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Mister Sandman, Bring Me Good Marks! On the Relationship Between Sleep Quality and Academic Achievement

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June 2014

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ABSTRACT

Mister Sandman, Bring Me Good Marks! On the Relationship Between Sleep Quality and Academic Achievement

This study assesses the relationship between sleep quality and academic achievement. We survey college students about their sleep quality by means of the Pittsburgh Sleep Quality Index (PSQI) before the start of their first exam period at university. PSQI scores are matched with course marks in this first exam period. Instrumenting PSQI scores by sleep quality during secondary education, we find that increasing total sleep quality with one standard deviation leads to 4.85 percentage point higher course marks.

JEL Classification: I10, J24, I23

Keywords: economics of education, economics of health, economics of sleep,
academic achievement, sleep quality

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1 Introduction

For decades, economists have been studying the determinants of academic attainment. Seminal studies such as Black et al. (2005), Ermisch & Francesconi (2001), McNabb et al. (2002), Ortiz & Dehon (2008), Sanbonmatsu et al. (2006), Vardardottir (2013) and Leos-Urbel et al. (2013) have identified prior accumulated human capital, the costs and returns of higher education, social background characteristics and gender as key determinants in explaining outcomes in higher education.

Recently, academics have also focused on the role of health factors on academic achievements. For instance Ding et al. (2009), García-Gómez et al. (2013), Fletcher (2014), Sabia (2007), Balsa et al. (2011) and Pieterse (Forthcoming) identify a negative relationship between poor general health, health shocks, ADHD, body weight, alcohol usage and maltreatment respectively on the one hand and academic performance on the other hand. In addition, Bharadwaj et al. (2013) reveal a positive relationship between early health interventions and academic achievement.

A neglected factor in the economic literature on academic achievements is sleep quality. From a theoretical point of view, a positive relationship between sleep quality and academic performance can be expected. Indeed, based on research within other academic fields such as medicine and biology, we know that night's rest is essential to helping maintain mood, motivation, memory and cognitive performance. While asleep, the brain integrates new knowledge and forms new associations (see, e.g., AlDabal & BaHammam, 2011; Beebe, 2011; Dahl & Lewin, 2002; Gais & Born, 2004; Siegel, 2001; Vandekerckhove & Cluydts, 2010; Walker & Stickgold, 2004).

In this study we empirically test the relationship between sleep quality and academic achievement. To this end, we survey first-year college students on their sleep quality, by means of the Pittsburgh Sleep Quality Index (Buysse et al., 1989), before the start of their first exam period at university. In addition, these students are surveyed on general social background and health characteristics. The resulting dataset is then matched with their academic achievement in terms of course marks in their first exam period. Subsequently, our research question is answered by exploring 2SLS estimations on the gathered data. To be able to correctly identify the influence of sleep quality on academic achievement, the respondents' sleep quality is instrumented by their sleep quality during secondary education.

This article is structured as follows. In the next section we provide the reader with some information on the data gathering, a description of these data and a descriptive analysis of the relationship between sleep quality and academic achievement. In Section 3 we outline our statistical research methods. Subsequently, in Section 4, we present and discuss the main statistical examination of the dataset and some robustness checks. A final section concludes.

2 Data

2.1 Data Gathering

Our dataset was constructed by merging survey data on first-year college students' sleep quality and further individual characteristics with their first college exam marks.

In December 2013, we conducted a survey across the students present at the start of the last lecture of the first-semester courses of Economics and Introduction to Accountancy at Ghent University in Belgium. These courses are part of the first year Bachelor programs of (Business) Economics and Commercial Sciences respectively, but are also taken by some students of other programs. In total, 394 (410) students attended the last lecture of Economics (Introduction to Accountancy). These students were asked to fulfil a paper-and-pencil questionnaire.

This questionnaire comprised five sections. A first section was dedicated to general questions about the subject's social-economic background characteristics (age, gender, parental education, household composition, nationality, language at parental home, living place, prior educational attainment, relationship status and general health). These characteristics are used in our analysis to explain both sleep quality (see, e.g. Hale et al., 2013, for recent evidence on the relationship between social background and sleep quality) and academic achievement.

In a second section, we surveyed quality of sleep by means of the validated Pittsburgh Sleep Quality Index (Buysse et al., 1989). This question module measures sleep quality during the previous month. The PSQI contains 19 self-rated questions yielding seven PSQI submeasures: sleep duration, sleep disturbance, sleep latency, day dysfunction due to sleepiness, sleep efficiency, overall perceived sleep quality and need of medicines to sleep. Each component is scored from 0 to 3. This yields a total PSQI score between 0 and 21, with higher scores indicating lower sleep quality. A total PSQI score greater than 5 is classified as poor quality sleep. The official Dutch translation of the PSQI was requested from Dr. Buysse and a user agreement was signed. The reader will notice that although the 'Quality' in PSQI refers to a qualitative measure of sleep,

some components have a rather quantitative point of view. We will come back to this issue in Section 4 when we focus on the particularly explanatory power of the two PSQI submeasures on sleep duration and overall perceived sleep quality.

In a third section of our survey we additionally let the students rate the sleep quality of their parents and their sleep quality during secondary education on a five-point Likert item. In addition, we asked whether they suffered from congenital medical problems that affected their sleep quality. These variables are important for our econometric analysis being predictors for sleep quality that cannot be determined by college outcomes.

In a fourth section, the students had to fulfil the validated Depression Anxiety Stress Scales (DASS-21) questionnaire.¹ DASS-21 is a set of three self-report scales designed to measure the negative emotional states of depression, anxiety and stress. Each of the three DASS-21 scales contains 7 items that are to be rated on a four-point Likert scale leading to a score between 0 and 21. The higher the score on these scales, the higher the emotional problems. Depression, anxiety and stress are regularly reported to be associated with both sleep quality (see, e.g., Breslau et al., 1996; Eller et al., 2006) and academic achievements (see, e.g., Andrews & Wilding, 2004; Eisenberg et al., 2009). Hence the importance of including them as control variables in our analysis.

In a last section, the students were asked whether they agreed with the fact that their survey answers would be merged with their first-semester exam marks by a third party. This clause was prepared in collaboration with the Chairman of the Board of Examiners of the Faculty of Economics and

¹ The Dutch translation of the DASS-21 questionnaire was downloaded from www.psy.unsw.edu.au/dass/.

Business of Ghent University. In total, 382 (352) of the students in the course of Economics (Introduction to Accountancy) gave us the permission to use their survey answers together with their exam marks for our research aims. From this population we retained, for reasons of methodology (see Section 3.1) and homogeneity, all full-time first year students in the Bachelor programs of (Business) Economics and Commercial Sciences (329 and 307 students respectively).

In February 2013, the survey data was matched with the marks of the students for their first semester courses, based on the student number the participants of the survey mentioned in the last section of the questionnaire. For reasons of privacy, this was done by a third party. Due to the fact that some of the students did not bring their student card with them and did not know their 8-digit student number by heart, the third party could only match survey data and exam marks for 328 (293) full-time first year students in the Bachelor programs of (Business) Economics (Commercial Sciences). All students in (Business) Economics took the courses of Accounting, Economics, Human Sciences, Law, Mathematics and Production Technology. For the students in Commercial Sciences, marks were registered for the courses of Accountancy, Commercial and Financial Transactions, English, French, Information Technology, Law, Mathematics and Microeconomics. As English, French and Information Technology could also be taken in the second semester, not all students in our data got marks for these courses.

2.2 Data Description

In Table 1 we report descriptive statistics for the variables used in the econometric analysis below. We separately report statistics on the total

sample, on the sample of good sleepers ($PSQI \leq 5$) and on the sample of bad sleepers ($PSQI > 5$). In total 69.57% of our subjects are good sleepers and 30.43% are bad sleepers.

TABLE 1 ABOUT HERE

Panel A provides the reader with statistics on the background characteristics of our subjects. The subsample of bad sleepers comprises more females,² more children of parents who passed away or divorced and more migrant youth. There are also more individuals in this subsample with bad general and mental health characteristics. Therefore, controlling for these characteristics when identifying the impact of sleep quality on study results is important. Panel B shows statistics for our potential instruments for sleep quality. These statistics provide already an indication for the relative strength of our potential instruments. The sleep quality during secondary education index seems to be the strongest predictor of poor quality of sleep. This index is 25.35% higher among bad sleepers than among good sleepers. Panel C shows that the average PSQI score among the population is 4.80, which is quite close to the threshold for poor sleep quality. Furthermore, as we can expect, the average scores for the PSQI submeasures of overall perceived sleep quality and sleep duration are substantially higher among the bad sleepers than among the good sleepers. For the course characteristics, presented in Panel D, we find no substantial differences between both subsamples by sleep quality.

² As shown recently by Schneider et al. (2012) this statistic might point to a gender-specific perception and assessment of health indicators. On the other hand, recent research by Venn et al. (2013) provides evidence for gender differences in approaches to self-management of poor sleep.

Panel E of Table 1 presents the outcome variables at the individual exam level. We construct four outcomes concerning academic achievement based on the individual exam marks at the end of the first semester. The first outcome variable (“exam mark: completed exams”) is equal to the exam mark (out of 20 points) for all exams made leaving out observations for which the students were not present at the exam and ipso facto did not pass the exam. The second outcome variable (“exam mark: potential exams”) is equal to the first one except that the exam mark when students did not show up for the exam was recoded to 0, thus increasing the number of observations slightly. We introduce this alternative outcome variable as bad sleepers might be more likely to skip exams, due to reasons of motivation and mood, than good sleepers. However, as in total only 0.74% of the potential exams were not taken, the difference between the first and the second outcome variable is very limited. The third and fourth variable capturing academic achievement are dummies indicating whether the student passes the exam or not, i.e. whether the mark for the particular individual in the course is at least 10 out of 20 points. The third variable (“exam passed (mark \geq 10): completed exams”) and fourth variable (“exam passed (mark \geq 10): potential exams”) again differ in whether exams for which the student did not show up were left out or were given a 0 mark.

In line with our expectations, both the exam marks and the exam passing chances are somewhat lower among the bad sleepers. A simple t-test shows that this difference is significant at the 1% significance level for all academic outcomes. However, this comparison does not take selection, neither on the aforementioned observable characteristics nor on unobservable characteristics that may correlate with both academic outcomes and sleep quality into account. The instrumental variable

regression we apply in this research takes the selection on observable characteristics into account and deals with potential problems of endogeneity. Therefore, the analyses outlined in the next section lead to a more founded answer to our research question.

3 Methods

3.1 Sleep Quality as an Endogenous Explanatory Variable

Sleep quality is potentially endogenous to academic achievement. Factors and events that are unobservable to the researcher may influence both academic achievement and contemporaneous sleep quality. Moreover, bad academic achievement or indications of bad academic achievement in the near future may induce sleepless nights. We aim at controlling for this problem in three ways.

First, in our analyses we control for a large set of individual background characteristics outlined in Panel A of Table 1. This set of variables includes measures for health in general and psychological health, adopting the DASS-21 scales, in particular. Thereby we aim at minimising the number of factors influencing both sleep quality and academic achievement that are omitted from the analysis and estimate the effect of sleep quality within homogeneous subgroups of individuals.

Second, and as described in Section 2.1, we measured sleep quality by means of the PSQI at the end of the first semester lectures at college, i.e. just before the start of Christmas holidays, which are used by the students to prepare the first semester exams, taking place immediately after the Christmas holidays. This is a conscious choice as thereby sleep quality is

estimated before exam stress takes place.

However, even if we control for a large set of individual background characteristics and use PSQI scores estimated before the exam period, sources of endogeneity, e.g. exam expectations and worries, might still be present. Therefore, we assess the impact of sleep quality on academic achievement with an instrumental variable econometric approach. This means that we use the exogenous variation in variables that predict our sleep quality measure but are not affected by academic achievement at college. Potential instruments are outlined in Panel B of Table 1: self-reported maternal sleep quality, paternal sleep quality index, sleep quality during secondary education index and (congenital) medical problems that affect sleep quality. There is no reason why these variables, after controlling for the variables outlined in Panel A of Table 1, might have a direct effect on course marks, except through their effect on contemporaneous sleep quality. However, most of these variables seem to be weak instruments. Table A.1 (in Appendix A) shows that the correlation rates between PSQI measures, the submeasure for sleep duration in particular, on the one hand and all potential arguments except sleep quality during secondary education are rather low.³ Therefore, in what follows, we will only use sleep quality during secondary education as an instrument for all PSQI scores.

3.2 Econometric Model

In order to answer our main research question, we regress variables capturing individual academic achievement on PSQI measures at the

³ We also tried various variables combining the reported maternal and paternal sleep quality but this hardly affects the low magnitude of the correlation rates.

individual level, a set of individual-specific control variables and course dummies. The variables we include in the different regressions are the ones outlined in Panel E, Panel C, Panel A and Panel D of Table 1 respectively.

The coefficients of interest can be estimated by means of ordinary least squares (OLS).⁴ However, for reasons outlined in Section 3.1, our main analyses adopts two-stage least squares (2SLS) techniques. As mentioned before, we use sleep quality during secondary education as an instrument for the PSQI-variable. In all models, standard errors are clustered at the subject level.

4 Results

In this subsection we discuss our empirical analyses. The regression results are reported in four tables. Table A.2, Table A.3, Table A.4 and Table A.5 in Appendix A present the results for the regressions with as a dependent variable the mark on completed exams, the marks on potential exams, the indicator variable for passing completed exams and the indicator variable for passing potential exams respectively. Each table comprises the estimation results for eight regression models labelled from (1) to (8).

Table 2 summarises the major results of Table A.2. We will focus on

⁴ For the academic achievement outcome “exam passed”, this boils down to the choice of estimating a linear probability model instead of a discrete choice model. As we cluster standard errors at the subject level, this linear probability model is robust to heteroskedasticity which is important given the binary nature of the outcome variable. In addition, we also we looked into the analogous results replacing the linear probability model with a probit model. The estimated marginal effects for the probit model were very similar to the OLS results.

these results since the empirical pattern observed in the other results tables is very comparable. In model (1) and model (2) the main explanatory variable is the standardised total PSQI score. In model (1) we get by means of an OLS regression a coefficient for this variable which is not significantly different from zero. However, this estimate might be biased due to the in Section 3.1 mentioned endogeneity problem. The test for endogeneity, presented in column (2), rejects, indeed, exogeneity of the total PSQI score with respect to the exam results. Therefore, model (2) is our benchmark model. The 2SLS estimate for the effect of the total PSQI score on the exam mark is about -0.97 and significantly different from 0 at the 5% significance level. This result can be interpreted as follows. An increase of the total PSQI score with one standard deviation, i.e. with about 2.23, leads to a decrease of the exam mark with about one point out of 20 (or 4.85 percentage points).

TABLE 2 ABOUT HERE

A comparison of the OLS and 2SLS results presented in column (1) and column (2) of Table 2 learns that, due to the endogeneity problem, OLS estimates are biased upwards. A potential omitted variable that could explain this bias is the internal and the external pressure a first-year student experiences. If this pressure is high, this may lead to higher marks on the one hand and lower sleep quality (and thereby a higher PSQI score) on the other hand.

We briefly discuss some secondary results reported in column (2) of Table 1. Note that a structural interpretation of some explanatory variables is hazardous as they might be endogenous to exam outcomes. The

observed (and strong) effects of ethnicity, program in secondary education and general end marks in secondary education, are generally consistent with our expectations. Somewhat surprising is the, albeit weakly significantly, negative effect of high educated fathers. This variable, however, correlates to an important extent with other drivers such as the program in secondary education.

In model (3) and model (4) we regress the mark for each completed exam on the dummy indicating bad sleepers. Again, exogeneity of this dummy is rejected so that we focus on the results presented in column (4). We get that the average exam mark is about 2.64 points lower among the bad sleepers *ceteris paribus*, an estimate which is significantly different from 0 at the 5% significance level.

As the total PSQI score is composed both by quantitative and qualitative indicators of sleep quality, it is interesting to test which of both dimensions is the most affecting exam results. Therefore, in model (5) and model (6) we substitute the total PSQI score by the PSQI submeasure of overall perceived sleep quality. In model (7) and model (8) we use the PSQI submeasure of sleep duration. The 2SLS estimation results have, for both submeasures, the expected negative sign and are significantly different from 0. However, the magnitude of the latter submeasure is somewhat higher. An increase of the overall perceived sleep quality with one standard deviation lowers the exam mark with about 0.89 points (4.45 percentage points) while an increase of the sleep duration index with one standard deviation lowers the exam score with about 1.28 points (6.38 percentage points). Interestingly, also the OLS estimate is significantly different from 0 for this submeasure. The reader might mention that also the test for endogeneity is less significant for this measure (compared with the test statistics in columns (2), (4) and (6)). This makes sense. While it is clear that

omitted variables like indications of bad exam results or internal and external pressure may affect (overall perceived) sleep quality, this is less clear for sleep duration.

This higher predictive power for sleep duration compared with overall perceived sleep quality can be explained by the types of sleep that a person goes through during a sleep period of about seven hours. The first half of the sleep period is dominated by a deep sleep, the slow-wave sleep (SWS). The second half of the sleep period is characterised by longer periods of rapid-eye-time-sleep (REM), during which more brain activity occurs. Individuals who score low in terms of sleep duration, will typically have less REM-sleep. It is known, however, that this type of sleep is important for storing knowledge in a more permanent way. In other words, the REM-sleep leads to memory consolidation. Moreover, it associates new information with existing knowledge (Diekelmann & Born, 2010; Smith & Lapp, 1991). It goes without saying that the latter mechanisms are important in the context of rehearsing, understanding, reproducing and applying new academic knowledge in preparation of an exam.

Table A.3 presents comparable results for the same academic outcome, i.e. exam scores, but now for all potential exams, recoding exams for which students did not show up to 0. Unsurprisingly, given the small number of potential exams that were not taken, this leads to results that are completely similar to those of Table A.2.

Table A.4 shows the regression results when using the dummy indicating exam success, i.e. indicating an exam mark of at least 10 points out of 20. First, we get that increasing the total PSQI score with one standard deviation lowers the probability of exam success with about 9.22 percentage points. This is a strong effect. However, our regression results

show that characteristics such as ethnicity, program in secondary education and general end marks in secondary education are still better predictors for exam success than sleep quality. Second, the effect of the dummy indicating bad sleepers is even higher. At the same time, the standard errors are quite high in regression model (4). Last, based on columns (6) and (8) we find again suggestive evidence for sleep duration being a better predictor for exam success than overall perceived sleep quality. The results presented in Table A.5, based on all potential exams, lead to the same conclusions.

5 Conclusion

In this study we empirically tested the impact of sleep quality on educational achievement. This research complements recent contributions looking into the role of other health factors on academic achievements.⁵ Furthermore, our hypothesis of a positive relationship between sleep quality and academic success was supported by the knowledge from other scientific fields that night's rest is essential to helping maintain mood, motivation, memory and cognitive performance.

In view of our research aims, we surveyed first-year college students on their sleep quality, by means of the Pittsburgh Sleep Quality Index (PSQI). In addition, these students were surveyed on general social background and health characteristics. The resulting dataset was matched with the marks they scored in their first examination period. To be able to correctly

⁵ In addition, it complements a very recent strand of literature focussing on the impact of sleep quality on employment outcomes (Jennum et al., 2014).

identify the influence of sleep quality on academic achievement, we used an instrumental variable econometric approach.

We found that an increase of one's PSQI score with one standard deviation, which implies a deterioration of his/her overall sleep quality, leads to a decrease of the exam mark with 0.97 out of 20 points (or with 4.85 percentage points). Moreover, this result seems to be to a large extent driven by aspects of sleep duration captured by the PSQI measure (rather than by qualitative aspects).

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Appendix A: Additional Tables

TABLE A.1 ABOUT HERE

TABLE A.2 ABOUT HERE

TABLE A.3 ABOUT HERE

TABLE A.4 ABOUT HERE

TABLE A.5 ABOUT HERE

Table 1 – Summary Statistics

	All observations		PSQI ≤ 5		PSQI > 5	
	Mean	SD	Mean	SD	Mean	SD
A. Background characteristics						
Age	18.03	0.431	18.01	0.363	18.08	0.552
Female Sex	0.503	0.500	0.467	0.499	0.583	0.493
Highest diploma mother						
Tertiary education: college	0.277	0.448	0.289	0.453	0.252	0.434
Tertiary education: outside college	0.411	0.492	0.424	0.494	0.382	0.486
No tertiary education	0.311	0.463	0.287	0.453	0.366	0.482
Highest diploma father						
Tertiary education: college	0.392	0.488	0.387	0.487	0.405	0.491
Tertiary education: outside college	0.309	0.462	0.322	0.467	0.280	0.449
No tertiary education	0.298	0.458	0.291	0.454	0.315	0.465
At least one of parents passed away	0.029	0.168	0.014	0.116	0.064	0.245
Parents divorced	0.199	0.399	0.168	0.374	0.269	0.444
Grandmother on mother's side foreign nationality	0.079	0.269	0.067	0.249	0.106	0.308
Number of siblings						
None	0.086	0.280	0.076	0.265	0.109	0.312
One	0.537	0.499	0.548	0.498	0.511	0.500
Two	0.298	0.458	0.288	0.453	0.322	0.468
More than two	0.079	0.270	0.089	0.284	0.058	0.234
Living in a student room	0.460	0.498	0.452	0.498	0.478	0.500
Program in secondary education						
Economics - languages/sports	0.286	0.452	0.268	0.443	0.327	0.469
Economics - maths	0.267	0.442	0.286	0.452	0.223	0.417
Ancient languages	0.166	0.372	0.167	0.373	0.164	0.371
Exact sciences - maths	0.179	0.383	0.182	0.386	0.172	0.377
General secondary education: other	0.056	0.230	0.061	0.239	0.046	0.209
Technical secondary education	0.046	0.210	0.037	0.188	0.067	0.251
General end marks in secondary education						
Less than 70%	0.013	0.113	0.016	0.127	0.005	0.070
Between 70% and 80%	0.393	0.488	0.372	0.483	0.440	0.497
More than 80%	0.594	0.491	0.612	0.487	0.555	0.497
In a relationship	0.413	0.492	0.428	0.495	0.379	0.485
General health						
Very good	0.359	0.480	0.408	0.492	0.247	0.431
Good	0.526	0.499	0.519	0.500	0.544	0.498
Moderate, bad or very bad	0.115	0.319	0.073	0.261	0.209	0.407
DASS-21 depression scale	3.148	3.519	2.543	3.005	4.553	4.166
DASS-21 anxiety scale	2.982	3.027	2.371	2.496	4.355	3.612
DASS-21 depression scale	5.178	3.964	4.390	3.572	6.958	4.222
B. Sleep quality predictors						
Maternal sleep quality index	2.753	0.970	2.681	0.951	2.919	0.995
Paternal sleep quality index	2.423	0.959	2.355	0.950	2.586	0.960
Sleep quality during secondary education index	2.079	0.749	1.929	0.669	2.418	0.807
Congenital medical problems that affect sleep quality	0.014	0.119	0.014	0.117	0.015	0.122
C. Sleep quality						
PSQI: total measure	4.802	2.228	3.624	1.149	7.408	1.779
Poor sleep quality (PSQI > 5)	0.306	0.461	0.000	0.000	1.000	0.000
PSQI: submeasure overall perceived sleep quality	0.937	0.626	0.710	0.493	1.452	0.590

PSQI: submeasure sleep duration	0.129	0.363	0.059	0.245	0.287	0.508
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D. Course characteristics

Number of ECTS-credits in program	26.704	1.338	26.760	1.416	26.579	1.132
Program of BE	0.500	0.500	0.490	0.500	0.522	0.500
Program of BE: Accounting	0.083	0.276	0.085	0.279	0.080	0.271
Program of BE: Economics	0.083	0.276	0.085	0.279	0.080	0.271
Program of BE: Human Sciences	0.083	0.276	0.085	0.279	0.080	0.271
Program of BE: Law	0.083	0.276	0.085	0.279	0.080	0.271
Program of BE: Mathematics	0.083	0.276	0.085	0.279	0.080	0.271
Program of BE: Production Technology	0.083	0.276	0.085	0.279	0.080	0.271
Program of CS: Accountancy	0.074	0.263	0.073	0.261	0.077	0.267
Program of CS: Commercial and Financial Transactions	0.074	0.263	0.073	0.261	0.077	0.267
Program of CS: English	0.059	0.236	0.057	0.231	0.066	0.248
Program of CS: French	0.039	0.193	0.034	0.181	0.049	0.216
Program of CS: Information Technology	0.030	0.170	0.034	0.180	0.021	0.143
Program of CS: Law	0.074	0.263	0.073	0.261	0.077	0.267
Program of CS: Mathematics	0.074	0.263	0.073	0.261	0.077	0.267
Program of CS: Microeconomics	0.074	0.263	0.073	0.261	0.077	0.267

E. Academic Achievement

Exam mark: completed exams	10.82	3.637	10.98	3.620	10.46	3.651
Exam mark: potential exams	10.74	3.740	10.91	3.711	10.36	3.779
Exam passed (mark \geq 10): completed exams	0.651	0.477	0.669	0.471	0.611	0.488
Exam passed (mark \geq 10): potential exams	0.646	0.478	0.665	0.472	0.605	0.489

Number of subjects	621	432	189
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All statistics are presented at the individual exam level. Used abbreviations: SD: standard deviation; BE: (Business) Economics; CS: Commercial Sciences.

Table 2 – Main Results

Regression number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Dependent variable	Exam mark: completed exams							
A. Main explanatory variables								
PSQI: total measure (normalised)	-0.103 (0.118)	-0.972** (0.386)						
Poor sleep quality (PSQI > 5)			-0.004 (0.227)	-2.639** (1.138)				
PSQI: submeasure overall perceived sleep quality (normalised)					0.071 (0.163)	-0.889** (0.358)		
PSQI: submeasure sleep duration (normalised)							-0.236** (0.103)	-1.275** (0.516)
B. Control variables								
Background characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Course dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of exam outcomes	3607	3601	3658	3652	3651	3645	3652	3646
Number of subjects	573	572	581	580	580	579	580	579
Wooldridge's (1995) robust endogeneity test (p-value)	-	0.016	-	0.009	-	0.004	-	0.029
First stage: effect of instrument on sleep quality measure	-	0.398*** (0.059)	-	0.146*** (0.027)	-	0.430*** (0.058)	-	0.303*** (0.061)

All PSQI scales are normalised by subtracting the sample mean and dividing the result by the sample standard deviation. Used instrumental variable for sleep quality measures in 2SLS: sleep quality during secondary education index. Standard errors are between parentheses and clustered at the subject level. ***(**)(*) indicates significance at the 1%(5%)(10%) level. The various numbers of exam outcomes and subjects can be explained by a different number of missing explanatory and instrumental variables across the regression models.

Table A.1 – Correlation between Sleep Quality Measures and Potential Instruments

	PSQI: total measure	Poor sleep quality (PSQI > 5)	PSQI: submeasure overall perceived sleep quality	PSQI: submeasure sleep duration
Maternal sleep quality index	0.176	0.116	0.115	0.007
Paternal sleep quality index	0.155	0.110	0.121	-0.011
Sleep quality during secondary education index	0.388	0.311	0.388	0.217
Congenital medical problems that affect sleep quality	0.057	0.003	0.077	0.029

The presented statistics are correlation coefficients.

Table A.2 – Complete Estimation Results: the Impact of Sleep Quality on Exam Marks (Completed Exams)

Regression number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Dependent variable	Exam mark: completed exams							
A. Main explanatory variables								
PSQI: total measure	-0.103 (0.118)	-0.972** (0.386)						
Poor sleep quality (PSQI > 5)			-0.004 (0.227)	-2.639** (1.138)				
PSQI: submeasure overall perceived sleep quality					0.071 (0.163)	-0.889** (0.358)		
PSQI: submeasure sleep duration							-0.236** (0.103)	-1.275** (0.516)
B. Control variables								
Age	-0.124 (0.237)	-0.102 (0.249)	-0.125 (0.238)	0.020 (0.272)	-0.122 (0.238)	-0.175 (0.240)	-0.096 (0.235)	0.038 (0.260)
Female Sex	-0.000 (0.229)	-0.011 (0.236)	0.002 (0.226)	0.041 (0.244)	0.001 (0.226)	-0.054 (0.239)	0.004 (0.225)	0.001 (0.239)
Highest diploma mother								
Tertiary education: college	-0.140 (0.308)	-0.188 (0.327)	-0.153 (0.304)	-0.239 (0.345)	-0.134 (0.306)	-0.250 (0.332)	-0.122 (0.304)	0.029 (0.330)
Tertiary education: outside college	-0.162 (0.268)	-0.173 (0.283)	-0.167 (0.267)	-0.223 (0.296)	-0.167 (0.267)	-0.097 (0.280)	-0.145 (0.266)	-0.047 (0.279)
No tertiary education (Reference)								
Highest diploma father								
Tertiary education: college	-0.687* (0.300)	-0.607* (0.326)	-0.694** (0.296)	-0.653* (0.336)	-0.706** (0.298)	-0.677** (0.320)	-0.679** (0.296)	-0.609* (0.320)
Tertiary education: outside college	-0.165 (0.284)	-0.217 (0.298)	-0.153 (0.281)	-0.171 (0.308)	-0.156 (0.283)	-0.271 (0.300)	-0.144 (0.279)	-0.112 (0.291)
No tertiary education (Reference)								
At least one of parents passed away	-0.056	0.326	-0.097	0.497	-0.117	0.115	-0.035	0.182

	(0.815)	(0.941)	(0.805)	(1.052)	(0.801)	(0.948)	(0.807)	(0.974)
Parents divorced	0.009 (0.276)	0.106 (0.285)	-0.020 (0.270)	0.123 (0.299)	-0.021 (0.271)	-0.023 (0.279)	0.029 (0.273)	0.236 (0.308)
Grandmother on mother's side foreign nationality	-1.463*** (0.453)	-1.269** (0.471)	-1.491*** (0.452)	-1.311** (0.487)	-1.510*** (0.458)	-1.09** (0.488)	-1.391** (0.461)	-0.956 (0.586)
Number of siblings								
None (Reference)								
One	-0.077 (0.397)	-0.036 (0.385)	-0.087 (0.399)	-0.143 (0.421)	-0.087 (0.400)	-0.027 (0.411)	-0.086 (0.396)	-0.082 (0.416)
Two	0.224 (0.418)	0.332 (0.404)	0.215 (0.422)	0.271 (0.441)	0.208 (0.422)	0.306 (0.430)	0.212 (0.417)	0.194 (0.441)
More than two	-0.135 (0.511)	-0.237 (0.537)	-0.104 (0.507)	-0.287 (0.567)	-0.110 (0.508)	-0.005 (0.555)	-0.147 (0.512)	-0.280 (0.555)
Living in a student room	0.239 (0.206)	0.360* (0.216)	0.221 (0.204)	0.253 (0.220)	0.216 (0.205)	0.378* (0.220)	0.183 (0.203)	0.031 (0.233)
Program in secondary education								
Economics - languages/sports	-1.729*** (0.355)	-1.674*** (0.374)	-1.768*** (0.345)	-1.647*** (0.402)	-1.775*** (0.346)	-1.710*** (0.369)	-1.807*** (0.346)	-2.015*** (0.405)
Economics - maths	-0.384 (0.317)	-0.470 (0.333)	-0.411 (0.310)	-0.556 (0.360)	-0.404 (0.309)	-0.450 (0.331)	-0.465 (0.311)	-0.744** (0.364)
Ancient languages	-0.458 (0.349)	-0.577 (0.372)	-0.466 (0.344)	-0.541 (0.393)	-0.464 (0.345)	-0.511 (0.366)	-0.501 (0.345)	-0.693* (0.383)
Exact sciences - maths (Reference)								
General secondary education: other	-0.463 (0.522)	-0.651 (0.575)	-0.423 (0.506)	-0.624 (0.571)	-0.411 (0.506)	-0.732 (0.570)	-0.473 (0.506)	-0.724 (0.566)
Technical secondary education	-3.711*** (0.617)	-3.577*** (0.619)	-3.762*** (0.614)	-3.468*** (0.642)	-3.774*** (0.615)	-3.656*** (0.640)	-3.721*** (0.607)	-3.584*** (0.656)
General end marks in secondary education								
Less than 70% (Reference)								
Between 70% and 80%	1.548*** (0.569)	1.695** (0.598)	1.525** (0.576)	1.960** (0.723)	1.522** (0.577)	1.713** (0.673)	1.630** (0.580)	2.093*** (0.639)
More than 80%	3.314***	3.377***	3.312***	3.597***	3.310***	3.444***	3.414***	3.882***

	(0.578)	(0.601)	(0.585)	(0.713)	(0.586)	(0.678)	(0.591)	(0.650)
In a relationship	0.022	-0.035	0.023	-0.100	0.023	-0.054	-0.007	-0.127
	(0.206)	(0.214)	(0.204)	(0.228)	(0.204)	(0.216)	(0.204)	(0.224)
General health								
Very good	0.585	0.222	0.614	0.206	0.625	0.312	0.578	0.417
	(0.390)	(0.424)	(0.380)	(0.446)	(0.381)	(0.399)	(0.381)	(0.424)
Good	0.315	0.139	0.318	0.026	0.325	0.196	0.306	0.237
	(0.368)	(0.384)	(0.361)	(0.413)	(0.361)	(0.366)	(0.361)	(0.398)
Moderate, bad or very bad (Reference)								
DASS-21 depression scale	-0.026	0.097	-0.046	0.094	-0.051	0.027	-0.046	-0.045
	(0.152)	(0.177)	(0.149)	(0.187)	(0.147)	(0.163)	(0.148)	(0.166)
DASS-21 anxiety scale	0.104	0.195	0.097	0.236	0.092	0.186	0.106	0.146
	(0.158)	(0.171)	(0.157)	(0.181)	(0.157)	(0.167)	(0.158)	(0.182)
DASS-21 stress scale	0.006	0.207	-0.016	0.136	-0.026	0.175	-0.022	-0.055
	(0.166)	(0.197)	(0.161)	(0.195)	(0.163)	(0.189)	(0.159)	(0.170)
Number of ECTS-credits in program	0.031	0.027	0.033	-0.018	0.031	0.068	0.032	0.026
	(0.081)	(0.082)	(0.081)	(0.088)	(0.081)	(0.086)	(0.080)	(0.081)
Program of BE: Accounting	-0.303	-0.299	-0.299	-0.295	-0.299	-0.306*	-0.285	-0.286
	(0.186)	(0.185)	(0.185)	(0.186)	(0.185)	(0.185)	(0.185)	(0.185)
Program of BE: Economics	-1.008***	-1.013***	-1.003***	-1.015***	-1.003***	-1.018***	-0.989***	-0.999***
	(0.177)	(0.176)	(0.177)	(0.176)	(0.177)	(0.176)	(0.177)	(0.176)
Program of BE: Human Sciences	-1.546***	-1.539***	-1.552***	-1.550***	-1.552***	-1.556***	-1.546***	-1.547***
	(0.202)	(0.203)	(0.200)	(0.201)	(0.200)	(0.201)	(0.201)	(0.201)
Program of BE: Law	-0.421**	-0.433**	-0.424**	-0.436**	-0.424**	-0.440**	-0.416**	-0.448**
	(0.177)	(0.177)	(0.175)	(0.177)	(0.175)	(0.176)	(0.176)	(0.177)
Program of BE: Mathematics	-1.540***	-1.541***	-1.529***	-1.539***	-1.529**	-1.546***	-1.513***	-1.518***
	(0.199)	(0.199)	(0.198)	(0.199)	(0.198)	(0.199)	(0.198)	(0.198)
Program of BE: Production Technology (Reference)								
Program of CS: Accountancy	-2.610***	-2.701***	-2.598***	-2.579***	-2.577***	-2.759***	-2.593***	-2.613***
	(0.368)	(0.380)	(0.363)	(0.385)	(0.365)	(0.384)	(0.361)	(0.374)
Program of CS: Commercial and Financial Transactions	0.167	0.078	0.186	0.203	0.199	0.015	0.192	0.172
	(0.327)	(0.341)	(0.322)	(0.352)	(0.324)	(0.347)	(0.320)	(0.336)

Program of CS: English	0.458 (0.310)	0.389 (0.331)	0.468 (0.305)	0.555 (0.342)	0.474 (0.307)	0.298 (0.336)	0.485 (0.303)	0.517 (0.324)
Program of CS: French	-1.203** (0.428)	-1.191** (0.436)	-1.162** (0.419)	-0.942** (0.440)	-1.152** (0.424)	-1.289** (0.440)	-1.107** (0.420)	-0.909** (0.444)
Program of CS: Information Technology	0.624* (0.362)	0.447 (0.383)	0.573 (0.361)	0.406 (0.396)	0.586 (0.361)	0.368 (0.392)	0.538 (0.357)	0.337 (0.379)
Program of CS: Law	-1.810*** (0.309)	-1.917*** (0.326)	-1.774*** (0.305)	-1.774*** (0.336)	-1.760*** (0.306)	-1.956*** (0.332)	-1.771*** (0.303)	-1.798*** (0.321)
Program of CS: Mathematics	-0.842** (0.359)	-0.930** (0.375)	-0.808** (0.354)	-0.789** (0.382)	-0.795** (0.356)	-0.976** (0.381)	-0.800** (0.351)	-0.810** (0.361)
Program of CS: Microeconomics	-0.744** (0.303)	-0.834** (0.322)	-0.714** (0.299)	-0.696** (0.334)	-0.697** (0.300)	-0.879** (0.328)	-0.709** (0.297)	-0.730** (0.315)
Constant	11.43** (5.233)	11.20** (5.490)	11.42** (5.230)	10.97* (5.721)	11.34** (5.246)	11.41** (5.375)	10.84** (5.210)	8.331 (5.764)
Number of exam outcomes	3607	3601	3658	3652	3651	3645	3652	3646
Number of subjects	573	572	581	580	580	579	580	579
Wooldridge's (1995) robust endogeneity test (p-value)	-	0.016	-	0.009	-	0.004	-	0.029
First stage: effect of instrument on sleep quality measure	-	0.398*** (0.059)	-	0.146*** (0.027)	-	0.430*** (0.058)	-	0.303*** (0.061)

All PSQI and DASS scales are normalised by subtracting the sample mean and dividing the result by the sample standard deviation. Used abbreviations: BE: (Business) Economics; CS: Commercial Sciences. Used instrumental variable for sleep quality measures in 2SLS: sleep quality during secondary education index. Standard errors are between parentheses and clustered at the subject level. ***(**)(*) indicates significance at the 1%(5%)(10%) level. The various numbers of exam outcomes and subjects can be explained by a different number of missing explanatory and instrumental variables across the regression models.

Table A.3 – Complete Estimation Results: the Impact of Sleep Quality on Exam Marks (Potential Exams)

Regression number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Dependent variable	Exam mark: potential exams							
A. Main explanatory variables								
PSQI: total measure (normalised)	-0.117 (0.121)	-0.934** (0.390)						
Poor sleep quality (PSQI > 5) (normalised)			0.015 (0.239)	-2.532** (1.144)				
PSQI: submeasure overall perceived sleep quality (normalised)					0.053 (0.168)	-0.858** (0.363)		
PSQI: submeasure sleep duration (normalised)							-0.245** (0.102)	-1.222** (0.518)
B. Control variables								
Age	-0.180 (0.234)	-0.160 (0.246)	-0.182 (0.234)	-0.043 (0.271)	-0.178 (0.234)	-0.229 (0.235)	-0.152 (0.233)	-0.033 (0.265)
Female Sex	-0.016 (0.232)	-0.026 (0.237)	-0.013 (0.229)	0.021 (0.245)	-0.014 (0.229)	-0.069 (0.241)	-0.011 (0.228)	-0.012 (0.241)
Highest diploma mother								
Tertiary education: college	-0.159 (0.312)	-0.203 (0.327)	-0.172 (0.308)	-0.256 (0.344)	-0.155 (0.310)	-0.268 (0.332)	-0.139 (0.309)	0.013 (0.336)
Tertiary education: outside college	-0.214 (0.279)	-0.226 (0.292)	-0.218 (0.277)	-0.281 (0.306)	-0.217 (0.278)	-0.157 (0.291)	-0.194 (0.277)	-0.096 (0.291)
No tertiary education (Reference)								
Highest diploma father								
Tertiary education: college	-0.574* (0.310)	-0.496 (0.332)	-0.584* (0.307)	-0.536 (0.345)	-0.595* (0.308)	-0.564* (0.329)	-0.569* (0.307)	-0.504 (0.326)
Tertiary education: outside college	-0.086 (0.292)	-0.123 (0.304)	-0.074 (0.289)	-0.082 (0.315)	-0.079 (0.291)	-0.183 (0.308)	-0.064 (0.287)	-0.030 (0.296)
No tertiary education (Reference)								
At least one of parents passed away	0.064	0.423	0.012	0.584	0.000	0.219	0.078	0.289

	(0.805)	(0.925)	(0.795)	(1.026)	(0.792)	(0.933)	(0.797)	(0.954)
Parents divorced	-0.034 (0.281)	0.063 (0.286)	-0.067 (0.275)	0.082 (0.230)	-0.067 (0.276)	-0.062 (0.280)	-0.015 (0.278)	0.182 (0.309)
Grandmother on mother's side foreign nationality	-1.466*** (0.455)	-1.274** (0.469)	-1.500*** (0.455)	-1.324** (0.485)	-1.513*** (0.461)	-1.113** (0.491)	-1.395** (0.463)	-0.985* (0.583)
Number of siblings								
None (Reference)								
One	-0.050 (0.389)	-0.019 (0.374)	-0.060 (0.393)	-0.124 (0.407)	-0.059 (0.394)	-0.008 (0.401)	-0.059 (0.389)	-0.057 (0.405)
Two	0.156 (0.416)	0.241 (0.402)	0.148 (0.421)	0.177 (0.437)	0.144 (0.421)	0.226 (0.428)	0.143 (0.416)	0.119 (0.437)
More than two	-0.093 (0.504)	-0.200 (0.527)	-0.060 (0.501)	-0.252 (0.554)	-0.066 (0.502)	0.026 (0.547)	-0.104 (0.506)	-0.228 (0.545)
Living in a student room	0.291 (0.210)	0.404* (0.217)	0.268 (0.208)	0.302 (0.222)	0.265 (0.209)	0.422* (0.221)	0.229 (0.208)	0.086 (0.238)
Program in secondary education								
Economics - languages/sports	-1.760*** (0.360)	-1.708*** (0.376)	-1.802*** (0.350)	-1.684*** (0.402)	-1.808*** (0.350)	-1.741*** (0.371)	-1.843*** (0.351)	-2.036*** (0.405)
Economics - maths	-0.396 (0.322)	-0.473 (0.335)	-0.421 (0.315)	-0.549 (0.360)	-0.416 (0.314)	-0.452 (0.334)	-0.478 (0.315)	-0.731** (0.364)
Ancient languages	-0.576 (0.361)	-0.690* (0.381)	-0.581 (0.356)	-0.661 (0.403)	-0.580 (0.357)	-0.623 (0.377)	-0.619* (0.358)	-0.796** (0.390)
Exact sciences - maths (Reference)								
General secondary education: other	-0.544 (0.517)	-0.706 (0.562)	-0.497 (0.502)	-0.678 (0.564)	-0.491 (0.503)	-0.786 (0.564)	-0.545 (0.498)	-0.755 (0.540)
Technical secondary education	-3.819*** (0.616)	-3.694*** (0.618)	-3.876*** (0.615)	-3.598*** (0.641)	-3.884*** (0.615)	-3.766*** (0.635)	-3.835*** (0.608)	-3.713*** (0.657)
General end marks in secondary education								
Less than 70% (Reference)								
Between 70% and 80%	1.771*** (0.544)	1.891*** (0.527)	1.746** (0.557)	2.118*** (0.643)	1.750** (0.561)	1.877*** (0.583)	1.858*** (0.563)	2.297*** (0.622)
More than 80%	3.575***	3.614***	3.574***	3.804***	3.578***	3.650***	3.684***	4.125***

	(0.555)	(0.533)	(0.569)	(0.635)	(0.573)	(0.591)	(0.575)	(0.634)
In a relationship	0.029	-0.029	0.031	-0.093	0.029	-0.045	-0.001	-0.114
	(0.212)	(0.220)	(0.210)	(0.232)	(0.210)	(0.221)	(0.211)	(0.228)
General health								
Very good	0.686*	0.345	0.722*	0.331	0.726*	0.425	0.680*	0.522
	(0.403)	(0.439)	(0.392)	(0.461)	(0.392)	(0.413)	(0.390)	(0.429)
Good	0.403	0.239	0.411	0.136	0.414	0.292	0.393	0.321
	(0.378)	(0.396)	(0.371)	(0.425)	(0.370)	(0.376)	(0.369)	(0.403)
Moderate, bad or very bad (Reference)								
DASS-21 depression scale (normalised)	-0.060	0.047	-0.082	0.041	-0.085	-0.018	-0.083	-0.086
	(0.170)	(0.196)	(0.167)	(0.207)	(0.165)	(0.182)	(0.165)	(0.180)
DASS-21 anxiety scale (normalised)	0.080	0.171	0.070	0.208	0.067	0.160	0.082	0.127
	(0.152)	(0.164)	(0.151)	(0.175)	(0.152)	(0.161)	(0.152)	(0.174)
DASS-21 stress scale (normalised)	0.030	0.217	0.005	0.152	-0.002	0.190	-0.002	-0.037
	(0.165)	(0.194)	(0.159)	(0.192)	(0.161)	(0.187)	(0.157)	(0.167)
Number of ECTS-credits in program	0.035	0.032	0.038	-0.012	0.036	0.071	0.037	0.032
	(0.081)	(0.082)	(0.082)	(0.087)	(0.081)	(0.086)	(0.080)	(0.081)
Program of BE: Accounting	-0.359*	-0.366**	-0.352*	-0.359**	-0.352*	-0.359**	-0.340*	-0.348*
	(0.184)	(0.183)	(0.183)	(0.182)	(0.183)	(0.182)	(0.183)	(0.183)
Program of BE: Economics	-0.944***	-0.957***	-0.938***	-0.951***	-0.938***	-0.951***	-0.925***	-0.938***
	(0.177)	(0.176)	(0.177)	(0.176)	(0.177)	(0.176)	(0.177)	(0.176)
Program of BE: Human Sciences	-1.520***	-1.525***	-1.524***	-1.530***	-1.524***	-1.530***	-1.520***	-1.525***
	(0.205)	(0.204)	(0.203)	(0.202)	(0.203)	(0.202)	(0.204)	(0.203)
Program of BE: Law	-0.586**	-0.601**	-0.586**	-0.601**	-0.586**	-0.601**	-0.575**	-0.590**
	(0.202)	(0.201)	(0.201)	(0.200)	(0.201)	(0.200)	(0.201)	(0.200)
Program of BE: Mathematics	-1.566***	-1.574***	-1.554***	-1.562***	-1.554***	-1.562***	-1.540***	-1.548***
	(0.204)	(0.203)	(0.203)	(0.202)	(0.203)	(0.202)	(0.203)	(0.203)
Program of BE: Production Technology (Reference)								
Program of CS: Accountancy	-2.544***	-2.637***	-2.528***	-2.509***	-2.508***	-2.681***	-2.523***	-2.544***
	(0.370)	(0.382)	(0.365)	(0.385)	(0.367)	(0.389)	(0.363)	(0.375)
Program of CS: Commercial and Financial Transactions	0.189	0.096	0.213	0.232	0.224	0.051	0.218	0.197
	(0.331)	(0.345)	(0.326)	(0.352)	(0.328)	(0.352)	(0.324)	(0.338)

Program of CS: English	0.527* (0.312)	0.455 (0.333)	0.541* (0.307)	0.625* (0.340)	0.545* (0.310)	0.379 (0.340)	0.558* (0.306)	0.586* (0.324)
Program of CS: French	-1.171** (0.430)	-1.169** (0.437)	-1.126** (0.421)	-0.924** (0.436)	-1.116** (0.427)	-1.245** (0.443)	-1.071** (0.422)	-0.896** (0.440)
Program of CS: Information Technology	0.592 (0.363)	0.417 (0.385)	0.551 (0.362)	0.383 (0.396)	0.560 (0.363)	0.354 (0.394)	0.510 (0.357)	0.314 (0.381)
Program of CS: Law	-1.890*** (0.320)	-1.982*** (0.333)	-1.849*** (0.315)	-1.830*** (0.340)	-1.838*** (0.318)	-2.011*** (0.341)	-1.844*** (0.313)	-1.865*** (0.329)
Program of CS: Mathematics	-0.912** (0.366)	-1.005** (0.381)	-0.871** (0.361)	-0.852** (0.386)	-0.860** (0.363)	-1.033** (0.388)	-0.866** (0.358)	-0.887** (0.367)
Program of CS: Microeconomics	-0.678** (0.305)	-0.771** (0.324)	-0.644** (0.301)	-0.626* (0.333)	-0.629** (0.303)	-0.802** (0.331)	-0.640** (0.299)	-0.660** (0.316)
Constant	11.88** (5.182)	11.73** (5.431)	11.88** (5.175)	11.52** (5.691)	11.81** (5.120)	11.93** (5.297)	11.31** (5.188)	9.056 (5.821)
Number of exam outcomes	3633	3627	3684	3678	3677	3671	3678	3672
Number of subjects	573	572	581	580	580	579	580	579
Wooldridge's (1995) robust endogeneity test (p-value)	-	0.025	-	0.012	-	0.007	-	0.043
First stage: effect of instrument on sleep quality measure	-	0.398*** (0.059)	-	0.146*** (0.027)	-	0.430*** (0.058)	-	0.303*** (0.061)

All PSQI and DASS scales are normalised by subtracting the sample mean and dividing the result by the sample standard deviation. Used abbreviations: BE: (Business) Economics; CS: Commercial Sciences. Used instrumental variable for sleep quality measures in 2SLS: sleep quality during secondary education index. Standard errors are between parentheses and clustered at the subject level. ***(**)(*) indicates significance at the 1%(5%)(10%) level. The various numbers of exam outcomes and subjects can be explained by a different number of missing explanatory and instrumental variables across the regression models.

Table A.4 – Complete Estimation Results: the Impact of Sleep Quality on Passing Exams (Completed Exams)

Regression number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Dependent variable	Exam passed (mark ≥ 10): completed exams							
A. Main explanatory variables								
PSQI: total measure (normalised)	-0.014 (0.013)	-0.092** (0.044)						
Poor sleep quality (PSQI > 5) (normalised)			-0.001 (0.027)	-0.248* (0.127)				
PSQI: submeasure overall perceived sleep quality (normalised)					0.006 (0.019)	-0.084** (0.041)		
PSQI: submeasure sleep duration (normalised)							-0.031** (0.011)	-0.120** (0.057)
B. Control variables								
Age	-0.024 (0.029)	-0.023 (0.030)	-0.024 (0.029)	-0.011 (0.032)	-0.024 (0.029)	-0.029 (0.029)	-0.020 (0.028)	-0.009 (0.029)
Female Sex	0.032 (0.027)	0.031 (0.027)	0.029 (0.026)	0.033 (0.028)	0.029 (0.026)	0.024 (0.027)	0.029 (0.026)	0.029 (0.027)
Highest diploma mother								
Tertiary education: college	-0.025 (0.036)	-0.027 (0.037)	-0.026 (0.036)	-0.032 (0.039)	-0.024 (0.036)	-0.033 (0.038)	-0.022 (0.035)	-0.007 (0.037)
Tertiary education: outside college	-0.023 (0.031)	-0.022 (0.032)	-0.021 (0.031)	-0.024 (0.033)	-0.021 (0.031)	-0.012 (0.032)	-0.018 (0.031)	-0.007 (0.031)
No tertiary education (Reference)								
Highest diploma father								
Tertiary education: college	-0.046 (0.033)	-0.039 (0.035)	-0.049 (0.033)	-0.046 (0.036)	-0.050 (0.033)	-0.048 (0.035)	-0.047 (0.033)	-0.042 (0.034)
Tertiary education: outside college	-0.014 (0.032)	-0.022 (0.033)	-0.011 (0.032)	-0.015 (0.034)	-0.011 (0.032)	-0.025 (0.034)	-0.009 (0.032)	-0.010 (0.033)
No tertiary education (Reference)								
At least one of parents passed away	-0.033	-0.021	-0.040	-0.008	-0.042	-0.043	-0.032	-0.037

	(0.090)	(0.097)	(0.089)	(0.108)	(0.088)	(0.098)	(0.089)	(0.098)
Parents divorced	0.003 (0.031)	0.012 (0.032)	-0.001 (0.031)	0.013 (0.034)	-0.001 (0.031)	-0.001 (0.031)	0.005 (0.031)	0.024 (0.034)
Grandmother on mother's side foreign nationality	-0.171** (0.055)	-0.152** (0.057)	-0.174** (0.055)	-0.155** (0.057)	-0.176** (0.055)	-0.134** (0.059)	-0.161** (0.056)	-0.121* (0.068)
Number of siblings								
None (Reference)								
One	-0.031 (0.049)	-0.028 (0.048)	-0.031 (0.050)	-0.037 (0.052)	-0.031 (0.050)	-0.026 (0.051)	-0.031 (0.049)	-0.031 (0.049)
Two	0.002 (0.052)	0.012 (0.051)	0.001 (0.053)	0.007 (0.055)	0.001 (0.053)	0.100 (0.054)	0.001 (0.052)	-0.001 (0.052)
More than two	0.001 (0.062)	-0.016 (0.063)	0.007 (0.062)	-0.018 (0.066)	0.007 (0.062)	0.009 (0.066)	0.001 (0.061)	-0.019 (0.062)
Living in a student room	0.035 (0.024)	0.046* (0.025)	0.032 (0.024)	0.035 (0.025)	0.032 (0.024)	0.046* (0.025)	0.027 (0.024)	0.013 (0.026)
Program in secondary education								
Economics - languages/sports	-0.163*** (0.043)	-0.159*** (0.045)	-0.177*** (0.043)	-0.166*** (0.048)	-0.177*** (0.043)	-0.172*** (0.045)	-0.181*** (0.043)	-0.200*** (0.048)
Economics - maths	-0.006 (0.038)	-0.016 (0.039)	-0.015 (0.038)	-0.030 (0.042)	-0.014 (0.038)	-0.020 (0.039)	-0.022 (0.038)	-0.047 (0.043)
Ancient languages	-0.041 (0.041)	-0.052 (0.043)	-0.047 (0.040)	-0.054 (0.044)	-0.046 (0.040)	-0.051 (0.042)	-0.051 (0.040)	-0.068 (0.044)
Exact sciences - maths (Reference)								
General secondary education: other	-0.061 (0.055)	-0.079 (0.059)	-0.059 (0.054)	-0.079 (0.059)	-0.058 (0.054)	-0.089 (0.060)	-0.065 (0.053)	-0.088 (0.057)
Technical secondary education	-0.425*** (0.074)	-0.413*** (0.074)	-0.440*** (0.074)	-0.413*** (0.076)	-0.441*** (0.074)	-0.430*** (0.076)	-0.434*** (0.073)	-0.422*** (0.076)
General end marks in secondary education								
Less than 70% (Reference)								
Between 70% and 80%	0.198** (0.093)	0.210** (0.090)	0.199** (0.095)	0.239** (0.106)	0.199** (0.096)	0.216** (0.096)	0.213** (0.096)	0.252** (0.100)
More than 80%	0.389***	0.396***	0.393***	0.421***	0.392***	0.406***	0.406***	0.447***

	(0.093)	(0.090)	(0.095)	(0.104)	(0.096)	(0.096)	(0.096)	(0.010)
In a relationship	0.008	0.001	0.006	-0.007	0.006	-0.003	0.002	-0.010
	(0.024)	(0.024)	(0.024)	(0.026)	(0.024)	(0.024)	(0.024)	(0.025)
General health								
Very good	0.057	0.024	0.055	0.017	0.056	0.027	0.050	0.036
	(0.043)	(0.048)	(0.043)	(0.050)	(0.043)	(0.046)	(0.043)	(0.046)
Good	0.020	0.004	0.014	-0.014	0.014	0.002	0.012	0.006
	(0.041)	(0.043)	(0.041)	(0.046)	(0.041)	(0.042)	(0.041)	(0.042)
Moderate, bad or very bad (Reference)								
DASS-21 depression scale (normalised)	-0.007	0.004	-0.111	0.002	-0.012	-0.005	-0.011	-0.011
	(0.018)	(0.020)	(0.017)	(0.020)	(0.017)	(0.018)	(0.017)	(0.018)
DASS-21 anxiety scale (normalised)	0.023	0.032*	0.022	0.035	0.021	0.030*	0.023	0.027
	(0.017)	(0.018)	(0.017)	(0.019)	(0.017)	(0.018)	(0.017)	(0.019)
DASS-21 stress scale (normalised)	-0.013	0.005	-0.014	0.001	-0.015	0.004	-0.015	-0.017
	(0.019)	(0.022)	(0.018)	(0.021)	(0.018)	(0.021)	(0.018)	(0.019)
Number of ECTS-credits in program	0.002	0.001	0.002	-0.003	0.002	0.005	0.002	0.001
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.10)	(0.010)	(0.010)
Program of BE: Accounting	-0.042*	-0.041	-0.035	-0.034	-0.035	-0.035	-0.035	-0.035
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Program of BE: Economics	-0.128***	-0.128***	-0.124***	-0.124***	-0.124***	-0.124***	-0.124***	-0.124***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Program of BE: Human Sciences	-0.159***	-0.158***	-0.158***	-0.157***	-0.158***	-0.158***	-0.158***	-0.158***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Program of BE: Law	-0.042	-0.042	-0.038	-0.038	-0.038	-0.038	-0.039	-0.040
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Program of BE: Mathematics	-0.157***	-0.157***	-0.149***	-0.150***	-0.149***	-0.150***	-0.150***	-0.150***
	(0.027)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Program of BE: Production Technology (Reference)								
Program of CS: Accountancy	-0.270***	-0.275***	-0.258***	-0.252***	-0.255***	-0.269***	-0.258***	-0.257***
	(0.044)	(0.045)	(0.044)	(0.045)	(0.044)	(0.045)	(0.044)	(0.044)
Program of CS: Commercial and Financial Transactions	0.090**	0.085**	0.103**	0.108**	0.103**	0.089**	0.102**	0.104**
	(0.041)	(0.042)	(0.040)	(0.043)	(0.040)	(0.042)	(0.040)	(0.040)

Program of CS: English	0.197*** (0.039)	0.194*** (0.040)	0.206*** (0.039)	0.218*** (0.042)	0.207*** (0.039)	0.194*** (0.041)	0.207*** (0.039)	0.213*** (0.040)
Program of CS: French	-0.056 (0.052)	-0.052 (0.052)	-0.042 (0.051)	-0.018 (0.054)	-0.044 (0.051)	-0.053 (0.053)	-0.036 (0.051)	-0.016 (0.053)
Program of CS: Information Technology	0.197*** (0.050)	0.185*** (0.051)	0.193*** (0.050)	0.181*** (0.052)	0.194*** (0.050)	0.177*** (0.052)	0.187*** (0.050)	0.173*** (0.050)
Program of CS: Law	-0.218*** (0.044)	-0.224*** (0.045)	-0.206*** (0.439)	-0.203*** (0.046)	-0.203*** (0.044)	-0.218*** 0.045	-0.207*** (0.044)	-0.206*** (0.044)
Program of CS: Mathematics	-0.105** (0.044)	-0.110** (0.044)	-0.091** (0.043)	-0.086 (0.045)	-0.092** (0.043)	-0.105** (0.045)	-0.092** (0.043)	-0.089** (0.043)
Program of CS: Microeconomics	0.009 (0.043)	0.004 (0.044)	0.020 (0.043)	0.025 (0.045)	0.023 (0.043)	0.009 (0.044)	0.019 (0.043)	0.021 (0.043)
Constant	0.882 (0.632)	0.879 (0.648)	0.870 (0.632)	0.845 (0.668)	0.864 (0.634)	0.889 (0.638)	0.797 (0.625)	0.599 (0.655)
Number of exam outcomes	3607	3601	3658	3652	3651	3645	3652	3646
Number of subjects	573	572	581	580	580	579	580	579
Wooldridge's (1995) robust endogeneity test (p-value)	-	0.057	-	0.0313	-	0.021	-	0.102
First stage: effect of instrument on sleep quality measure	-	0.398*** (0.059)	-	0.146*** (0.027)	-	0.430*** (0.058)	-	0.303*** (0.061)

All PSQI and DASS scales are normalised by subtracting the sample mean and dividing the result by the sample standard deviation. Used abbreviations: BE: (Business) Economics; CS: Commercial Sciences. Used instrumental variable for sleep quality measures in 2SLS: sleep quality during secondary education index. Standard errors are between parentheses and clustered at the subject level. ***(**)(*) indicates significance at the 1%(5%)(10%) level. The various numbers of exam outcomes and subjects can be explained by a different number of missing explanatory and instrumental variables across the regression models.

Table A.5 – Complete Estimation Results: the Impact of Sleep Quality on Passing Exams (Potential Exams)

Regression number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Dependent variable	Exam passed (mark ≥ 10): potential exams							
A. Main explanatory variables								
PSQI: total measure (normalised)	-0.014 (0.013)	-0.089** (0.044)						
Poor sleep quality (PSQI > 5) (normalised)			-0.000 (0.027)	-0.240* (0.126)				
PSQI: submeasure overall perceived sleep quality (normalised)					0.006 (0.019)	-0.081** (0.041)		
PSQI: submeasure sleep duration (normalised)							-0.032** (0.011)	-0.116** (0.056)
Age	-0.026 (0.029)	-0.025 (0.029)	-0.026 (0.029)	-0.013 (0.031)	-0.026 (0.019)	-0.031 (0.029)	-0.022 (0.028)	-0.012 (0.029)
Female Sex	0.031 (0.027)	0.030 (0.027)	0.028 (0.026)	0.031 (0.028)	0.028 (0.026)	0.023 (0.027)	0.028 (0.026)	0.028 (0.027)
Highest diploma mother								
Tertiary education: college	-0.026 (0.036)	-0.028 (0.037)	-0.027 (0.036)	-0.033 (0.038)	-0.026 (0.036)	-0.034 (0.038)	-0.023 (0.036)	-0.008 (0.038)
Tertiary education: outside college	-0.026 (0.031)	-0.025 (0.032)	-0.024 (0.031)	-0.028 (0.033)	-0.024 (0.031)	-0.016 (0.032)	-0.021 (0.031)	-0.010 (0.032)
No tertiary education (Reference)								
Highest diploma father								
Tertiary education: college	-0.039 (0.033)	-0.033 (0.035)	-0.042 (0.033)	-0.039 (0.36)	-0.043 (0.033)	-0.041 (0.035)	-0.040 (0.033)	-0.036 (0.034)
Tertiary education: outside college	-0.009 (0.032)	-0.016 (0.033)	-0.006 (0.032)	-0.010 (0.034)	-0.006 (0.032)	-0.019 (0.034)	-0.005 (0.032)	-0.005 (0.033)
No tertiary education (Reference)								
At least one of parents passed away	-0.026	-0.016	-0.034	-0.003	-0.035	-0.038	-0.025	-0.031

	(0.089)	(0.096)	(0.088)	(0.106)	(0.088)	(0.097)	(0.088)	(0.097)
Parents divorced	-0.001 (0.031)	0.009 (0.032)	-0.004 (0.031)	0.010 (0.034)	-0.004 (0.031)	-0.003 (0.031)	0.003 (0.031)	0.020 (0.034)
Grandmother on mother's side foreign nationality	-0.170** (0.055)	-0.150** (0.056)	-0.173** (0.055)	-0.154** (0.056)	-0.175** (0.055)	-0.134** (0.059)	-0.160** (0.056)	-0.122* (0.067)
Number of siblings								
None (Reference)								
One	-0.031 (0.048)	-0.028 (0.047)	-0.031 (0.049)	-0.037 (0.051)	-0.031 (0.049)	-0.026 (0.050)	-0.031 (0.048)	-0.031 (0.048)
Two	-0.003 (0.051)	0.005 (0.050)	-0.003 (0.052)	-0.000 (0.054)	-0.004 (0.052)	0.004 (0.053)	-0.004 (0.051)	-0.006 (0.051)
More than two	0.001 (0.061)	-0.016 (0.062)	0.008 (0.061)	-0.018 (0.065)	0.008 (0.061)	0.009 (0.065)	0.001 (0.061)	-0.017 (0.061)
Living in a student room	0.037 (0.024)	0.048* (0.025)	0.034 (0.024)	0.037 (0.025)	0.034 (0.024)	0.048 (0.025)	0.029 (0.024)	0.016 (0.026)
Program in secondary education								
Economics - languages/sports	-0.164*** (0.043)	-0.160*** (0.045)	-0.178*** (0.043)	-0.168*** (0.048)	-0.179*** (0.043)	-0.173*** (0.045)	-0.183*** (0.043)	-0.201*** (0.048)
Economics - maths	-0.007 (0.038)	-0.016 (0.039)	-0.016 (0.038)	-0.029 (0.042)	-0.015 (0.038)	-0.020 (0.040)	-0.022 (0.038)	-0.046 (0.042)
Ancient languages	-0.048 (0.041)	-0.059 (0.043)	-0.053 (0.041)	-0.061 (0.045)	-0.053 (0.041)	-0.058 (0.042)	-0.058 (0.041)	-0.073 (0.044)
Exact sciences - maths (Reference)								
General secondary education: other	-0.065 (0.054)	-0.081 (0.058)	-0.064 (0.054)	-0.082 (0.058)	-0.063 (0.054)	-0.092 (0.059)	-0.069 (0.053)	-0.088 (0.055)
Technical secondary education	-0.429*** (0.073)	-0.418*** (0.073)	-0.444*** (0.073)	-0.418*** (0.076)	-0.445 (0.073)	-0.434*** (0.075)	-0.438*** (0.072)	-0.428*** (0.075)
General end marks in secondary education								
Less than 70% (Reference)								
Between 70% and 80%	0.204** (0.089)	0.214** (0.085)	0.206** (0.091)	0.240** (0.100)	0.206** (0.091)	0.217** (0.091)	0.220** (0.092)	0.257** (0.096)
More than 80%	0.396***	0.401***	0.401***	0.423***	0.401***	0.409***	0.414***	0.454***

	(0.089)	(0.085)	(0.091)	(0.099)	(0.091)	(0.091)	(0.092)	(0.096)
In a relationship	0.008	0.009	0.007	-0.007	0.007	-0.002	0.002	-0.009
	(0.024)	(0.024)	(0.024)	(0.026)	(0.024)	(0.025)	(0.024)	(0.025)
General health								
Very good	0.063	0.032	0.061	0.025	0.062	0.033	0.056	0.043
	(0.044)	(0.048)	(0.044)	(0.050)	(0.044)	(0.046)	(0.043)	(0.046)
Good	0.026	0.010	0.020	-0.006	0.021	0.009	0.018	0.012
	(0.041)	(0.043)	(0.042)	(0.046)	(0.041)	(0.042)	(0.041)	(0.042)
Moderate, bad or very bad (Reference)								
DASS-21 depression scale (normalised)	-0.009	0.001	-0.013	-0.002	-0.014	-0.008	-0.014	-0.014
	(0.018)	(0.020)	(0.018)	(0.021)	(0.018)	(0.019)	(0.018)	(0.019)
DASS-21 anxiety scale (normalised)	0.021	0.030	0.020	0.033*	0.019	0.029*	0.021	0.026
	(0.017)	(0.018)	(0.017)	(0.019)	(0.017)	(0.017)	(0.017)	(0.018)
DASS-21 stress scale (normalised)	-0.012	0.006	-0.013	0.002	-0.013	0.005	-0.014	-0.016
	(0.019)	(0.021)	(0.018)	(0.021)	(0.018)	(0.021)	(0.018)	(0.018)
Number of ECTS-credits in program	0.002	0.001	0.002	-0.003	0.002	0.005	0.002	0.001
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Program of BE: Accounting	-0.046*	-0.046*	-0.040	-0.040	-0.039	-0.039	-0.039	-0.039
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Program of BE: Economics	-0.125***	-0.125***	-0.121***	-0.121***	-0.121***	-0.121***	-0.121***	-0.121***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Program of BE: Human Sciences	-0.158***	-0.158***	-0.160***	-0.157***	-0.156***	-0.157***	-0.157***	-0.157***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Program of BE: Law	-0.053*	-0.053	-0.049*	-0.049*	-0.049*	-0.049	-0.049*	-0.492*
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Program of BE: Mathematics	-0.158***	-0.158***	-0.150***	-0.150***	-0.150***	-0.150***	-0.150***	-0.151***
	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Program of BE: Production Technology (Reference)								
Program of CS: Accountancy	-0.267***	-0.272***	-0.254***	-0.249***	-0.252***	-0.265***	-0.255***	-0.254***
	(0.044)	(0.045)	(0.044)	(0.045)	(0.044)	(0.045)	(0.044)	(0.044)
Program of CS: Commercial and Financial Transactions	0.090**	0.085**	0.103**	0.108**	0.103**	0.090**	0.102**	0.104**
	(0.041)	(0.042)	(0.040)	(0.043)	(0.040)	(0.042)	(0.040)	(0.040)

Program of CS: English	0.200*** (0.039)	0.197*** (0.040)	0.210*** (0.039)	0.221*** (0.041)	0.210*** (0.039)	0.198*** (0.041)	0.210*** (0.038)	0.216*** (0.040)
Program of CS: French	-0.054 (0.052)	-0.050 (0.052)	-0.039 (0.051)	-0.016 (0.053)	-0.041 (0.051)	-0.050 (0.052)	-0.033 (0.051)	-0.015 (0.052)
Program of CS: Information Technology	0.195*** (0.050)	0.182*** (0.050)	0.192*** (0.050)	0.179*** (0.052)	0.193*** (0.050)	0.176** (0.052)	0.185*** (0.050)	0.171*** (0.050)
Program of CS: Law	-0.223*** (0.044)	-0.228*** (0.045)	-0.211*** (0.044)	-0.205*** (0.045)	-0.208*** (0.044)	-0.221*** (0.045)	-0.211*** (0.044)	-0.210*** (0.044)
Program of CS: Mathematics	-0.107** (0.043)	-0.113** (0.044)	-0.094** (0.043)	-0.089** (0.045)	-0.094** (0.043)	-0.107** (0.044)	-0.095** (0.043)	-0.093** (0.043)
Program of CS: Microeconomics	0.012 (0.043)	0.006 (0.044)	0.023 (0.043)	0.028 (0.045)	0.026 (0.043)	0.013 (0.044)	0.022 (0.043)	0.024 (0.043)
Constant	0.897 (0.626)	0.900 (0.642)	0.885 (0.625)	0.869 (0.661)	0.879 (0.627)	0.908 (0.632)	0.813 (0.620)	0.637 (0.651)
Number of exam outcomes	3633	3627	3684	3678	3677	3671	3678	3672
Number of subjects	573	572	581	580	579	579	580	579
Wooldridge's (1995) robust endogeneity test (p-value)	-	0.067	-	0.034	-	0.024	-	0.120
First stage: effect of instrument on sleep quality measure	-	0.398*** (0.059)	-	0.146*** (0.027)	-	0.430*** (0.058)	-	0.303*** (0.061)

All PSQI and DASS scales are normalised by subtracting the sample mean and dividing the result by the sample standard deviation. Used abbreviations: BE: (Business) Economics; CS: Commercial Sciences. Used instrumental variable for sleep quality measures in 2SLS: sleep quality during secondary education index. Standard errors are between parentheses and clustered at the subject level. ***(**)(*) indicates significance at the 1%(5%)(10%) level. The various numbers of exam outcomes and subjects can be explained by a different number of missing explanatory and instrumental variables across the regression models.