University of Nottingham

School of Economics

Economics Dissertation

Rest yourself richer? A literature review on the effect of sleep on wages and productivity

Imran Rahman-Jones

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Contents

"That sleep is the largest single use of time by most people makes it a worthwhile subject for economic analysis."

− *Biddle & Hamermesh* (1990, p. 927)

1 Introduction

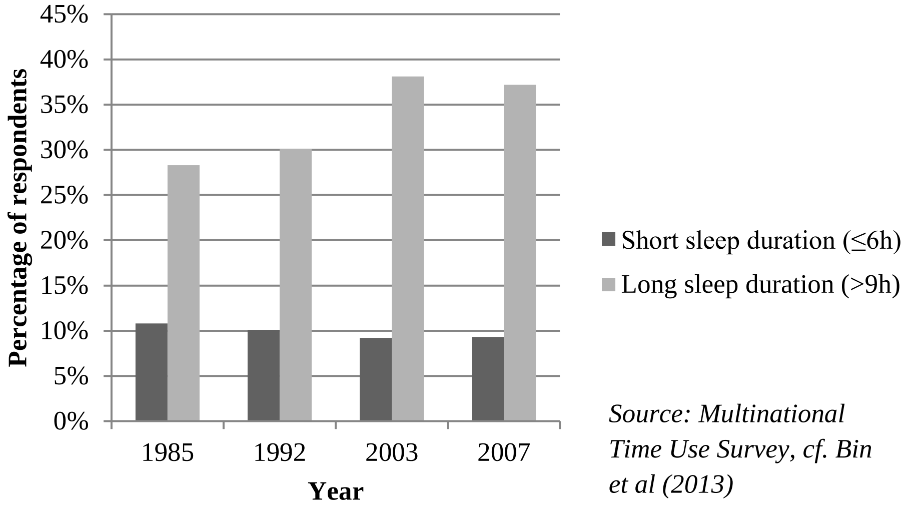
This dissertation is motivated by the claim made by some economists (Biddle & Hamermesh, 1990; Szalontai, 2006) that sleep has been largely ignored in economics when considering time use and productivity. The dissertation will aim to conclude whether, according to the available literature, changes in sleeping time and patterns can increase wages and productivity.

1.1 Motivating Data

A 2015 survey conducted by the RAND institute of over 21,000 participants found a positive relationship between sleep time and workplace productivity (Hafner et al, 2015). Using an OLS regression, the study found that a sleep time of less than five hours per night had a greater impairment on productivity than factors such as having an overweight Body Mass Index (BMI), having an underweight BMI, or physical inactivity. Although the effect of sleep had less effect on work impairment as sleep time increased, the relationship stayed positive up to a sleep duration of between 7 and 8 hours per night. Given this evidence, it is surprising that few companies recognise sleep as a major factor for the health of the labour force. Perhaps more pressingly, it seems that they have also omitted consideration of sleep as a driver of productivity.

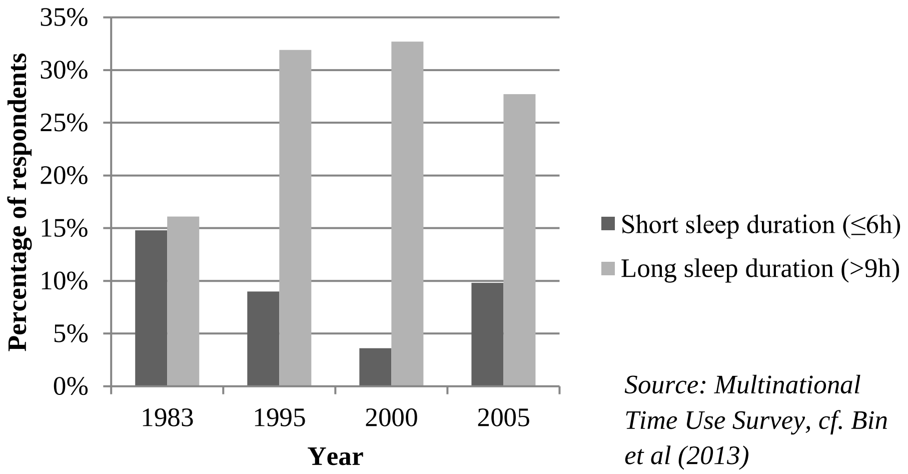
Bin et al (2013) conducted a study to compare the prevalence of short sleep duration (six hours of sleep or less per night) and long sleep duration (more than nine hours of sleep per night) over time. They used data from the Multinational Time Use Study (MTUS) and considered the changing patterns over time in ten countries. They found that in certain countries such as the UK and USA, prevalence of sleep of short duration has fallen over time, whilst prevalence of sleep of long duration has risen over time (Figures 1 and 2). See Appendix 5.1 for more comprehensive data from all ten countries.

Figure 1: Change in sleep duration, USA



Source: Multinational Time Use Survey, cf. Bin et al (2013)

Figure 2: Change in sleep duration, UK



Source: Multinational Time Use Survey, cf. Bin et al (2013)

Although this data is not conclusive that sleep duration has increased across all countries, it does indicate that sleep duration has risen overall in recent years in certain countries. What is more, the fluctuations in sleep duration over time show that sleep is a variable that can, to a certain extent, be controlled. This gives weight to the idea that an individual may be able to change their sleep to an optimal level which can maximise their productivity. Furthermore, increasing their productivity may be the only way for an individual to increase their wages. Three major factors which influence the wage rate are productivity, the unemployment rate and price level (Ásgeirsdóttir & Ólafsson, 2015). Whilst individuals cannot independently influence the unemployment rate or price level, they can modify their productivity. Therefore if sleep has an effect on productivity, it can be manipulated by an individual in order to increase their wages.

1.2 Research Question

Sleep deserves to be studied in closer detail in order to determine its effect on productivity. Economists often consider sleep no deeper than eight hours to be discounted from each day when looking at time use and utility. However, sleep can in fact be considered as a choice variable: beyond a certain amount needed for biological functioning, consumers can and indeed do change the amount of sleep they 'consume' as a response to normal economic incentives (Biddle & Hamermesh, 1990).

It is important to make a distinction between wages and productivity. While wages can be used as a proxy for productivity (Meager & Speckesser, 2011; Klein, 2012), an inverse relationship between sleep and wages does not necessarily mean that sleep and productivity are inversely related. For example, if an individual increases their sleep time by one hour and nonmarket wake time remains the same, there is a negative effect on wages as one hour has been substituted away from work[1]. Bolge et al (2009) show that sleep has a positive effect on productivity (see section 2.2). If the substitution effect is greater than the productivity effect, wages will fall with an increase in sleep, even if productivity has risen.

This dissertation question is also worth investigating because it may contribute toward ameliorating the current productivity problem Britain is experiencing (Barnett et al, 2014). The current literature suggests that changes in sleep patterns can have a positive effect on productivity. Therefore sleep could become a factor which policy makers and business leaders consider when looking to improve productivity.

[1] Nonmarket wake time is time spent awake but not working.

1.3 Structure of Paper

This literature review begins with more macro-orientated research, with larger national and international data sets being used to determine the effects of sleep on wages and productivity. As these studies use time-use data to measure sleep time, a section is devoted to analysing the benefits and withdrawals of this type of data. Individuals who do not work standard hours are also considered separately as their sleep patterns are usually drastically different and are not usually considered in studies using time-use surveys.

Next, more micro-orientated studies will be considered (except Giuntella et al, 2015, which is a national level survey but which will be discussed in this section). Here, the effect of sleep on productivity is studied closer than its effect on wages. Specific productivity-reducing traits will be examined, in particular the relationship of sleep, cognition and productivity. Insomnia is considered to observe the specific relationship between sleep deprivation and productivity. The 2015 RAND study will be evaluated in more detail as an interesting case study in how workplaces can help improve employee productivity.

Modern workplace practises, specifically flexitime work and napping, are then reviewed in terms of their effects on sleep which in turn can affect productivity and wages. Finally, a discussion and conclusion section considers the application of sleep research in the modern day and identifies areas where more research should be carried out.

2 Literature Review

2.1 Macro-level data

When incorporating sleep into a consumer choice model at the most basic level, it can be taken as a period of time which yields no utility and has no effect on income or productivity. In this case, each rational agent would sleep only for the biological minimum required. Evidence shows that this is not the case, as an individual’s sleep varies each night (Biddle & Hamermesh, 1990). At a more complex level, sleep can be considered as time spent where utility is gained, where no goods are used but time is taken away from income-generating activities.

Biddle & Hamermesh's (1990) seminal paper 'Sleep and the Allocation of Time' was the first in economics to consider sleep at the most complex level: as a choice variable. Rather than regarding sleep as a commodity which yields utility to an individual and takes up time but not goods, they go further by assuming that sleep adds to an agent's productivity. This more complex consideration to sleep means that causality between sleep duration and wage rate can run in both directions. Whilst less sleep allows time for more of work, greater sleep time can increase productivity, and thus increase wages.

Sleep duration is subject to variation, depending on the same economic factors which affect other choices in time allocation, such as leisure time. The authors therefore establish a model where, put simply, "the price of a unit of sleep is the wage rate minus any addition to labor income that occurs as a result of the effect of extra sleep on productivity." (1990, p. 934). This means that, *ceteris paribus*, the greater contribution sleep makes to productivity, the lower the price of sleep. Equally, a higher wage rate means that the price of sleep is higher due to its higher opportunity cost.

From a sample size of 706 individuals, and after controlling for demographic and economic factors, Biddle & Hamermesh (1990) find that higher wage rates are associated with less sleep time. Each one-hour increase in work time results in a 13-minute reduction in sleep time. This is a significant substitution effect, although it does not establish causation. It could be the case that changes to sleep time are caused by factors beyond the individual's control, which also have an effect on work time. The authors rule this out through three explanations. Firstly, survey evidence shows that sleep time is higher on weekends compared to weekdays (1990, p. 925). This suggests that working reduces sleep time. Secondly, individuals with young children sleep less. This implies that individuals are able to adjust their sleep time depending on circumstances. Thirdly, higher levels of education are negatively correlated with sleep time. The authors interpret this as a wage effect, showing a causality between higher wages and lower sleep time.

The conclusion from this paper, that less sleep is associated with higher wages, is strengthened by subsequent replication studies. Szalontai (2006) uses the same model for a study in South Africa. The results are largely similar. Wages and educational attainment are also negatively correlated with sleep time, to a much lower magnitude, although still at a statistically significant level. This may be partly as a result of the poor quality of the income data collected in the survey. To counter this, Szalontai (2006) employs a post hoc estimation procedure which uses proxies for wages. These proxies include indicators on whether a household has access to electricity, a car, a television and a telephone. After the procedure is applied, the authors estimate that a 50% increase in wages would lead to approximately 12 minutes less sleep time per night (2006, p. 866). This reinforces the substitution effect explanation.

Ásgeirsdóttir & Ólafsson (2015) conducted a similar but more expansive study. They used data from the American Time Use Study (ATUS) collected between 2003 and 2013 (n=79,298). As well as studying the effect of sleep on wages, they looked at whether there was a correlation between sleep duration and the business cycle. This was in part motivated by Brochu et al (2012), who used time-use survey data from Canada and found that in a recession, sleep time increases by an average of 3 hours per week. This would be consistent with Biddle & Hamermesh (1990), as wages fall during recessions, and thus the price of sleep also falls. For males, reduced working hours during recessions are also associated with more sleep (substituting from time spent working to time spent sleeping), although this effect is not observed in females. Conversely, Ásgeirsdóttir & Ólafsson (2015) found no relationship between sleep duration and the business cycle in their results.

Ásgeirsdóttir & Ólafsson (2015) also made a distinction between workers who were paid an annual salary and those who earned an hourly wage. On one hand, workers who are paid an hourly wage should have more control over the number of hours they work. On the other hand, because of the nature of most hourly-paid jobs, these workers are in general less-educated and less well-paid which means that it is likely that they have less leverage in employment contract negotiations. Nevertheless, workers who are paid hourly wages are likely to have more flexibility in working hours. The results show that hourly-paid males (females) receive 57% (58%) of the wages of salaried males (females). Hourly-paid males (females) sleep 18 minutes (14 minutes) more than salaried males (females). This suggests that part of the inverse relationship between sleep and wages comes from the nature of the work. Lower-paid jobs are more likely to be paid with hourly wages, which can lead to more flexibility in time use. Individuals on hourly wages may decide to forego some work time in order to sleep more compared to salaried subjects.

Within both groups, a very small wage effect was found. For salaried males, a 1% increase in wages was associated with 3 seconds less of sleep per night. No statistically significant relationship among females was found. The relationship was stronger among hourly-paid workers, with a 1% wage rise associated with a 9 second reduction in sleep time. These results were statistically significant among males and females, although the relationship was much stronger among males.

So far, the studies mentioned have found an inverse relationship between sleep and wages. The question still remains on the direction of the causation. Biddle & Hamermesh's (1990) model suggests that the causation in fact runs in both directions. Recall that the price of sleep for an individual equals their wage rate minus the wages gained from higher productivity from sleep. Higher wages cause the price of sleep to increase through a higher opportunity cost of sleeping (substitution effect). This provides an incentive to reduce sleep. However this reduction in sleep has a negative effect on wages through lower productivity. Reasons how productivity is affected are explored in section 2.2. In theory, the relationship between sleep and wages is ambiguous. Biddle & Hamermesh (1990) focus mainly on the relationship between wages and sleep duration. Their results, as well as the results of similar studies, suggest that the substitution effect dominates the productivity effect.

However, there is evidence to show that the productivity effect may dominate the substitution effect. Gibson & Shrader (2015) find a novel way to isolate and observe the magnitude of the productivity effect using a natural field experiment. There is an established link between human circadian rhythm (the natural 'body-clock') and daylight levels. Roenneberg, et al (2007) show that later sunset times induce individuals to go to sleep later. At the same time, waking-up times do not change depending on sunset or sunrise times, mainly due to school and work start times remaining unchanged (Hamermesh et al, 2008). Therefore later sunset times are associated with shorter sleep duration. Sunset time varies on a daily basis, which means that short-run variations in sleep can be identified (Frazis & Stewart, 2012). Using ATUS data, Gibson & Shrader (2015) show this to be the case: later sunset times are associated with later bedtimes, whilst waking-up times remain unchanged. When comparing sleep time and wages and controlling for a number of demographic and economic factors[2], the authors find that in the short run, a one-hour increase in sleep per week increases wages by 1.5%.

Gibson & Shrader (2015) also examine the relationship between sleep and productivity in the long run. To do this, they exploit differences in sunset time within time zones. Because the differences in sunset time between two locations does not change over time, this will identify long-run differences in sleep time[3]. There are four time zones on mainland America: Eastern, Central, Mountain and Pacific. Each is one hour behind the other, so that Pacific Time is Eastern Time -3. Within each individual time zone, sunset is roughly one hour earlier on the eastern border of each time zone than on its western border. The ATUS data shows that, as expected, this translates into inhabitants on the eastern side sleeping earlier and therefore longer than the inhabitants on the western side. This relationship is largely linear, so that the further apart two locations are (in terms of longitude) in a time zone, the larger the difference is in sleep time and in wages. The average relationship is similar across time zones. The authors find that in the long run, a one-hour increase in sleep per week increases wages by 4.9%.

These results are made more compelling by the fact that, as in Biddle & Hamermesh's (1990) model, sleep time is inversely correlated with work time. More sleep would reduce wages as individuals work fewer hours. As expected, Gibson and Shrader (2015) find that in the long run, one extra hour of sleep per week reduces work time by 0.7 hours per week[4]. To put this another way, one hour fewer of sleep increases work time by 0.7 hours. This shows that the substitution effect is still present, but it is outweighed by the productivity effect.

There are a number of checks which need to be carried out by the authors in order to verify robustness of the short- and long-run figures. Seasonal employment changes are ruled out as occupation shares in

[2] See Appendix 5.3 for more detail.
[3] Areas which do not observe Daylight Saving Time are discounted from the study for consistency.
[4] No change is found in the short run.

the sample are constant throughout the year; as is the share of respondents reporting a positive wage. In terms of long-run wages, the main threat to the robustness of the data is the possibility of sorting. People may purposefully move to an area with an earlier sunset time in order to earn higher wages. The authors find no historical evidence for this occurring. When the authors remove counties located at borders where time zones overlap to remove the possibility that they may have chosen their time zone based on economic considerations, there is no statistically distinguishable change in results. The authors also exclude the Eastern time zone, which has a higher population density and is wealthier than other regions. Separately, they exclude high-wage cities[5]. In both cases, the results remain largely unchanged. These checks allow the authors to rule out sorting effects. They further support this by observing that the increase in wages is entirely offset by higher house prices. This reduces the incentive for individuals to move to the eastern side of a time zone in order to increase their real income.

The authors are keen, and rightly so, to highlight some important nuances in the implications from their results. They point out that their estimates capture the effect of increasing mean sleep in a location, rather than the effects of individual sleep. Therefore an individual who increases their sleep will not necessarily increase their wages. When managers consider productivity in setting wages, they may base this on average productivity in the area rather than individual worker productivity. An individual's change in productivity is unlikely to affect the mean, which will therefore have no effect on wages. Finally, individuals need not move in order to gain more sleep. As the authors put it, "a worker who decides to sleep more need not move to another location; she can simply sleep more." (2015, p. 15).

2.1.1 Time-Use Surveys

The studies cited so far in section 2.1 have used time-use survey data in their research. Therefore it is worthwhile to consider the advantages and drawbacks of using this data. A list of the time-use surveys used by papers cited in this dissertation are available in Appendix 5.2.

[5] San Francisco, Los Angeles, Chicago, Boston and New York.

There are two main ways in which time-use data is collected (Bin et al, 2013). The first entails a recall interview. Respondents are interviewed by telephone to detail their time-use from 4 a.m. the previous day to 4 a.m. on the day of the interview. The start and finish times of each activity is recorded. The second main survey type is through the use of a time diary. Respondents are asked to carry a diary with them for one day and write down each activity throughout the day. Times are divided into ten-minute slots, from 4a.m. for 24 hours[6].

There are limitations to these methods. They both rely on self-reported data. The recall method also relies on memory, which can be fallible to human error in estimating times and durations. This means that data can potentially be unreliable. There are some difficulties in observing sleep duration. For example, the time an individual goes to bed may be quite different to the time they actually fall asleep. This may result in an overestimated value for sleep duration.

Another issue with time-use surveys is that they are typically only collected for one 24-hour period. Therefore the data collected for an individual will not necessarily be for a typical or average day. Furthermore, as Frazis & Stewart (2012) argue, individuals who work non-standard hours may have inaccurate weekly or monthly estimates (2012, p. 232). Weekly or monthly figures are estimated on the basis that workers work five days per week. In reality, non-standard workers may work more or less than five days per week, so multiplying the working hours in their surveys will mis-estimate actual working hours. This also applies to sleep hours. For this reason, the papers cited so far exclude respondents who do not work conventional hours. Non-standard workers will be further addressed in section 2.1.2.

There are clearly drawbacks of using time-use survey data which need to be considered when conducting research based on these data. However, what is clear is that these are the best methods available when gathering data on sleep durations. Using this data is much more reliable than simply asking subjects how long they slept for, or how long they sleep per night on average. The data is also

[6] An example of a written time diary can be found in Appendix 5.2.

used by Gibson & Shrader (2015) when considering work time, so that they can isolate the productivity effect from the wage effect. What is more, surveys typically gather comprehensive demographic information which is used for control variables. As Juster and Stafford (1991) argue, "the only way in which reliable data on time allocation have been obtained is by the use of time diaries, administered to a sample of individuals in a population and organized in such a way as to provide a probability sample of all types of days and of the different seasons of the year." (1991, p. 473).

2.1.2 Non-Standard Workers

As previously mentioned, only individuals working conventional hours have been considered so far. This is partly because it is more difficult to obtain reliable time-use survey data for them. In the case of Gibson & Shrader (2015), non-standard workers were excluded as their sleep patterns of would not follow daylight levels, so the sunset instrument would not be relevant. However, it is important to consider the 33% of men and 22% of women who do not work standard hours[7]. Shift work is most common among young people, and is most prevalent in the two lowest income quintiles (Weston, 2014).

Czeisler et al (1982) find that "worker productivity improve[s] when schedules are introduced that are designed to incorporate circadian principles." (1982, p. 460). The authors studied workers at a potash-harvesting plant in Utah, USA. Previously, employees worked the same eight-hour shift (either 08:00-16:00, 16:00-00:00 or 00:00-08:00) for seven days before being moved to the preceding shift. 81% of workers reported that it took 2 days or more to adjust to their new shift schedule each time, including 26% who were unable to adjust before being rotated to the next schedule. The authors hypothesise that this lack of sleep has a negative effect on productivity. This is further supported by the fact that 29% of employees admitted to falling asleep at work at least once during the previous 3 months. Moreover, a meta-analysis of 36 studies by Pilcher et al (2000) concludes that rotating shift work is associated with less sleep time.

[7] Defined by Weston (2014) as the percentage of the working population who work outside of the hours of 7am and 7pm.

Czeisler et al (1982) divided the workers into two groups: the control group stayed on the same shift-rotating schedule whilst the treatment group were moved onto a schedule which rotated every 21 days. There was also a group of workers at the company who worked fixed daytime shifts with no rotation. After nine months, workers in the treatment group reported less dissatisfaction with the frequency of shift rotation (20% down from 90%), as well as increases in self-reported job satisfaction and health level. In terms of productivity, the rate of potash harvesting increased by around 25%. Furthermore, absenteeism and personnel turnover fell to the rate of daytime workers, which according to the authors should continue to improve productivity in the long run. Pilcher et al's (2000) meta-analysis concludes that "slowly rotating shifts have the least negative impact on sleep length of shift-work schedules including a night shift" (Pilcher, et al., 2000, p. 155). This further supports the argument that shift workers are less productive because, at least in part, their schedules are in general associated with lower sleep durations.

It should be noted that Czeisler et al (1982) make no mention of days off for the shift workers. Although the shift rotation schedule is known, the effect of shift work on days off is not stated. On the other hand, Åkerstedt (2003) concludes in a report entitled 'Shift work and disturbed sleep/wakefulness':

> Irregular work hours seem to exert strong, acute effects on sleep and alertness in relation to night and morning work. The effects seem, however, to linger, and also affect days off. The level of the disturbances is similar to that seen in clinical insomnia, and may be responsible for considerable human and economic costs due to fatigue related accidents and reduced productivity. (2003, p. 92)

It should be noted that the sample group of 153 male workers in the Czeisler et al (1982) experiment is relatively limited[8]. A much larger study by Drake et al (2004) found, in a sample of 2,570 individuals (male and female), that shift workers had a "significantly" higher rate of productivity-reducing traits such as absenteeism and depression (2004, p. 1453). However, the survey methodology of this study should be reviewed. As discussed in section 2.1.1, time-use surveys are generally accepted as the best measurement of sleep duration. Drake et al (2004) determine sleep duration by asking respondents their

[8] Sample of 85 rotating shift workers, and a control group of 68 nonrotating shift workers.

average nightly sleep time for weekdays and weekends over the previous two weeks. Relying on memory recall for the past two weeks is fallible to human error and could lead to inaccuracies between reported sleep duration and actual sleep duration. In order to measure absenteeism, the surveyors asked respondents were asked how many days of work they had missed in the last three months due to sleepiness. Again, this can be fallible to errors in memory, or underreporting by survey respondents. The authors find a link between shift work and reduced productivity, although the attribution of this to lack of sleep should be considered with some scepticism in this particular case.

2.2 Micro-level data

2.2.1 Productivity-Reducing Traits

The previous section shows that literature relating sleep duration and productivity, as measured by output per worker, should be further studied among shift workers. However, there is a larger body of literature which studies the relationship between sleep duration and productivity-reducing traits. Therefore although the exact effect of productivity in terms of output per worker may not be deduced, a relationship may be established between sleep duration and productivity.

Previously in this paper, it was stated that shift work is associated with lower income. One field where this is untrue is among doctors, who are paid above average salaries (NHS Employers Organisation, 2013). A study by Landrigan et al (2004) designed a shift schedule which allowed more sleep for interns compared with their current schedule. In the treatment schedule, total working hours were reduced from 77-81 hours per week to 60-63 hours per week. The maximum length of a shift was also shorter. This treatment increased the daily average sleep by around one hour. 2,203 patient-days were observed (1,294 on the traditional schedule and 909 on the treatment schedule). Per 1,000 patient-days, interns on the traditional schedule made 136.0 serious medical errors, compared with 100.1 for interns on the treatment schedule ($P<0.001$)[9]. These results give further indication of the effect sleep can have on workplace performance.

Similarly, Gold et al (1992) surveyed nurses and compared rotating shift workers with fixed shift workers. They found that:

> Sleep deprivation and misalignment of circadian phase as experienced during rotating shift work are each associated with frequent lapses of attention and increased reaction time, leading to increased error rates on performance tasks. (1992, p. 1013)

Furthermore, rotating shift workers were 2.8 times more likely to report poor quality sleep and twice as likely to commit an accident or error than fixed shift workers.

2.2.2 Sleep, Cognition and Productivity

How does lack of sleep lead to individuals making errors such as those described above? Sleep deprivation is associated with lower cognitive performance (Alhola & Polo-Kantola, 2007) and lower short- and long-term memory consolidation (Walker, 2009). Acute sleep loss is also associated with lower attention spans and reaction times (Miller et al, 2014). These are likely factors in reducing productivity.

Williamson & Feyer (2000) compared sleep-deprived subjects with intoxicated subjects in a series of cognitive and motor tests. They found that on average over the eight tests, performance after being awake for 16.9-18.6 hours was equivalent to performance with a blood alcohol concentration (BAC) of 0.05% (95% confidence interval)[10]. The sample in this experiment was limited to 39 subjects, of which 37 were male, so sample bias may be present in this instance, although this is likely to affect the magnitude of the effect of sleep deprivation rather than the sign of the relationship.

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[9] Serious medical errors were defined and classified beforehand by physicians. Interns were under continuous direct observation by physicians.

[10] A BAC of 0.05% is "widely agreed to be hazardous." (Williamson & Feyer, 2000, p. 649)

Chronic sleep loss (insufficient sleep over a long period of time) has a similar effect on individuals to acute sleep loss. Van Dongen et al (2003) observed 48 subjects over 14 days in a laboratory setting. Two groups of 13 subjects each were restricted to 4 and 6 hours sleep respectively, for 14 days. One group of 13 subjects underwent total sleep deprivation for 3 nights, amounting to 88 continuous hours of wakefulness. A control group of 9 subjects slept for 8 hours per night for 14 days. All subjects undertook neurobehavioural performance assessments every 2 hours of wake time. These assessments included reaction time tasks, memory tasks and arithmetic tasks to measure cognitive performance. Results in these tests deteriorated steadily over the 14 days (except in the control group). After 14 days, subjects who had experienced 4 hours of sleep per night performed equivalent to subjects who had been deprived of sleep for 3 nights. Subjects restricted to 6 hours of sleep per night performed equivalent to those who had been deprived for 1-2 nights. As expected, there was little change among the control group.

This experiment shows that chronic sleep loss can erode cognitive performance relatively quickly. Furthermore, self-reported sleepiness fell only slightly over the 14 days for the 4-hour and 6-hour groups. This gives an indication that, even if an employee does not feel tired, their cognitive performance may still be deteriorating without their knowledge. This may explain why chronic sleep loss is not perceived to be a pressing issue (2003, p. 117). A similar study by Van Dongen & Dinges (2005) yeilds similar outcomes.

Corresponding results can also be observed in the field, on a larger scale. Giuntella et al (2015) use a methodology similar to Gibson & Shrader (2015) to measure the relationship between sleep and cognitive skills among 35,000 individuals in China. Geographically, China spans over five time zones. However, since 1949 the whole country has observed one time zone (UTC+8). Therefore, there are around four hours between sunset time on the eastern side compared to on the western side of the country. The authors focus on the areas in UTC+7, UTC+8 and UTC+9 which represents 98% of the population and 97% of GDP.

As China does not conduct a national time-use survey, the authors use data from the Chinese Health and Retirement Longitudinal Study (CHARLS), which studies Chinese residents over the age of 45. Respondents are asked to report how many hours on average they slept per night in the last month. Furthermore, the CHARLS includes data on cognitive performance, through measures such as simple numerical tests, word recall and ability to redraw a geometrical image. The authors find that "individuals living in late sunset areas tend to sleep significantly less than those in early sunset areas, and have poorer cognitive outcomes." (2015, p. 16). After controlling for regional, economic and demographic effects, they find that an increase in average nightly sleep duration by one hour (approximately 15% of average sleep duration in the sample) increases old age cognitive skills by 25%, mental skills by 18% and numerical skills by 33% (2015, p. 21)[11]. For comparison, concluding primary education increases cognition scores by 20% according to Huang & Zhou (2013).

It should be noted that Giuntella et al (2015) acknowledge that there may be other unobserved factors which impact cognitive skills. However, they are confident that their controls mitigate any confounding factors. Furthermore, the sample only includes individuals over the age of 45 so the overall effect of sleep on the total population is unclear, although an age control is included.

2.2.3 Insomnia and Productivity

Sufferers of chronic sleep deprivation can be observed to establish a direct link with productivity, rather than with cognition. A study by Bolge et al (2009) of 41,184 respondents of the US National Health and Wellness Survey, found that diagnosed insomniacs (12% of the sample) experience a 10% productivity loss compared to non-insomniacs. This was mostly due to presenteeism: when the worker is present at work but is working below their full individual capacity. Absenteeism was also reported, but was less of a significant factor.

Kessler et al (2011) find that insomniacs experience a 3.1% productivity loss compared to non-insomniacs. At first glance, this looks to be a much smaller effect when compared to Bolge et al (2009).

[11] For a list of controls and a summary of the model used, see Appendix 5.3.3.

However, the two studies are not directly comparable. Kessler et al (2011) presents results from the America Insomnia Survey which defines insomnia less strictly than a medical diagnosis. In this survey, insomnia is defined as "difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, or non-restorative sleep" for a period of more than 30 minutes per night and at a frequency of at least three times per week in the last month (2011, p. 1162). The authors acknowledge this as "broadly defined insomnia" (2011, p. 1162), which resulted in 23.2% of working people being classed as insomniacs. People with a 'milder' form of insomnia may experience less of a fall in productivity than those medically diagnosed, which may explain why the average productivity loss is much lower in the Kessler et al (2011) sample compared with the Bolge et al (2009) sample.

There is evidence that insomnia is underdiagnosed and underreported. Sarsour et al (2011) find that 53.2% of moderate/severe insomnia sufferers, as defined by the Insomnia Severity Index, have received no insomnia-related healthcare. This suggests that restricting the categorisation of insomnia to only those who have been diagnosed (as in Bolge et al, 2009) may result in an underestimation of the effect of sleep deprivation on productivity. Sarsour et al (2011) find that in the moderate/severe insomnia group, those who receive no insomnia-related healthcare experience 77.9% greater productivity loss compared to those who do receive insomnia-related healthcare. Their sample (n = 1,329) consists of members of a single health insurance plan in the Midwestern USA. Whereas Bolge et al (2009) and Kessler et al (2011) apply a post-stratification weight based on data from the US Census Bureau, Sarsour et al (2011) do not apply demographic controls which is likely to result in sample bias.

Furthermore, the studies measures productivity differently to one another. Details of the methodologies are found in Appendix 5.4.

2.2.4 The 2015 RAND Report: Britain's Healthiest Company

A study by the RAND Institute concludes similar findings related to presenteeism (Hafner et al, 2015). In a survey of 21,822 employees in 82 different UK companies, the researchers found that

> employees sleeping fewer than five hours per night show an increased work impairment due to presenteeism of 6.93 percentage points compared to employees who sleep on average eight or more hours per night. (2015, p. 23)

Consistent with the works cited in section 2.2.3, this study finds no significant relationship between sleep and absenteeism.

There are some further considerations to bear in mind with the RAND study. Although the RAND Corporation is an independent body, the study was conducted on behalf of and funded by Vitality Health, a health and life insurance company, as part of a competition entitled ‘Britain’s Healthiest Company’ (Hafner et al, 2015, p. iii). Vitality Health may have an interest in over-reporting ill-health among workers as an incentive for companies to take out insurance on its employees. Moreover, as the winners and runners-up of the competition are published, firms which consider themselves to have healthy employees are more likely to enter the competition for reputational benefits. The authors note that if selection bias is prevalent and they are underestimating the effects of health factors on productivity, then their data represents a lower bound of the actual effects. However, the nature of the self-reported data means that employees may under-report bad lifestyle habits, although this is likely to be more of a problem for habits such as smoking and exercise rather than for sleep duration.

2.3 Modern Workplace Practises

Although the magnitude of the relationship between sleep and productivity is arguable, this dissertation has found that research points to a link between sleep duration and productivity. Therefore it is useful to consider how this information may be applied in the workplace.

The literature so far has viewed the need for sleep as homogenous among the population. In reality, each individual requires a different amount of sleep, depending on age and other biological factors (Van Dongen & Dinges, 2005; Miller et al, 2014). Given that higher durations of sleep increase productivity, sleep can be seen as a form of human capital production. Therefore, it follows that a biological requirement of less sleep is a form of human capital (Ásgeirsdóttir & Zoega, 2011). Furthermore, an individual’s chronotype should be taken into account. This is the natural tendency to awaken early in the morning or late in the morning.

Using Danish time-use data from 2001 and 2008/2009, Bonke (2012) divides people into morning-type and evening-type chronotypes. Weekend data is particularly useful here as there is less pressure to rise early for work so natural chronotypes can be more easily observed. After controlling for amount of sleep, wages, age and age-squared, on average morning-type individuals earn 4-5% more than evening types. The author concludes that this is because society is organised in favour of morning-types, for example through early work times. Morning-types are likely to be more productive at these times, which translates into higher wages. Given that circadian rhythm may fall into more morning- or evening-type categories among people, it may be that companies are not maximising productivity among evening-type people by making them work relatively early hours. More flexibility in working hours may help improve total productivity.

A report by the International Labour Office (ILO) presents finds that 45% of US workers perceive no ability to control their work schedule, whilst 15% of workers believe that they can. The remaining 40% feel that they can influence their work schedule to an extent. Findings are similar in Australia (Golden, 2012). In a meta-analysis of existing literature, the ILO concludes that evidence shows that flexitime practises do increase employee productivity (Golden, 2012). Kelly and Moen (2007) draw similar conclusions.

However, it is difficult to distinguish the extent to which sleep has influenced productivity in these instances. Individuals may change working hours based on other factors, such as care commitments or the presence of children. Furthermore, productivity may increase due to worker satisfaction. The existence of a flexitime policy may indicate that the company instigates other workplace practises which are favourable to employees and thus improve morale and employee motivation (Alhola & Polo-Kantola, 2007). This makes it more difficult to isolate productivity improvements which are solely dependent on flexitime policies. Moreover, the existence of a flexitime policy may encourage an employee to work harder (thus increase productivity) because they have an incentive to stay at that company to keep these benefits (Golden, 2012). More research should be undertaken to study the effect of flexitime working specifically on sleep and productivity.

Another modern workplace practise which may improve productivity is napping. Rejuvenation may make an employee more alert and increase their output and efficiency. Napping could help alleviate syptoms resulting from the misalignment of circadian rhythms among shift workers (Takahashi, 2003). Furthermore, with higher amounts of sleep deprivation, a shorter nap is necessary to reduce tiredness. Van Dongen & Dinges (2005) conducted an experiment similar to their 2003 study cited in section 2.2.2 (Van Dongen et al, 2003). Over a period of 88 hours, subjects were allowed a 2-hour nap every 12 hours. They were awake for the rest of the period. At the end of the period, their psychomotor vigilance tests scores were better than those who stayed awake for 88 hours. However, subjects in this treatment group also experienced a period of reduced cognitive performance immediately after each nap. This phenomenon, known as sleep inertia, is commonly observed after naps (Takahashi, 2003). Furthermore, the effects of sleep inertia increase as sleep deprivation accumulates (Van Dongen & Dinges, 2005). Sleep inertia is not observed after shorter naps of 10-30 minutes, so shorter naps may be beneficial to employees (Tietzel & Lack, 2001; Takahashi, 2003).

Despite this, Van Dongen & Dinges (2005) conclude that "strategic napping cannot be considered a universal substitute for obtaining sufficient amounts of sleep." (2005, p. 242). The existence of a nap room at a company may result in employees changing their sleeping habits and reduce night time sleep, which could have an overall detrimental effect on wages and productivity. Permitting napping in break times or lunch hours may encourage more effective napping practises (Takahashi, 2003). More research should be carried out into best napping practises.

3 Discussion and Conclusion

This dissertation has reviewed literature which evaluates the effects of sleep on wages and productivity. Whilst higher wages increase the opportunity cost of sleeping, more sleep increases productivity through increasing cognitive performance. Although the bulk of the papers have been from the field of economics, some psychological and medical literature has been considered. Given that the economic research is still relatively recent (and therefore thin), the synthesis of relevant evidence from other, more developed fields supports and strengthens the underlying economic arguments .

More research should be undertaken from economists to examine the relationship between sleep, wages and productivity in the field of non-standard working hours and modern workplace practises. Studies have typically taken place in developed countries where data is more reliable and more readily available. Future research should consider the effects of sleep in developing countries. Moreover, given that working practises and the work-life balance change relatively quickly in the modern world, older papers such as Biddle and Hamermesh (1990) use time-use data collected as early as 1966 (Szalai, 1972, p. 24), whose results may have little relevance to the world today. Therefore their paper may be more useful for the model and theoretical framework than for its empirical results.

The limitations of this literature review should also be considered. The sleep variable addressed in this paper is quantity. Sleep quality is harder to measure outside of a laboratory setting, but is likely to have a large effect on productivity (Ásgeirsdóttir & Zoega, 2011). The effect of sleep can be hard to isolate from other factors, and as was shown in section 2.1, causation between sleep and wages runs in both directions.

It is difficult to make policy recommendations on sleep as a way of increasing average national productivity. The value of this paper may lie on an individual level, if a worker wishes to improve productivity or earn a higher wage. What is clear is that sleep duration is a choice that individuals control, so any form of regulating or controlling sleeping hours from a firm or government is extremely difficult. Allowing employees to pursue flexitime hours or implementing modern workplaces practises gives workers more flexibility in controlling their sleep time and may improve worker productivity.

It is clear that the role of sleep in modern life is becoming more high-profile. Large corporations such as Google Inc and The Huffington Post encourage good sleeping habits among their employees (Harvard Medical School, 2009; Tett, 2016). Arianna Huffington has written and spoken on the importance of good sleep hygiene (Kellaway, 2016). The introduction of the ‘night shift’ feature on

Apple devices shows that consumers are also more aware of the importance of sleep, and the ways in which modern life can affect it[12] (Hoyos, 2016). The increasing interest and attention paid to the role of sleep in the modern world should result in more focused academic research into its economic effects.

[12] The 'night shift' feature allows users to reduce the amount of blue light emanating from their screens which can help improve sleep quality.

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5 Appendix

5.1 Country data from Bin et al (2013)

Copy of Table 3: “Adjusted Proportions of Short and Long Sleep Durations in Each Country by Survey Year.” (Bin, et al., 2013, p. 5)

Because demographics within countries may have changed between each year of survey taken, proportions have been adjusted for gender, age, number of weekend days included, and month of data collected. This allows for comparison within countries. Proportions are not comparable between countries because of differences in survey methodologies and age ranges sampled.

Short sleep duration is defined as sleeping 6 or fewer hours per night; long sleep duration is defined as sleeping more than 9 hours per night.

Country	**Year**	**Short Sleep Duration**		**Long Sleep Duration**	
		%	**SE**	**%**	**SE**
Australia	1992	5.0	0.3	29.2	0.6
	1997	3.7	0.2	34.0	0.6
	2006	4.6	0.3	31.8	0.6
Canada	1986	10.9	0.5	30.5	0.7
	1992	11.5	0.4	25.2	0.5
	1998	11.3	0.4	27.4	0.5
Finland	1979	3.4	0.3	28.6	0.8
	1987	3.5	0.3	27.7	0.6
	1999	3.4	0.4	33.8	0.9
Germany	1991	3.9	0.2	23.5	0.5
	2001	3.4	0.2	23.2	0.5
Italy	1989	2.7	0.1	41.5	0.3
	2002	6.8	0.1	34.5	0.3
Netherlands	1975	0.5	0.2	22.4	1.2
	1980	0.7	0.2	24.2	0.9
	1985	0.7	0.2	18.0	0.7
	1990	0.9	0.2	22.0	0.7
	1995	0.8	0.2	21.5	0.7
	2000	0.5	0.2	28.8	1.1
	2005	0.8	0.2	24.6	1.0

Country	Year	Short Sleep Duration		Long Sleep Duration	
		%	SE	%	SE
Norway	1971	2.5	0.3	28.2	0.8
	1980	4.1	0.4	24.5	0.7
	1990	3.8	0.4	21.0	0.7
	2000	5.7	0.4	26.8	0.7
Sweden	1990	7.7	0.5	22.7	0.7
	2000	4.7	0.4	30.4	0.8
UK	1992	9.0	0.8	31.9	1.3
	2000	3.6	0.2	32.7	0.6
	2005	9.8	0.5	27.7	0.7
USA	1985	10.8	0.6	28.7	0.9
	1992	10.1	0.3	30.1	0.5
	1994	13.5	1.0	24.4	1.3
	2003	9.2	0.1	38.1	0.2
	2004	9.7	0.3	35.5	0.4
	2005	9.1	0.3	37.1	0.4
	2006	9.5	0.3	37.9	0.4
	2007	9.3	0.3	37.2	0.4

5.2 List of Time-Use Studies

5.2.1 Bin et al (2013): MTUS

The MTUS is a collection of time-use studies from 25 different countries. The data is then collated by the Centre for Time Use Research Oxford University. Bin et al (2013) used data from ten countries: Australia, Canada, Finland, Germany, Italy, Netherlands, Norway, Sweden, the UK and the USA. The survey methods used were a combination of recall interviews and written diaries, over a period of between one and seven days, depending on the country. Demographic data was also collected.

5.2.2 Biddle & Hamermesh (1990): Data from Szalai (1972) and 1975-6 TUS, 1981 TUS

Biddle & Hamermesh use three different time-use data sets.

Szalai (1972) collated time diaries from sites in 12 countries beginning in 1966: Belgium, Bulgaria, Czechoslovakia, France, the German Federal Republic, the German Democratic Republic, Hungary, Peru, Poland, the USA, the USSR and Yugoslavia.

The 1975-1976 time use study was conducted by the University of Michigan. 2,406 respondents kept time diaries for four separate days over one year. These were in October-November 1975, and February, May and September 1976. Demographic data was also collected.

The 1981 time-use study, also conducted by the University of Michigan, was similar in methodology to the 1975-1976 study. Data was collected from 606 respondents.

5.2.3 Szalontai (2006): 2000 time use survey by Statistics South Africa

Szalontai (2006) used data from the time-use survey conducted by Statistics South Africa in three tranches: February, June and October 2000. Unlike the 1975-1976 and 1981 Michigan surveys, the same respondents were not surveyed in each of the tranches. This was the first time-use study undertaken in South Africa. The number of respondents totalled 14,533. The collection method was through a face-to-face interview, asking respondents to recall the previous 24 hours, splitting the day into 30-minute segments. Demographic data was collected, and stratification methods were applied to control for over- and underrepresented groups.

5.2.4 Ásgeirsdóttir & Ólafsson (2015), Gibson & Shrader (2015): ATUS

Ásgeirsdóttir & Ólafsson (2013) and Gibson & Shrader (2015) use data from the American Time Use Survey. Data is collected by the Bureau of Labor Statistics and is released annually. Both papers use data from 2003-2013. Respondents are surveyed by telephone and asked to recall their time use in the 24 hours from 04:00 the previous day to 04:00 on the day of the interview.

5.2.5 Brochu et al (2012): Statistics Canada General Social Survey, 1992, 1998 and 2005

The methodology of Statistics Canada is largely the same as that used in the ATUS.

5.2.6 Giuntella et al (2015): CHARLS

The Chinese Health and Retirement Longitudinal Study CHARLS was designed to study Chinese residents aged 45 and above. The first study was conducted in 2011 and spanned around 17,500 individuals. The second study was conducted in 2013. The survey contains information on demographics, health status, health care and insurance, employment, income, pensions, assets and regional economic information.

In terms of sleep information, the question asked in the survey is "During the past month, how many hours of actual sleep did you get at night (average hours for one night)?" As is clear, this information is not as reliable as sleep information taken from time diaries, so should be treated with some reservation. However, the metric used to measure sleep in the authors' model is sunset time, which has been shown by Gibson & Shrader (2015) as a valid proxy for sleep duration (albeit in the USA rather than China).

5.2.7 Bonke (2012): Danish Time-Use Survey 2001 and Danish Time-Use and Consumption Survey 2008/9

Both surveys included two 24-hour time diaries to be filled in – one for a weekday and one for a weekend day. The 2001 survey was conducted for two months in spring and two months in autumn, whilst the 2008/9 survey lasted for one continuous year, from April 2008 to April 2009.

Both surveys followed the guidelines developed by Eurostat, for which an example page can be seen overleaf (Eurostat, 2009).

Time	**What were you doing?** *Record your main activity for each 10-minute period from 07.00 to 10.00!* Only one main activity on each line! Distinguish between travel and the activity that is the reason for travelling.	**What else were you doing?** *Record the most important parallel activity.* *Indicate if you used, in the main or parallel activity, a computer or internet. You do not need to record the use of a computer or internet during working time.*	**Where were you?** *Record the location or the mode of transport* e.g. at home, at friends' home, at school, at workplace, in restaurant, in shop, on foot, on bicycle, in car, on motorbike, on bus, …	**Were you alone or together with somebody you know?** *Mark "yes" by crossing* Alone	With other household members: Partner	Parent	Household member up to 9 years	Other household member	Other persons that you know
07.00-07.10	*Woke up the children*		*At home*	☐	☐	☐	☒	☐	☐
07.10-07.20	*Had breakfast*	*Talked with my family*		☐	☒	☐	☒	☐	☐
07.20-07.30				☐	☒	☐	☒	☐	☐
07.30-07.40	*Cleared the table*	*Listened to the radio*		☐	☐	☐	☒	☐	☐
07.40-07.50	*Helped the children dress*	*Talked with my children*		☐	☐	☐	☒	☐	☐
07.50-**08.00**	--"-- *Went to the day care centre*	--"--	*On foot*	☐	☐	☐	☒	☐	☐
08.00-08.10	*Went to work*	*Read the newspaper*	*Bus*	☐	☐	☐	☐	☐	☒
08.10-08.20	*Went to work*			☒	☐	☐	☐	☐	☐
08.20-08.30	*Work*	--"--	--"-- *Workplace*	☐	☐	☐	☐	☐	☒
08.30-08.40				☒	☐	☐	☐	☐	☐
08.40-08.50		--"--		☒	☐	☐	☐	☐	☐
08.50-**09.00**				☒	☐	☐	☐	☐	☐
09.00-09.10				☒	☐	☐	☐	☐	☐
09.10-09.20				☒	☐	☐	☐	☐	☐
09.20-09.30				☒	☐	☐	☐	☐	☐
09.30-09.40				☒	☐	☐	☐	☐	☐
09.40-09.50				☒	☐	☐	☐	☐	☐
09.50-**10.00**				☒	☐	☐	☐	☐	☐

Use an arrow, citation marks or the like to mark an activity that takes longer than 10 minutes.

5.3 Equations used in selected literature

5.3.1 Biddle & Hamermesh (1990); Szalontai (2006)

The following regression is estimated by Biddle and Hamermesh (1990) and Szalontai (2006):

$$T_s = \gamma_{1,s} + \gamma_{2,s} W_m + \gamma_{3,s} I + \beta_s \boldsymbol{X} + \mu_s$$

Where T_s is sleep duration; $\gamma_{i,s}$ are parameters to be estimated; W_m is the logarithm of the wage rate; I is the logarithm of the respondent's household's other income; and μ is an independently and identically distributed error term. ***X*** is a vector of the following demographic controls: work time, married, years married, age, age squared, male, excellent or good health, children under 3 years old, protestant and black.

5.3.2 Gibson & Shrader (2015)

Gibson & Shrader's (2015) first stage equations estimate the effect of sunset time on sleep duration. The reduced form equations measure the effect of sunset time on the natural logarithm of wages. If sunset time is a valid measure of sleep duration, causal estimates of the effects of sleep on wages by comparing α_1 with α_2 and φ_1 with φ_2 (Gibson & Shrader, 2015, pp. 8-10).

<u>Short run</u>

First stage

$$T_{S,ijt} = \alpha_1 sunset_{jt} + \gamma_{1,j} + x'_{it}\delta_1 + \eta_{1,ijt}$$

Reduced form

$$ln(\omega_{ijt}) = \alpha_2 sunset_{jt} + \gamma_{2,j} + x'_{it}\delta_2 + \eta_{2,ijt}$$

Where $T_{S,ijt}$ is night time sleep for individual *i* in location *j* on date *t*; $sunset_{jt}$ is the sunset time on that date in that location; γ_j is a location fixed effect; x_{it} is a vector of individual level controls; ω_{ijt} is a measure of wages or earnings observed at time t; and $\eta_{k,ijt}$ is the error term for the first stage (k = 1) and reduced form (k = 2).

Long run

First stage

$$T_{S,j} = \varphi_1 sunset_j + x'_j\zeta_1 + \varepsilon_{1,j}$$

Reduced form

$$ln(\omega_j) = \varphi_2 sunset_j + x'_j\zeta_2 + \varepsilon_{2,j}$$

Where $T_{S,j}$ is average night time sleep in location; $sunset_j$ is the average sunset time in that location; x_j is a vector of controls; ω_j is a measure of wages in location j; and $\varepsilon_{k,j}$ is the error term for the first stage (k = 1) and reduced form (k = 2).

5.3.3 Giuntella et al (2015)

Giuntella et al (2015) ran two regressions. This first estimated the effect of sleep on cognitive skills, whilst the second estimated the effect of sunset time on sleep.

$$C_{ict} = \beta_0 + \beta_1 S_{ict} + \beta_2 X_{ict} + \beta_3 K_{ct} + \beta_4 I_{ict} + \eta_r + \epsilon_{ict}$$

$$S_{ict} = \alpha_0 + \alpha_1 sunset_{ct} + \alpha_2 X_{ict} + \alpha_3 K_{ct} + \alpha_4 I_{ict} + \eta_r + v_{ict}$$

Where C_{ict} is a metric for cognitive skills for individual i, living in city c and interviewed on date t; S_{ict} is the self-reported average sleep duration in the last month for individual i in city c on date t; X_{ict} are standard sociodemographic controls at the individual level (age, gender, education, marital status, employment status, subjective income, household consumption, living in urban or rural area); K_{ct} are a set of economic and geographic characteristics of the city c (GDP, population, pollution level, landscape); I_{ict} are the interview characteristics (survey wave and month fixed effects); η_r are the regional fixed effects and $sunset_{ct}$ is the average sunset time in city c at time t. ϵ_{ict} and v_{ict} are error terms.

5.3.4 Bonke (2012)

Bonke (2012) ran two regressions in his model relating chronotype with income, one which did not include socioeconomic controls and one which did include these controls.

$$Y = \alpha_1 + \beta_1 Ch + \theta_1 S + \varphi_1 Z + \varepsilon_1$$

$$Y = \alpha_2 + \beta_2 Ch + \theta_2 S + \varphi_2 Z + \delta_2 X + \varepsilon_2$$

Where *Y* is personal gross income; *Ch* is chronotype (morning- or evening-type); *S* is sleeping hours; *Z* is age and sex controls; *X* is socioeconomic controls and ε is the error term.

5.4 Productivity measures

In sections 2.2.3 and 2.2.4 of the dissertation, a number of different methods are used to measure productivity. These are briefly described below.

5.4.1 World Health Organisation Health and Work Performance Questionnaire (used by Kessler et al, 2011; Sarsour et al, 2011)

This questionnaire uses self-reported data. Absenteeism is reported as the percentage of work days missed in the 30 days preceding the questionnaire. Presenteeism is reported as the level of performance, expressed as a percentage, where 0% is doing no work at all and 100% is performing at the level of a top worker, in the last 30 days.

5.4.2 Work Productivity and Impairment Questionnaire (used by Bolge et al, 2009; Hafner et al, 2015)

This questionnaire also uses self-reported data. Absenteeism is reported as the percentage of work time missed as a result of ill-health in the 7 days preceding the questionnaire. Presenteeism is reported as the percentage of impairment while working due to ill-health in the previous 7 days. An overall percentage is also requested, of the total work impairment due to ill-health in the previous 7 days.

5.5 Insomnia measures

In section 2.2.3 of the dissertation, a number of different methods are used to measure insomnia. These are briefly described below.

5.5.1 US National Health and Wellness Survey (used by Bolge et al, 2009)

Data was taken from the 2005 National Health and Wellness Survey. This studies a cross-section of over-18s and is an online survey. Respondents were categorised as insomniac if they self-reported a physician diagnosis of insomnia occurring at least twice a month.

5.5.2 Brief Insomnia Questionnaire (used by Kessler et al, 2011)

The Brief Insomnia Questionnaire consists of 32 questions asked by an interviewer. This questionnaire was developed for the American Insomnia Survey, the findings of which were reported in Kessler et al (2011). Here, insomnia is defined as night time symptoms occurring at least 3 times per week for a minimum of 30 minutes, and which have been occurring for a minimum of one month.

5.5.3 Insomnia Severity Index (used by Sarsour et al, 2011)

The Insomnia Severity score is based on seven questions which assess the severity of individual insomnia-related symptoms, the level of interference of these symptoms and individual satisfaction with sleep patterns. The maximum possible score is 28. The moderate/severe insomnia group, as described in the paper, consists of patients with a score of 15 or above. The Insomnia Severity Index has been validated against polysomnographic and sleep diary data.

5.6 Table of works cited

	1 Introduction		2 Literature Review								3 Discussion and Conclusion
	1.1 Motivating Data	1.2 Research Question	2.1 Macro-side	2.1.1 Time-Use Surveys	2.1.2 Non-standard workers	2.2.1 Productivity-reducing Traits	2.2.2 Sleep, Cognition and Productivity	2.2.3 Insomnia and Productivity	2.2.4 The 2015 RAND Study	2.3 Modern Workplace Practises	
Åkerstedt (2003)					x						
Alhola & Polo-Kantola (2007)							x			x	
Ásgeirsdóttir & Ólafsson (2015)	x		x								
Ásgeirsdóttir & Zoega (2011)										x	x
Barnett et al (2014)		x									
Biddle & Hamermesh (1990)		x	x								x
Bin et al (2013)	x			x							
Bolge et al (2009)		x						x			
Bonke (2012)										x	
Brochu et al (2012)			x								
Czeisler et al (1982)					x						
Drake et al (2004)					x						
Eurostat (2009)										x	
Frazis & Stewart (2012)			x	x							
Gibson & Shrader (2012)			x	x	x		x				
Giuntella et al (2015)							x				
Gold et al (1992)						x					
Golden (2012)										x	
Hafner et al (2015)	x								x		
Hamermesh et al (2008)			x								
Harvard Medical School (2009)											x

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	1.1 Motivating Data	1.2 Research Question	2.1 Macro-side	2.1.1 Time-Use Surveys	2.1.2 Non-standard workers	2.2.1 Productivity-reducing Traits	2.2.2 Sleep, Cognition and Productivity	2.2.3 Insomnia and Productivity	2.2.4 The 2015 RAND Study	2.3 Modern Workplace Practises	
Hoyos (2016)											x
Huang & Zhou (2013)							x				
Juster & Stafford (1991)				x							
Kellaway (2016)											x
Kessler et al (2011)								x			
Klein (2012)		x									
Landrigan et al (2004)						x					
Meager & Speckesser (2011)		x									
Miller et al (2014)							x			x	
NHS Employers Organisation (2013)						x					
Pilcher et al (2000)					x						
Roenneberg et al (2007)			x								
Sarsour et al (2011)								x			
Szalai (1972)			x								
Szalontai (2006)			x								
Takahashi (2003)										x	
Tett (2016)											x
Tietzel & Lack (2001)										x	
Van Dongen & Dinges (2005)							x			x	
Van Dongen et al (2003)							x			x	
Walker (2009)							x				
Weston (2014)					x						
Williamson & Feyer (2000)							x				