



**BS ritgerð  
í hagfræði**

**The Demand for Sleep in the United States**  
An Empirical Analysis

Sigurður Páll Ólafsson

Leiðbeinandi: Tinna Laufey Ásgeirsdóttir  
Hagfræðideild  
Febrúar 2015



**HÁSKÓLI ÍSLANDS**

**The Demand for Sleep in the United States**  
*An Empirical Analysis*

Sigurður Páll Ólafsson

Lokaverkefni til BS-gráðu í hagfræði  
Leiðbeinandi: Tinna Laufey Ásgeirsdóttir

Hagfræðideild  
Félagsvísindasvið Háskóla Íslands

Febrúar 2015

The Demand for Sleep in the United States

An Empirical Analysis

This thesis is equivalent to 12 ECTS credits towards a BS-degree from the Economics Department of the University of Iceland School of Social Sciences.

© 2015 Sigurður Páll Ólafsson

This thesis cannot be reproduced without the author's consent.

Printing: Háskólaprent ehf.

Reykjavík, Iceland, 2015

## **Foreword**

This is a 12 ECTS credit equivalent thesis towards a BS degree in economics. The supervisor of this thesis is associate professor Tinna Laufey Ásgeirsdóttir. I thank Tinna for her valuable insights and directions, which gave me the guidance I needed to complete this thesis. I would also like to thank my parents for their vital support throughout my education.

## **Abstract**

This paper examines empirically the demand for sleep, with special attention given to its price, or more specifically its opportunity cost represented by wages. This is done using continuously gathered data from the American Time Use Survey. To gauge the causal direction of the relationship, exogenous variation in labor-market conditions were of interest. Thus variation in the unemployment rate by State is also used to investigate the cyclical nature of sleep duration. The models in the analysis are estimated using State fixed effects. Furthermore, the models are estimated separately for males and females and separately for those receiving a salary or hourly wages. The results reveal an inverse relationship between sleep duration and wages. This is in accordance with sleep duration being an economic choice variable rather than a predetermined subtraction of the 24-hour day. Although this inverse relationship is not significant in all the estimations for subjects who receive a fixed salary, it is constant and strong among subjects who receive hourly wages. This translates into elasticity measures of  $-0.01261$  for those who receive hourly wages and  $-0.00678$  for those who receive a fixed salary. A positive, strong and significant relationship between sleep duration and usual hours of work per week is also detected. Somewhat surprisingly, however, no relationship was detected between sleep duration and the business cycle.

## Table of Contents

|                                    |    |
|------------------------------------|----|
| Foreword .....                     | 4  |
| Abstract.....                      | 5  |
| Table of Contents.....             | 6  |
| List of Tables .....               | 7  |
| 1 Introduction.....                | 9  |
| 2 Data and Methods.....            | 16 |
| 3 Results .....                    | 25 |
| 3.1 Robustness checks .....        | 32 |
| References .....                   | 40 |
| Appendix A: Robustness Checks..... | 45 |

## List of Tables

|   |    |
|---|----|
| Table 1. Model specifications.....      | 22 |
| Table 2. Summary statistics pt. 1. .... | 26 |
| Table 3. Summary statistics pt. 2. .... | 27 |
| Table 4. Regression results.....        | 31 |





# 1 Introduction

When asked what determines the wage rate, economists often mention factors such as productivity, the unemployment rate or the price level. Unfortunately, the average Joe can do very little to significantly affect the price level or the unemployment rate. He can, however, increase his productivity in several ways. What determines productivity is, in fact, a fundamental question in economics and the answer can affect the decisions of individuals as well as public policy.

The two most common and effective ways to become more productive and increase wages are education and experience. Despite arguably being the largest determinants of productivity, education and experience are far from being the only ones. Sleep duration might for example be another important factor. In fact, sleep has often been associated with increased alertness, cognitive performance and decision making abilities, as well as being regarded as vital for health and wellbeing (Amin et al., 2012; Ellenbogen, 2005; Gildner, Liebert, Kowal, Chatterji, & Snodgrass, 2014; Van Dongen, Maislin, Mullington, & Dinges, 2003). Consequently, sleep not only generates utility, it also generates alertness and is therefore likely to increase productivity, possibly resulting in higher wages. In fact, a recent study shows that one additional hour of sleep per night causes wages to increase by 16% on average, making sleep a key determinant of productivity (Gibson & Shrader, 2014). Specifically, the authors observe that people living in the same time zones devote different amounts of time to sleep, depending on sunset time. They claim that all else being equal, a worker in the east of a given time zone will go to bed earlier than a worker in the west, due to earlier sunset time in the east. However, as a result of synchronized work schedules, the two workers wake up at the same time. Thus, the worker who lives farther east enjoys more sleeping hours than does the worker who lives farther west, making the former more productive. The authors then use sunset time as an instrument to estimate the causal effect of sleep on wages. To put the Gibson and Shrader (2014) results in perspective, the productivity effect, representing the positive causal effect of sleep on wages, is greater than previously reported by one extra year of schooling (Patrinos & Psacharopoulos, 2002).

However, income might affect sleep duration as well, and not just the other way around. Let us take an example of a worker who recently got a raise. The worker's time is now more valuable and the opportunity cost of time spent sleeping has thus increased. As a result, in order to earn an even higher income this worker might choose to spend more time working, therefore reducing the time left available for other activities, including sleeping, which has become more expensive (substitution effect). However, the increased consumption possibilities might cause this decision maker to increase consumption of all normal desiderata, including sleep (income effect).

The relationship between sleep and income can thus be expected to run both ways. Sleep generates alertness, which increases productivity and is therefore expected to raise wages. The causal effect of income on sleep duration would therefore include both income and substitution effects, which are expected to work in the opposite directions. Although either effect could theoretically dominate, a dominant income effect would suggest the unlikely case of sleep being a Giffen good. However, in order for the empirical evidence that only tests correlation, but not causation, to show that the substitution effect outweighs the income effect, the substitution effect not only needs to outweigh the income effect per se, it also needs to outweigh the productivity effect running in the opposite causal direction. The relationship between sleep duration and wages is therefore perhaps not as obvious as it initially appears.

This paper examines empirically the demand for sleep, with special attention given to its price, or more specifically opportunity cost, using continuously gathered data from the American Time Use Survey (ATUS). The data span 11 years, from January 2003 to December 2013. As the relationship between sleep duration and income is theoretically ambiguous and with possible causal pathways running both ways, we furthermore examine the effect of aggregate economic conditions on sleep duration. Economic conditions are arguably exogenous in this relationship, but with obvious labor-market consequences, such as lowered real income. If the relationship running from income to sleep duration was strong enough, we would thus theoretically expect people to substitute towards time intensive consumption, such as sleeping, during

times of economic hardship. If we find a strong relationship between sleep duration and income, but not a strong relationship between aggregate economic conditions and sleep duration would be lend circumstantial evidence to other causal pathways playing an important role in this relationship. Due to the use of this exogenous variations created by economic fluctuations, this paper relates to two strands of literature; both that of sleep and wages, and also to the growing literature on the effects of business cycles on various health, lifestyle and behavioral outcomes.

Furthermore, we divide subjects into two wage groups, subjects who receive a fixed salary and subjects who receive hourly wages. Comparing the wage groups should be interesting, as we believe there might be a structural difference between the groups. In particular, jobs that pay hourly wages might offer increased flexibility for employees, as opposed to jobs that pay fixed salaries. For example, we believe workers who receive hourly wages are generally in a better position to decide themselves, at least to some extent, when and for how long they work and, therefore, how much they earn. We would thus expect a lesser sleep response to wages for salaried workers.

Other theoretical relationships have previously been predicted in the literature (Asgeirsdottir & Zoega, 2011). Although not the main focus of the analysis, those are additionally tested by the inclusion of important controls, such as the hypothesized negative relationship between sleep duration and the presence of young children in the household; the relationship between sleep duration and age; the hypothesized negative relationship between sleep duration and hours spent working; and possible variation in sleep duration across ethnic groups.

This is to our knowledge the first paper to use the ATUS data to explore the effect of the aggregate economic conditions on sleep duration. We believe this is also the first paper, using the ATUS data, to approach the relationship between sleep duration and income from the perspective of the opportunity cost of time, or more precisely, the opportunity cost of sleeping.

When describing the optimal management of time, economists have predominantly neglected the time spent sleeping in their models, often treating it as a predetermined subtraction of the 24-hour day. However, there is a growing literature on the subject, encouraging economists to make room for sleep variables in those

models. The reason is that sleep duration is an economic choice variable which may vary substantially both between individuals as well as within individuals over time, depending on that individuals willed behavior.

The first ones to address this topic were Biddle and Hamermesh (1990). They assume sleep has a utility generating effect and a positive effect on income as well. Their results show that high-income men substitute away from time intensive commodities such as sleep, resulting in an inverse relationship between sleep duration and income. Interestingly, the results show that men did not substitute away from sleep to more market work. The amount of time men spent working did, in fact, not change. Instead, time devoted to other non-market production and enjoying leisure increased. How flexible each individual is in determining hours worked may play a role here, leading us to the above mentioned separation between salaried workers and those receiving hourly wages.

Using South African data, Szalontai (2006) repeats the analysis of Biddle and Hamermesh and reports very similar results. Specifically, he detects a negative relationship between sleep duration and income. Furthermore, Szalontai concludes that changes in economic wellbeing leads to changes in the demand for sleep, making sleep an economic phenomenon as well as a biological one. Additionally, Asgeirsdottir and Zoega (2011) provide further theoretical elaboration and examine the effect of other variables as well, such as difficulties sleeping or the presence of young children in the household.

Recent work from Iceland reports an increase in sleep duration as a result of the global financial crisis which struck the country in October 2008 (Asgeirsdottir, Corman, Noonan, Olafsdottir, & Reichman, 2014; Asgeirsdottir & Zoega, 2011). These results are in line with Brochu et al. (2012) who find that sleep duration decreases when the economy is doing relatively better. However, as predicted by economic theory (Asgeirsdottir & Zoega, 2011) the case may be a bit more complex if economic insecurity increases sleep difficulties, which may theoretically reduce sleep duration. As a matter of fact, a recent study from Greece reports an increase in sleep difficulties, leading to reduced sleep duration among public employees facing job insecurity three years after the economic collapse in the country (Nena et al. 2014). The generally

reported negative association between sleep duration and income may thus suggest that the investment in health and alertness can seem too expensive during economic prosperity, *ceteris paribus*, although the cyclicity of sleep difficulties may also play a role.

Fluctuations in labor-market conditions over the business cycle have been used for exogenous variation in wages to examine their effect on sleep duration (Brochu, Armstrong, & Morin, 2012). Arguably the biggest aggregate shock occurring within the time range of the currently used data is the financial crisis of 2007-8, which, although a tragic event, offers researchers a rare opportunity to analyze the effects of a negative economic shock. The unemployment rate in the United States rose from 4.4% in May 2007 and reached its peak of 10.0% in October 2009. Since then, the unemployment rate declined steadily and was 6.7% at the end of the study period. Real GDP fell by 0.3% in 2008 and again by 2.8% in 2009 and real wages fell by 1% in 2008. Real wages also fell in 2011 and 2012 (Bureau of Economic Analysis, 2014; Bureau of Labor Statistics, 2014; Economic Report of the President, 2013). These sorts of changes in the economic environment are bound to change people's behavior, including the way they spend their time. Thus, the nature of the data not only allows us to analyze how people spend their time; it also allows us to analyze how shocks affect utility-maximizing agents's time management.

Economic fluctuations, such as the ones discussed here are interesting in the current context, as the causal relationship between sleep duration and labor-market opportunities is difficult to disentangle. That is, one may be inclined to believe that business cycles create somewhat exogenous variations in labor-market conditions that can shed some light on causal pathways. Although one may possibly come up with stories about how sleep changes are the cause of decreased labor-market activity in recessions, or even the cause of the recessions themselves, those stories would probably be less convincing to most, than the causal explanation that aggregate economic conditions affect sleep as explained above.

Sleep behavior is obviously a biological phenomenon and not just economic. Sleep timing and duration depend on numerous factors and willed behavior is only one of them. It is a well-established fact that base sleep need varies across individuals

(Aeschbach et al., 2003; Van Dongen, Vitellaro, & Dinges, 2005). Thus, some people simply need less sleep than others in order to invest in full alertness for the following day. In other words, there is certain price discrimination present as the cost of investing in full alertness varies between individuals. This price discrimination gives people who need less sleep a definite advantage over their more sleep-needy counterparts, who as a result are either constantly less alert and sleep deprived or have fewer waking hours to generally get things done. This variation in base sleep need may partly be genetically determined (He et al., 2009). However, a recent study has shown that individuals with short habitual sleep duration, do generally carry more sleep debts than those who sleep longer hours (Klerman & Dijk, 2005). It thus appears clear that both biological and economic factors can be expected to affect sleep duration.

Sleep patterns have been shown to vary significantly across demographics such as age, gender, education, race, marital status and the presence of young children in the household (Asgeirsdottir & Zoega, 2011; Brochu et al., 2012; Knutson, Van Cauter, Rathouz, DeLeire, & Lauderdale, 2010; Kronholm, Harma, Hublin, Aro, & Partonen, 2006; Stamatakis, Kaplan, & Roberts, 2007; Stepnowsky, Moore, & Dimsdale, 2003). However, the reasons for these variations are not fully understood yet and could very well be determined by willed behavior due to varying economic incentives across demographic subgroups.

One of many demographic factors that have been associated with sleep duration is age, which has frequently been reported to have a U-shaped relationship with sleep duration, with both young and old people reporting longer sleeping hours than others. A U-shaped relationship has also been detected between sleep duration and variables such as sleep quality and use of sleep medication, with both long and short sleepers reporting more sleeping difficulties than do mid-range sleepers. Furthermore, medical studies have shown a U-shaped relationship between sleep duration and BMI, as both long and short sleepers are more likely to have characteristics related to poor health (Grandner & Kripke, 2004; Kaneita et al., 2007; Kripke et al., 2001; Kripke DF, Garfinkel L, Wingard DL, Klauber MR, & Marler MR, 2002). This might indicate that more sleep is not always better as the rate of alertness

generated while sleeping is almost certainly not constant, and may in fact not be monotonic. Motivated by these findings, we also investigate a possible non-linear relationship between sleep duration and wages. In fact, Gibson and Shrader (2014) have recently done a similar exercise, using the same data but a slightly smaller sample and a different theoretical foundation, and found that wage-optimizing sleep was around 9 hours per night.

How to spend the 24 hours we get each day is an economic decision, as is how much we decide to sleep. Our time is scarce and the alertness we get from sleeping can be seen as a renewable scarce resource (Asgeirsdottir & Zoega, 2011). We go to sleep when we are tired and when we wake up, hopefully we feel more alert and more capable of dealing with the tasks we need to solve that given day. In doing so, we consume the alertness we got from sleeping and as a result we feel less and less alert as the day goes on. This process continues until we feel the need to renew the alertness by going back to sleep. It is therefore quite obvious that the decision of how much time should be spent sleeping is just like any other decision about how and when to exploit a scarce resource. And just like any scarce resource decision, the decision on how much time to spend sleeping can be analyzed with the tools of economics.

In the next chapter, we will introduce the ATUS data and explain the variables and demographics used in the analysis. Furthermore, the methods applied in the analysis are explained and discussed. Results from the empirical estimations can be found in chapter 3. Finally, the drawbacks and advantages of the analysis along with its results are discussed in the fourth and last chapter.

## 2 Data and Methods

The data used in the paper stem from the ATUS, sponsored by the Bureau of Labor Statistics in the United States. They are collected via interviews every month from January 2003 to December 2013. The ATUS provides nationally representative data on how 148,345 individuals spent their time on the day preceding the interview, as well as labor-market and demographic information. It is a subsample of the Current Population Survey (CPS) and respondents, aged 15 or over, were chosen randomly from households finishing their final interview with the CPS. The CPS information, including some demographics of interest, is thus available on the ATUS participants.

The ATUS sample is a stratified three-stage sample. Because the role of the CPS is not only to produce nationally reliable estimates, but also State reliable estimates as well, the CPS oversamples the less-populous States. In order to make the data nationally representative, the ATUS reverses this oversample in the first stage of selection. Subsequently, households are stratified based on the ethnicity of the householder, the presence and age of children, and the number of adults in adults-only households. To improve the reliability of the data for the following demographic groups, households with a Hispanic or non-Hispanic black householder are oversampled. Furthermore, households with children are oversampled to ensure sufficient measures of childcare. At the last stage of selection, a household member over the age of 14 is randomly selected to be the designated person for ATUS.

Respondents are interviewed only one time, by phone, on how they spent the preceding day, starting at 4 AM. Activities are categorized in more than 400 different categories represented by a six-digit code. The ATUS sample is randomized by day, with approximately half of the respondents answering the survey during the weekend and the other half approximately evenly distributed on each weekday (American Time Use Survey User's Guide 2003-2013, 2014)

The key sleep variable in the analysis is sleep duration. Sleep duration is defined as the sum of the reported time spent sleeping, lying sleepless and "sleeping, not elsewhere classified" in this 24-hour period. Therefore sleeping can be thought of as time spent in bed rather than time spent actually sleeping. This definition of sleep includes daytime napping as well, which can make comparison of average sleep



duration between studies difficult, as most studies exclude naps in their definition of sleep, either due to lack of information or perhaps a lack of relevance. However, the total amount of rest fits the purposes of the current analysis better, as the main focus of the analysis is the opportunity cost of sleeping, which is the same whether subjects are actually asleep, trying to fall asleep or taking a nap. Obviously, subjects generate more alertness actually sleeping as opposed to just lying sleepless. However, lying sleepless is essentially resting and could therefore generate some alertness as well, though the process is perhaps not as efficient as the subject would have liked.

In order to examine a plausible relationship between sleep duration and the business cycle we need a variable modelling the business cycle. The variable used to reflect the economic environment is the seasonally adjusted, monthly rate of unemployment by State from the Bureau of Labor Statistics. In other words, our business cycle variable takes the value of the seasonally adjusted unemployment rate of the State in which the subject concerned lives. Note that the higher the value of the business cycle variable, the worse is the economic condition.

As mentioned before, the ATUS oversamples weekends so approximately half of the participants answer the survey on weekend days. Furthermore, the survey diary day starts at 4 AM and ends at 4 AM the following day. This causes a slight inconvenience, not only because sleep duration is expected to be longer on weekends than during regular weekdays, but also because sleep timing, that is the time when people go to sleep, is expected to change during the weekend. This is best explained by an example. Let us take a subject who participated in the ATUS on a Friday. Chances are that after sleeping nine hours, they woke up early Friday morning; say 7 AM, to go to work. In the evening they attended some event, and therefore did not go to sleep until 1 AM, knowing that they did not have to wake up at a specific hour the next day. In fact, let us say they woke up at noon on Saturday. Despite getting many hours of sleep both Friday and Saturday night, nine hours and eleven hours respectively, this would still lead to the reported sleep duration on Friday being only six hours (4 AM to 7 AM on Friday and 1 AM to 4 AM on Saturday). The reverse scenario is likely to happen on Sundays, when subjects are likely to wake up late in the morning and go early to bed in the evening. In order to react to this measurement obstacle and

simultaneously taking into account that sleep behavior is expected to change during weekends, four dummy variables controlling for diary days were constructed; Friday; Saturday; Sunday; and one variable for other weekdays. Other weekdays are pooled into only one variable as sleep duration is not expected to vary significantly between Mondays, Tuesdays, Wednesdays and Thursdays.

The definition of a salary in the ATUS is the following: usual weekly earnings before taxes and other deductions and including any overtime pay, commissions, or tips usually received. Thus, benefits are excluded and the variable represents solely labor-market income. This definition is convenient for the current analysis as the true opportunity cost of time, and therefore the opportunity cost of sleeping, is best described in terms of labor-market income, rather than other income that is independent of time spent in the labor market. Furthermore, as the opportunity cost of sleeping is likely viewed in terms of hourly wages rather than weekly salary, it is hourly wages we are really interested in. Only subjects who receive hourly wages, as opposed to a fixed weekly salary, report their hourly wages. For other subjects, we only have information on fixed weekly salaries.

For subjects who do not report receiving hourly wages, weekly salaries were divided by usual hours spent working per week in order to reflect hourly wages. Those two different constructions of hourly wages thus need to be kept in mind and taken into account in the estimation. Furthermore, to allow meaningful examination of the relationship between sleep duration and wages it was essential to construct a real-wage variable to prevent inflation from affecting the results. In doing so, monthly values of the consumer price index for all urban consumers (CPI-U) from the Bureau of Labor Statistics were used to determine real wages. The formula used was of the form

$$Real\ wages_{y,m} = Nominal\ wages_{y,m} * \frac{(CPI - U)_{2013,12}}{(CPI - U)_{y,m}} \quad (1)$$

With  $m$  denoting the month the respondent concerned was interviewed and  $y$  denoting the year. In this way the wages for every subject are viewed in terms of December 2013 price levels.

Demographics include age in continuous form and an indicator of gender. The variables widowed, divorced, separated, never married and married represent marital status. Raising children is known to reduce time available for sleep, work and other non-market activities, such as enjoying leisure. Furthermore, young children may also keep their parents awake at night and more time is generally spent raising them during the first few years. Thus a dummy variable was constructed for the presence of a child under the age of five in the household.

Subjects were identified by residency using Federal Information Processing Standard (FIPS) State code, wherein subjects living in the same State were assigned the same numeric code. The CPS identifies Hispanics as those who reported their origin as Cuban, Mexican, Puerto Rican, Central, South American, or other Hispanic origin. Now, Hispanic people can obviously be of any race. However, Hispanic people were pooled together in one race category. Those categorized as non-Hispanic were then categorized as black, Asian, native or white. 672 subjects did not belong in any of these categories and were pooled together in one group and coded as others.

Six categories were created for educational attainment. The first group contains subjects who finished 12th grade or less, without a diploma degree. High school graduates with diploma or equivalent degrees are in the second group. Subjects who have an occupational or vocational associate degree fill the third group and in the fourth group are subjects with an associate degree in an academic field. Subjects who hold a Bachelor's degree are in group number five and lastly, subjects who have attained a Master's-, Professional school- or Doctoral degree are pooled together into group number six.

Being on a holiday is expected to change people's sleep behavior. As it was considered irrelevant for the purpose of the analysis how people spend their time during holidays, subjects reporting being on a holiday once participating in the survey were excluded from the estimations. Some subjects reported usually working unrealistically many hours per week. For example, three subjects reported usually spending 160 out of the 168 hours available per week, or just short of 23 out of the 24 hours available per day, doing paid market work. In order to prevent those outliers from affecting the analysis, those subjects reporting usually working more than 90

hours per week were excluded from the analysis. As a result, 119 subjects were dropped.

The reason why subjects who participated in the survey on a weekend day were not excluded from the analysis is that the hours of work variable reflects the usual hours of work per week and not just on the diary day itself, enabling the inclusion of subjects who participated in the survey during the weekend. Furthermore, delaying sleep time for a few days, for example, to use the weekends to catch up on lost sleep is more reasonable than doing so on holidays. However, as sleep behavior is expected to differ on the weekend as opposed to weekdays, dummy variables controlling for the diary day were used, as explained above.

We would like to examine only the variations in our key variables, that is sleep duration, wages, hours of work and the business cycle, and not short- or long term trends in the data. Therefore, a continuous time variable taking the value 1 in January 2003 and up to 132 for December 2013 was constructed. Using simple OLS regression of the form described below, this variable was then used to detect time trends in the key variables.

$$X_t = \beta_0 + \beta_1 * time + \varepsilon_t$$

$X_t$  denotes sleep duration, wages, hours of work or an indicator for the business cycle. Time is the continuous time variable described above and  $\varepsilon_t$  represents the regression residuals. The coefficients  $\beta_0$  and  $\beta_1$  were then estimated for a given variable  $X$ . If  $\beta_1$  differed significantly from zero, then the variable was detrended using the formula

$$X_t - (\beta_0 + \beta_1 * time)$$

One shortcoming of the data stem from the fact that the ATUS continuously asks new individuals for time-use diaries, so an individual panel cannot be constructed. Using individual panel data would have been desirable since, as discussed in the introduction, biological sleep need varies between individuals. The individuals who happen to require shorter sleep duration to recharge their batteries and invest in full alertness for the following day, therefore, have more hours to generally get things

done, compared to their sleepier counterparts. This is a big advantage; let us take students for example. Even though students are usually given the same amount of time to prepare for a test, a student who has low sleep needs can spend more time studying without compromising alertness on the test day, compared to a sleepier fellow student. All else being equal, we would expect the former student to perform better than his sleepier counterpart. The accumulated effect on human capital over time could possibly be enormous, since individuals with low sleep needs can constantly spend more time on various projects than other individuals with higher sleep needs.

As discussed above, we only have one estimate per subject and as a consequence we are unable to take into account individual heterogeneity in sleep needs and the cumulative effects this may have caused with individual fixed effects. However, we do have multiple observations per State. There are probably some fundamental differences between the States, the natural rate of unemployment probably differs across the States, so does the level of output and the weather for example. In order to control for these differences we estimate a State-fixed-effects model. Instead of observing variations within individuals, we examine variations within the States.

The estimated model is on the form:

$$Y_{i,t} = \beta_0 + \beta X_{i,t} + \alpha_i + u_{i,t}$$

where  $Y_{i,t}$  denotes the sleep duration of individual  $i$  at time  $t$ ,  $X_{i,t}$  is the time variant  $1 \times k$  vector of the  $k$  regressors presented in the model, containing both the independent variables of interest, as well as the controls.  $\alpha_i$  is the unobserved time-invariant state effect and  $u_{i,t}$  is the error term.

We estimate four model specifications. In all the specifications, the vector  $X$  contains information on age and age squared, female indicator in full-sample estimations and controls for race, marital status, the presence of young children in the household, weekday and the level of education attained. However, it contains some additional information depending on which model specification is of interest. The following table describes the distinction between the four models.

**Table 1. Model specifications**

| Model:                | Model 1                  | Model 2        | Model 3                  | Model 4                  |
|-----------------------|--------------------------|----------------|--------------------------|--------------------------|
| Besides the           |                          |                |                          | Real wage                |
| covariates always     | Real wage                |                | Real wage                | (Real wage) <sup>2</sup> |
| included, vector X    | (Real wage) <sup>2</sup> | Business cycle | (Real wage) <sup>2</sup> | Business cycle           |
| additionally includes |                          |                | Business cycle           | Weekly work hours        |

The opportunity cost of time is especially relevant for those who receive hourly wages and thus, the models were estimated separately for subjects who receive hourly wages and those who receive a fixed salary. The model was also estimated for the wage groups combined. As the hourly wages variable is constructed differently between the two groups, a dummy variable indicating in which of the aforementioned wage group a given subject belongs, is included in the estimations where the wage groups are both included. That is, while information on hourly wages for those who usually get paid by the hour is readily available in the data, the variable representing hourly wages for those who receive a fixed salary was constructed manually. As a result there is a potential information bias, which the dummy variable helps controlling for.

All the specifications are estimated exclusively for employed subjects. Even though unemployed subjects or those out of the labor force can obviously have positive income, for example in the form of benefits, it is impossible to divide this income by zero working hours and thus view it in terms of hourly wages, which is our measure of opportunity cost. Moreover, such income does not meaningfully represent the opportunity cost of time spent sleeping, as it is independent of time spent in the labor market. While not being zero, that opportunity cost is nonetheless difficult to gauge.

Furthermore, as many determinants of sleep duration are known to vary by gender, the models were estimated separately for each gender as well. Lastly, it is vital to be careful once interpreting the business cycle coefficient, since the

higher the value of the variable, the worse is the economic condition. Therefore, a positive and significant coefficient would indicate that sleep duration is countercyclical. Conversely, a negative and significant coefficient would reveal sleep duration as a procyclical variable.

In order to test the sensitivity of the primary results several robustness checks were performed on model 4. The model was estimated with a 20 hours working restriction. That is, subjects who reported usually working less than 20 hours per week were excluded from the analysis. The estimates are expected to produce somewhat different results. On one hand, excluding part-time workers who work less than 20 hours per week increases the homogeneity of the sample, likely causing changes in the estimations. For example, the working hour restriction most likely causes the exclusion of most students who do part-time work. Another reason is that as the wage variable for subjects receiving fixed wages was constructed by dividing usual weekly earnings by usual hours spent working per week. Those subject who reported working very few hours, occasionally appear to receive very high hourly wages. For example, one subject who reported usually working one hour per week receives \$1,953 per hour, which, incidentally, is also the subject's weekly salary.

Additionally, the model was estimated using only subjects who participated in the ATUS on Monday through Thursday, as the definition of the diary day (from 4 AM to 4 AM) and general incentives are likely to cause increased variation in sleep duration when Fridays, Saturdays and Sundays are included. The model was also estimated using only subjects who reported at least five hours of sleep. The rationale is that one might postpone sleep for one or few days, maybe in order to get something important done. In fact, a few subjects report zero sleeping hours on the diary day. However, one cannot be sleepless for many days and zero to four hours of sleep cannot be considered a long-term equilibrium sleep duration. Eventually, one has to catch up on the sleep loss. Therefore, it is of interest to check if the results change when subjects who reported less than five hours of sleep are excluded.

Model 2, which describes the relationship between sleep duration and the business cycle, is the only model that does not include a wage variable. Thus, it is the only model that is able to include both employed subjects as well as those unemployed

or out of the labor force. To examine the robustness to the sample construction of the main analysis, which includes solely employed subjects, the model was estimated again using all subjects, independent of their labor status.

Finally, making an effort to capture the causal pathway from wages to sleep duration, we used the business cycle variable as an instrument for wages and estimated the models using a two-stage least square estimation. Although the causal relationship from wages to sleep duration is of great interest, we did not make this one of our main estimations. The reason is that the theoretical validity of aggregate unemployment as an instrument in this case is not clear. The aggregate unemployment rate is certainly strongly related to wages, and it can certainly be hypothesized that the only relationship between the business cycle and sleep duration runs through wages. However, this theoretical pathway is not clear and the understanding of this relationship is in its infancy. Thus this method is perhaps not entirely valid as the selection of the instrumental variable is debatable. Although included for completeness, results from those estimations should be taken at face value.



### 3 Results

Summary statistics of the main variables can be found in Tables 2 and 3. The results show that the average reported sleep duration was 8.54 hours. When viewing the genders separately we can see that among subjects who receive a fixed salary, females reported sleeping 10 minutes longer on average per night than males. Among subjects who receive hourly wages the difference was 6 minutes per night, with females reporting longer sleep duration. Additionally, the summary statistics tables indicate that those who receive hourly wages spent more time sleeping than those who receive a fixed salary. The difference was 18 minutes per night on average for males and 14 minutes for females. Moreover, those who receive a fixed salary reported higher wages than those who earn hourly wages. For males, the wages reported by the latter wage group was only 57% of the wages reported by the former wage group. For females, the difference was very similar; 58%. A plausible reason for this difference is partly found lower in the table as, on average, subjects who receive a fixed salary seem to be more educated than those who earn hourly wages.

Now, it is important to remember two things discussed in the previous chapter. Firstly, the reported sleep duration is actually total time spent in bed. Therefore, even though one group reports longer sleep duration than some other group, it does not necessarily mean that the former group spends more time actually sleeping than the latter group. As noted before, problems interpreting the summary statistics tables were expected but this definition of sleep duration fits the main analysis perfectly. Secondly, comparing wage groups might be problematic as well. The reason is that we had to manually construct the wages-per-hour variable for subjects who receive fixed weekly salaries. However, information on wages per hour for the other wage group was readily available in the dataset. So there is a potential information bias in the analysis, which could possibly explain some of the differences between the wage groups.

**Table 2. Summary statistics pt. 1.**

| Variable          | Fixed salary                    |           |                     |           |                       |           |
|-------------------|---------------------------------|-----------|---------------------|-----------|-----------------------|-----------|
|                   | Employed subjects<br>(N=78,588) |           | Males<br>(N=17,778) |           | Females<br>(N=16,620) |           |
|                   | Mean                            | Std. Dev. | Mean                | Std. Dev. | Mean                  | Std. Dev. |
| Sleep duration    | 8.543                           | 2.170     | 8.300               | 1.992     | 8.470                 | 1.996     |
| Wages             | 22.795                          | 19.601    | 32.478              | 23.282    | 27.466                | 27.186    |
| Unemployment rate | 6.603                           | 2.226     | 6.617               | 2.223     | 6.621                 | 2.220     |
| Hours of work     | 40.054                          | 12.3764   | 46.467              | 11.260    | 41.013                | 11.170    |
| Paid hourly       | .5623                           | .4961     | -                   | -         | -                     | -         |
| Female            | .527                            | .499      | -                   | -         | -                     | -         |
| Age               | 41.677                          | 12.933    | 43.151              | 11.419    | 43.334                | 11.531    |
| Married           | .549                            | .498      | .699                | .459      | .558                  | .497      |
| Widow             | .028                            | .164      | .010                | .099      | .036                  | .186      |
| Divorced          | .139                            | .346      | .094                | .293      | .170                  | .376      |
| Separated         | .029                            | .167      | .018                | .133      | .029                  | .167      |
| Never married     | .255                            | .436      | .179                | .383      | .208                  | .406      |
| Child under 5     | .200                            | .400      | .239                | .426      | .182                  | .385      |
| Friday            | .098                            | .297      | .099                | .299      | .100                  | .300      |
| Saturday          | .254                            | .435      | .247                | .431      | .253                  | .435      |
| Sunday            | .252                            | .434      | .255                | .436      | .251                  | .434      |
| Other weekdays    | .396                            | .489      | .398                | .490      | .396                  | .489      |
| Education group 1 | .097                            | .296      | .044                | .205      | .025                  | .156      |
| Education group 2 | .430                            | .495      | .283                | .451      | .287                  | .452      |
| Education group 3 | .052                            | .222      | .038                | .191      | .036                  | .187      |
| Education group 4 | .054                            | .225      | .042                | .201      | .049                  | .217      |
| Education group 5 | .232                            | .422      | .345                | .475      | .335                  | .472      |
| Education group 6 | .136                            | .343      | .248                | .432      | .267                  | .443      |
| White             | .693                            | .461      | .761                | .426      | .732                  | .443      |
| Black             | .123                            | .328      | .074                | .262      | .123                  | .328      |
| Hispanic          | .133                            | .340      | .098                | .297      | .090                  | .286      |
| Asian             | .036                            | .186      | .054                | .226      | .043                  | .203      |
| Native            | .012                            | .108      | .009                | .094      | .008                  | .092      |
| Others            | .005                            | .068      | .004                | .067      | .004                  | .064      |

**Table 3. Summary statistics pt. 2.**

| Variable          | Hourly wages        |           |                       |           |
|-------------------|---------------------|-----------|-----------------------|-----------|
|                   | Males<br>(N=19,407) |           | Females<br>(N=44,190) |           |
|                   | Mean                | Std. Dev. | Mean                  | Std. Dev. |
| Sleep duration    | 8.608               | 2.359     | 8.714                 | 2.232     |
| Wages             | 18.628              | 11.033    | 15.980                | 9.756     |
| Unemployment rate | 6.610               | 2.228     | 6.576                 | 2.231     |
| Hours of work     | 40.469              | 11.828    | 34.487                | 11.845    |
| Age               | 40.005              | 13.682    | 40.818                | 13.956    |
| Married           | .521                | .500      | .459                  | .498      |
| Widow             | .012                | .108      | .047                  | .212      |
| Divorced          | .119                | .323      | .167                  | .373      |
| Separated         | .026                | .160      | .039                  | .193      |
| Never married     | .322                | .467      | .288                  | .453      |
| Child under 5     | .190                | .393      | .193                  | .394      |
| Friday            | .096                | .294      | .097                  | .297      |
| Saturday          | .257                | .437      | .257                  | .437      |
| Sunday            | .248                | .432      | .254                  | .435      |
| Other weekdays    | .399                | .490      | .392                  | .488      |
| Education group 1 | .170                | .376      | .126                  | .332      |
| Education group 2 | .562                | .496      | .527                  | .499      |
| Education group 3 | .058                | .234      | .067                  | .251      |
| Education group 4 | .049                | .215      | .069                  | .253      |
| Education group 5 | .126                | .332      | .164                  | .370      |
| Education group 6 | .035                | .184      | .047                  | .211      |
| White             | .648                | .478      | .651                  | .477      |
| Black             | .120                | .326      | .160                  | .366      |
| Hispanic          | .190                | .392      | .144                  | .351      |
| Asian             | .024                | .153      | .028                  | .164      |
| Native            | .015                | .121      | .014                  | .116      |
| Others            | .004                | .066      | .005                  | .073      |

The main results of the analysis can be viewed in table 4, which contains point estimates and standard errors on the main variables of interest for all the model specifications. The findings from the first model show that the relationship between sleep duration and wages was a non-linear negative one when we look at the wage groups combined. However, separating the wage groups revealed that the group of subjects receiving hourly wages really drove the results. The relationship between sleep duration and wages was statistically insignificant for subjects who receive a fixed salary. However, wages and the squared term of wages were significantly associated with sleep duration for those who reported receiving hourly wages, resulting in a non-linear curve describing the relationship between sleep duration and wages. When viewing both genders combined, this non-linear curve for subjects who receive hourly wages is minimized at \$58 per hour. With less than 1% of the sample earning more than \$58 per hour the curve is essentially a downward sloping convex one. Although the wage coefficients did not differ significantly between males and females, the curve is minimized at \$64.5 per hour for males and \$50.5 per hour for females. 0.7% of males in the sample earned above \$64.5 per hour and 1.2% of females earned wages above \$50.5 per hour.

Model 2 reveals that there was no significant relationship between sleep duration and the business cycle. Furthermore, since there was no relationship between sleep duration and the business cycle, model 3, including both the wages variable and the business cycle variable, adds very little to the first model, which includes only the former variable.

The last model highlights the strong negative relationship between sleep duration and usual hours of work per week. This inverse relationship was not very surprising. It is, however, interesting that the correlation between the variables was significantly stronger for subjects who receive a fixed salary. Assuming the causal pathway runs from working hours to sleep duration, working one hour longer reduces sleep duration by a larger amount for those who receive a fixed salary than for those who receive hourly wages. Furthermore, the inclusion of usual working hours per week in the model altered the wages coefficients from model 1. Whereas in the first model, the relationship between sleep duration and wages was only significant for subjects

who receive hourly wages, the relationship appears significant for both wage groups and both genders in model 4. Only when we examined the genders combined, the squared term of wages did appear significant. This applied to both wage groups. For the group receiving fixed salaries, the non-linear curve describing the relationship between sleep duration and wages is minimized at \$1177 per hour. However, the relationship was linear and inverse when the genders were separated. For the other wage group, the same curve is minimized at \$69 per hour. With less than 1% of the wage sample receiving more than \$69 per hour and exactly one subject in the salaried sample receiving above \$1177 per hour, the curve describing the relationship between sleep duration and wages can essentially be viewed as a strictly downward sloping convex one. These results indicate that people who earn high wages generally sleep less than those who earn low wages.

However, as we have already shown the relationship between sleep duration and the business cycle to be an insignificant one, we decided to present a revised edition of model 4. The only distinction between the original and the revised edition is that the business cycle variable is excluded from the revised edition because including an insignificant variable in the model has no advantages for the analysis. In fact, including such variables could possibly have some variance inflating impact on the estimations, thus potentially harming the analysis. The estimation of the revised edition of model 4, presented at the bottom of table 4, shows however, that excluding the business cycle variable yielded results almost identical to the original edition of model 4.

Other results of the analysis (available upon request) show that sleep duration was positively associated with being female among subjects who reported receiving a fixed salary. Interestingly, this relationship was not detected among females who reported receiving hourly wages. A negative relationship between sleep duration and age was detected in all estimations except for men who receive hourly wages. Interestingly, the squared term was only significant for subjects who receive a fixed salary, indicating a non-linear relationship between sleep duration and age. This convex curve describing the relationship between sleep duration and age for all subjects who receive a fixed salary is minimized at the age of 64.

Married subjects generally reported significantly lower sleep duration than did divorced and separated subjects as well as subjects who have never been married. Widowed subjects did not seem to differ significantly from their married counterparts. This was the general rule, though the results were not completely consistent across wage groups and genders. Furthermore, as expected the presence of a child under the age of five in the household was associated with shorter sleep duration.

Those subjects in education groups two through six reported shorter sleep duration than subjects in education group one. Among those five groups, groups two through six, only group two and six differ from one another, with group six reporting significantly lower sleep duration than did group number two. Some differences between races were observed as Hispanic and Asian subjects reported longer sleep duration than did whites, blacks, natives and others. Although blacks occasionally reported longer sleep duration than whites the results were not consistent, neither across labor-market groups nor genders.

As expected, the regression analysis suggests sleep duration was longer among subjects participating in the survey during the weekend. The Sunday effect was especially big, with sleep duration increasing by more than one and a half hour compared to a 49 minutes increase on Saturdays relative to regular weekdays. The Friday effect was, however, negative as the subjects reported sleeping roughly 16 minutes shorter than during regular weekdays. These results did not differ significantly between wage groups or gender. The variation, especially between Sundays and Fridays, was expected and is partly due to the 24-hour diary day starting and ending at 4 AM.

The estimations reveal that the same variables consistently had the strongest association with sleep duration. Those were the positive association between sleep duration and weekend days, the weekend effect, as well as the inverse relationship between sleep duration and hours spent doing paid work.

**Table 4. Regression results.**

| Model 1                          | Total                    | Fixed salary            |                        | Total                  | Hourly wages           |                        | Combined                 |
|----------------------------------|--------------------------|-------------------------|------------------------|------------------------|------------------------|------------------------|--------------------------|
|                                  | (N=34398)                | Males<br>(N=17778)      | Females<br>(N=16620)   | (N=44190)              | Males<br>(N=19407)     | Females<br>(N=24783)   | Total<br>(N=78588)       |
| Wages                            | -0.00036<br>(.00057)     | -.00026<br>(.00095)     | -.00025<br>(.00083)    | -.0169***<br>(.0027)   | -.0186***<br>(.0039)   | -.0157***<br>(.0039)   | -.0020***<br>(.00053)    |
| Wages <sup>2</sup>               | 1.23e-07<br>(5.90e-07)   | -6.80e-07<br>(2.36e-06) | 1.41e-07<br>(6.83e-07) | .00015***<br>(.000037) | .00014***<br>(.000050) | .00016***<br>(.000060) | 1.32e-06**<br>(6.17e-07) |
| <b>Model 2</b>                   |                          |                         |                        |                        |                        |                        |                          |
| Business cycle                   | -.00099<br>(.0066)       | .0059<br>(.0092)        | -.0082<br>(.0095)      | -.00075<br>(.0067)     | -.0060<br>(.0104)      | .0038<br>(.0088)       | -.00095<br>(.0048)       |
| <b>Model 3</b>                   |                          |                         |                        |                        |                        |                        |                          |
| Wages                            | -0.00039<br>(.00057)     | -.00031<br>(.00095)     | -.00027<br>(.00083)    | -.0169***<br>(.0027)   | -.0185***<br>(.0039)   | -.0157<br>(.0039)      | -.0020***<br>(.00053)    |
| Wages <sup>2</sup>               | 1.51e-07<br>(5.91e-07)   | -5.86e-07<br>(2.36e-06) | 1.63e-07<br>(6.83e-07) | .00015***<br>(.000037) | .00014***<br>(.000050) | .00016<br>(.000060)    | 1.33e-06**<br>(6.17e-07) |
| Business cycle                   | -.00080<br>(.0066)       | .0060<br>(.0092)        | -.0079<br>(.0095)      | -.00018<br>(.0067)     | -.0056<br>(.0104)      | .0044<br>(.0088)       | -.00090<br>(.0048)       |
| <b>Model 4</b>                   |                          |                         |                        |                        |                        |                        |                          |
| Wages                            | -.0029***<br>(.00058)    | -.0037***<br>(.00096)   | -.0022**<br>(.00084)   | -.0106***<br>(.0027)   | -.0121***<br>(.0039)   | -.0094**<br>(.0040)    | -.0031***<br>(.00053)    |
| Wages <sup>2</sup>               | 1.25e-06**<br>(5.89e-07) | 1.69e-06<br>(2.34e-06)  | 9.48e-07<br>(6.83e-07) | .000077**<br>(.000037) | .000079<br>(.000050)   | .000076<br>(.000060)   | 1.56e-06**<br>(6.14e-07) |
| Business cycle                   | -.00093<br>(.0066)       | .0046<br>(.0091)        | -.0071<br>(.0095)      | -.0031<br>(.0067)      | -.00118<br>(.0104)     | .0031<br>(.0088)       | -.0027<br>(.0047)        |
| Working hours                    | -.0201***<br>(.00094)    | -.0236***<br>(.0013)    | -.0167***<br>(.0014)   | -.0140***<br>(.00095)  | -.0146***<br>(.0015)   | -.0115***<br>(.0012)   | -.0168***<br>(.00066)    |
| <b>Model 4 (Revised edition)</b> |                          |                         |                        |                        |                        |                        |                          |
| Wages                            | -.0029***<br>(.00058)    | -.0038***<br>(.00096)   | -.0022**<br>(.00084)   | -.0106***<br>(.0027)   | -.0121***<br>(.0039)   | -.0095**<br>(.0040)    | -.0031***<br>(.00053)    |
| Wages <sup>2</sup>               | 2.35e-06**<br>(5.89e-07) | 1.69e-06<br>(2.34e-06)  | 9.49e-07<br>(6.83e-07) | .000077**<br>(.000037) | .000079<br>(.000050)   | .000077<br>(.000060)   | 1.56e-06**<br>(6.14e-07) |
| Working hours                    | -.0201***<br>(.00094)    | -.0237***<br>(.0013)    | -.0167***<br>(.0014)   | -.0140***<br>(.00095)  | -.0175***<br>(.0015)   | -.0115***<br>(.0012)   | -.0168***<br>(.00066)    |

\*\*\* p < .01, \*\* p < .05, \* p < .10. Standard errors in brackets.

### **3.1 Robustness checks**

Results from the robustness checks can be found in Appendix A. The findings from model 4 did not change much when a 20-hour minimum work hour restriction was imposed. Obviously, the coefficients slightly changed but not to a significant degree. However, the most notable change was that the previously significant association between sleep duration and wages was no longer significant for females. The negative relationship between sleep duration and hours worked became significantly stronger for subjects who received hourly wages, perhaps indicating that every extra hour of work reduces sleep duration to a greater extent than did the preceding hour of work. That is, when working hours are constantly increased, the amount of time spent sleeping lowers at an increasing rate. The coefficient for the fixed-salary group suggests a stronger relationship as well, although the work-hour restriction did not significantly affect the previous results.

Subjects who are unemployed or out of the labor force were added to the sample and model 2 was estimated again. Furthermore, model 2 was also estimated without employed subjects. The rationale was to examine whether the relationship between sleep duration and the business cycle is dependent upon labor-market status, as the variation can certainly both happen at the extensive and intensive margins of labor supply. The results show that even though the business cycle coefficients obviously changed, no statistically significant relationship was found between sleep duration and the business cycle. Although, when estimating model 2 using all subjects irrelevant of labor-market status, the relationship between sleep duration and the business cycle became close to being a positively significant one.

The model was then estimated without subjects who participated in the survey on Fridays, Saturdays and Sundays. Although the point estimates of wages indicated a stronger relationship between sleep duration and wages than reported in the main analysis, the estimates did not differ significantly. As a result, we conclude that the dummy variables for subjects who participated in the survey on a Friday or during the weekend successfully controlled for the variation in sleep duration during the weekend.



The minimum 5-hour sleep restriction hardly changed the wage coefficients from model 4. However, the relationship between sleep duration and hours of work, although still being a statistically significant one, weakened significantly.

Furthermore, the two-stage least squared estimation indicated no causal pathway from variations in the business cycle to changes in sleep duration. Although the method is questionable, its results support the findings of the main analysis showing no relationship between sleep duration and the business cycle. Although the relationship between wages and the business cycle was positive and highly statistically significant, we reiterate that estimations using the business cycle for exogenous variation should be read as merely circumstantial evidence.

## 4 Discussion

The decision of when to sleep and for how long is to some extent an economic decision as well as a biological necessity. Sleep generates alertness which can be exploited the following day. However, the time spent sleeping reduces the time available for using the alertness generated by the sleep. The decision of when and how much we sleep is therefore similar to the decision of when and how to exploit any renewable natural resource (Asgeirsdottir & Zoega, 2011).

The main purpose of the current analysis is to empirically estimate the demand for sleep and, therefore, the relationship between sleep duration and hourly wages, representing its opportunity cost. The theory proposed here is that wages have a negative impact on sleep duration, because even though the income and substitution effect are expected to work in opposite directions, we would not expect the income effect to outweigh the substitution effect. However, Gibson and Shrader (2014) recently reported that longer sleep duration leads to higher wages, through what we have called the productivity effect. The productivity effect arises because by getting enough sleep we are investing in alertness, which can be used the following day to increase productivity, and thus wages. Since the productivity effect helps the income effect to battle the substitution effect, the relationship between sleep duration and wages appeared ambiguous prior to the estimation of the demand function.

One of the most striking results of the analysis was the seemingly fundamental difference between the wage groups. Comparing them revealed that the relationship between wages and sleep duration was stronger for the group receiving hourly wages. Indeed, the first and third models showed no significant relationship between sleep duration and wages among those who receive a fixed salary. This relationship for the other wage group was a downward sloping convex one. Furthermore, while females who receive a fixed salary tended to spend more time sleeping than males, there was no such significant difference between the genders among those who receive hourly wages. Another interesting result was the inverse relationship between sleep duration and wages. The relationship was an inverse one despite the positive causal pathway from sleep to wages reported by Gibson and Shrader (2014). Therefore, the substitution effect outweighed the income and productivity effects combined.

The average sleep duration reported of just above 8.5 hours is approximately one to one and a half hour longer than reported in other similar studies (Groeger, Zijlstra, & Dijk, 2004; Kronholm et al., 2006; Tribl et al., 2002). There are two simple explanations for this. The fact is not necessarily that Americans sleep more than others. First, the definition of sleep duration used in this analysis is time spent sleeping, napping or trying to sleep. While this definition of sleep duration is perhaps not the most precise one in terms of analyzing how much time people actually spend sleeping, it actually fits the purpose of the main analysis perfectly since the opportunity cost of time in bed is the same regardless of whether you are napping, resting or actually sleeping. This definition of sleep, although problematic for comparison of average sleep duration, is therefore appropriate in this analysis and is expected to yield more precise estimations than if sleep duration was defined as actual time asleep. Second, the information presented in the survey is self-reported through phone. When information about sleep duration is self-reported, rather than observed, people may be expected to overestimate their time spent sleeping (Lauderdale et al., 2008). The reason might be that while it is rather easy to determine when you wake up in the morning, it is quite difficult to determine precisely the moment you fall asleep. As a result, sleep duration reported in self-reported surveys is in fact, time spent in bed, which is obviously higher than actual sleep duration.

The convex relationship between age and sleep duration among subjects who receive a fixed salary is in line with the previous literature, although the shortest sleep duration has previously been observed when people are in their thirties and forties but not in their sixties as the results in the current analysis suggest (Jean-Louis, Kripke, Ancoli-Israel, Klauber, & Sepulveda, 2000; Szalontai, 2006). This inconsistency might be due to the fact that the current analysis includes only employed subjects and thus does not reflect the society as a whole. However, a robustness check to model 2 was performed using employed subjects as well as those unemployed or out of the labor force. By minimizing the same curve for this sample, we see that the shortest sleep duration is observed around the age of 50; 47 for males and 53 for females.

As noted earlier, the point estimates for the female dummy was positive for both labor-market groups. However it was only a statistically significant factor for

subjects who receive a fixed salary. This is therefore at least somewhat consistent with previous reports (Brochu et al., 2012; Burgard & Ailshire, 2013) as they find that in general, females tend to devote more time to sleep than do males. However, we have shown this not to be true for females who receive hourly wages. Not surprisingly and in line with other studies (Matchock & Mordkoff, 2014; Szalontai, 2006), an inverse association between the presence of young children in the household and sleep duration was detected. Young children often need constant attention and the time spent raising them is generally partly taken from time spent sleeping. An inverse relationship was also detected between sleep duration and hours spent working. This was expected and is consistent with previous studies (Basner et al., 2007; Chatzitheochari & Arber, 2009; Krueger & Friedman, 2009)

As far as marital status is concerned, the findings are in line with several other studies claiming that marital status is associated with sleep duration. However, results appear to be quite inconsistent across studies. While some studies, including this one, suggest that married subjects sleep less than divorced subjects and subjects who have never been married (Szalontai, 2006), others suggest the opposite (Knutson et al., 2010; Stranges et al., 2008). Studies even show no relationship at all between marital status and sleep duration (Brochu et al., 2012). The reasons for this inconsistency are unclear. However, one can speculate that it is partly due to the various incentives people face depending on their social class or context in which they live. Furthermore, at least one study has reached the conclusion that being single increases the odds of both short and long sleep (Hale, 2005). As a result, when constantly searching for a linear relationship between marital status and sleep duration, results can become inconsistent. The third possible explanation for the inconsistencies in the association between sleep duration and marital status has to do with how the questions about marital status are presented. If the questions or the response options differ across surveys, then inconsistencies are to be expected.

One of the most surprising results of the current analysis is the consistently insignificant results of the business cycle variable. This is somewhat contrary to a recent study from Iceland, which observes an increase in sleep duration following the financial crisis and the collapse of the banking system in the country (Asgeirsdottir et

al., 2014). However, the impact of the crisis in the USA is perhaps not comparable to the impact it had on Iceland. Iceland has a very small and volatile currency, which took a massive dive during the financial crisis in the country. At the end of 2007, one US dollar was equivalent to 62.25 Icelandic krona. Less than a year later, in November 2008 when the exchange rate between the US dollar and the Icelandic krona reached its peak, one US dollar was equivalent to 135.32 Icelandic krona. At the end of December 2013, the end of the study period, the exchange rate between the US dollar and the Icelandic krona was  $115 \frac{\text{krona}}{\$}$  (Central Bank of Iceland, 2014). This massive downfall in the exchange rate of the Icelandic krona resulted in high inflation and as a result, real wages fell by 3.7% in 2008 and 7.3% in 2009, as opposed to just over 1% downfall in the real wage rate in 2008 in the US. The real wage rate rose again in the US in 2009 but decreased in 2011 and 2012 by 0.8% and 0.2% respectively (Statistics Iceland, 2014; Economic Report of the President, 2013). As one can imagine, the impact the crisis surely must have been very different in the two countries. When all this is taken into consideration, it is perhaps not surprising that Icelanders substituted away from good-intensive activities to time-intensive activities to a greater extent than Americans did in the time period under examination.

There is another plausible explanation for why no relationship was detected between sleep duration and the business cycle. The unemployment rate might not be a sufficient indicator for the business cycle. When the business cycle peaks, the unemployment rate is expected to be low and vice versa. However, there are more variables that depend on the business cycle, the price level for example, so using the unemployment rate as an indicator for the business cycle might be an oversimplification. Yet another likely reason is the short time span of the data.

One shortcoming of the data is its time span. As one of the objectives of this analysis is to examine the relationship between sleep duration and the business cycle, we would like the data to span at least two periods of upturns and downturns in the business cycle. However, the data range from January 2003, when the American economy is recovering from the burst of the dot-com bubble, to December 2013, when the economy is recovering from the very next crisis, the Great Recession. Therefore, the time span of the data is relatively short for the purposes of the business cycle

analysis. Another plausible weakness of the data stem from the information being self-reported. This can bias the estimates as people might be inaccurate in their reports or they might even lie, for example, about their actual management of time. Even if there were not systematic differences in peoples' misclassifications, such additional errors would still lead to an attenuation bias.

The revised edition of model 4 was checked for multicollinearity using the correlation coefficient matrix and the variance inflation factor (VIF). There are mainly two rules of thumb used when applying the VIF method. These are the rule of ten and the rule of four, the latter being stricter. If the VIF surpasses the cut-off values, then the model might suffer from multicollinearity. The analysis shows we have three VIFs over four; education group number 2, age and hours worked. The VIF for education group number 2 is 5.41, 10.23 for hours worked and 11.40 for age. Looking at the correlation coefficient matrix, we see that age is mainly correlated to demographics such as marital status and the presence of a young child in the household. The two variables that have the largest correlation with hours worked are the female dummy and an indicator for subjects who receive hourly wages, with correlation coefficients -0.2693 and -0.2513 respectively. The most notable correlation with education group 2 is a -0.2267 correlation to wages and a 0.2582 correlation to the indicator representing subjects who receive hourly wages. While this may have some variance inflating impact on the analysis, we believe it is not a major drawback as model 3 does not contain hours worked and when analyzing the VIFs, it is clear that no VIF exceeds the cut-off value of ten and only two VIFs, those for age and education group 2, exceed the cut-off value of four.

Finally, we were interested in finding the price elasticity of sleep. That is, we wanted to find the percentage change in sleep duration given a certain percentage change in wages. To find the price elasticity of sleep, we take the logarithm of both wages and sleep duration and estimate the revised edition of model 4 for both wage groups. However, the squared term of wages was excluded, as it did not show a significant association with sleep duration. As it is impossible to take logarithm of negative values we cannot detrend the variables like we did in the main estimations, at least not to the same extent. We can either estimate the model without detrending

the sleep variable (there is no significant trend in the wage variable) or we can detrend only the slope and keep the intercept value. Therefore, the mean will be fixed, but not zero. We chose to go with the latter application even though we need to exclude 53 subjects who receive hourly wages and 31 subjects receiving a fixed salary, as they reported 0 hours of sleep and, therefore, appear to have slept a negative amount of time once we have detrended the slope. The price elasticity of sleep proved to be  $-0.01261$  for the group receiving hourly wages and  $-0.00678$  for the group receiving a fixed salary and the demand for sleep is thus quite inelastic.

Overall, we find a negative relationship between sleep duration and wages. This is in accordance with sleep duration being an economic choice variable that responds to economic incentives. As sleep duration varies, not only between individuals but also within individuals over time, sleep duration should preferably be included as a choice variable in time-use models rather than a predetermined subtraction of the 24-hour day. By assuming fixed hours of sleep in time-use models, we are also assuming fixed amount of alertness or at the very least, underestimating the variation of alertness across individuals. Furthermore, as sleep duration has been shown to affect productivity, it must be considered vital for both individual decision-making as well as for public policy. Future work should investigate to further extent which particular aspects of the financial crisis, or of any economic shock for that matter, affect sleep duration and to what extent. It would, furthermore, be important to disentangle the various causal pathways underlying the relationship between sleep duration and wages.

## References

- American Time Use Survey User's Guide (2014).  
<<http://www.bls.gov/tus/atususersguide.pdf>> (Accessed 9/24/14)
- Aeschbach, D., Sher, L., Postolache, T. T., Matthews, J. R., Jackson, M. A., & Wehr, T. A. (2003). A longer biological night in long sleepers than in short sleepers. *Journal of Clinical Endocrinology & Metabolism*, *88*(1), 26–30. doi:10.1210/jc.2002-020827
- Amin, M. M., Graber, M., Ahmad, K., Manta, D., Hossain, S., Belisova, Z., ... Gold, A. R. (2012). The Effects of a Mid-Day Nap on the Neurocognitive Performance of First-Year Medical Residents: A Controlled Interventional Pilot Study. *Academic Medicine*, *87*(10), 1428–1433. doi:10.1097/ACM.0b013e3182676b37
- Asgeirsdottir, T. L., Corman, H., Noonan, K., Olafsdottir, P., & Reichman, N. E. (2014). Was the economic crisis of 2008 good for Icelanders? Impact on health behaviors. *Economics & Human Biology*, *13*, 1–19.  
doi:10.1016/j.ehb.2013.03.005
- Asgeirsdottir, T. L., & Zoega, G. (2011). On the economics of sleeping. *Mind & Society*, *10*(2), 149–164. doi:10.1007/s11299-011-0086-5
- Basner, M., Fomberstein, K. M., Razavi, F. M., Banks, S., William, J. H., Rosa, R. R., & Dinges, D. F. (2007). American time use survey: Sleep time and its relationship to waking activities. *Sleep*, *30*(9), 1085–1095.
- Biddle, J., & Hamermesh, D. (1990). Sleep and the Allocation of Time. *Journal of Political Economy*, *98*(5), 922–943. doi:10.1086/261713
- Brochu, P., Armstrong, C. D., & Morin, L.-P. (2012). The “trendiness” of sleep: an empirical investigation into the cyclical nature of sleep time. *Empirical Economics*, *43*(2), 891–913. doi:10.1007/s00181-011-0508-6
- Burgard, S. A., & Ailshire, J. A. (2013). Gender and Time for Sleep among U.S. Adults. *American Sociological Review*, *78*(1), 51–69. doi:10.1177/0003122412472048



- Bureau of Economic Analysis (2014). GDP percent change based on chained 2009 dollars. <<http://www.bea.gov/national/index.htm#gdp>> (Accessed 9/5/14).
- Bureau of Labor Statistics (2014). Labor Force Statistics from the Current Population Survey: Unemployment rate. <<http://data.bls.gov/timeseries/LNS14000000>> (Accessed 9/5/14).
- Chatzitheochari, S., & Arber, S. (2009). Lack of sleep, work and the long hours culture: evidence from the UK Time Use Survey. *Work Employment and Society*, 23(1), 30–48. doi:10.1177/0950017008099776
- Central Bank of Iceland (2014). Exchange rate. <<http://www.cb.is/exchange-rate/time-series/>> (Accessed 9/15/14).
- Ellenbogen, J. M. (2005). Cognitive benefits of sleep and their loss due to sleep deprivation. *Neurology*, 64(7), E25–E27.
- Gibson, M., & Shrader, J. (2014). Time Use and Productivity: The Wage Returns to Sleep. *eScholarship*. Retrieved from <http://escholarship.org/uc/item/8zp518hc>
- Gildner, T. E., Liebert, M. A., Kowal, P., Chatterji, S., & Snodgrass, J. J. (2014). Associations between Sleep Duration, Sleep Quality, and Cognitive Test Performance among Older Adults from Six Middle Income Countries: Results from the Study on Global Ageing and Adult Health (SAGE). *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, 10(6), 613–21. doi:10.5664/jcsm.3782
- Grandner, M. A., & Kripke, D. F. (2004). Self-reported sleep complaints with long and short sleep: A nationally representative sample. *Psychosomatic Medicine*, 66(2), 239–241. doi:10.1097/01.PSY.0000107881.53228.4D
- Groeger, J. A., Zijlstra, F. R. H., & Dijk, D. J. (2004). Sleep quantity, sleep difficulties and their perceived consequences in a representative sample of some 2000 British adults. *Journal of Sleep Research*, 13(4), 359–371. doi:10.1111/j.1365-2869.2004.00418.x

- Hale, L. (2005). Who has time to sleep? *Journal of Public Health*, 27(2), 205–211.  
doi:10.1093/pubmed/fdi004
- He, Y., Jones, C. R., Fujiki, N., Xu, Y., Guo, B., Holder, J. L., ... Fu, Y.-H. (2009). The Transcriptional Repressor DEC2 Regulates Sleep Length in Mammals. *Science*, 325(5942), 866–870. doi:10.1126/science.1174443
- Jean-Louis, G., Kripke, D. F., Ancoli-Israel, S., Klauber, M. R., & Sepulveda, R. S. (2000). Sleep duration, illumination, and activity patterns in a population sample: Effects of gender and ethnicity. *Biological Psychiatry*, 47(10), 921–927.  
doi:10.1016/S0006-3223(99)00169-9
- Kaneita, Y., Uchiyama, M., Takemura, S., Yokoyama, E., Miyake, T., Harano, S., ... Ohida, T. (2007). Use of alcohol and hypnotic medication as aids to sleep among the Japanese general population. *Sleep Medicine*, 8(7-8), 723–732.  
doi:10.1016/j.sleep.2006.10.009
- Klerman, E. B., & Dijk, D. J. (2005). Interindividual variation in sleep duration and its association with sleep debt in young adults. *Sleep*, 28(10), 1253–1259.
- Knutson, K. L., Van Cauter, E., Rathouz, P. J., DeLeire, T., & Lauderdale, D. S. (2010). Trends in the Prevalence of Short Sleepers in the USA: 1975-2006. *Sleep*, 33(1), 37–45.
- Kripke, D. F., Brunner, R., Freeman, R., Hendrix, S. L., Jackson, R. D., Masaki, K., & Carter, R. A. (2001). Sleep Complaints of Postmenopausal Women. *Clinical Journal of Women's Health*, 1(5), 244–252. doi:10.1053/cjwh.2001.30491
- Kripke DF, Garfinkel L, Wingard DL, Klauber MR, & Marler MR. (2002). MOortality associated with sleep duration and insomnia. *Archives of General Psychiatry*, 59(2), 131–136. doi:10.1001/archpsyc.59.2.131
- Kronholm, E., Harma, M., Hublin, C., Aro, A. R., & Partonen, T. (2006). Self-reported sleep duration in Finnish general population. *Journal of Sleep Research*, 15(3), 276–290. doi:10.1111/j.1365-2869.2006.00543.x

- Krueger, A., Abraham, K., & Stock, J. (2013). Economic Report of the President. Hours and earnings in private nonagricultural industries, 1966–2012. <[http://www.whitehouse.gov/sites/default/files/docs/erp2013/full\\_2013\\_economic\\_report\\_of\\_the\\_president.pdf](http://www.whitehouse.gov/sites/default/files/docs/erp2013/full_2013_economic_report_of_the_president.pdf)> (Accessed 9/5/14).
- Krueger, P. M., & Friedman, E. M. (2009). Sleep Duration in the United States: A Cross-sectional Population-based Study. *American Journal of Epidemiology*, 169(9), 1052–1063. doi:10.1093/aje/kwp023
- Lauderdale, D. S., Knutson, K. L., Yan, L. L., Liu, K., Rathouz, P. J. (2008). Self-Reported and Measured Sleep Duration. *Epidemiology*, 19(6), 838-845. doi:10.1097/EDE.0b013e318187a7b0
- Matchock, R. L., & Mordkoff, J. T. (2014). Effects of sleep stage and sleep episode length on the alerting, orienting, and conflict components of attention. *Experimental Brain Research*, 232(3), 811–820. doi:10.1007/s00221-013-3790-z
- Nena, E., Steiropoulos, P., Papanas, N., Kougkas, D., Zarogoulidis, P., & Constantinidis, T. C. (2014). Greek financial crisis: From loss of money to loss of sleep. *Hippokratia*, 18(2), 135-138
- Patrinos, A. H., & Psacharopoulos, G. (2002). *Returns to Investment in Education: A Further Update*. The World Bank. Retrieved from [https://www.google.is/search?q=Returns+to+investment+in+education:+A+further+update&ie=utf-8&oe=utf-8&rls=org.mozilla:en-US:official&client=firefox-a&channel=fflb&gws\\_rd=cr&ei=eNMSVN6YNImsSOL7ogegO](https://www.google.is/search?q=Returns+to+investment+in+education:+A+further+update&ie=utf-8&oe=utf-8&rls=org.mozilla:en-US:official&client=firefox-a&channel=fflb&gws_rd=cr&ei=eNMSVN6YNImsSOL7ogegO)
- Stamatakis, K. A., Kaplan, G. A., & Roberts, R. E. (2007). Short sleep duration across income, education, and Race/Ethnic groups: Population prevalence and growing disparities during 34 years of follow-up. *Annals of Epidemiology*, 17(12), 948–955. doi:10.1016/j.annepidem.2007.07-096
- Statistics Iceland (2014). Real wages. <<http://www.statice.is/Statistics/Wages,-income-and-labour-market/Wage-index>> (Accessed 9/15/14).

- Stepnowsky, C. J., Moore, P. J., & Dimsdale, J. E. (2003). Effect of ethnicity on sleep: Complexities for epidemiologic research. *Sleep, 26*(3), 329–332.
- Stranges, S., Dorn, J. M., Shipley, M. J., Kandala, N.-B., Trevisan, M., Miller, M. A., ... Cappuccio, F. P. (2008). Correlates of Short and Long Sleep Duration: A Cross-Cultural Comparison Between the United Kingdom and the United States The Whitehall II Study and the Western New York Health Study. *American Journal of Epidemiology, 168*(12), 1353–1364. doi:10.1093/aje/kwn337
- Szalontai, G. (2006). The demand for sleep: A South African study. *Economic Modelling, 23*(5), 854–874. doi:10.1016/j.econmod.2005.10.011
- Tribl, G. G., Schmeiser-Rieder, A., Rosenberger, A., Saletu, B., Bolitschek, J., Kapfhammer, G., ... Zeitlhofer, J. (2002). Sleeping habits in the Austrian population. *Sleep Medicine, 3*(1), 21–28. doi:10.1016/S1389-9457(01)00117-4
- Van Dongen, H. P. A., Maislin, G., Mullington, J. M., & Dinges, D. F. (2003). The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep, 26*(2), 117–126.
- Van Dongen, H. P. A., Vitellaro, K. M., & Dinges, D. F. (2005). Individual differences in adult human sleep and wakefulness: Leitmotif for a research agenda. *Sleep, 28*(4), 479–496.

## Appendix A: Robustness Checks

**Table A1**

Model 4 estimated with a 20-hour working restriction

|                    | Fixed salary         |                      |                      | Hourly wages         |                      |                      | Combined               |
|--------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|------------------------|
|                    | Total<br>(N=33321)   | Males<br>(N=17434)   | Females<br>(N=15887) | Total<br>(N=40285)   | Males<br>(N=18339)   | Females<br>(N=21946) | Total<br>(N=73606)     |
| Wages              | -.0048***<br>(.0018) | -.0058**<br>(.0025)  | -.0043<br>(.0028)    | -.0088***<br>(.0029) | -.0107***<br>(.0041) | -.0071*<br>(.0042)   | -.0046***<br>(.00086)  |
| Wages <sup>2</sup> | .000027<br>(.000020) | .000034<br>(.000027) | .000025<br>(.000032) | .000053<br>(.000040) | .000063<br>(.000054) | .000041<br>(.000064) | .000043**<br>(.000019) |
| Business<br>cycle  | .00090<br>(.0066)    | .0061<br>(.0091)     | -.0051<br>(.0097)    | -.0070<br>(.0070)    | -.0095<br>(.0107)    | -.0049<br>(.0094)    | -.0039<br>(.0049)      |
| Working<br>hours   | -.0234***<br>(.0011) | -.0255***<br>(.0014) | -.0210***<br>(.0016) | -.0197***<br>(.0012) | -.0218***<br>(.0018) | -.0176***<br>(.0017) | -.0216***<br>(.00081)  |

\*\*\* p < .01, \*\* p < .05, \* p < .10. Standard errors in brackets.

**Table A2**

Model 4 estimated without Friday and weekend responses

|                    | Fixed salary              |                          |                           | Hourly wages           |                       |                      | Combined                  |
|--------------------|---------------------------|--------------------------|---------------------------|------------------------|-----------------------|----------------------|---------------------------|
|                    | Total<br>(N=13661)        | Males<br>(N=7080)        | Females<br>(N=6581)       | Total<br>(N=17459)     | Males<br>(N=7753)     | Females<br>(N=9706)  | Total<br>(N=31120)        |
| Wages              | -.0053***<br>(.00093)     | -.0068***<br>(.0013)     | -.0039***<br>(.0014)      | -.0168***<br>(.0039)   | -.0214***<br>(.0056)  | -.0132**<br>(.0056)  | -.0054***<br>(.00082)     |
| Wages <sup>2</sup> | 6.39e-06***<br>(1.62e-06) | 7.50e-06**<br>(3.13e-06) | 5.50e-06***<br>(2.02e-06) | .00016***<br>(.000054) | .00019**<br>(.000073) | .00014<br>(.000084)  | 7.05e-06***<br>(1.68e-06) |
| Business<br>cycle  | -.0068<br>(.0092)         | -.0092<br>(.0126)        | -.0062<br>(.0136)         | -.0050<br>(.0097)      | -.0123<br>(.0147)     | -.000038<br>(.0129)  | -.0066<br>(.0068)         |
| Working<br>hours   | -.0233***<br>(.0013)      | -.0268***<br>(.0018)     | -.0200***<br>(.0019)      | -.0204***<br>(.0014)   | -.0228***<br>(.0022)  | -.0179***<br>(.0018) | -.0220***<br>(.00095)     |

\*\*\* p < .01, \*\* p < .05, \* p < .10. Standard errors in brackets.

**Table A3**

Model 4 estimated using only subjects who reported at least five hours of sleep

|                    | Fixed salary             |                        |                        | Hourly wages           |                        |                       | Combined                  |
|--------------------|--------------------------|------------------------|------------------------|------------------------|------------------------|-----------------------|---------------------------|
|                    | Total<br>(N=33394)       | Males<br>(N=17206)     | Females<br>(N=16188)   | Total<br>(N=42598)     | Males<br>(N=18628)     | Females<br>(N=23970)  | Total<br>(N=75992)        |
| Wages              | -.0026***<br>(.00053)    | -.0035***<br>(.00089)  | -.0020**<br>(.00078)   | -.0137***<br>(.0025)   | -.0163***<br>(.0036)   | -.0117***<br>(.0037)  | -.0029***<br>(.00049)     |
| Wages <sup>2</sup> | 1.14e-06**<br>(5.41e-07) | 1.94e-06<br>(2.13e-06) | 8.40e-07<br>(6.34e-07) | .00012***<br>(.000035) | .00013***<br>(.000046) | .00012**<br>(.000057) | 1.55e-06***<br>(5.63e-07) |
| Business<br>cycle  | -.0015<br>(.0061)        | .00033<br>(.0084)      | -.0034<br>(.0089)      | -.0050<br>(.0062)      | -.0142<br>(.0096)      | .0017<br>(.0082)      | -.0042<br>(.0044)         |
| Working<br>hours   | -.0163***<br>(.00088)    | -.0190***<br>(.0012)   | -.0137***<br>(.0013)   | -.0085***<br>(.00089)  | -.0107***<br>(.0014)   | -.0069***<br>(.0012)  | -.0122***<br>(.00062)     |

\*\*\* p < .01, \*\* p < .05, \* p < .10. Standard errors in brackets.

**Table A4**

Robustness checks on model 2

|          | Without labor-market status restrictions |                    |                      | Without employed subjects |                    |                      |
|----------|--|--------------------|----------------------|---------------------------|--------------------|----------------------|
|          | Total<br>(N=148150)                      | Males<br>(N=64613) | Females<br>(N=83537) | Total<br>(N=55388)        | Males<br>(N=19438) | Females<br>(N=35950) |
| Business | .0067*                                   | .0072              | .0066                | .0081                     | .0031              | .0107                |
| cycle    | (.0036)                                  | (.0055)            | (.0048)              | (.0062)                   | (.0107)            | (.0076)              |

\*\*\* p &lt; .01, \*\* p &lt; .05, \* p &lt; .10. Standard errors in brackets.