers of 'hard' subjects. Thus, it is important to remunerate them appropriately to attract and retain them.

Table 11 – Regression estimates of the effect of regional outside wages on pupil performance in 'hard' and 'soft' VWO tracks

Edu type: VWO				
Tracks	'Hard'	'Hard'	'Soft'	'Soft'
#	(21)	(22)	(23)	(24)
Dependent variable	State exam GPA	Pass rate	State exam GPA	Pass rate
Outside wage	-1.789**	-0.719***	0.834	0.162
	(0.783)	(0.250)	(0.727)	(0.268)
Controls	yes	yes	yes	yes
School, year and track FE	yes	yes	yes	yes
N	6812	6812	6715	6715
Adj. R2	0.421	0.155	0.262	0.115

Robust standard errors in parentheses
Significance levels: * p<0.10, ** p<0.05, *** p<0.01
'Hard' tracks: 1) Nature & Technology, 2) Nature & Health, 3) Nature & Technology / Nature & Health
'Soft' tracks: 1) Economy & Society, 2) Culture & Society, 3) Economy & Society / Culture & Society

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

6.2.2. HAVO

Table 12 summarizes the econometric analysis results for HAVO for different tracks. None of the coefficients is statistically different from zero, except for regression (32). In contrast to VWO, there is no evidence that 'hard' tracks have a negative and strong link between outside wage and pupil performance. This finding is further confirmed after I run separate regressions for 'hard' and 'soft' tracks. The results of these regressions are shown in **Table 11a** in Appendix. All coefficients on outside wage are small in magnitude and statistically insignificant.

Table 12 - Regression estimates of the effect of regional outside wages on pupil performance in HAVO tracks Nature & Technology, Nature & Health, Culture & Society, Economy & Society

Panel A				
Edu type: HAVO; Tracks: Nature & Technology (N&T); Nature & Health (N&H)				
#	(25)	(26)	(27)	(28)
Track	N&T	N&T	N&H	N&H
Dependent variable	State exam GPA	Pass rate	State exam GPA	Pass rate
Outside wage	-0.987 (1.623)	-0.697 (0.519)	1.008 (0.963)	0.0820 (0.427)
Controls	yes	yes	yes	yes
School, year FE	yes	yes	yes	yes
N	1979	1979	2328	2328
Adj. R2	0.311	0.125	0.375	0.146
Panel B				
Edu type: HAVO; Tracks: Culture & Society (C&S); Economics & Society (E&S)				
#	(29)	(30)	(31)	(32)
Track	C&S	C&S	E&S	E&S
Dependent variable	State exam GPA	Pass rate	State exam GPA	Pass rate
Outside wage	1.227 (1.092)	0.568 (0.502)	-0.664 (0.686)	-0.613** (0.290)
Controls	yes	yes	yes	yes
School, year FE	yes	yes	yes	yes
N	2357	2357	2393	2393
Adj. R2	0.315	0.092	0.474	0.293
Robust standard errors in parentheses				
Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

6.3. Comparison with other studies

In subsection **8.2** I explain why my overall findings differ from Britton & Propper (2016). Here, I compare their coefficients with the ones obtained in this paper. Given the similarities in both methodologies and datasets, they should be comparable. They found that a 10% increase in outside wage leads to a 2% decrease in the average state exam GPA. For all combined VWO tracks I found that a 10% increase in outside wage is associated with a 0.053 point decrease in state exam GPA, which corresponds to a 0.8% decrease in the average exam GPA (from regression 1). Therefore, our estimates are comparable, even though in this paper the effect in this specification is smaller and statistically insignificant. A 10% increase in outside wage is associated with a 0.32 point decrease in state exam GPA for the VWO Nature and Technology track, which is a 4.8% drop in the average GPA. For the technical VWO tracks combined, a 10% increase in outside wage is associated with a 2.7% drop in the average state exam GPA. Therefore, for more specific technical tracks I

find from 1.3 to 2.4 times stronger impact than Britton & Propper (2016). It is likely that if their focus was exclusively on technical subject teachers they would have found similar results to mine.

7. Robustness checks and sensitivity analysis

7.1. No school fixed effect

In all regression specifications in section **6** I have controlled for school fixed effects by adding school dummies. I have argued that they make analysis much more credible. However, there is a downside – using school dummies does not exploit all the between-school variation. In my case, I have a panel dataset with only 5 years, but with 548 VWO establishments and 545 HAVO establishments. Thus, if I do not use school dummies I increase statistical power of the analysis. Here I estimate the main regression specifications without school dummies. I add region dummies instead, in order to control for fixed region effects. It is important to do that to separate the effect of the average salary level in the region from fixed regional specifics. It is very likely that pupil performance from the same schools correlate with each other, therefore I use clustered standard errors at establishment level in order to have standard errors of the right magnitude (Angrist & Pischke, 2008).

Table 13 is a replication of **Table 6** in **6.1**. It summarizes regression analysis that covers all tracks in VWO, but without school dummies. Coefficients on outside wage are of similar magnitude and are still statistically insignificant. Findings for HAVO without school fixed effects are also similar to the ones with school fixed effects.[28]

[28] Not reported in order to save space. They are available upon request from the author.

Table 13 – Regression estimates of the effect of regional outside wages on pupil performance in VWO without school fixed effects

Edu type: VWO Tracks: all				
#	(1b)	(2b)	(3b)	(4b)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-0.327	-0.322	-0.202	-0.205
	(0.757)	(0.756)	(0.206)	(0.205)
Controls	no	yes	no	yes
School FE	no	no	no	no
Year, track, region FE	yes	yes	yes	yes
N	13 734	13 734	13 734	13 734
Adj. R2	0.263	0.266	0.068	0.068
Standard errors are clustered around educational establishments. Shown in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 14 shows that findings for the VWO track Nature and Technology with and without school fixed effects are similar. This similarity remains for all other tracks both for VWO and for HAVO.[29] Overall conclusion is that regressions with school fixed effects, and regressions without school fixed effects (but with clustered standard errors and with region dummies) yield very similar results.

Table 14 – Regression estimates of the effect of regional outside wages on pupil performance in the VWO track Nature & Technology without school fixed effects

Edu type: VWO Track: Nature & Technology				
#	(13b)	(14b)	(15b)	(16b)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-3.817**	-3.681**	-1.250**	-1.261**
	(1.676)	(1.685)	(0.522)	(0.522)
Controls	no	yes	no	yes
School FE	no	no	no	no
Year FE	yes	yes	yes	yes
N	2131	2131	2131	2131
Adj. R2	0.069	0.071	0.035	0.037
Standard errors are clustered around educational establishments. Shown in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

[29] Not reported in order to save space. They are available upon request from the author.

7.2. No exclusion of schools with missing control variable observations

In section **6** I have excluded few schools that miss control variable values for some years in order to compare results for regressions with controls and without controls. Here I check if the exclusion of these schools does not affect overall findings. **Table 15** shows results without excluded observations. Regression (1c) and (3c) correspond to VWO regressions (1) and (3), which were shown in **Table 6**. Regression (5c) and (7c) correspond to regressions (5) and (7), which were shown in **Table 7**. The signs, significance levels and magnitudes remain essentially the same when I add schools with missing controls. Thus, results that were found before are robust to exclusion of the school with missing controls.

Table 15 – Regression estimates of the effect of regional outside wages on pupil performance in VWO and HAVO without exclusion of observations with missing control variables

Tracks: all				
Edu type:	VWO	VWO	HAVO	HAVO
#	(1c)	(3c)	(5c)	(7c)
Dependent variable	State exam GPA	Pass rate	State exam GPA	Pass rate
Outside wage	-0.417	-0.253	0.237	-0.173
	(0.522)	(0.175)	(0.480)	(0.187)
Controls	no	no	no	no
School, year and track FE	yes	yes	yes	yes
N	14 077	14 077	13 384	13 384
Adj. R2	0.376	0.126	0.337	0.125
Robust standard errors in parentheses				
Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 16 shows that the finding of a strong negative link between outside wage and pupil performance for the VWO Nature and Technology track is also robust to exclusions of schools with missing control variables. The coefficients in regressions (13c) and (15c) are very similar to the coefficients in regressions (13) and (15), which were shown in **Table 9.** Other regression specifications are also robust to exclusion of schools with missing control variables.[30]

[30] Not reported in order to save space. They are available upon request from the author.

Table 16 – Regression estimates of the effect of regional outside wages on pupil performance in the VWO track Nature & Technology without exclusion of observations with missing control variables

Edu type: VWO Track: Nature & Technology		
#	(13c)	(15c)
Dependent variable	State exam GPA	Pass rate
Outside wage	-2.752*	-1.145**
	(1.628)	(0.469)
Controls	no	no
School, year FE	yes	yes
N	2186	2186
Adj. R2	0.285	0.078
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01		

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

7.3. Dealing with overlapping cohorts and serial correlation

The datasets analysed in section **6** covered all years from 2010 to 2014. It implies that all 5 cohorts in each school overlap in a sense that they are taught by the same teachers. If there is a change in outside wage and a teacher decides to leave, then it could have an impact on all cohorts. For example, if a good teacher has quit in October 2011, then it would affect not only pupils graduating in 2012, but also the ones who are graduating in 2013 and 2014 since this teacher was teaching all of them. This can lead to serial correlation that might result in biased estimates. One way to tackle this is to choose a sample of not overlapping cohorts. Britton & Propper (2016) use five-year gaps for school performance observations. To implement such approach in this thesis, I would need to have a 6-year gap for VWO school performance observations and a 5-year gap for HAVO. I have a dataset from 2010 to 2014, thus I am not able to implement such approach. However, I can restrict my sample only to 2 years – 2010 and 2014. Though it will not be able to fully eliminate a possible serial correlation, it should be able to substantially limit it. If the results with the reduced sample are similar to the results with the full sample, then I can assume that overlapping cohorts and serial correlation is not a problem.

Table 17 shows the results for all VWO tracks for the year 2010 and 2014. Coefficients are all negative and similar to the ones from the main analysis as it was shown in **Table 6.**

Table 17 – Regression estimates of the effect of regional outside wages on pupil performance in VWO only in 2010 and 2014

Edu type: VWO; Tracks: all Years: 2010 and 2014				
#	(1d)	(2d)	(3d)	(4d)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-0.438	-0.332	-0.383*	-0.389*
	(0.634)	(0.644)	(0.199)	(0.203)
Controls	no	yes	no	yes
School, year, track FE	yes	yes	yes	yes
N	5484	5484	5484	5484
Adj. R2	0.401	0.403	0.137	0.137
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 18 is similar to **Table 17** with the difference that it focuses on HAVO. Comparing to **Table 7**, coefficients on State Exam GPA are somewhat higher, but coefficients on Pass rate are lower in absolute terms, however they still remain insignificant.

Table 18 – Regression estimates of the effect of regional outside wages on pupil performance in HAVO only in 2010 and 2014

Edu type: HAVO; Tracks: all Years: 2010 and 2014				
#	(5d)	(6d)	(7d)	(8d)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	0.523	0.470	-0.0896	-0.101
	(0.585)	(0.583)	(0.226)	(0.228)
Controls	no	yes	no	yes
School, year, track FE	yes	yes	yes	yes
N	5226	5226	5226	5226
Adj. R2	0.351	0.362	0.145	0.146
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 19 shows results for the VWO track Nature and Technology for years 2010 and 2014. All coefficients are negative and economically significant. However, the coefficients are statistically significant only in specifications with pass rate as the dependent variable. In regression (15d) and (16d) the coefficients are essentially the same as in regressions (15)

and (16) which cover all years.[31] The coefficients in regressions (13d) and (14d), while still meaningful, are smaller than in regression (13) and (14). The differences and lack of significance might arise due to a smaller sample size. That is why it is important to look at the specifications where I separately pool together 'hard' and 'soft' tracks.

Table 19 – Regression estimates of the effect of regional outside wages on pupil performance in the VWO track Nature & Technology only in 2010 and 2014

Edu type: VWO; Track: Nature & Technology Years: 2010 and 2014				
#	(13e)	(14e)	(15e)	(16e)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-1.787	-1.281	-1.479**	-1.536**
	(2.148)	(2.240)	(0.634)	(0.649)
Controls	no	yes	no	yes
School, year FE	yes	yes	yes	yes
N	859	859	859	859
Adj. R2	0.307	0.313	-0.053	-0.050
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 20 shows results for pooled 'hard' and 'soft' VWO tracks with the sample restricted to two years, 2010 and 2014. Overall, coefficients are very similar to the same regressions but covering all years from 2010 to 2014. The only exception is the coefficient in regression (21d), which becomes somewhat smaller compared to the original regression (21) and now it is not statistically significant. However, it is still negative and economically significant.

[31] See **Table 9** in section **6**.

Table 20 – Regression estimates of the effect of regional outside wages on pupil performance in VWO 'hard' and 'soft' tracks only in 2010 and 2014

Edu type: VWO; Years: 2010 and 2014				
Tracks	Hard	Hard	Soft	Soft
#	(21d)	(22d)	(23d)	(24d)
Dependent variable	State exam GPA	Pass rate	State exam GPA	Pass rate
Outside wage	-1.141	-0.807***	0.870	0.101
	(0.932)	(0.277)	(0.847)	(0.305)
Controls	yes	yes	yes	yes
School, year and track FE	yes	yes	yes	yes
N	2734	2734	2677	2677
Adj. R2	0.427	0.154	0.292	0.138
Robust standard errors in parentheses Significance levels: * p<0.10, ** p<0.05, *** p<0.01 'Hard' tracks: 1) Nature & Technology, 2) Nature & Health, 3) Nature & Technology AND Nature & Health 'Soft' tracks: 1) Economy & Society, 2) Culture & Society, 3) Economy & Society AND Culture & Society				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

I conclude that, overall, the findings are robust to overlapping cohorts and serial correlation.

7.4. Keeping outliers and measurement errors

I have excluded some outliers and observations with measurement errors in the analysis performed in section **6**. Here I check if findings are similar when outliers and observations with measurement errors are not excluded. Coefficients change slightly, but essentially remain the same for the main specification and for per track analysis, both for VWO and for HAVO. The only exception is the coefficient on pupil-teacher ratio, which becomes smaller in magnitude and less significant statistically. This is expected, since there was a substantial error in data on the number of teachers for one school.[32]

7.5. Track and time fixed effect interactions

In regression specifications where there were several tracks I have controlled for track and time fixed effects. However, it is also possible to generate interactions between tracks and years, with the idea that each track might have a 'unique' fixed effect each year. I have made such interactions and added them in regression analysis. I have found that estimates change only slightly and that my findings are not affected.[33]

[32] Findings are not reported in order to save space. They are available upon request from the author.
[33] Findings are not reported in order to save space. They are available upon request from the author.

8. Key findings, policy implications and discussion

8.1. Key findings and Policy implications

Overall, there are 3 main findings which have important policy implications. The first key finding is that, overall, both for VWO and for HAVO, there is no evidence that outside wage is a strong determinant of pupil performance. It implies that teachers from some regions are unlikely to be seriously underpaid relative to market wage-levels and relative to other regions. There is no strong evidence that teachers are attracted by higher wages outside of schools, which would lead to a situation where there is a lack of qualified teachers, which would in turn adversely affect pupil performance.

Key finding 1: *There is NO evidence to suggest that in some regions of the Netherlands general secondary education teachers as a whole are seriously underpaid relative to market wage-levels and relative to other regions, which would adversely affect pupil performance via school inability to attract and retain qualified teachers.*

Policy implication 1: *There is NO strong need to change salaries of ALL general secondary education teachers in order to attract the best teachers to improve pupil performance.*

The second key finding is that VWO teachers in specialized technical tracks in some regions seem to be underpaid relative to market wage-levels and relative to other regions. The most pressing situation is for the Nature and Technology track where it appears that outside wage has a statistically and economically strong negative impact on pupil performance. It implies that these teachers are attracted by job opportunities and wages outside of schools, which leads to a shortage of qualified teachers at schools, which has a negative impact on pupil performance. There is also similar evidence for the other two technical tracks, namely Nature and Health, and the combined track Nature and Technology / Nature and Health. However, this evidence is weaker than for the Nature and Technology track. There is no such evidence for the non-technical tracks.

Key finding 2*: There is evidence that technical track VWO teachers are underpaid relative to market-wages, especially in the Nature and Technology track.*

Policy implication 2*: Salaries of VWO teachers in technical tracks should be more flexible and more aligned to regional free market wages. It is likely that they should be increased in some regions. This will help to attract and retain qualified teachers, which is important for pupil performance. It is especially crucial for the Nature and Technology VWO track.*

The third key finding is a generalization of the second finding.

***Key finding 3**: In certain cases teacher pay is an important determinant of pupil performance.*

***Policy implication 3**: Teacher pay is a tool that can be used to attract and retain good teachers, which would have a positive impact on pupil performance.*

8.2. Discussion

In this subsection I discuss the possible reasons behind the obtained results.

8.2.1. Key finding 1

In subsection **3.2.2** I have described a policy that was implemented in the Netherlands in 2009. This policy allowed for the increase of salaries of teachers in Randstad.[34] Thus, it is likely that after this policy implementation, teachers became less attracted by employment outside of schools, because their school wages became more aligned with market wages. This can explain **Key finding 1** that, overall, outside wages do not affect pupil performance.

In subsection **5.3.1** I have shown that average salary variation across regions in the Netherlands is not significant. It implies that in the Netherlands it might not be that important to have different teacher pay levels in different regions, because outside wage levels across regions are similar. Britton & Propper (2016) found that in England outside wage is an important determinant of pupil performance for all secondary schools, which contrasts to my findings for the Netherlands. I do not present statistics here, but it is likely that the variation in salary levels across different regions in England is higher than in the Netherlands. I expect especially big differences in salaries between London and rural areas in England. As a result, these differences in outside wages could be much more important for teachers in England, when they make a decision whether to switch a job from a public school to a job in the private sector, or to move to another school in another region. In addition, purely in statistical terms, a higher variation in outside wages makes statistical analysis much stronger, which gives a higher chance of obtaining significant results. All of this can explain **Key finding 1**.

[34] Randstad is an agglomeration consisting of the 4 biggest Dutch cities, namely Amsterdam, Rotterdam, the Hague, Utrecht, and their surrounding areas.

8.2.2. Key finding 2

Key finding 2 might imply that technical subject teachers are in higher demand in private markets compared to other teachers. In order to teach physics at VWO, one should have a certain level of ability and solid knowledge of the subject. Such a person might be a very attractive employee in different industries, from engineering and IT companies to financial institutions, which need analysts who are able to understand complicated statistical models. The 2013 OECD Teaching and Learning International Survey (TALIS) mentions that one of the key challenges of the Dutch educational system is to attract the best teachers, especially in maths and science (European Commission, 2015). Their findings are in line with the findings of this thesis.

To further investigate the differences in labour demand for technical and non-technical teachers, I have looked at open vacancies and salary levels on www.jobbird.com.[35] I have split data in 'wealthier' provinces (North Holland, South Holland, and Utrecht) and 'poorer' provinces (Drenthe, Flevoland, Friesland, Gelderland, Groningen, Limburg, Overijssel).[36] [37] I have looked at the number of vacancies and salary levels, firstly for technical jobs and then for non-technical jobs. **Figure 4** shows the analysis for technical subject teachers, while **Figure 5** for non-technical subject teachers. It appears that both for technical and for non-technical jobs there are more open vacancies in 'wealthier' provinces relative to the population sizes. Also, salary levels are higher in wealthier provinces for both job types. For technical jobs, the possibility to earn a high salary (>3500 EUR gross) in wealthier regions is much higher than in poorer provinces.[38] For non-technical jobs, this is also true, but the difference between provinces is far less pronounced. For example, 13% of technical jobs in wealthier provinces have a salary over 5000 EUR, but in poorer provinces it is only 1%. For non-technical jobs respective numbers are 12% and 6%. This analysis indicates that the regional variation in outside wages is much higher for technical than for non-technical jobs, which explains **Key finding 2**.[39]

[35] It is one of the biggest online job-portals in the Netherlands (Valkenburg, 2013).
[36] Open vacancy data is changing all the time. Data used in the analysis was obtained on 20-09-2016.
[37] I make only two groups, because there are not that many open vacancies.
[38] Teacher salary range is around EUR 2500 – 5000 (see subsection **3.2.1**). Therefore, it makes sense to look at vacancies with salary level amounting at least EUR 3500.
[39] This analysis is conducted only to illustrate some labour market trends. Strong conclusions cannot be derived from it.

Figure 4 *– Technical subject teacher demand*

provinces: North Holland, South Holland, Utrecht

salary range	# of vacancies	%		population
€ 0 - 1 750	335	9%		7 572 073
€ 1 750 - 2 500	1094	31%		
€ 2 500 - 3 500	1044	29%		
€ 3 500 - 5 000	635	18%		% per
€ 5 000 +	466	13%		population
Total	**3574**	**100%**		0.0472%

provinces: Drenthe, Flevoland, Friesland, Gelderland, Groningen, Limburg, Overijssel

salary range	# of vacancies	%		population
€ 0 - 1 750	324	20%		6 397 321
€ 1 750 - 2 500	639	40%		
€ 2 500 - 3 500	460	29%		
€ 3 500 - 5 000	142	9%		% per
€ 5 000 +	17	1%		population
Total	**1582**	**100%**		0.0247%

Source: created by the author. Vacancy data obtained from jobbird.com (2016). Population data obtained from Statistics Netherlands (2016c).
Note: In order to obtain open vacancies that are relevant for technical subject teachers, I choose job-functions Technical advice and Technical executive.

Figure 5 *– Non-technical subject teacher demand*

provinces: North Holland, South Holland, Utrecht

salary range	# of vacancies	%	population
€ 0 - 1 750	261	15%	7 572 073
€ 1 750 - 2 500	420	25%	
€ 2 500 - 3 500	507	30%	
€ 3 500 - 5 000	301	18%	% per population
€ 5 000 +	201	12%	
Total	**1690**	**100%**	0.0223%

provinces: Drenthe, Flevoland, Friesland, Gelderland, Groningen, Limburg, Overijssel

salary range	# of vacancies	%	population
€ 0 - 1 750	190	26%	6 397 321
€ 1 750 - 2 500	244	33%	
€ 2 500 - 3 500	180	24%	
€ 3 500 - 5 000	90	12%	% per population
€ 5 000 +	41	6%	
Total	**745**	**100%**	0.0116%

Source: created by the author. Vacancy data obtained from jobbird.com (2016). Population data obtained from Statistics Netherlands (2016c).
Note: In order to obtain open vacancies that are relevant for non-technical subject teachers, I choose the following job-functions: Commercial / Sales, Design / Creation / Journalism, Legal, Hospitality / Retail, Marketing / Advertising / Media, HRM.

8.2.3. Key finding 3

Key finding 3 and **Policy implication 3** are in line with standard microeconomic theories, which state that for rational utility-maximizing individuals, holding all else equal, a higher pay is better. This finding is supported by other empirical studies (Britton & Propper, 2016; Greavesyand & Sibieta, 2014).

9. Limitations and further research

9.1. Limitations

There are some limitations in this study, which might undermine my findings and policy recommendations. Here, I present the ones I was able to identify.

1) The first limitation is that my dataset covers only a 5-year time span. This time-period might be not long enough to employ robust fixed effect regression analysis,

because it is harder to separate fixed from non-fixed effects. I was not able to overcome this limitation - data on earlier years is not publicly available and I have not been able to obtain more data directly from DUO and/or the Ministry of Education. This limitation affects the statistical power of my tests: I might find insignificant results, where in truth there is a strong relationship.

2) The second limitation is that I do not control for pupil innate ability, which can lead to biased results due to Omitted Variable Bias (OVB). Innate ability could be the key factor in explaining pupil performance. When planning this research the initial idea was to control for secondary school pupil ability by adding their performance on the primary school ending exams (CITO tests in the Netherlands). Britton & Propper (2016) used such an approach. Unfortunately, I was not able to obtain this data.

   I have controlled for school fixed effects to partially overcome this limitation. The idea is that higher-ability pupils self-select to 'better' schools, but lower-ability pupils tend to end-up in 'worse' schools. Further, I use pupil-teacher ratio in controls. Disadvantaged pupils and pupils form ethnic minorities tend to perform worse on exams. To help these students there is a tendency to have smaller classes for such pupils in the Netherlands. Therefore, pupil-teacher ratio also can help to control for pupil background and ability to some extent.

   OVB is a concern when the omitted variable is correlated with the variable of interest, which is outside wage in this case. It is uncertain if these variables are correlated, but I might suspect that people with higher ability move to higher paying regions where they can use most of their potential. Higher-ability parents are more likely to have also higher-ability children. The association between outside wage and pupil performance is negative, but the association between outside wage and pupil ability is positive. This implies that in my specifications without controls for pupil ability the magnitude of coefficients on outside wage could be understated. It means that reported magnitudes of coefficients are at the lower bound and in real life could be higher. Therefore, the finding that technical subject VWO teachers are underpaid is still valid.

3) Similarly to innate ability, factors like family background, ethnicity, educational attainment of parents, and family income-level are also important determinants of

pupil performance. Such statistics are considered too sensitive and are not publicly available, as a result, I was not able to obtain them. On the one hand, more high-paying regions can attract people from better backgrounds and with higher incomes. On the other hand, ethnic minorities, people from worse backgrounds and people with lower incomes can be attracted to the highest-paying regions. Therefore, it is unclear how my results are affected.

To compensate for the lack of these important variables I have used school fixed effects and pupil-teacher ratio. It is likely that the composition of pupils and their backgrounds do not change rapidly across schools, therefore school fixed effects could be helpful. Pupil-teacher ratio could be a crude proxy for these factors for the reasons mentioned in the previous point on pupil innate ability.

4) The fact that I use the average wage in the region as a measure of the outside wage is a plus on the one hand. Such general wage is exogenous to schools, which means my identification strategy should work. However, there is a downside, the average wage in the region is too general and might not be relevant for teachers. It would be beneficial to obtain wages per regions that are specific to teachers. Unfortunately, such specific data was not available. It is very likely that the average wage in a region is correlated with a specific wage a teacher can earn outside of a school in that region. Still, it is far from certain that regional variation in specific outside wages teachers can earn is similar to the variation of general average regional wages. Therefore, it is uncertain how this limitation affects my results.

5) In my analysis I use only outside wages, as I was not able to obtain data on wages teachers earn at schools (inside wages). On the one hand, teacher pay is set at the state level and is mainly fixed across regions, so it should not be a big concern. On the other hand, schools might still have some flexibility to set teacher salaries by moving teachers to different salary scales. Thus, it would be better to control for inside wages. Britton & Propper (2016) as their main independent variable use wage gap, which is the difference between inside and outside teacher wages. In one specification, similarly to this paper, they exclude inside wage and use only outside wage. They find that the coefficient on the outside wage is essentially the same as the coefficient on the wage gap. It is likely that in the Netherlands situation is

similar to the one in England. Overall, this limitation should not significantly undermine my analysis.

6) Additionally, it would be beneficial to add teacher experience to the regression analysis, as it is an important determinant of teacher ability to teach pupils effectively and thus improve their performance (Papay & Kraft, 2015; Harris & Sass, 2011; Rockoff, 2004). I do not have this variable, however, I control for teacher age, which could to a small degree correlate with teacher experience.

Some of these limitations are more important, some less, but overall they do not seem to be too severe to make my findings totally uncredible.

9.2. Further research

The first suggestion is to perform similar analysis as in this paper, but that would take into account limitations identified in the previous subsection. Most important objective would be to tackle limitations (1), (2), and (4). It would not be that hard to obtain data for a longer time-period from the Ministry of Education and/or DUO. Wage data that is more specific to teachers should be available at CPB (Bureau for Economics Policy Analysis) or CBS (Statistics Netherlands). It is possible to obtain primary school exit exams, which might be a good proxy for pupil ability.

To validate the findings of this paper it would be very beneficial to conduct a qualitative study. It would be especially valuable to support the finding that there is a high demand for qualified technical subject teachers in labour markets and that, as a result, some of them do not choose to work at schools. Such study would include in-depth interviews of school principals, private sector HR professionals and education experts. The main question would be how hard it is to attract and retain qualified teachers for different subjects. Another question is whether technical subject teachers are of high demand in the private sector. It would be valuable to identify how important are teacher wages at schools and salaries outside of schools for the process of selecting best teachers.

10. Conclusions

This paper exploits teacher pay regulation to assess the impact of relative teacher salary on pupil performance. Teacher pay is fixed across the Netherlands.[40] In contrast, market wages that teachers can earn vary across different regions of the country. This variation in outside wages is exogenous, which allows me to reveal the causal relationship between teacher pay and pupil performance.

This research focuses on general secondary education in the Netherlands, namely VWO and HAVO education types. The dataset consists of all VWO and HAVO schools and covers the 2010-2014 time-period. Pupil performance is measured by final state examination grades and by state examination pass rates. Outside wage is defined as the average salary in a region. In my econometric model I control for pupil-teacher ratio, the average teacher age, female pupil percent, female teacher percent, school fixed effects, year fixed effects and track fixed effects.

There are 3 main findings. The first finding is that, for the whole general secondary education, outside wage does not affect pupil performance. The most likely explanation is that there is not much variation in average wages across regions in the Netherlands. Thus, there is no need to differentiate teacher salaries across regions even further after the 2009 policy, which has increased teacher salaries in Randstad. The second finding is that outside wage has a strong negative impact on pupil performance specifically in the technical tracks of VWO. A 10% increase in outside wage is associated with a 2.7% drop in the average state exam GPA for the technical VWO tracks, which is statistically and economically very significant. The magnitude is even higher for the Nature and Technology track, where a 10% increase in outside wage leads to a 4.8% decrease in the average state exam GPA and to a 12.4 percentage point decrease in pass rate, which is very significant economically. The third finding is that, in specific cases, teacher pay can affect pupil performance.

Given these findings I make 3 policy recommendations. The first one is that there is NO strong need to change salaries of ALL general secondary education teachers in order to attract the best teachers to improve pupil performance. The second recommendation is that the salaries of VWO teachers in technical tracks should be more aligned to regional wages. They should be increased in high-paying regions in order to attract and retain qualified

[40] The only exception is Randstad where teacher pay is higher. See section **3.2.2** for details.

teachers, which is important for pupil performance. It is especially crucial for the Nature and Technology VWO track. The third recommendation is more general - teacher pay is a tool that can be used to attract and retain good teachers.

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Appendix

Table of Figures (in the main text)

Table of Tables (in the main text)

Tables in Appendix

Table A – the list of unique VMBO pathways, sector and learning track combinations

#	Unique track
1	VMBO_BL_Economie_Consumptief
2	VMBO_BL_Economie_Handel en Administratie -ISP
3	VMBO_BL_Intersect. programma_Sport, Dienstverlening en Veiligheid
4	VMBO_BL_Techniek_Bouwtechniek
5	VMBO_BL_Techniek_Elektrotechniek
6	VMBO_BL_Techniek_Grafische Techniek
7	VMBO_BL_Techniek_Installatietechniek
8	VMBO_BL_Techniek_Metaaltechniek
9	VMBO_BL_Techniek_Voertuigentechniek
10	VMBO_BL_Zorg & Welzijn_Uiterlijke Verzorging
11	VMBO_BL_Zorg & Welzijn_Verzorging
12	VMBO_KL_Economie_Consumptief
13	VMBO_KL_Economie_Handel en Administratie -ISP
14	VMBO_KL_Intersect. programma_Sport, Dienstverlening en Veiligheid
15	VMBO_KL_Techniek_Bouwbreed -ISP
16	VMBO_KL_Techniek_Elektrotechniek
17	VMBO_KL_Techniek_Grafische Techniek
18	VMBO_KL_Techniek_Installatietechniek
19	VMBO_KL_Techniek_Metaaltechniek
20	VMBO_KL_Techniek_Voertuigentechniek
21	VMBO_KL_Zorg & Welzijn_Uiterlijke Verzorging
22	VMBO_KL_Zorg & Welzijn_Verzorging
23	VMBO_TL__
24	VMBO_BL_Zorg & Welzijn_Zorg en Welzijn -ISP
25	VMBO_KL_Techniek_Bouwtechniek
26	VMBO_KL_Zorg & Welzijn_Zorg en Welzijn -ISP
27	VMBO_BL_Economie_Administratie
28	VMBO_KL_Economie_Administratie
29	VMBO_GL_Intersect. programma_ICT -route
30	VMBO_KL_Economie_Consumptief Breed -ISP
31	VMBO_BL_Techniek_Metalectro -ISP
32	VMBO_KL_Techniek_Metalectro -ISP
33	VMBO_BL_Landbouw_Landbouw Breed -ISP
34	VMBO_GL_Economie_Handel en Administratie -ISP
35	VMBO_GL_Landbouw_Landbouw Breed -ISP
36	VMBO_GL_Techniek_Bouwtechniek
37	VMBO_GL_Techniek_Metalectro -ISP
38	VMBO_GL_Zorg & Welzijn_Verzorging
39	VMBO_KL_Landbouw_Landbouw Breed -ISP
40	VMBO_GL_Economie_Technologie Orientatie
41	VMBO_GL_Techniek_Technologie Orientatie
42	VMBO_GL_Zorg & Welzijn_Technologie Orientatie
43	VMBO_GL_Zorg & Welzijn_Zorg en Welzijn -ISP
44	VMBO_BL_Economie_Consumptief Breed -ISP
45	VMBO_BL_Techniek_Bouwbreed -ISP
46	VMBO_BL_Techniek_Techniek Breed -ISP
47	VMBO_KL_Economie_Handel en Verkoop
48	VMBO_BL_Economie_Handel en Verkoop
49	VMBO_BL_Intersect. programma_Techniek & Dienstverlening
50	VMBO_KL_Intersect. programma_Techniek & Dienstverlening
51	VMBO_BL_Economie_Mode en Commercie
52	VMBO_KL_Economie_Mode en Commercie
53	VMBO_KL_Intersect. programma_ICT -route
54	VMBO_BL_Intersect. programma_ICT -route
55	VMBO_KL_Techniek_Techniek Breed -ISP
56	VMBO_BL_Landbouw_Landbouw en Natuurlijke Omgeving
57	VMBO_KL_Landbouw_Landbouw en Natuurlijke Omgeving

58	VMBO_BL_Intersect. programma_Dienstverlening & Commercie
59	VMBO_KL_Intersect. programma_Dienstverlening & Commercie
60	VMBO_GL_Economie_Administratie
61	VMBO_GL_Techniek_Elektrotechniek
62	VMBO_GL_Techniek_Voertuigentechniek
63	VMBO_GL_Techniek_Metaaltechniek
64	VMBO_BL_Techniek_Instalektro -ISP
65	VMBO_KL_Techniek_Instalektro -ISP
66	VMBO_GL_Landbouw_Landbouw en Natuurlijke Omgeving
67	VMBO_BL_Techniek_Kust-, Rijn- en Binnenvaart
68	VMBO_KL_Techniek_Kust-, Rijn- en Binnenvaart
69	VMBO_KL_Intersect. programma_Techniek & Commercie
70	VMBO_BL_Intersect. programma_Techniek & Commercie
71	VMBO_BL_Techniek_Transport en Logistiek
72	VMBO_KL_Techniek_Transport en Logistiek
73	VMBO_GL_Techniek_Techniek Breed -ISP
74	VMBO_GL_Techniek_Bouwbreed -ISP
75	VMBO_GL_Intersect. programma_Techniek & Commercie
76	VMBO_GL_Intersect. programma_Dienstverlening & Commercie
77	VMBO_GL_Economie_Handel en Verkoop
78	VMBO_GL_Techniek_Grafische Techniek
79	VMBO_GL_Intersect. programma_Techniek & Dienstverlening
80	VMBO_GL_Economie_Consumptief Breed -ISP
81	VMBO_GL_Economie_Mode en Commercie
82	VMBO_GL_Techniek_Transport en Logistiek
83	VMBO_BL_Techniek_Haven- en Vervoerschool
84	VMBO_KL_Techniek_Haven- en Vervoerschool
85	VMBO_GL_Zorg & Welzijn_Uiterlijke Verzorging
86	VMBO_GL_Economie_Consumptief
87	VMBO_GL_Techniek_Instalektro -ISP
88	VMBO_GL_Techniek_Installatietechniek
89	VMBO_GL_Techniek_Kust-, Rijn- en Binnenvaart
90	VMBO_GL_Techniek_Haven- en Vervoerschool
91	VMBO_BL_Economie_EO
92	VMBO_GL_Economie_EO
93	VMBO_KL_Economie_EO
94	VMBO_BL_Zorg & Welzijn_ZWE
95	VMBO_KL_Zorg & Welzijn_ZWE
96	VMBO_BL_Techniek_MTR
97	VMBO_GL_Techniek_MTR
98	VMBO_KL_Techniek_MTR
99	VMBO_BL_Techniek_BWI
100	VMBO_BL_Techniek_PIE
101	VMBO_KL_Techniek_BWI
102	VMBO_KL_Techniek_PIE
103	VMBO_GL_Techniek_BWI
104	VMBO_GL_Techniek_PIE
105	VMBO_GL_Zorg & Welzijn_ZWE
106	VMBO_BL_Economie_HBR
107	VMBO_KL_Economie_HBR

Source: created by the author based on the data from DUO (2016).
Note: a VMBO pathway, sector and learning track are separated by '_' symbol.

Table B – the list of variables used in regression analysis

Variable type	Variable name	Example
indicator	year	2012
indicator	BRIN_number	05XJ
indicator	establishment_number	05XJ00
indicator	school_name	Het Lyceum Rotterdam
indicator	city_name	ROTTERDAM
indicator	province	Zuid-Holland
indicator	edu_type	HAVO
indicator	track_name1	Economie en Maatschappij
indicator	full_ID	2012_05XJ00_HAVO - E&M
indicator	region_code	29
indicator	region_name	Groot-Rijnmond
school characteristic	pupil_amount_per_track	25
school characteristic	graduate_amount_per_track	23
school characteristic	fail_to_graduate_amount	2
pupil performance	pass_rate	92%
pupil performance	school_exam_GPA	6.2
pupil performance	state_exam_GPA	6.7
pupil performance	total_GPA	6.6
school characteristic	male_pupil_amount	13
school characteristic	female_pupil_amount	12
school characteristic	female_pupil_percent	48%
school characteristic	teacher_amount	33
school characteristic	female_teacher_amount	13
school characteristic	male_teacher_amount	20
school characteristic	female_teacher_percent	40%
school characteristic	teacher_FTE	0.66
school characteristic	teacher_age	47.26
school characteristic	pupil_number	335
school characteristic	pupil_teacher_ratio	10.11
outside wage	outside_wage	4638
outside wage	outside_wage_lag1	4539
outside wage	outside_wage_lag2	4420
outside wage	outside_wage_lag3	4310
outside wage	outside_wage_lag4	4204
outside wage	outside_wage_lag5	4085

Source: created by the author based on the data from DUO (2016).

Table C – COROP regions and average gross salaries

#	Regions	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	Achterhoek	3 352	3 461	3 583	3 745	3 828	4 026	4 108	4 211	4 267
2	Aggl. Arnhem/Nijmegen	3 657	3 732	3 862	4 008	4 100	4 282	4 387	4 505	4 599
3	Aggl. Haarlem	3 663	3 758	3 774	3 970	4 070	4 240	4 352	4 429	4 527
4	Aggl. Leiden en Bollenstreek	3 655	3 750	3 900	4 007	4 145	4 310	4 455	4 560	4 666
5	Aggl. 's-Gravenhage	3 928	3 993	4 120	4 252	4 383	4 547	4 645	4 777	4 869
6	Alkmaar en omgeving	3 612	3 680	3 775	3 937	4 036	4 221	4 329	4 439	4 533
7	Delft en Westland	3 690	3 742	3 848	3 981	4 145	4 123	4 218	4 307	4 411
8	Delfzijl e.o.	3 492	3 740	3 846	4 062	4 222	4 328	4 495	4 619	4 658
9	Flevoland	3 567	3 646	3 775	3 917	3 998	4 186	4 292	4 377	4 449
10	Groot-Amsterdam	4 226	4 319	4 478	4 586	4 685	4 715	4 829	4 930	5 049
11	Groot-Rijnmond	3 856	3 927	4 085	4 204	4 310	4 420	4 539	4 638	4 733
12	Het Gooi en Vechtstreek	3 690	3 779	3 913	4 043	4 112	4 515	4 594	4 687	4 742
13	IJmond	3 909	3 983	4 223	4 286	4 269	4 290	4 429	4 550	4 681
14	Kop van Noord-Holland	3 526	3 608	3 726	3 845	3 956	4 144	4 209	4 341	4 380
15	Midden-Limburg	3 455	3 560	3 684	3 795	3 890	4 083	4 170	4 274	4 334
16	Midden-Noord-Brabant	3 554	3 679	3 749	3 910	3 973	4 155	4 243	4 359	4 418
17	Noord-Drenthe	3 564	3 681	3 801	3 945	3 983	4 142	4 268	4 369	4 404
18	Noord-Friesland	3 565	3 672	3 780	3 943	4 046	4 232	4 364	4 432	4 520
19	Noord-Limburg	3 461	3 525	3 622	3 752	3 878	4 038	4 135	4 189	4 237
20	Noordoost-Noord-Brabant	3 707	3 809	3 936	4 026	4 119	4 302	4 410	4 534	4 596
21	Noord-Overijssel	3 583	3 667	3 782	3 895	4 009	4 203	4 294	4 385	4 492
22	Oost-Groningen	3 340	3 449	3 574	3 660	3 779	3 827	3 904	4 018	4 087
23	Oost-Zuid-Holland	3 564	3 612	3 754	3 832	3 932	4 213	4 292	4 408	4 481
24	Overig Groningen	3 766	3 867	3 996	4 100	4 234	4 243	4 336	4 447	4 520
25	Overig Zeeland	3 421	3 570	3 687	3 840	3 924	4 144	4 230	4 310	4 360
26	Twente	3 467	3 569	3 699	3 832	3 952	4 133	4 229	4 336	4 407
27	Utrecht	3 960	4 030	4 185	4 291	4 398	4 535	4 630	4 756	4 841
28	Veluwe	3 576	3 692	3 796	3 938	4 071	4 255	4 367	4 474	4 527
29	West-Noord-Brabant	3 596	3 691	3 814	3 967	4 077	4 257	4 370	4 475	4 529
30	Zaanstreek	3 554	3 583	3 781	3 936	3 995	4 113	4 239	4 424	4 489
31	Zeeuwsch-Vlaanderen	3 769	3 951	4 017	4 257	4 309	4 255	4 354	4 525	4 619
32	Zuid-Limburg	3 615	3 709	3 814	3 965	4 085	4 262	4 362	4 467	4 524
33	Zuidoost-Drenthe	3 410	3 467	3 668	3 857	3 953	4 057	4 161	4 278	4 390
34	Zuidoost-Friesland	3 390	3 516	3 645	3 681	3 838	4 115	4 234	4 319	4 402
35	Zuidoost-Noord-Brabant	3 782	3 877	3 989	4 149	4 227	4 375	4 497	4 635	4 717
36	Zuidoost-Zuid-Holland	3 644	3 734	3 922	4 044	4 119	4 313	4 411	4 535	4 609
37	Zuidwest-Drenthe	3 410	3 543	3 709	3 804	3 910	4 048	4 163	4 266	4 340
38	Zuidwest-Friesland	3 280	3 400	3 499	3 623	3 759	4 015	4 117	4 203	4 276
39	Zuidwest-Gelderland	3 494	3 622	3 748	3 868	3 968	4 140	4 185	4 300	4 380
40	Zuidwest-Overijssel	3 568	3 582	3 695	3 875	3 950	4 157	4 247	4 326	4 381

Source: created by the author based on information by Statistics Netherlands (Statistics Netherlands, 2016a).

Note: I take the average salaries per year and divide them by 12 in order to obtain the average monthly amount.

Table 10a – Regression estimates of the effect of regional outside wages on pupil performance in VWO tracks Nature & Health, Nature & Technology / Nature & Health, Economy & Society, Economy & Society / Culture & Society

Edu type: VWO				
Panel A - Track: Nature & Health				
#	(33)	(34)	(35)	(36)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-1.220 (1.168)	-1.272 (1.178)	-0.268 (0.472)	-0.336 (0.477)
Controls	no	yes	no	yes
School, year FE	yes	yes	yes	yes
N	2345	2345	2345	2345
Adj. R2	0.291	0.291	0.141	0.143
Panel B - Track: Nature & Technology / Nature & Health				
#	(37)	(38)	(39)	(40)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	-0.108 (1.064)	-0.449 (1.067)	-0.209 (0.306)	-0.299 (0.312)
Controls	no	yes	no	yes
School, year FE	yes	yes	yes	yes
N	2336	2336	2336	2336
Adj. R2	0.407	0.414	0.161	0.163
Panel C - Track: Economy & Society				
#	(41)	(42)	(43)	(44)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	0.591 (1.088)	0.548 (1.082)	0.839* (0.458)	0.904** (0.461)
Controls	no	yes	no	yes
School, year FE	yes	yes	yes	yes
N	2330	2330	2330	2330
Adj. R2	0.364	0.372	0.181	0.184
Panel D - Track: Economy & Society / Culture & Society				
#	(45)	(46)	(47)	(48)
Dependent variable	State exam GPA	State exam GPA	Pass rate	Pass rate
Outside wage	1.437 (1.343)	1.276 (1.352)	-0.151 (0.443)	-0.0853 (0.453)
Controls	no	yes	no	yes
School, year FE	yes	yes	yes	yes
N	2069	2069	2069	2069
Adj. R2	0.237	0.245	0.111	0.110
Robust standard errors in parentheses				
Significance levels: * p<0.10, ** p<0.05, *** p<0.01				

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).

Table 11a – Regression estimates of the effect of regional outside wages on pupil performance in 'hard' and 'soft' HAVO tracks

Edu type: HAVO				
Tracks	'Hard'	'Hard'	'Soft'	'Soft'
#	(49)	(50)	(51)	(52)
Dependent variable	State exam GPA	Pass rate	State exam GPA	Pass rate
Outside wage	-0.113 (0.747)	-0.244 (0.273)	0.234 (0.638)	-0.128 (0.275)
Controls	yes	yes	yes	yes
School, year and track FE	yes	yes	yes	yes
N	6503	6503	6533	6533
Adj. R2	0.358	0.136	0.303	0.132

Robust standard errors in parentheses
Significance levels: * p<0.10, ** p<0.05, *** p<0.01
'Hard' tracks: 1) Nature & Technology, 2) Nature & Health, 3) Nature & Technology / Nature & Health
'Soft' tracks: 1) Economy & Society, 2) Culture & Society, 3) Economy & Society / Culture & Society

Note: Outside wage is defined as the natural logarithm of the average of 5 past year wages per region (as in equation (1)).