SLEEP INEQUALITY AROUND THE WORLD: AN EMPIRICAL APPROACH

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Abstract

Sleeping is probably the most frequent consumption and investment activity of humans, but it has been relatively understudied in economics. In this paper we use a time use global dataset and test competing theories to explain the differences in sleeping time between the rich and the poor around the world. We find that high income full-time workers tend to sleep *less* than those of low-income. Average estimates show a 10-20 minute lower sleep for the top quartile vis-a-vis poorer quartile of full-time workers. This stylized fact is robust to several covariates using panel data regressions, holding both across countries and, most importantly, within the countries in our sample. Furthermore, the observed negative covariation of income and sleep among workers, is consistent with a potential substitution effect with several leisure activities, like commute, surfing on the internet and outside socializing activities, all of which are also positively (and significantly) correlated with household income.

Keywords: Allocation of Time, Time Use Surveys
JEL Code: J22, J29

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INTRODUCTION

Understanding how people allocate their time among different activities is an old question in economics. However, most studies have focused on time devoted to work, leisure or home production, ignoring the activity in which people allocate most of their scarce time: sleep. Furthermore, nowadays there is not a convincing answer to questions like the differences in sleeping time between socio-economic groups, the economic consequences of the sleep decision or its demographic determinants, and moreover, in the few studies that deal with sleeping there is not even a consensus. In this context, there still a plenty of unanswered questions that require rigorous evidence to shed some light on them.

At present, there are some studies in economics focused on the relation between sleeping and variables like labor supply or productivity (Biddle and Hammermesh (1990), Szalontai (2003), Brochu et al. (2012), Gibson and Shrader (2015)), but they work only with one country as reference. From our perspective, even though they certainly contribute to the understanding of the relation between sleeping and economic activity, it is not clear whether their results are a symptom of a global phenomenon or are valid just for a particular case. For this reason, we believe that is more accurate and also represents a bigger improvement to the knowledge on this topic, to carry out a comparative study that documents the most relevant stylized facts about sleep and economics around the world.

In this context, using a set of different time use surveys from several countries, we document for the first time the relation between sleep, income and other socio-demographic characteristics in a group of developed and developing countries. Particularly, we find a negative correlation between sleeping hours and household income among the countries in our sample in *full-time male workers between 25 and 65 years old*. Multivariate regression evidence support our finding, even when controlling for a set of covariates like age, children, marital status and family composition variables. Furthermore, our results remain valid after several robustness checks considered.

Following Aguiar and Hurst (2009b), we complement the analysis studying the relation of household income with other leisure activities that might be acting as substitutes, to understand some potential mechanisms that could be explaining the observed correlation with sleeping. In the first instance, we run regressions using big aggregates of time use activities as outcomes, observing that some of them like home production or "passive" activities do not have any relation with household income. Nevertheless, outside socializing activities, like going to restaurants or participating in community events, and leisure do show a significant correlation. Even more, after disaggregating these activities, we find that commute, time spent watching tv, internet usage, childcare and outside socializing activities are significantly correlated with household income.

With this evidence, we analyze a family of models that might be suitable to understand the sleeping decision in economics and propose a new one that encompasses them all. Specifically, we check testable predictions of the static labor supply model and a household model that incorporates the relation between sleep and productivity proposed by Biddle and Hammermesh (1990).[1] Between these two type of models, we find that the productivity model's predictions fits better with the evidence observed in our data. In particular, a reduction on sleeping time after an increase in the wage rate is the prediction that makes this model a better theoretical framework to analyze sleep in economics. We extend this framework by incorporating, in a very general setting, some of the potential mechanisms that can account for our main stylized facts and check if the predictions are consistent with our data. Besides a opportunity cost mechanism, which is common to most economic models, we consider the substitution between leisure activities and sleep, and the potential productivity effects related to sleep which have been

[1] The model of Biddle and Hammermesh (1990) has also been used by Szalontai (2003) and Gibson and Shrader (2015)

documented by the medicine literature (McKenna et al. (2007), Harrison and Horne (1999), Harrison and Horne (2000)).

Our study contributes to the growing literature of economics of time use analyzing the differences in sleeping time between socioeconomic groups in several countries. Existing papers about sleeping in economics, are mainly concerned with addressing the question of whether sleep should be a choice variable and have focused their analysis only in one country. In this line, probably the most important paper is Biddle and Hammermesh (1990), who were the first in providing empirical evidence on this topic. The authors present a simple model where agents optimize over sleep, work and leisure, and then try to demonstrate that an increase in time spent in the labor market reduces sleep time.[2] Specifically, they found that each additional hour of market work reduces sleep by almost 10 minutes, and also show the existence of gender differences, finding that women sleep less than men. Other papers linked to this topic are Szalontai (2003), who studies the demand for sleep in South Africa, and a recent study from Gibson and Shrader (2015), that analyzes the effects of sleep on wages.[3]

Another strand of the literature led by Mark Aguiar and Erik Hurst studies the economics of time use in a broader sense. Specifically, they have focused in time use trends in the US, with emphasis in the allocation of time during recessions, trends in home production or trends in leisure inequality (Aguiar and Hurst (2009b), Aguiar and Hurst (2009a) Aguiar et al. (2012)). In this sense, our paper is close to Aguiar and Hurst (2009a) who studies the increase of leisure inequality in the United States since 1965 until today. They found that time allocated to leisure has increased during these five decades for both men and women, but after 1985 there has been an important increase in leisure inequality, were less educated men have experienced an increase in time allocated to leisure, while more educated men recorded a decrease in leisure time.[4] However, as mentioned above, unlike their work we focus on the hours of sleep, which is a parameter of documented relevance in public health.[5]

A recent paper by Gimenez-Nadal and Sevilla (2012) analyze the trends in time allocation and the trends in leisure inequality in several industrialized countries. Authors document general decreases in men's market work coupled with increases in men's unpaid work and childcare, and increases in women's paid work and childcare coupled with decreases in unpaid work. This paper is similar to our study analyzing the inequality between different of the population in several countries. However, it is worth noting some important differences between both studies. For example, our paper focuses in a cross-section of countries an not on time trends. This difference is important because the interpretation the results in both studies is completely different, specially if we take into account that we only focus on sleep, and not on leisure as a whole category. Furthermore, our paper only considers surveys from years after 2000 and analyzes differences in sleep time between income groups, and not differences in leisure as a category between educational levels.

Our paper also contributes to the extense literature on medicine and public health on sleep. Unlike our discipline, this literature is concerned with the effects of large differences in sleep on health or mortality, and also on the patterns of sleeping on the population and its socioeconomic factors. In this context, Cappuccio et al. (2010), Hale (2005) and Krueger and Friedman (2009) are some of the studies that deal with these topics. Even though methodologies differ in each case, all of them provide evidence on a negative relation between "high risk" sleepers

[2]The authors use data from the study of Szalai (1972) and the *1975-1976 Time Use Study* in the US to provide evidence on the economics of sleep. The first source include information about many countries, but was used only to estimate the correlation between sleep and employment status.

[3]To our knowledge, this paper is the only one that tries to identify a causal effect of sleep.

[4]Unlike our study, (Aguiar and Hurst, 2009a) include sleep time in their leisure definition.

[5]There are other economics papers that deal with sleeping time but from a different perspective like Kamstra et al. (2000), who studies the relation between weekends and the performance of stock markets, and the daylight saving time, or Brochu et al. (2012), who focuses on the relation between employment and the cyclical nature of sleep.

and health status.[6] On the other hand, papers like McKenna et al. (2007), Harrison and Horne (1999) and Harrison and Horne (2000) are concerned with the effects of sleeping on the decision process of individuals. This strand of the literature finds that decisions involving risk or that are intensive in cognitive skills are negatively affected by sleep deprivation.

Even though the literature in medicine and public health have tried to explain more broadly the causes and consequences of sleep in society, they have not related inequalities in sleep with household income, and even more, most of them have worked only with the US, or with data from only one country.[7]

Furthermore, it is worth noting that even though the results of our study do not reflect causality, and omit some important topics like the quality of sleep or the distribution of power within the household, the improvement we introduce to the literature is bigger than this cost. More importantly, we believe we open the way for empirical studies to test the effects of the potential mechanisms that can explain the negative correlation observed between sleep and household income using a more appropriate design.

The rest of the paper proceeds as follows: Section 2 describes our data and presents descriptive statistics. In section 3 we present and analyze the evidence on the relation between sleep and household income. Section 4 complements the previous section with multivariate regression analysis on the relation between sleep and other leisure activities which give us a clue of the potential mechanisms. In section 5 we present different family of models that can be used to represent the main stylized facts , and also propose a new model that encompasses the others. Finally section 6 concludes.

SLEEP DATA

DATA SOURCES AND DEFINITIONS

The goal of our paper is to study differences in the time allocated to sleep among income groups in a set of developed and developing countries. The sleep data we use comes from the *Multinational Time Use Study*, a compilation of time use surveys from many countries which is available on `https://timeuse.org`. Time use surveys ask individuals what they where doing during an specific time period (e.g. an hour or half an hour), and therefore the minutes they allocate to sleep have to be computed as the integral of the sleeping time. The sample consists of surveys from 16 countries, where some of them contain several rounds of the survey. Also, most of the countries in the sample are developed, including the US, UK, Germany or Norway, but there are some developing countries like South Africa or Slovenia.

Nevertheless, our purpose is to compare the most homogeneous population as possible, in such a way that we can rule out the influence of other factors, like age, gender, residence area or work time. For this reason, we restrict our sample to full-time male workers between 25 and 65 years old, and exclude weekends from the main analysis (Biddle and Hammermesh (1990), Gibson and Shrader (2015), Hale (2005), Krueger and Friedman (2009)). Moreover, we work only with surveys that were collected after year 2000, and with only the last wave of each survey.

In addition, we define full-time workers as those individuals who report to work 8 or more hours the day the survey was collected. This definition is not entirely accurate because some people could have reported more than what they usually work the day of the survey, but it was the best criteria we have to harmonize the databases that

[6]High risk sleepers are those people who sleep less than 6 hours or sleep more than 9 hours a day.

[7]Biddle and Hammermesh (1990) use data for different countries but only to provide descriptive statistics of sleep. They do not test any hypothesis related with income using countries different from the US.

were not on *MTUS* data.[8]

Thus, the final subsample of MTUS that we use only includes 11 countries that meet these requirements. The countries included are: Denmark, Germany, Italy, Netherlands, Norway, South Korea, Slovenia, South Africa, Spain, United Kingdom and the US.

We also incorporate data from three developing countries from South America: Chile, Ecuador and Peru. In the case of Chile, we use the only round of the *Encuesta de Uso del Tiempo* (EUT) prepared by the National Institute of Statistics (INE). The sample we use consists of 3561 observations from almost 1600 households that were surveyed in Santiago, the main city of this country. The survey include a rich set of variables that account for the activities that the individuals where doing during the day before the survey. Specifically, the questionnaire includes time intervals of 30 minutes from 5:30 a.m to 5 a.m, where the respondents have to answer what were they doing at that time. Every activity they report is associated with an specific code in our data (e.g. Sleeping=6211) and it is divided into main activity and secondary activity. The survey also contains socio-economic information, like gender, age, education and income.

In the case of Ecuador, we use the *Encuesta Específica de Uso del Tiempo 2012* (EUT) prepared by the National Institute of Statistics and Censuses of this country. As the rest of the surveys we are working with, this nationally representative survey collects information about the activities people were doing during the day, but specifically they ask about what they were doing last week. The sample from EUT also has a rich set of socio-demographic variables. Finally, the data of Peru corresponds to the *Encuesta Nacional de Uso del Tiempo 2010* developed by the Ministry of Women and Social Development, and the structure of this data is the same as in the case of Chile and Ecuador.

The two main variables in the study are the sleep hours of each individual an household income. Specifically, with regard to the hours of sleep, even thouhg there are some differences among the countries on how they report the time people spend sleeping, in most of them the variable is expressed as the minutes each person allocate to this activity. That is, to construct the hours of sleep we only have to divide the original variable by 60.[9] In the case of household income, to construct the variable we follow *MTUS* harmonized definition and divide household income in three groups: *Top 25% Income*, *Middle 50% Income* and *Lowest 25% Income*.[10] We also use a set of covariates that include age, marital status, household size and the number and age of children within the household.[11]

DESCRIPTIVE STATISTICS

We present cross-country evidence on the relation between sleep hours and income considering the entire sample of each one of the 14 countries of the study. In panel a) of Figure 1, we graph tha relation between sleeping hours and GDP per capita. Specifically, we can see that there is a negative relation between both variables, and more concretely, more developed countries like Germany, Norway, UK or Netherlands sleep less on average than developing countries. Even though this relation is not statistically significant, an interesting fact that we can rescue from panel a), is that most of the countries in our sample sleep more on average than the medical accepted standard of 8 hours (Krueger and Friedman (2009), Cappuccio et al. (2010), Bin et al. (2013))[12]. More interestingly, between

[8] As a robustness check we present alternative definitions of full-time workers.

[9] The construction of the variables is detailed in the Appendix.

[10] In the case of Chile, household income variable is categorical variable, so we took the value of the highest category and calculate the 25% of this values to compute the three income groups. In the case of Ecuador and Peru, household income variable was continuous, so we just ordered the observations according to income and then constructed the three income groups.

[11] As a robustness check we test our results with a subsample of *MTUS* data that include more activities but that its available only for a subset of countries. This data include additional covariates like health status and occupation.

[12] See Hale (2005) and Krueger and Friedman (2009) for a reference on the effects of sleep deprivation and oversleeping.

the countries that sleep less than 8 hours, there is not a big difference between developed and developing countries. In particular, Peru and Ecuador are the countries that sleep less on average in our data, and the difference with other developed countries like South Korea or Denmark is only of 15 minutes. Moreover, with the exception of South Africa, the same phenomenon occurs in those countries that sleep more than 8 hours, which reveals that income seems not to be very important for explaining "high risk" sleep behaviors.

One hasty interpretation of the negative relation observed, would be to ensure that the opportunity cost of sleeping is higher in more developed countries or, in other words, that sleep is more expensive when income increases. However, before jumping too quickly into conclusions, it is worth focusing on a more homogeneous group across countries. For this reason, in panel (b) of Figure 1 we show the same plot but now restricting the sample to adult men. We consider as adults people between 25 and 65 years old, working full time (8 or more hours a day)[13].

Now we observe a significant negative relation between sleeping hours and GDP per capita which is consistent with the general notion that as the price of time increases and income rises, the demand for sleep will fall. That is, in more developed countries allocating more time to sleep is more costly than in less developed ones. Furthermore, it is worth noting that the number of sleeping hours diminish importantly when restricting the sample. Specifically, in developed countries people sleep approximately 7.5 hours a day, which is almost 1 hour less than when we consider the whole sample. This means that restricting the sample not only changes the slope, but also the average level.

The negative relation observed in Figure 1 is just a raw picture of how both variables actually behaves. For this reason, telling more about this relation requires going to the microdata. In this context, we constructed a set of "sleep inequality" indicators for each survey in our final sample to compare the sleep behavior of individuals within each country. Firstly, we computed the average number of sleep hours for the three income groups included in our sample: *High Income*, *Middle* and *Low Income*, and then we generate a variable that measures the difference in sleeping hours between the two extreme groups. We also include a measure of the proportion of the population that sleeps less than 6 hours, which is used frequently in public health and medicine literature as a measure of risk sleep behavior (Hale (2005), Krueger and Friedman (2009), McKenna et al. (2007)). Finally, we compute a sleep hours Gini that accounts for the distribution of sleeping hours in the population and some standard cross-country variables like the Gini coefficient for each country and the per capita GDP.[14]

The first relevant indicator is *Sleep Poverty*. Table 1 shows that there is not a clear trend that relates the percentage of sleep deprivated men with the income of the country. In particular, we can see that developed countries like the US or Norway present a similar percentage of men who sleep less than six hours than developing countries like Ecuador or Slovenia, that revolves around 15%. Moreover, Chile and Denmark show the higher percentages of "sleep poverty" in the sample. This is not consistent with the clear macro evidence presented on Figure 1, were we observe a negative relation between income and sleep. However, if we want to analyze differences among income groups, there are other indicators that are more useful.

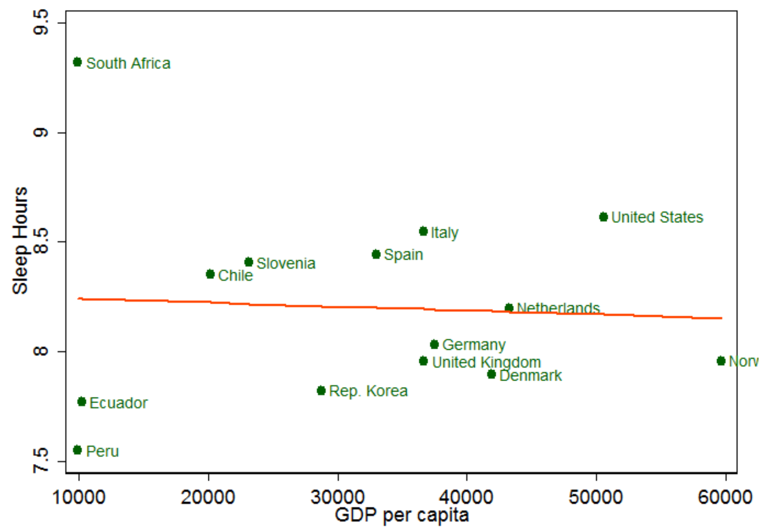
To illustrate the differences in sleeping hours between the rich and the poor, we constructed the following three indicators: $H_{25\%}$, $L_{25\%}$ and $H_{25\%} - L_{25\%}$. The first two represents the average of sleep hours of the 25% highest income group and of the 25% lowest income group respectively. While the third one is just the difference between the indicators. The trend we observe in these indicators is probably the most striking result of the table, and also a first approach to the most relevant result of the paper. We find a consistent negative difference between the sleeping hours of the richest and the poorest in every country of our sample, with the exception of Slovenia and the UK.

[13] On the Appendix we present the same graph, but now restricting the sample to urban areas.

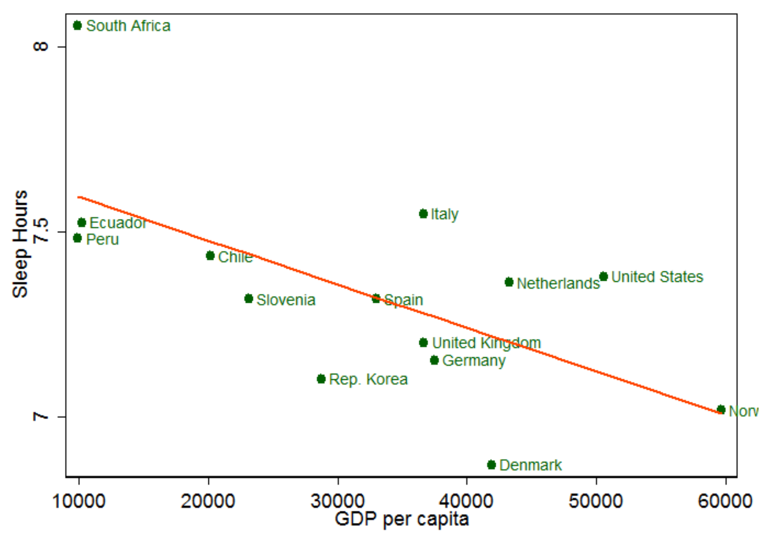
[14] GDP per capita is measured in US dollars from 2011.

Figure 1: Sleep Hours vs GDP per capita

(a)



(b)



Note: Author calculations using: EUT-Chile, EUT-Ecuador, ENUT-Peru, MTUS and WDI. When multiple surveys are available, for this plot we use the last round available (see Appendix). Panel (a) displays the relationship between average sleeping time in the sample and GDP per capita (PPP) of men between 25 and 65 years old in the country. The line is average sleeping time for country i, is fitted as a regression $\bar{s}_i = 8.261 - 1.802e - 0.6GDP_i^{PC}$ (p-value of the slope 0.835). In contrast, panel (b) displays sleeping time only for full-time male workers between 25 and 65 years old (This is not a gender bias in our focus but simply a way to focus on a more homogeneous group across countries.). The line is average sleeping time for country i, is fitted as a regression $\bar{s}_i = 7.712 - 0.00002GDP_i^{PC}$ (p-value of the slope 0.014). GDP per capita (PPP) is in US dollars from 2011.

Table 1: Descriptive Statistics

Country	GDP per capita	Gini	Sleep "Poverty"	$H_{25\%}$	$L_{25\%}$	$H_{25\%} - L_{25\%}$	Sleep Gini	$N_{L25\%}$	$N_{H25\%}$	Total
Denmark	41,886	24.060	21.911	6.844	7.228	-0.384	9.842	27	171	398
Germany	37,458	29.440	16.319	7.039	7.483	-0.444	8.851	40	182	722
Italy*	36,622	31.140	8.642	7.317	7.812	-0.495	8.019	49	42	486
Netherlands	43,243	31.140	10.839	7.306	8.350	-1.044	7.773	22	621	1,455
Norway	59,620	27.57	14.286	6.956	7.772	-0.816	9.167	30	53	180
Rep. Dem. Korea	28,716	-	17.436	7.292	7.187	-0.326	8.964	327	929	3,424
Slovenia	23,115	-	11.679	7.179	6.852	0.327	11.296	9	56	110
South Africa	9,927	57.770	10.312	7.624	8.628	-1.004	10.730	180	323	1,101
Spain	32,994	35.750	12.575	7.213	7.476	-0.263	9.411	110	172	893
UK	36,665	37.630	15.765	7.069	6.444	0.624	9.616	3	126	254
USA	50,549	41.120	16.405	7.229	7.827	-0.598	10.773	101	411	957
Chile	20,141	50.840	22.088	6.833	7.371	-0.538	12.128	198	3	239
Ecuador	10,233	46.570	15.132	7.443	7.728	-0.285	8.248	72	2,912	3,714
Peru	9,915	44.920	15.390	7.200	8.056	-0.856	8.676	361	1,033	3,109

Note: Authors calculations using *EUT-Chile, EUT-Ecuador, ENUT-Peru, MTUS* and*WDI*. *Sleep Poverty* is computed as the percentage of adults that sleep less than 6 hours a day. $H_{25\%}$ corresponds to the Highest 25% of the income distribution of each country, while $L_{25\%}$ corresponds to the Lowest 25%. $H_{25\%} - L_{25\%}$ is the difference between $H_{25\%}$ and $L_{25\%}$. *Sleep Gini* measures the Gini coefficient associated with the sleeping hours distribution. All calculations were done using full-time male workers between 25 and 65 years old. GDP per capita (PPP) is in US dollars of 2011.
* Sleep indicators were constructed using the level of education instead of the level of income because these variable is not available for this country.

However, in some of the countries one of the the groups is underrepresented. For example, in the case of Chile, there are 198 individuals in the lowest 25% income group, but just 3 in the highest 25% income group. This is exactly what happens in the case of Slovenia and the UK, where there are only 3 and 9 individuals in the poorest quartile respectively, compared to 53 and 129 in the richest quartile. In other words, the comparison in these two cases (and in also in the case of Chile) are less reliable than in the rest of the countries.

The negative difference observed means that people belonging to high income households are, on average, sleeping less than people of poorer households. In a traditional static labor supply model, this would mean that, under normality of sleep, an increase on wages also represents an increase on the opportunity cost of sleeping, so more productive workers necessarily will sleep less than the unproductive ones. Of course, this simple setting ignores the possibility of complementarities between leisure activities or the fact that sleep (or other leisure activities) might affect the productivity of workers (among other explanations), but on first instance, is a good approximation of the relation between the two variables. and moreover, is consistent with the evidence presented on Figure 1.

The last indicator of Table 1 is *sleep gini*. To construct this variable we assume the distribution of sleep hours is the same as the distribution of the population, and then we compute the gini with the standard formula. As we can see, the value of this indicator does not fluctuate too much among the countries of the sample. This fact was expected, given that, even tough sleep hours might be a choice variable, all the people must sleep a minimum of hours during the day to be able to work or function properly. This implies that the distribution of sleeping hours in every survey must not be too "unequal". Most importantly, however, is the fact that inequality in sleep hours measured by the sleep gini, seems to be related (partially) to income inequality. Particularly, countries with a low income gini like Denmark, Norway or Netherlands also present the lowest sleep gini, while countries like Chile or South Africa or the USA with high inequality present a more unequal sleep distribution. However, the evidence is not conclusive because there are some countries like Ecuador or Peru with a high income gini that present one of the lowest sleep gini in our sample.

Figure 2 complements the evidence provided in Table 2 and shows the average hours of sleep of the Highest Income and the Lowest Income group for each country in our final sample[15]. We observe that, in all the countries of our sample people of poorer households sleep more than people in richer ones, even though the difference on the average sleep time seems not to be very big (approximately 20 minutes). However, the correct analysis is to extrapolate this number to longer time period, like weeks or months. For example, *ceteris paribus*, if the difference persists for all the week, poorer people will be sleeping 1 hour and 40 minutes more than the richest group, and if the difference persists for a month it will be of 7 hours. From our point of view, the magnitude of these numbers justify by itself a more exhaustive analysis of this topic.

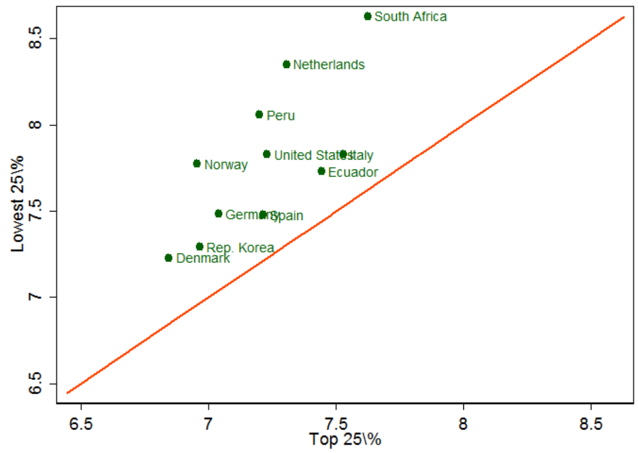
THE POOR SLEEP MORE: SLEEP INEQUALITY AND THE COVARIATION WITH HOUSEHOLD INCOME

The main finding from last section was that people in poorer households sleep more on average than richer ones, and this phenomenon seems to be common to most of the countries in our sample. In this section we conduct regression analysis restricting the sample again to adult full-time male workers to analyze if the observed differences are significant or not.

As a first approach, we compute within-country regressions to test if the stylized fact is valid in all the countries of our sample. Our concern in this case is on within country sleep-income elasticities, $\partial S_{country}/\partial Income_{country}$.

[15] We omit Slovenia, UK and Chile from the graph because $L_{25\%}$ is underrepresented in these three countries.

Figure 2: Sleep Hours and Household Income Groups



Note: Author calculations using: EUT-Chile, ENUT-Ecuador, MTUS and WDI. These are full-time male workers who live between 25 and 65 years old. *Lowest 25% Income* corresponds to the lowest 25% of the income distribution of each survey in our final sample, while *Top 25% Income* corresponds to the highest 25% of the income distribution of each survey in our final sample.

Particularly, we run OLS regressions in each country of the sample using the income dummies as the main regressors. We omit the *Middle 50%* dummy, so the estimates must be interpreted as the difference with respect to this variable. Also, within countries elasticities were computed controlling for a set of covariates including age, age squared, marital status and family composition variables. In all the specifications the dependent variable is the number of sleep hours.

Table 3: Sleep Hours vs. Household Income (Within-Country)

Country	Lowest 25%	Highest 25%	$H_{25\%} - L_{25\%}$	N	Adj. R^2
Denmark	0.388	-0.028	-0.416	398	0.048
	(0.272)	(0.126)	[0.133]		
Germany	0.303	-0.027	-0.330	722	0.006
	(0.190)	(0.114)	[0.126]		
*Italy**	0.257	0.014	-0.243	486	0.030
	(0.183)	(0.196)	[0.329]		
Netherlands	0.888***	0.004	-0.883***	1,455	0.040
	(0.214)	(0.058)	[0.000]		
Norway	1.217***	0.140	-1.077***	180	0.094
	(0.352)	(0.200)	[0.004]		
South Korea	0.181***	-0.185***	-0.366***	3,424	0.116
	(0.066)	(0.043)	[0.000]		
Slovenia	-0.087	0.005	0.092	110	0.217
	(0.945)	(0.297)	[0.927]		

Continued on next page...

... Continuation Table 3

South Africa	0.480***	-0.508***	-0.988***	1,101	0.164
	(0.122)	(0.101)	[0.000]		
Spain	0.179	-0.134	-0.313**	893	0.105
	(0.133)	(0.092)	[0.030]		
United Kingdom	-0.723	0.031	0.754	254	0.035
	(0.813)	(0.193)	[0.356]		
United States	0.253	-0.130	-0.383**	957	0.113
	(0.166)	(0.094)	[0.022]		
Chile	-0.251	-1.032	-0.781	239	0.140
	(0.302)	(1.415)	[0.571]		
*Ecuador***	-0.117	-0.342***	-0.225	3,714	0.038
	(0.151)	(0.048)	[0.124]		
*Peru***	0.462***	-0.287***	-0.749***	3,109	0.090
	(0.068)	(0.044)	[0.000]		

Significance Level: * 10%; ** 5%; *** 1%. The table reports OLS regression estimates where the dependent variable corresponds to the number of sleep hours. The equation we estimate is: $s_i = \alpha + \beta_1 Income_i^{Low25} + \beta_2 Income_i^{Top25} + \gamma' X_i + \epsilon_i$. Lowest 25% and Highest 25% columns correspond to the coefficients of each income dummy in each regression. *Diff.* correspond to an F test of the difference between the coefficients. P-values of the F test are in brackets. In each regression we use: age, age squared, marital status, working hours, household size and the number of children as covariates. We use robust standard-errors.

*We use the level of education as the main regressor because income variables were not available. The level of education is divided in three categories: *less than secondary*, *complete secondary* and *above secondary*. We omitted the *complete secondary* dummy in the regression.

**We do not include household size and the number of children as covariates in these regressions because this variables were not available on these databases.

We can observe that belonging to the lowest 25% income group increased the number of sleep hours (or has no effect), while belonging to the highest 25% decreased the number of sleep hours in the countries of the sample (or has no effect). More importantly, the difference between the coefficients is statistically significant in the countries of the sample, which is consistent with the negative correlation observed on the descriptive statistics. In those countries where we observed a positive relation on Table 1, the difference is not statistically significant, which also support our finding of sleep inequality. Moreover, it is worth noting that in some of the countries as Chile or Slovenia, the number of observations is very small, so the fact we do not observe a significant coefficient could be related to the lack of power to reject our null hypothesis. Nevertheless, this is only a conjecture and do not represent a threat to the main argument we are trying sustain with our data.

With regard to the magnitude of the coefficients, there is heterogeneity between the countries of the sample. For example, in the case of Netherlands or South Africa, we observe a significant difference that is equal to almost one hour, while in the case of South Korea or the USA the difference is of approximately 20 minutes. However, in all cases the differences seems to be big, considering that if we extrapolate them to other time units like weeks or months, the magnitudes increase considerably. For instance, in the case of the USA, if the sleep hours differences between income groups persist during one week, people from the poorest households would be sleeping 2 hours more than people from the richest ones, and almost 12 hours if we extrapolate the differences to months. Moreover, the observed differences in sleep hours in the US support the evidence provided by Aguiar and Hurst (2009a), who find significant differences on leisure among educational levels. Although they do not test directly differences on sleep, this activity is included on their leisure definition, and also shows important differences in the average of sleep hours between the groups.

Additionally, as a robustness check, we also analyze the relation on adult full-time female workers [16] However, the negative relation is only valid in two of the countries of the sample. In the rest of the countries the difference between both income groups is not statistically significant. This result suggest that sleep inequality is related mainly to male workers, even though in the case of women the number of observations are even smaller than in the case of men.

BETWEEN-COUNTRY INEQUALITY

Now we proceed to run multivariate panel regressions to analyze the covariation of sleep with household income across countries. For this we construct a panel data using all the time use surveys that meet our requirement to compare an homogeneous population. First we estimate the following equation:

$$s_{ic} = \alpha_c + \beta Income_{ic} + \gamma' X_{ic} + \epsilon_{ic} \quad (1)$$

where s_{ic} are the sleep hours of individual i in country c. $Income_{ic}$ corresponds to household income, which is a categorical variable in our sample. X_{ic} is a vector of covariates, which include the following variables: age, age squared, marital status, number of work hours, number of people in the household and number of children under 18 years old. α_c is a country fixed effect and ϵ_{ic} is the error term. Standard errors are clustered at the country level to correct the heterokedasticity associated to this specification. Results are presented on Table 4:

Table 4: Sleep Hours vs. Household Income

Dependent Variable	Sleep Hours		Log Sleep Hours	
Level of Income	(1)	(2)	(3)	(4)
Income	-0.239***	-0.190***	-0.031***	-0.025***
	(0.043)	(0.054)	(0.005)	(0.006)
Country fixed Effects	✓	✓	✓	✓
Couple	✓	✓	✓	✓
Age	✓	✓	✓	✓
Age2	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓
Number of people in the household		✓		✓
Number of children<18 in the household		✓		✓
N	16,556	9,733	16,551	9,728
Adj. R^2	0.033	0.087	0.027	0.090
N. Countries	13	11	13	11

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. We report resuls using sleep hours and

[16] Results are presented on the Appendix.

the logarithm of sleep hours as the dependent variable. The equation we estimate is: $s_{ic} = \alpha_c + \beta Income_{ic} + \gamma' X_{ic} + \epsilon_{ic}$. In columns (1)and (3) we use: age, age squared marital status and the level of working hours as covariates; in columns (2) and (4) we use: age, age squared, marital status, level of work hours, household size and the number of children. Countries included are: Denmark, Germany, Netherlands, Norway, South Korea, Slovenia, South Africa, Spain, United Kingdom, United States, Chile, Ecuador and Peru. Standard errors are clustered at the country level.

Our estimates show that there is a negative effect of household income on the hours of sleep, which is robust to several specifications. Particularly, in the first two columns of Table 4 we observe that an increase in the category of household income, which can be interpreted as an increase in the "income percentile" of it, reduces the hours of sleep in approximately 12 percentage points, that is equivalent to almost 10 minutes of sleep, and is very similar to the results found in Biddle and Hammermesh (1990) and Szalontai (2003) for the US and South Africa respectively. In columns (3) and (4) we run the same regression but using the logarithm of hours of sleep as the dependent variable. In this case, there is also a negative and significant effect on the hours of sleep of around 3%, or in other words, an increase in the income category reduces the percentage of sleep hours during the day in 3%. It is worth noting that in columns (2) and (4) the sample size is smaller than in columns (1) and (3), which is due to the lack of information on family composition variables in Ecuador and Peru, that are two of the countries with more observations in our sample

Even though these results support the within regression evidence, meaning that income inequality seems to be relevant also between countries, the income definition we use on equation (1) is not entirely accurate because the variable we are using is a categorical one. Given this definition of household income, and our focus in sleep inequality, we construct three dummy variables from the original household income categorical variable and omit the *Middle 50%* category. The idea is to analyze the correlation with sleep on the poorest and the richest, and determine if there are significant differences between these groups. We estimate equation (2), which differs from equation (1) only in the two additional dummy variables we include. Formally,

$$s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Top25} + \gamma' X_{ic} + \epsilon_{ic} \quad (2)$$

where $Income_{ic}^{Top25}$ takes the value 1 if individual i belongs to the lowest 25% of the income distribution and $Income_{ic}^{Top25}$ takes the value 1 if the individual i belongs to the highest 25% of the income distribution. On Table 5 we present the results of these estimates and report and F test of the difference between both coefficients with their respective p-value.

Table 5: Sleep Hours vs. Household Income

Dependent Variable	Sleep Hours		Log Sleep Hours	
Level of Income	(1)	(2)	(3)	(4)
Lowest 25 %	0.279***	0.284***	0.036***	0.038**
	(0.080)	(0.087)	(0.010)	(0.012)
Highest 25 %	-0.222***	-0.147**	-0.029***	-0.018**
	(0.045)	(0.056)	(0.006)	(0.006)
$High_{25\%} - Low_{25\%}$	-0.501***	-0.430***	-0.065***	-0.057***

Continued on next page...

... Continuation Table 5

	[0.000]	[0.003]	[0.000]	[0.002]
Country fixed Effects	✓	✓	✓	✓
Couple	✓	✓	✓	✓
Age	✓	✓	✓	✓
Age2	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓
Number of people in the household		✓		✓
Number of children <18 in the household		✓		✓
N	16,556	9,733	16,551	9,728
Adj. R^2	0.033	0.087	0.027	0.090
N. Countries	13	11	13	11

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. We report results using sleep hours and the logarithm of sleep hours as the dependent variable. The equation we estimate is: $s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Top25} + \gamma' X_{ic} + \epsilon_{ic}$. In column (1) and (3) we use: age, age squared marital status and the level of working hours as covariates; in column (2) and (4) we use: age, age squared, marital status, level of work hours, household size and the number of children as covariates. $High_{25\%} - Low_{25\%}$ corresponds to an F test of the difference between the coefficients of $Highest25\%$ and $Lowest25\%$. We report p-values of the test in brackets. Countries included are: Denmark, Germany, Netherlands, Norway, South Korea, Slovenia, South Africa, Spain, United Kingdom, United States, Chile, Ecuador and Peru. Standard errors are clustered at the country level.

As we expected, the sign of the coefficients differ in each income group. In the case of $Income_{ic}^{Low25}$, in all specifications we can see that there is a positive significant effect of belonging to this group. Particularly, belonging to the poorest 25% of the households increase the hours of sleep in approximately 20 minutes, which is equivalent to almost one hour and 40 minutes in one week. While in the case of the percentage of sleep hours, we observe an increase of almost 5%. In addition, the coefficient of $Income_{ic}^{Top25}$ presents a negative sign in all of the specifications, which means that beloging to the richer income group of the population reduces the sleeping hours, and is consistent with the results presented on previous tables. The F test also revealed that the differences between the poorest and the richest are even larger and statistically significant in all the specifications considered, indicating that the Lowest 25% income group sleep approximately 30 minutes more during the day than the Highest 25% income group (15 hours in one month!)[17]

In sum, the evidence on sleep inequality provided by within and between countries regressions suggests that this is a phenomenon that spans more than one country. Even if we consider that our sample is not representative at the national level (we only consider men) and the results do not reflect causality, the mere correlation between our two variables of interest, sleep and income, represents an improvement that deserves more attention from the academy, given the impact it could have on economics decisions of agents.

[17] Following Cameron et al. (2008) and Cameron and Miller (2015), we compute the p-values of the $High_{25\%} - Low_{25\%}$ coefficient using bootstrapping with asymptotic refinement (BAR) and wild bootstrapping (WB) to correct for the small number of clusters we used in our main specification. The significance of results remain the same after we made this adjustment. Particularly, the p-value when we use BAR is 0.003, and when we use WB is 0.004.

ROBUSTNESS CHECKS

To analyze the consistency of our previous results we present several robustness checks to see if the negative relation between sleep time and household income still holds. Some of the checks we consider include: additional covariates like zone or child heterogeneity, modify our definition of full-time workers or check the sleep behavior in weekends.

ADDITIONAL COVARIATES: ZONE AND CHILDREN'S HETEROGENEITY

Besides the omitted variable bias we could avoid if we include additional covariates in our specification, one important question we could ask is what would happen to the sleep-income relation if we restrict even more our sample. To answer this question, we decided to consider in our estimates only those people who live in urban areas, which is an even more restricted sample than the original. This could be relevant because of several dynamics that can emerge in urban and rural places that could determine different sleep patterns (Szalontai (2003), Brochu et al. (2012), Gibson and Shrader (2015), Hale (2005)). A simple example of this fact has to do with the "lifestyles" of both zones, where leisure activities could differ substantively. For instance, in rural zones where the supply of leisure activities is, in general, smaller, the best alternative that individuals have in their free time is to sleep, which is also a less expensive activity. This would imply that our original estimates are upward bias because the probability of sleeping in their free time is higher for individuals who live in rural areas.

To account for this fact, we simply run the same regression as before but on this new subsample of people who live in urban areas. However, one problem with this approach, is that not all the countries in the sample has this variable available, so the number of observations in our estimates not only is reduced because of the zone restriction, but also because of the availability of the variable. Specifically, Denmark, Germany and the UK do not count with this variable.

Estimates show that the negative relation between sleep and income is smaller when we restrict the sample to urban areas, although the difference is not large and still statistically significant. In particular, we observe in the first column of Table 6 that belonging to the *Lowest 25%* group increase the hours of sleep in approximately 14 minutes with respect to the middle income group, while in the case of the *Top 25%* there is a reduction in the hours of sleep of around 10 minutes with respect to the same group. In consequence, the difference is basically the same than in the original case without the zone constraint, which means that sleep inequality does not disappears and is not particularly larger in urban areas.

The second check involving the inclusion of additional covariates, is to consider the heterogeneity between the children within the household. Particularly, we focus on heterogeneity in the age of children. This issue have been largely studied by the economics of the family literature using collective decision models, where the bargaining between household members determine efficient outcomes (Blundell et al. (2005), Browning et al. (2014), Donni (2009)). Particularly, there is a difference in parents behavior when children are between 0 and 5 years old, and when children are between 15 and 18. In the first case, parents internalize the fact that they have to take decisions for their children and also take care of them, affecting in this way their demand for sleep (e.g. allocating more time to childcare than sleep). To account for this possibility, we include a categorical variable that considers the age of the youngest child in the household. As in the case of the zone constraint, there are some countries that do not have this variable available, and also some countries that do have this variable, but with a lot of missings. This imply that our estimates were computed using a number of observations considerable lower than in the original case.

Results presented on column 2 of Table 6 show that the difference between the poorest quartile and the richest one increase compared to the original estimation, although the difference is relatively small. Specifically, the F test of the difference between both coefficients is of 0.456, which represents approximately 28 minutes. While in the case of the logarithm of sleep hours the difference is of almost 6%, which is 1 percentage point larger than in the original case. This result suggests that children heterogeneity could be an important determinant in the demand for sleep, even though the mechanism is not completely clear. But, as in previous checks, the most important fact about this results is that sleep not only persists, but increase when taking into account the age of the youngest child of the household.

FULL-TIME DEFINITION

The second robustness check we consider, is if our main stylized fact survives if we modify the full-time definition we are using. As we pointed out in previous sections, we defined full-time workers as those individuals that report to have worked 8 or more hours during the day. The problem with this definition, is that it is not very accurate because of the possibility that the hours reported are not something systematic in the individual behavior of the respondents. In other words, there might be some respondents that overreported (or underreported) their hours of work. To account for this possibility we estimate equation (2) but using two different definitions for full-time workers. First we reduce the “working hours cutoff”, and consider individudals who work 6 or more hours as full-time workers [18].

Obtained estimates presented on column 3 of Table 6 show that the correlation between sleep and household income still significant in this case, and the magnitude of the coefficient practically do not change in any of the specifications considered (0.430 in our original estimation against 0.432 when we modify the full-time definition). This means that the restriction in the number of hours we imposed seems to be not very relevant in our original results, or in other words, the full-time restriction is not sensitive to an small change.

The other modification to the full-time definition, was to use the definition contained in the MTUS data. Specifically, the employment status question on MTUS identify full-time workers as those who report to have worked more than 30 hours the week before the survey was collected. This definition let individuals from the south american countries in our sample out of the estimates. In principle, this definition is more accurate than ours because it does not consider only one day as reference, but a whole week. Nevertheless, Ecuador and Peru are two of the countries with more observations in the sample, so the estimates might not necessarily be more precise than in the original case.

As in the previous modification, we observe that the difference in the hours of sleep between income groups still statistically significant, however, the magnitude of the difference decrease importantly in this case. Now the difference is of approximately 17 minutes, which represents more than 10 minutes less than in the original estimation. This result imply that our full-time definition might be overestimating the negative difference between income groups. However, a difference of 17 minutes a day still a big number when extrapolating it to weeks or months, which means that it worth further study of this issue.

WEEKENDS

Other concern with the negative correlation documented in the paper, has to do with the sleeping patterns on weekends. Particularly, there is the possibility that the difference in sleep hours between the bottom and the top income quartile decreased because high income people compensate their sleep deprivation during the week sleeping more on weekends (Gibson and Shrader (2015)). To account for this, we took advantage of the fact that the time

[18] We could not choose 7 hours as the new cutoff because in our sample there were not individuals who work more than 7 and less than 8 hours.

use surveys in our sample include a variable that identifies if the individual report their time use activities during the week or on weekends, and analyze the correlation between sleep and income in four regressions: i) one including people that report activities during the week and on weekends together, ii) one regression restricting the sample to those that report their activities only during weekends but without imposing a restriction on their working hours, iii) a regression with only weekends and imposing a restriction on working hours (more than 8 hours) and iv) a regression using the MTUS full-time definition. This last regression also represents a kind of placebo test to see if our results have to do with the activities during the working days, or are a more global phenomenon. In the last two scenarios, the number of observations is smaller in comparison with the regression on people who report their activity during the week, because less people report their activities during weekends and because only MTUS countries met MTUS definition of full-time workers.

In the first case with the whole sample (week+weekends) presented in column 5 of Table 6, we find that the coefficient is smaller than in the case when we consider only week days, reducing the difference between groups in approximately 4 minutes. This result is valid for the poorest and the richest quartile dummies, and consequently to the difference between the two groups. That is, when considering those people who report to have worked 8 or more hours, the sleep-difference coefficient is attenuated if we take into account people who report their activity during weekends. A simple interpretation of this result is that there is a change in roles between people from both quartiles. That is, the attenuation in the coefficient might be due to the fact that the richest quartile tend to allocate more hours to sleep on weekends than the poorest quartile.

However, to understand better the sleeping patterns on weekends and check if our interpretation is valid, we analyze the sleep-income correlation restricting the sample to those people who report their activity during weekends, and also report to work 8 or more hours. In column 6 of Table 6 we show that there are significant differences between the highest 25% income group and the Middle 50%, but no between this last group and the Lowest 25% group. More importantly, however, the difference between the poorest and the richest still significant and is of approximately 17 minutes. That is, there seems to be a compensation in the number of hours that the rich sleep during the weekends, but that is not enough to eliminate the big difference between both groups. In contrast, a second lecture that can be made in light of this results, is that the differences in sleep hours seems to be a problem that goes beyond week days, and probably goes beyond work, because in other case we should observe no statistically significant differences between both groups. Nevertheless, we should be careful about this interpretation, because we restrict the sample to people that report to work 8 or more hours, so basically the results still reflect working decisions.

The ideal scenario to test our hypothesis would be one where we have the activities people do during the day, and the activities the same people do during weekends while not working. For this reason, restrict the sample to those people who reported their activity during weekends and also reported to work 8 or more hours is not very accurate as a placebo test, because we still imposing the restriction on hours of work. To explode the two full-time definitions we have at hand, we run two additional regressions related to the activity during weekends. Firstly, we run a regression without restricting the sample to those who reported to work 8 or more hours. This implies that the estimation will be not necessarily on full-time workers (according to the original definition we use on the main estimation), but will include part-time workers and also people who do not work on weekends. Even though this estimation may not be too accurate either, it is the best we can do given our original definition of full-time. Secondly, to check the robustness of this approach, we run a regression using the MTUS full-time definition. That is, we document the hours of sleep during weekends, but restricting the sample to MTUS countries and to those people who report to have worked 30 or more hours the week before the survey was collected, but report zero hours of work during weekends.

On column 7 of Table 6 we see that without the hours restriction we impose in the full-time definition, the difference between the poorest and the richest still statistically significant, and moreover, it increased in approximately 6 minutes. While in column 8, we present the estimates when using MTUS definition, observing that differences are significant and higher than when using our full-time definition. Specifically, as in previous cases, we observe that there are not statistically significant differences of belonging to the 25% income group with respect to Middle 50%, but the coefficient of belonging to the highest 25% income group still significant. The F test between both coefficients also still significant and are of approximately half an hour. These results supports the evidence presented on column 6, where we restricted the sample to full-time workers on weekends (work 8 or more hours), and let us rule out the fact that the sleep inequality is a phenomenon that occurs only during work days, which was our prior. Furthermore, the possibility that other activities besides work (e.g: leisure, home production, etc) are more important as substitutes of sleeping is more likely.

In sum, the persistence of sleep differences between the richest and the poorest during weekends reveals us that there is no "compensation effect" that changes the direction of the inequality, which means that the differences on sleep hours between both groups stills significant. While on the other side, this same result let us rule out the possibility that that the inequality has to do only with the activities of the week.

OTHER CHECKS

Our last checks are related with other potential channels that might be affecting the hours of sleep. Particularly, we focus on the occupation of workers and on the labor status of partners. The first case might be relevant because the type of work of individuals can affect their quality of life and at the same time, the hours allocated to sleeping (and the quality of sleep). Public health have documented this possibility, although there is not conclusive evidence on the topic (Nakashima et al. (2011), Sun et al. (2015)). The second case is an attempt to account for the effect that bargaining within the household might have on sleeping hours, which has been extensively documented by the economics of the family literature (Browning et al. (2014), Donni (2009)), but that have focused mainly on labor supply or home production and not on sleeping hours.

These two checks are analyzed using a different data than previous regressions. Specifically, we use an additional data provided by MTUS that account for more activities than the original, and that also has more covariates to control for in the analysis. In particular, *MTUS* project provided us with an additional data with a subsample of 11 countries (most of them developed), that include 69 time use activities and additional socioeconomic variables like health status, occupation and time stress, and that also include information on partner's time use. The disadvantage of this data, and the reason of why we do not use it in all the study, is because the countries which have available all the variables is too small compared to the original. Moreover, we let out of the sample south american countries, which are very important in our analysis.

On Table 7 we show the results when controlling for occupation. We construct a dummy variable that takes the value 1 if the individual is a blue-collar worker and 0 in other case. In addition we also use health status as covariate[19], which also has to do with the effect the "quality" of life might have on sleeping hours. We can see that the difference in sleeping hours between the richest and the poorest quartile still significant even after controlling for health status, but disappears when controlling for occupation. This result is valid also for the logarithm of sleeping hours, even though in the case of occupation the difference is significant but only at the 0.9 of significance.

Results suggests that the significant difference observed in previous regressions is being explained basically for

[19]Health status is a categorical variable that can take 4 values: Poor, Fair, Good and Very Good.

Table 6: Robustness Checks

Panel A: Sleep Hours								
	Additional Covariates		*Full-Time Definition*			*Weekends*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lowest 25 %	0.224***	0.332**	0.276***	0.211***	0.239**	0.036	0.144	0.244
	(0.60)	(0.124)	(0.079)	(0.032)	(0.081)	(0.117)	(0.095)	(0.016)
Highest 25 %	-0.154***	-0.124**	-0.156**	-0.074	-0.155**	-0.257**	-0.244***	-0.309***
	(0.041)	(0.054)	(0.055)	(0.051)	(0.056)	(0.113)	(0.039)	(0.051)
$High_{25\%} - Low_{25\%}$	-0.378***	-0.456***	-0.432***	-0.285***	-0.395***	-0.294**	-0.389***	-0.533***
	[0.000]	[0.009]	[0.003]	[0.001]	[0.004]	[0.045]	[0.012]	[0.028]
Country fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Couple	✓	✓	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓	✓	✓
Age2	✓	✓	✓	✓	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓	✓	✓	✓	✓
Number of people in the household	✓	✓	✓	✓	✓	✓	✓	✓
Number of child<18 in the household	✓	✓	✓	✓	✓	✓	✓	✓
N	6,953	6,427	14,198	14,292	11,311	11,610	11,227	5,471
Adj. R^2	0.101	0.094	0.067	0.144	0.099	0.149	0.166	0.021
N. Countries	8	11	11	9	11	11	11	9

Table 6: Robustness Checks (*Continued*)

Panel B: Log Sleep Hours	*Additional Covariates*		*Full-Time Definition*		*Weekends*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lowest 25 %	0.031***	0.044	0.037***	0.029***	0.031**	-0.001	0.013	0.029
	(0.008)	(0.017)	(0.010)	(0.005)	(0.010)	(0.026)	(0.011)	(0.016)
Highest 25 %	-0.018**	-0.016**	-0.020**	-0.010	-0.019**	-0.037*	-0.026***	-0.032***
	(0.005)	(0.007)	(0.006)	(0.006)	(0.007)	(0.018)	(0.018)	(0.004)
$High_{25\%} - Low_{25\%}$	-0.049***	-0.061***	-0.057**	-0.039***	-0.050***	-0.037	-0.039**	-0.061**
	[0.000]	[0.045]	[0.001]	[0.000]	[0.003]	[0.126]	[0.014]	[0.014]
Country fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Couple	✓	✓	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓	✓	✓
Age2	✓	✓	✓	✓	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓	✓	✓	✓	✓
Number of people in the household	✓	✓	✓	✓	✓	✓	✓	✓
Number of child<18 in the household	✓	✓	✓	✓	✓	✓	✓	✓
N	6,949	6,423	14,193	14,288	11,304	1,608	11,221	5,468
Adj. R^2	0.104	0.095	0.067	0.111	0.106	0.164	0.167	0.016
N. Countries	8	11	11	9	11	11	11	9

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. Panel A reports results using sleep hour as dependent variable and Panel B reports results using the logarithm of sleep hours.. The equation we estimate is: $s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Top25} + \gamma' X_{ic} + \epsilon_{ic}$. $High_{25\%} - Low_{25\%}$ corresponds to an F test of the difference between the coefficients of $Highest25\%$ and $Lowest25\%$. In column (1) we restrict the sample to urban areas. In column (2) we use the age of the youngest child as covariate. Column (3) uses 6 hours of work to define full-time workers and column (4) uses the definition of MTUS. Columns (5) to (8) report results when we considered weekends in the analysis. Column (5) includes people who report their activity during the weekends in the sample; column (6) considers only those who report their activity during weekends. Column (7) do not restricts the sample to full-time male workers and include weekends; and column (8) includes weekends and uses the full-time definition of MTUS. We report p-values of the test in brackets. Standard errors are clustered at the country level.

the type of jobs of individuals, and more specifically, for the fact of being blue-collars or not. This result seems to be a problem to the main argument we are trying to make in the study, but it has to be interpreted carefully. The reason is that the number of observations is certainly smaller than in our main specification making these estimates less precise. Additionally, there are only 5 countries on this data, and only 2 on the occupation regression (Spain and the US), compared to the 11 countries used in our original regression. In other, words, results might be different when considering low-medium income countries like Chile, Ecuador, Slovenia, South Africa, etc.

Table 7: Sleep vs. Household Income

Dependent Variable	Sleep Hours			Log Sleep Hours		
Level of Income	(1)	(2)	(3)	(1)	(2)	(3)
Lowest 25%	0.422**	0.169	0.159	0.056*	0.012	0.012
	(0.145)	(0.076)	(0.061)	(0.024)	(0.010)	(0.007)
Highest 25%	-0.170	-0.043	-0.108	-0.017	-0.007	-0.015
	(0.106)	(0.077)	(0.113)	(0.010)	(0.011)	(0.011)
$High_{25\%} - Low_{25\%}$	-0.592**	-0.212***	-0.267	-0.073*	-0.019***	-0.027*
	[0.041]	[0.000]	[0.121]	[0.058]	[0.000]	[0.085]
Country fixed Effects	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓
Age2	✓	✓	✓	✓	✓	✓
Number of people in the household	✓	✓	✓	✓	✓	✓
Number of child<18 in the household	✓	✓	✓	✓	✓	✓
Health Status		✓	✓		✓	✓
Blue-Collar			✓			✓
N	3,728	1,908	873	3,723	1,907	872
Adj. R^2	0.094	0.051	0.105	0.089	0.060	0.127
N. Countries	5	3	2	5	3	2

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. We report results using sleep hours and the logarithm of sleep hours as the dependent variable. The equation we estimate is: $s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Top25} + \gamma' X_{ic} + \epsilon_{ic}$. In columns (1) and (4) we use: age, age squared marital status, the level of working hours as and the number of children younger than 18 years old as covariates; in columns (2) and (5) we add health status as a covariate. In columns (3) and (6) we add a dummy that takes the value 1 if individuals are blue-collar workers. $High_{25\%} - Low_{25\%}$ corresponds to an F test of the difference between the coefficients of $Highest25\%$ and $Lowest25\%$. We report p-values of the test in brackets. Countries included are: Netherlands, South Africa, Spain, United Kingdom and the United States. Standard errors are clustered at the country level.

On the other hand, to account for chores of the members within the household, we restrict our sample only to those individuals who report to live with their partners. This decision is directly related with household economics literature, that emphasizes the intra-household allocation of resources that involves a bargaining process between partners, and more specifically, with the labor supply decisions of different members within a household (Apps and Rees (1997), Blundell et al. (2005), Donni (2009), Browning et al. (2014)). Particularly, female labor supply is larger than in richer households, so in most of the cases household chores are more equally distributed. This implies that home production activities like child or adult care are executed by both members, reducing in this way the number of hours men can allocate to sleep.[20]

The most important characteristic of the subsample is the information on the employment status of the partner, which is a dummy variable that takes the value of 1 if the partner is working (not necessarily full-time worker). With this information, we construct our main variable, which corresponds to the interaction between the employment status of the partner and the dummy variables the indicates the level of income of individuals in the sample. This is our *household chores* variable that tries to measure if in households where chores are more equally distributed, the hours of sleep of individuals decreased.[21] Additionally, we also include the health status of the individuals as a covariate and present estimates using our definition of full-time workers and the one used by MTUS.[22] The equation we estimate is the following:

$$\begin{aligned} s_{ic} &= \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Middle50} + \beta_3 Income_{ic}^{Low25} * PartnerStatus \\ &+ \beta_4 PartnerStatus + \gamma X_{ic} + \epsilon_{ic} \end{aligned}$$

where $PartnerStatus$ represents the partner's employment status, while $Income_{ic}^{Low25} * PartnerStatus$ is the interaction of this variable with the low income dummy we have previously defined. The coefficient of interest in this equation is β_3, that corresponds to our household chores variable. Estimates results are presented in Table 8

Table 8: Household Chores

Variable	Sleep Hours			Log Sleep Hours		
Level of Income	(1)	(2)	(3)	(4)	(5)	(6)
Lowest 25%	0.178***	0.169***	0.191	0.016	0.015	0.031
	(0.012)	(0.017)	(0.167)	(0.007)	(0.007)	(0.026)
Middle 50%	0.021	0.022	-0.069	0.001	0.001	-0.006
	(0.067)	(0.065)	(0.027)	(0.007)	(0.007)	(0.008)
*Lowest 25% * PartnerStatus*	0.367	0.384	-0.244***	0.066	0.069	-0.030**
	(0.198)	(0.186)	(0.014)	(0.027)	(0.024)	(0.004)
Partner Status	-0.091	-0.076	0.011	-0.013	-0.011	(0.004)
	(0.077)	(0.088)	(0.014)	(0.043)	(0.011)	(0.007)
Country fixed Effects	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓
Age2	✓	✓	✓	✓	✓	✓
Health Status	✓	✓	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓	✓	✓
Number of people in the household		✓	✓		✓	✓
Number of children<18 in the household		✓	✓		✓	✓

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[20] In this discussion we ignore any concern about the endogeneity of variations in income. Even though the ideal would be to have an exogenous variation in the bargaining power of the household members, we think this fact is not relevant for the former discussion about sleep inequality.

[21] In this setting, "equally distributed" means households where both members of the couple are working.

[22] We did not include occupation because that variable was only present in one of the two countries of our sample.

... Continuation Table 8

N	2,369	2,369	4,469	2,368	2,368	4,467
Adj. R^2	0.095	0.099	0.156	0.106	0.107	0.138
N. Countries	3	3	3	3	3	3

Significance Level: $*$ 10%; $**$ 5%; $***$ 1%. The table reports panel fixed effects regression estimates. Columns (1) to (3) use the number of sleep hours as dependent variable, while columns (4) to (6) use the logarithm of sleep hours. The equation we estimate is the following $s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Top25} + \beta_3 Income_{ic}^{Low25} * PartnerStatus + \beta_4 PartnerStatus + \gamma X_{ic} + \epsilon_{ic}$. The level of income is a categorical variable with three categories: Top 25% of the income distribution, Middle 50% if the income distribution and Lowest 25% of the income distribution. Our main regressors is the interaction between the employment status of the partner and household income variables: *Lowest25%*PartnerStatus*. In columns (1) to (3) we use: age, marital status and health status as covariates; in columns (4) to (6) we use: age, marital status, health status, household size and the number of children as covariates. All regressions were done using full-time male workers between 25 and 65 years old. In columns (1), (2), (4) and (5) we define full-Time workers as those workers who work more than 8 hours. In columns (3) and (6) we define full-time workers as those individuals who report to work more than 30 hours the week before the survey was collected. Countries included are: Netherlands, Spain and the United States. Standard errors are clustered at the country level.

We find that when using our definition of full-time workers, compared to richest quartile, poorest households sleep approximately 10 minutes more, but in terms of the percentage of sleeping hours the relation is not significant. Moreover, poor individuals whose partners are working, also do not have any significant difference to the richest quartile in any specification when using our definition of full-time. Nevertheless, when using MTUS definition results change radically. In particular, we observe a negative and significant coefficient in our variable of interest. That is, poor people who worked more than 30 hours the week before the survey was collected, and whose partners are working seems to decrease their sleeping hours compared to the richest quartile.

Results in this case are hard to interpret, because there seems to be very sensitive to the definition of full-time workers we use. Besides, the number of observations (and the number countries) is too large, so estimates might not be too precise. However, the mere possibility that the number of sleeping hours might get reduced when the partner works, let us conjecture about a potential mechanism that can explain the sleep inequality find in our main regression. Particularly, it would mean that when chores within the household are more equally distributed in terms of work time, sleeping hours of men get reduced. That is, intra-household bargaining seems to be a relevant factor to analyze the inequality of sleep. However, to be sure about this possibility, we need a better data with more countries and more observations just as the one we use in the main specification.

CHANELS BEHIND SLEEP INEQUALITY

Having established that the poor tend to sleep more, in this section we try to mechanically account for other activities that can tell us what are the poor (and the higher income population) doing instead of sleeping. This is of course a mere correlation, but can give us a hint of what activities (and in consequence the mechanisms) are the ones that are substituting the hours of sleep. Particularly, given that we are studying the sleep behavior of full-time workers, our analysis focuses on non-working activities.

NON-WORKING ACTIVITIES

As we did with sleep and work on previous sections, we compute the hours allocated by people to several non-working activities using the minutes they reported on each survey. We run the same regression specified on equation (2) but using different leisure categories as the dependent variable. First we focus on four big aggregates of activities: leisure, socializing activities, individual leisure activities and home production. This four categories have already been studied in economics, so the exercise we are trying to do is not only to compute the correlation with household income, but also to compare our results with the rest of the literature.

Leisure is computed residually as the difference between 24 hours, sleep, commute, work and home production[23]; *Home Production* is defined as the sum of the time allocated to: Cook, Wash up, Housework, Odd Jobs, Gardening, Shopping and Childcare; *Socializing activities* include: sports and exercise, go to restaurants, go out with friends, participate in religious or communitary activities; and *Individual leisure activities* include: watch TV and listen to radio, play computer games, surf on the internet and read.

The two last agreggates, *Socializing* and *Individual* activites, where included only as a way to account for different type of leisure that could present differences across income groups, and are supported by the evidence presented on Aguiar and Hurst (2009a) for the US on leisure inequality, and on several studies related to leisure activities and labor supply or sleep ((Wagner et al. (2012), Lanaj et al. (2014), Lechner (2009), Rooth (2011), Lundborg et al. (2014)).

Home production, on the other side, is also a big aggregate of activities, and according to household economics literature it is an important determinant in economic activity.[24] To measure this variable we use the definition proposed by Duernecker and Herrendorf (2014) and also use by Bick et al. (2015).

Table 9: Non Work Activities vs. Household Income

Level of Income	Leisure	Social	Individual	Home Production
Lowest 25 %	-0.165***	-0.150	-0.086	-0.062
	(0.045)	(0.085)	(0.048)	(0.057)
Highest 25 %	0.060	0.182**	-0.079	-0.035
	(0.061)	(0.057)	(0.059)	(0.046)
$High_{25\%} - Low_{25\%}$	0.226**	0.332**	0.008	0.026
	[0.028]	[0.033]	[0.932]	[0.713]
Country fixed Effects	✓	✓	✓	✓
Couple	✓	✓	✓	✓
Age	✓	✓	✓	✓
Age2	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓
Number of people in the household	✓	✓	✓	✓
Number of child<18 in the household	✓	✓	✓	✓
N	9,733	9,733	9,733	9,733
Adj. R^2	0.259	0.023	0.115	0.076

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[23] See the Appendix for the activities used in the construction of *Leisure* and *Home Production*.
[24] See Browning et al. (2014) for a review.

... Continuation Table 9

N. Countries	11	11	11	11

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. Each column represents a different regression where the dependent variable is a non sleep activity. In all cases we use the number of hours as dependent variable. The equation we estimate is: $l_{ic} = \alpha_c + \beta Income_{ic} + \gamma X_{ic} + \epsilon_{ic}$. In each regression we use the following covariates: age, age squared, marital status, level of work hours, household size, the number of children and the age of the youngest child as covariates. $High_{25\%} - Low_{25\%}$ corresponds to an F test of the difference between the coefficients of $Highest25\%$ and $Lowest25\%$. We report p-values of the test in brackets. Countries included are: Chile, Ecuador, Netherlands, Norway, South Korea, Slovenia, Spain and the United States. Standard errors are clustered at the country level.

Table 9 shows that two of the activities we use have a significant difference between the richest and the poorest. Specifically, leisure and socializing activities are positively correlated with household income, and the difference between the richest and the poorest is of approximately 15 minutes and 20 minutes respectively. This means that leisure activities and a subset of leisure composed by those activities that involve interaction with other people, present a different type of "inequality" than sleep, where the poor allocate significantly less time than the rich. However, even if these results can be interpreted as first approximation to the possible activities that might be substituting sleep, to infer something is very difficult because of the level of aggregation we are using. That is, conjecture about a potential mechanism that could explain sleep inequality requires more information about the specific activities included in these time aggregates.

To understand better which non-work activities can explain the differences in sleep between the rich and the poor, we decided to disaggregate even more the set of activities presented on table 9. This is because, for example, the non significant correlation on individual activities and Home Production might be due to the level of aggregation we are using, and not necessarily due to a non existent relation with household income. This means that some of the activities might have a significant substitution effect, but that once we aggregate them all in one category, this effect is confounded and disappears.

On table 10 we present the activities we used after separating the four big aggregates previously used. The activities we use are: *Outside, Childcare, Spouse, TV, Internet* and *Commute*

Table 10: Non Work Activities vs. Household Income

Level of Income	Outside	Childcare	Spouse*	TV	Internet	Commute
Lowest 25 %	-0.123*	-0.016	0.052	-0.003	-0.037**	-0.057
	(0.067)	(0.033)	(0.050)	(0.092)	(0.015)	(0.051)
Highest 25 %	0.187***	0.064**	-0.024	-0.138**	0.026*	0.122***
	(0.045)	(0.022)	(0.058)	(0.061)	(0.013)	(0.033)
$High_{25\%} - Low_{25\%}$	0.310**	0.081	-0.076	-0.135	0.064**	0.178**
	[0.015]	[0.124]	[0.304]	[0.376]	[0.027]	[0.013]
Country fixed Effects	✓	✓	✓	✓	✓	✓
Couple	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓
Age2	✓	✓	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓	✓	✓

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... Continuation Table 10

Number of people in the household	✓	✓	✓	✓	✓	✓
Number of children<18 in the household	✓	✓	✓	✓	✓	✓
N	9,733	9,733	9,694	9,733	9,733	9,733
Adj. R^2	0.012	0.129	0.126	0.074	0.022	0.038
N. Countries	11	11	10	11	11	11

Significance Level: * 10%; ** 5%; *** 1%. The table presents Panel Fixed Effects regression estimates. Each column represents a non sleep activity. In all cases we use the number of hours as dependent variable. The equation we estimate is: $l_{ic} = \alpha_c + \beta Income_{ic} + \gamma X_{ic} + \epsilon_{ic}$. The level of income is a categorical variable with three categories: Top 25% of the income distribution, Middle 50% if the income distribution and Lowest 25% of the Income Distribution. Covariates included in the estimates are: age, marital status, household size and the number of children as covariates. All regressions were done using full-time male workers between 25 and 65 years old. Full-Time workers are defined as those workers who work more than 8 hours and worked more than 30 hours the week before the survey was collected. Countries included are: Chile, Ecuador, Netherlands, Norway, South Korea, Slovenia, Spain and the United States. Standard errors are clustered at the country level. *Time allocated to the partner is not available in Chile, so the number of countries is 10 in this case.

Now we observe that five of the six time use activities that we proposed as possible substitutes to sleeping present significant differences between the highest income group and the middle one, and three of them present a significant difference with the lowest income group. This corroborates our intuition about finding a significant correlation once we disaggregate the activities of Table 9. Particularly, the positive difference of *Internet* was not being captured when included in the *Individual* category with other activities like reading or watching tv. The only activity which do not present a significant correlation with income after controlling for family composition variables, age, marital status and country fixed effects is time spent with the partner.

The three activities that do have a significant difference between income groups are: *Outside, Internet* and *Commute*, and even more, the three present a positive sign, which means that an increase in household income will increase the time allocated to these activities. The results give us a hint of the possible trade off faced by individuals when deciding how much time allocate to different activities during the day, because of the opposite sign of the coefficients of these correlations when compared to the sleep-income one. This result could also be complemented with a simultaneous equation model (SEM) estimation as in Biddle and Hammermesh (1990). However, given that we are working only with the last year of each survey, we cannot use previous years as instruments to identified the relevant parameters. Moreover, many of the surveys have only one wave available, making in it impossible to estimate a SEM. For this reason, the positive correlation observed between income and the leisure activities is the only evidence we are able to use to conjecture about potential substitution effects.

We will postpone the discussion about specific mechanisms that might explain sleep inequality to section 5, where we analyze the problem in a simple household decision model. However, we believe is important to emphasize again, the fact that these results are only a raw picture of the whole process that might be behind the differences in sleep between income groups, and for this reason do not have a behavioral interpretation. Moreover, the results are not necessarily conclusive with respect to the effect that activities like childcare, spouse time or even individual activities might have. This is because with a better data on the information on the time use of a couple, or information of their children, testing the correlation between these variables and household income would be more accurate.

HETEROGENEITY: TIME USE INTERACTIONS

Given the evidence on the relation between leisure and household income, we now check if there is some heterogeneity in how different income groups allocate their leisure time. In other words, we want to check if the patterns of substitution are different for the leisure activities depending if the individual is poor or rich. For this we run panel fixed effects regressions including an interaction between income groups dummies and the leisure activities. Formally, the equation we estimate is:

$$\begin{aligned} s_{ic} &= \alpha_c + \beta_1 Income_{ic}^{Mid50} + \beta_2 Income_{ic}^{Top25} \\ &+ \beta_3 TimeUse + \beta_4 Income_{ic}^{Top25} * TimeUse + \gamma' X_{ic} + \epsilon_{ic} \end{aligned}$$

This equation is different from equation (3) no only in the interaction included, but also on the income dummies we are using. Now we include the *Highest 25%* and the *Middle 50%* dummy, so the coefficient of each variable is interpreted as the difference with respect to the *Lowest 25%* category. The coefficient of interest, however, is β_4 associated to the interaction between household income dummies and leisure activities. Following the jargon used in the impact evaluation literature, if $\beta_4 = 0$ then the effect related to the leisure activity does not vary by income group, and the average homogenous effect would be captured in β_3. Even though the coefficient does not have a causal interpretation, it can help us clarify the trade-off between different type of leisure activities and complement our previous findings. Results are presented in Table 11:

Table 11: Panel Regression: Sleep Hours vs. Household Income

Level of Income	Outside	Childcare	TV	Internet	Commute
Middle 50 %	-0.192***	-0.194***	-0.196***	-0.194***	-0.187***
	(0.044)	(0.047)	(0.043)	(0.044)	(0.045)
Highest 25 %	-0.352***	-0.343***	-0.381***	-0.339***	-0.312***
	(0.086)	(0.075)	(0.076)	(0.080)	(0.094)
*Highest 25%*Time Use*	0.034	0.094**	0.018*	0.054	0.019
	(0.023)	(0.034)	(0.010)	(0.071)	(0.032)
Time Use	-0.147***	-0.254***	-0.159***	-0.226***	-0.311***
	(0.015)	(0.030)	(0.043)	(0.050)	(0.042)
Country fixed Effects	✓	✓	✓	✓	✓
Couple	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓
Age2	✓	✓	✓	✓	✓
Number of people in the household	✓	✓	✓	✓	✓
Number of children<18 in the household	✓	✓	✓	✓	✓
N	10,894	10,894	10,894	10,894	10,894
Adj. R^2	0.110	0.096	0.106	0.093	0.118
N. Countries	11	11	11	11	11

Significance Level: * 10%; ** 5%; *** 1%. The table reports Panel Fixed Effects regression estimates. In each column we use the number of sleep hours as dependent variable. The equation we estimate is the following: $s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Mid50} + \beta_2 Income_{ic}^{Top25} + \beta_3 TimeUse + \beta_4 Income_{ic}^{Top25} * TimeUse + \gamma X_{ic} + \epsilon_{ic}$. The level of income is a categorical variable with three categories: Top 25% of the income distribution, Middle 50% if the income distribution and Lowest 25% of the income distribution. Outside activities are defined as the sum of: go out with friends and go to restaurants; Childcare is defined as the time spent with children including helping with homework, do exercise or play, medical care and travel time; TV is time allocated watching TV or listening to radio; Internet is defined as the time allocated to surf on the internet, including check emails, and cyberloafing; Commute is the time allocated to travel to work or to study. In all specifications we use: age, age squared, marital status, household size, working hours and the number of children as covariates. All regressions were done using full-time male workers between 25 and 65 years old. Full-Time workers are defined as those workers who work more than 8 hours. Countries included are: Chile, Ecuador, Netherlands, Norway, South Korea, Slovenia, Spain and the United States. Standard errors are clustered at the country level.

As we can see, most of the estimates are consistent with the correlations between household income and time use activities previously presented. That is, the significant negative coefficient observed in all the leisure activities in this case, are compatible with the positive leisure-income correlation of last section. Particularly, the three variables that present significant positive differences in sleep between the richest and the poorest (*Outside, Internet* and *Commute*) are negatively correlated to time allocated to sleep, while the interaction coefficient, β_4, is not significant in any of these cases. This means that the reduction in the hours of sleep when there is an increase in the three leisure activities is homogeneous between the rich and the poor. It is worth noting, however, that the non significant effect of the interaction is no evidence against our main stylized fact of sleep inequality, but a simple sign that there is a difference in the intercept between both groups and not in the slope.

On the other hand, the coefficient of interest (β_4) is only relevant when we use as regressors the two variables that do not present a significant coefficient on the last section: *Childcare* and *TV.* The interpretation of this result is that the mechanical reduction in the hours of sleep, linked to an increase in the time allocated to these leisure activities, is different depending if the individual is poor or rich, and more specifically, it is larger in the case of this last group. However, these activities do not respond to a increase in income. For this reason they are not relevant in explaining our main stylized fact about sleep inequality.

In sum, the evidence on the relation between leisure activities and household income, and on the existence of heterogeneous effects between these two variables and sleep hours show us two main results. In the first place, there are three leisure activities that present a significant positive correlation with income. Specifically, outside leisure activities, watching TV and commute time present positive significant differences between the 25% highest income group and the 25% income group, which make us think about a substitution between sleep and these three activities. While on the other hand, when we regress sleep hours against the interaction of these variables, the results showed that there is no evidence on heterogenous effects among income groups. These two results will be important to disentagle which are the potential mechanisms through which leisure, and in particular outside activities, watch TV and commute time, can explain the sleep inequality between the poorest and the richest.

TESTING THEORIES

Given the evidence presented on the relation between sleep, household income and leisure activities, now we analyze some theories that might be suitable to understand the sleeping decision in economics. Particularly, we focus on theories that might help us to explain the negative correlation we observed between sleep and household income in adult full-time male workers. We use as insights testable implications of two of the models that have being used to explain the demand for sleep, and then propose a new one that encompasses them. We also take into account non-working activities in the model and compare the predictions of it with our evidence. Our goal is to incorporate some potential mechanisms summarized by the economics, medicine and public health's literature in the most simple framework as possible to make some predictions that can be contrasted with our data.

A Simple Framework

The most simple approach to analyze the demand for sleep is the static labor supply model. In this setting, sleep should be considered as a time intensive commodity whose "consumption" yields utility to individuals. In other words, an individual decision model where the utility of agents depends only on consumption and sleep time. Predictions in this setting are not different from the traditional static model because they depend on the normality (or inferiority) of the commodities. More precisely, the effect of an increase in wages will be positive or negative depending on the magnitude of the substitution and income effect if sleep time is a normal good. While if sleep time is an inferior good, the effect of an increase in wages will always be negative.

This framework, although very general, incorporates only one of the potential mechanisms that could explain our stylized fact, and that has to do with the **opportunity cost** argument. That is, richest people tend to sleep less than poor people because the cost of not being working (wage), is higher for them under the assumption of normality of sleep. Certainly this result is consistent with the negative relation we observe within and between countries, meaning (in this context) that the substitution effect between work and sleep is higher than the income effect. Nevertheless, even if this argument is reasonable (in the case of full-time workers), the static labor supply model ignores any other potential mechanism that could explain the inequality on sleep. In particular, if the opportunity cost is the only explanation to this inequality, we should not observe a significant relation between sleep hours and other leisure activities, because this would imply that individuals are substituting sleep hours for other activities besides working. Formally this means that we should observe: $\partial s/\partial Income < 0$ and $\partial s/\partial l = 0$, where s are sleep hours and l is the time allocated to other leisure activities. However, this is not consistent with the evidence presented on table 10, where we observe that an increase in the time allocated to several leisure activities like commute, outside socializing activities or surfing on the internet were negatively (and significantly) correlated with sleep hours, or $\partial s/\partial l < 0$.

On the other hand, a second issue we must deal with has to do with how to incorporate the sleep-productivity relation in the model. According to our main stylized fact, there should not be a positive relation between these two variables, because of the negative correlation observed on sleep and income.[25] However, productivity might be a function of many variables besides sleep (e.g: human capital accumulation). Even some leisure activities like sports or non-cognitive skills, might affect the productivity of workers, increasing variables like teamwork, organization or health (Lechner (2009), Rooth (2011), Lundborg et al. (2014)). Moreover, there are studies linked to medicine and public health that relate the hours of sleep to productivity on work (McKenna et al. (2007), Killgore et al. (2008), Hale (2005), Krueger and Friedman (2009)).

The static labor supply model does not endogenize the wage, so it is impossible to account for any sleep-leisure effect on productivity. Biddle and Hammermesh (1990) was the first study in economics in analyzing this topic, and propose a simple model where wage is a linear function of sleep. Solving a household labor supply model in the tradition of Becker, the authors conclude that there is a negative effect between wage and sleep, which depends on the productivity effect that affects the opportunity cost of sleeping. In this context and in the same fashion of Biddle and Hammermesh (1990), we propose to endogenize wage including leisure, human capital and all the other variables that could affect wages, so we can explain why sleep-productivity effects are not present.

[25] We assume that household income is composed mainly by wages, and wages reflect productivity

We incorporate both problems in the most simple framework as possible, assuming that there is substitution between consumtion and sleep and endogenizing wage in the same way that Biddle and Hammermesh (1990). At the same time, we ignore some topics concerning bargaining within the household that are relevant in labor supply and time use studies. This modelling decision has to do mainly with simplicity, but also with the lack of data to capture evidence regarding this topic. Moreover, we also introduce commuting costs in the model following i Puigarnau and Ommeren (2010).

In this setting, we assume that each individual in the economy must maximize a utility that depends on two commodities, a composite good Z that include leisure goods as going to bars or restaurants or practicing sports, and the same time goods as books or videogames used also for leisure activities. The other good that gives utility to households (individuals) in the model is sleep. The idea of the this framework is to ilustrate not only the trade-off between consumption and leisure, but also the trade-off between these two activites and sleep, incluiding the relation it might have with wages. Moreover, α represents the relative utility enjoyed by the individual per hour of sleep.[26]

$$U(Z, \alpha S), \qquad U_i > 0, U_{ii} < 0 \qquad i = \{Z, S\}$$

The composite good Z requires inputs to be produced. Specifically, it requires time t_Z and goods X to be produced, such that $t_Z = bZ$ and $X = aZ$, whose price is p. As in the basic labor supply model, there are two restrictions that might be met: i) a resource restriction and ii) a time restriction. Following Biddle and Hammermesh (1990) and Gibson and Shrader (2015), the resource restriction depends on sleep and also on other variables (e.g: human capital, leisure, etc), that for simplicity we assume are summarized in a positive constant ϕ: $w = f(\phi, s)$, where $f'() > 0$ and $f''() < 0$. Furthermore, we add a commuting cost kc, where k is distance and c is the cost per kilometre.[27] This cost is associated to the time that involves commuting.[28] Finally, we do not assume any particular structure for $f()$, and a priori we do no not impose any separability constraint on U_{ij}, with $i \neq j$, so now the household optimizes over sleep and the composite good subject to time and income constraints:[29]

$$\max U(Z, \alpha S)_{\{Z,S,\lambda\}} + \lambda[f(\phi, S)(1 - S - bZ - D) - kc - paZ]$$

After consolidating the constraints and solving the model we obtain the optimality conditions, where the marginal cost depends on the opportunity cost of not working and the productivity effects of sleep.

$$U_Z f(\phi, S) - U_Z f_S h - \alpha U_S b f(\phi, S) - pa\alpha U_S = 0 \tag{3}$$

That is, the marginal utility of increasing one of the commodities is equal to the marginal cost, which include

[26] This approach is also used in Gibson and Shrader (2015).

[27] Participation in the labor market implies that the daily wage exceeds the daily monetary commuting costs, so $wh > kc$

[28] In our analysis commuting speed is exogenously given.

[29] We ignore the inclusion of non-labor income in the model because of the restriction in our analysis to full-time male workers, whose income is composed mainly by the wage

the cost of production and the productivity gains in the case of leisure and sleep. Our main concern, however, has to do with the comparative statics regarding sleep and household income: $\frac{\partial S^*}{\partial \phi}$, and particularly, verify if the sign of this derivative is negative. Additionally we also analyse $\frac{\partial Z^*}{\partial \phi}$, which is the effect on leisure of a marginal increase in wage.

Additionally, if we consider the restriction of the model:

$$f(\phi, S)(1 - S - bZ - D) - kc - paZ \quad = \quad 0 \tag{4}$$

we can apply the implicit function theorem (IFT) with equations (3) and (4), and evaluate the derivatives mentioned above. Nevertheless, to account for the potential substitution between sleep and leisure, we will assume that $U_{ZS} < 0$. Given this, the next proposition summarize the conditions that must be met to ensure the negativity of these derivatives:

Proposition 1 *Under substitutability between leisure and sleep, $U_{ZS} < 0$, the model predicts that:*

- $\frac{\partial S^*}{\partial \phi} < 0$
- $\frac{\partial Z^*}{\partial \phi} > 0$

Specifically, the results of the model are:[30]

$$\begin{aligned} \frac{\partial S^*}{\partial \phi} &= \{\{U_{ZZ}[f(\phi, S) - f_s h] \\ &- U_{SZ}[bf(\phi, S) + pa] - bU_Z f_S\} f_\phi h + \{[bf(\phi, S) + pa][U_Z f_\phi - U_S b f_\phi]\}\} J^{-1} < 0 \end{aligned}$$

$$\begin{aligned} \frac{\partial Z^*}{\partial \phi} &= \{-\{[f_S h - f(\phi, S)][bf(\phi, S) + pa]\} \\ &- f_\phi h\{U_{ZS}[f(\phi, S) - f_S h] - U_{SS}[bf(\phi, S) + pa] - U_Z[f_S h - f_S - U_s b f_S]\}\} J^{-1} > 0 \end{aligned}$$

DISCUSSION

The proposed model is a simple attempt to explain the negative relation between sleep and household income emphasizing two main arguments: i) opportunity cost and ii) sleep-leisure substitution. The first one is a common denominator in most economics models, and in this sense our model is not an exception: sleep time is more expensive for richer households. However, there is a subtle difference, because now the complete argument states that for richer households, the productivity gains linked to sleep are not enough to compensate the net cost increase (wage minus commuting costs). This is the same argument presented in Biddle and Hammermesh (1990) and Gibson and Shrader (2015) but without specifying a functional form for the productivity equation as they do, and including commuting costs.

The sleep-leisure substitutability, $U_{ZS} < 0$ assumption, let us conjecture about one of the potential mechanisms that could explain the negative correlation of household income and sleeping. Specifically, we argue that poor

[30] J^{-1} is the inverse of the Jacobian of the system.

people face an stricter budget constraint than the richest in terms of leisure. In particular, household income affects leisure's "consumption", but this effect is significantly bigger in the case of the poor. Therefore, as a consequence, they will have to substitute expensive leisure activities for other ones that are cheaper, like sleep.

This argument emphasize an income effect that, to our knowledge, has not been tested formally in the literature of economics of sleep. In our framework, given the substitutability assumption, the relation between leisure and household income can be expressed as $\frac{\partial Z^*}{\partial \phi}$, which we prove to be positive. This result is supported by the positive correlation observed between these two variables in our data. More specifically, we believe this argument is valid mainly for two of the leisure activities for which we find a significant relation: *outside activities* and *internet*. That is, an increase in household income reduce the hours of sleep not only because an increase in the opportunity cost, but also because now people have access to valuable leisure goods, as internet or socializing activities.

Some recent studies in economics of time use partially support this idea. Particularly, Hammermesh and Lee (2007) and Buddelmeyer et al. (2015) make emphasis on the relation between income, time and financial "stress", which are subjective measures of how individuals perceive their resources. The authors argue that financial stress is positively related to household income, or in other words, richer people feel more pressure on how to allocate they resources. One of the possible implications of this fact, is precisely the decrease in the time they allocate to sleep, because now they spend money (and time) in more activities than the poor. [31]

Furthermore, in the particular case of internet, there is another potential mechanism consistent with the evidence we provide, related to the link between electronic devices and sleep. Wagner et al. (2012) and Lanaj et al. (2014) shows the negative consequences that the use of electronic devices, like smartphones or computers might have on sleep (and work) when they are used before developing this activity. The authors also discussed the difference among income groups, finding that high income households tend to use more this type of devices that poorer households, supporting the negative correlation between income and sleeping.

In addition, sleep research in public health have found significant correlations between sleep duration, the quality of sleep and the occupation of individuals. In this context, the negative relation of household income with sleeping may be caused by the occupation and the quality of life associated to it, and not because of the substitutability between leisure and sleep. For instance, Sun et al. (2015) find that blue-collar workers and civil servants have the shortest sleep duration and the poorest quality of sleep among chinese workers, when compared to other occupations like farmers. Nakashima et al. (2011), on the other hand, studied the behavior of white-collar workers, finding that those who work more overtime hours sleep significantly less than the rest and have a poorer sleep quality. In our setting we do not model the occupation of individuals, but the possible effect this variable might have on sleep duration is implicit on the wage equation, $w = f(\phi, S)$, and its effect goes in the same direction as the substitutability argument. This is because, given the opportunity cost, it will be too costly to substitute sleep for work if they have a better occupation in which the pay is better, even if it implies overtime hours.

On the other hand, there are some mechanisms that can also explain the negative relation between sleep and household income but that were not consider explicitly in the model. Specifically, topics related to the intrahousehold allocation of resources or chores within the household were not inlcuded. In our model, the preferences of the household are summarized in the utility function of the the individual, so there is not an explicit bargainig process between the members. In other words, the utility function of each member i of the household, $u_i(Z, S)$ is summarized in the household utility function $U(Z, S)$. This setting could problematic if we are trying to emphasize activities like childcare or home production, because in this context the bargaining power is relevant (Blundell et al. (2005), Browning et al. (2014), Guryan et al. (2008)). However, even though we do not consider the bargainig pro-

[31] Other studies discuss more inderectly the possible effects that sports and exercise activities might have on labor market outcomes (Lechner (2009), Rooth (2011)), which could also be associated to a substitution between these type of activities and sleep.

cess in the model, we do presented suggestive evidence on the relation between income and sleep when considering the labor status of the partner, finding no significant effect.

Finally, a mechanism that we cannot tested directly in our data has to do with the **inferior good** argument. Even though the negative relation on sleep and household income could be explained by this argument, this is an issue that has to do basically with preferences, and is not empirically testable with time use (or other) survey data. In other words, we cannot discard the argument but we do not emphasize the role of this mechanism on the model because of the inability we have to test it on any data.

CONCLUDING REMARKS

In this paper we document how people allocate their time to the most time-consuming activity during the day: sleep. Economics literature has not paid sufficient attention to the study of this variable, even though medicine and public health literature have documented for a long time the significant relation between sleep and several socio-demographic variables that might have and effect on economic activity. Moreover, the few studies that deal with this issue have focus only in the sleep differences in one country, which from our perspective is not enough to ensure that "inequaility" of hours of sleep is a global issue.

In this context, our study is the first one in exploring the inequality in the hours of sleep using a global dataset of countries. We constructed a panel of several time use studies around the world and analyze differences in sleep hours across income groups. Our main result is that people from higher income households sleep significantly less than people from poorer households, wich is something systematic in the countries in our sample, and also robust to several covariates and specifications.

We also analyzed different theories that can explain these results and test them with our data. The opportunity cost and the substitution effect between leisure and sleep are the two potential mechanisms that are consistent with our evidence. Although other mechanisms like the effect of childcare or commuting cannot be completely discarded. We finally propose a simple model that is consistent with all the evidence we found. Particularly, a negative correlation between sleep and household income is consistent with a labor supply model where individuals maximize their utility with respect to three variables: consumption, leisure time and sleep, and where productivity depends on sleep.

In future studies we recommend to pay attention to the potential mechanisms we analyzed and try to disentangle if there is causal effect of these variables on the inequality of sleep hours. Also use new data to test other theories about the mechanisms behind the inequality of sleep, like household bargaining, would be an important improvement to the understanding of the demand for sleep.

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APPENDIX A: DATA WORK

EUT CHILE

Time diaries in *EUT-CHILE* correspond to the activities that the respondents report to have been doing during the day. Particularly, each time use variable in the survey represents an activity within a time interval of 30 minutes, and each activity has an associated code. Also, activities where divided into primary and secondary (e.g: Main activity in the time interval 5:00-5:30 am=6211 (Sleep)). We only consider the main activity in the analysis.

The process to generate the hours allocated to each variable is the following:

1) Generate temporal auxiliary variables that takes the value 1 if the respondents report to being doing the activity we are interested in and 0 in another case.

2) Sum the auxiliary variables and multiply the result by 30, because each column represents a 30 minute interval.

3) Divide the total minutes variable by 60.

Income in *EUT-CHILE* corresponds to a categorical variable with the following categories[32]

1. Less than $ 144,000
2. Only the minimum income $ 144,000
3. More than $ 144,000 and less or equal $ 250,000
4. More than $ 250,000 and less than $350,000
5. More than $350,000 and less than $500,000
6. More than $ 500,000 and less than $700,000
7. More than $700,000 and less $ 1,000,000
8. More than $1,000,000 and less than $ 1,500,000
9. More than $1,500,000 and less than $2,500,000
10. More than $2,500,000

We collapse all the categories into the three ones established on *MTUS* data (*Bottom 25%, Middle 50%* and *Top 25%*) dividing the biggest income bound ($ 2,500,000) into 4. However, because few observations fall into the *Top 25%* category using this criteria, we determine that *Bottom 25%* will be composed by all individuals whose original category is less or equal to the fifth one. *Middle 50%* will be those whose categories between the sixth one and the eighth one, and *Top 25%* will be those whose category is bigger than the eighth one.

On the other side, time use variables used in the study are:

- Sleep: Night time (or main sleep) and naps

[32] Numbers are in chilean pesos.

- Working hours: Work time on the main job or to other jobs
- Commute: Displacements in bus, tax, subway, car, or other mechanism (including walking) related to formal job.
- Home Production: Cook, Wash up, Housework, Odd Jobs, Gardening, Shopping, Childcare and Adult care.
- Passive activities: Watch TV, surf on the internet (chating, download and upload things, cyberloafing, check email, etc.), listen to radio and read.

Variables used (including covariates) are summarized in Table 12:

Table 12: Definition Variables

Variables	Definition
Working	1 if individual reports to have worked the week before the survey and receive a payment (money or in kind); 0 in other case
Full	1 if individual is full-time worker (work 8 or more hours the day of the survey); 0 in other case
Sleep Hours	Number of sleep hours (including naps)
Couple	1 if individual has a couple; 0 in other case
Household size	Number of people in the household
Children younger than 18 years	Number of children younger than 12 years
Education	Higher level of education: 1 if less than secondary education; 2 if secondary education and 3 if above secondary education.
Low Education	1 if less than secondary education; 0 in other case.
High Education	1 if above secondary education; 0 in other case
Income	Level of household income: 1 if belongs to the 25% lowest income; 2 if belongs to the middle 50% and 3 if belongs to the 25% highest income.
Poor	1 if belongs to the 25% lowest income; 0 in other case.
Rich	1 if belongs to the 25% highest income; 0 in other case.

EUT ECUADOR

Time diaries in *EUT-ECUADOR* correspond to the activities that the respondents report to have been doing during the a day of the week before the survey was collected. They have two variables associated to the time allocated to each activity: one for hours and one for minutes. Also, activities where divided according to the day of the week. Specifically, they ask respondents to report the time (hours and minutes) allocated to each activity during the week and also on weekends.

The process to generate the hours allocated to each variable is the following:

1) Multiply the reported hours by 60 in each activity
2) Sum the transformed variables with the minutes variables to obtain the total time
3) Divide this variables by 60.

Income in *EUT-ECUADOR* corresponds to a continuous variable, which is the sum of labor income (main and secondary activity), income derived from investments and income derived from transfers. Then we divide the income distribution in four groups (not with the same number of observations) and grouped the two middle categories. This way we generate the same income categories as in *MTUS*.

On the other side, time use variables used in the study are:

- Sleep: Night time (or main sleep) and naps
- Working hours: Work time on the main job or to other jobs
- Commute: Displacements in bus, tax, subway, car, or other mechanism (including walking) related to formal job.
- Home Production: Cook, Wash up, Housework, Odd Jobs, Gardening, Shopping, Childcare and Adult care.
- Passive activities: Watch TV, surf on the internet (chating, download and upload things, cyberloafing, check email, etc.), listen to radio and read.

Variables used (including covariates) are summarized in Table 13:

Table 13: Definition Variables

Variables	Definition
Age youngest child	Records information on the age of the youngest child in the household. Takes the value 1 if child is between 0-4; 2 if child between 5-12; 3 if child between 13-17 and 4 if child is over 18
Working	1 if indiviudal is full-time or part-time worker, or if he is working but do not remember the number of hours he worked; 0 in other case
Full	1 if individual is full-time worker (worked 8 or more hours the day of the survey); 0 in other case
Sleep Hours	Number of sleep hours
Travelling	Number of hours travelling to/from work or education
Childcare	Number of hours taking care of the child: homework, physical or medical care, play sports, readm talk and travels related to child.
Spouse	Number of hours with the spouse or partner
Home Production	Number of hours allocated to: childcare, food preparation, clean, wash-up, gardening, maintain home, odd jobs, pet care, adult care, purchasing household goods.
Private Leisure	Number of hours allocated to: sports, exercise, tv, radio, read, email, computer games, web, go out, restaurants, pubs or cafes, other leisure.
Urban	1 if individual lives in a urban area; 0 in other case
Couple	1 if individual has a couple; 0 in other case
Household size	Number of people in the household
Children younger than 18 years	Number of children younger than 18 years

Continued on next page...

... Continuation Table 13

Education	Higher level of education: 1 if less than secondary education; 2 if secondary education and 3 if above secondary education.
Low Education	1 if less than secondary education; 0 in other case.
High Education	1 if above secondary education; 0 in other case
Income	Level of household income: 1 if belongs to the 25% lowest income; 2 if belongs to the middle 50% and 3 if belongs to the 25% highest income.
Poor	1 if belongs to the 25% lowest income; 0 in other case.
Rich	1 if belongs to the 25% highest income; 0 in other case.

ENUT PERU

Time diaries in *ENUT-PERU* correspond to the activities that the respondents report to have been doing during the a day the survey was collected. They have two variables associated to the time allocated to each activity: one for hours and one for minutes. Also, activities where divided according to the day of the week. Specifically, they ask respondents to report the time (hours and minutes) allocated to each activity during the week and also on weekends.

The process to generate the hours allocated to each variable is the following:

1) Multiply the reported hours by 60 in each activity

2) Sum the transformed variables with the minutes variables to obtain the total time

3) Divide this variables by 60.

Income in *EUT-PERU* corresponds to a continuous variable, which is the sum of labor income (main and secondary activity), income derived from investments and income derived from transfers. The survey divide income questions depending on the way people received their income, that is: diary, weekly, every 15 days or monthly. We are interested in monthly income, so for those who report their diary income, we multiply the number by 20, which represents a proxy of the business day during one month. In the case of weekly income, we multiply the number by four and in the case of 15-days income we multiply the number by 2.

Then we divide the income distribution in four groups (not with the same number of observations) and grouped the two middle categories. This way we generate the same income categories as in *MTUS*.

Variables used (including covariates) are summarized in Table 14:

Table 14: Definition Variables

Variables	Definition
Working	1 if individual is full-time or part-time worker, or if he is working but do not remember the number of hours he worked; 0 in other case
Full	1 if individual is full-time worker (worked 30 or more hours last week according to MTUS definition); 0 in other case
Sleep Hours	Number of sleep hours
Travelling	Number of hours travelling to/from work or education
Childcare	Number of hours taking care of the child: homework, physical or medical

Continued on next page...

... Continuation Table 14

	care, play sports, read, talk and travels related to child.
Spouse	Number of hours with the spouse or partner
Home Production	Number of hours allocated to: childcare, food preparation, clean, wash-up, gardening, maintain home, odd jobs, pet care, adult care, purchasing household goods.
Private Leisure	Number of hours allocated to: sports, exercise, tv, radio, read, email, computer games, web, go out, restaurants, pubs or cafes, other leisure.
Urban	1 if individual lives in a urban area; 0 in other case
Couple	1 if individual has a couple; 0 in other case
Household size	Number of people in the household
Children younger than 18 years	Number of children younger than 18 years
Education	Higher level of education: 1 if less than secondary education; 2 if secondary education and 3 if above secondary education.
Low Education	1 if less than secondary education; 0 in other case.
High Education	1 if above secondary education; 0 in other case
Income	Level of household income: 1 if belongs to the 25% lowest income; 2 if belongs to the middle 50% and 3 if belongs to the 25% highest income.
Poor	1 if belongs to the 25% lowest income; 0 in other case.
Rich	1 if belongs to the 25% highest income; 0 in other case.

MULTINATIONAL TIME USE SURVEY (MTUS)

We use two different databases provided by MTUS to evaluate the possible mechanisms associated with sleep inequality. The differences between these databases have to do with the number of countries in each one and with the number of categories of time use activities. In both cases, as mentioned in the main text, we restrict our sample to **adult full-time male workers who live urban areas**, and we work with the last wave of each survey and only with post-2000 surveys.

HARMONISED SIMPLE FILE

In this data, each row represents a 24- hour observation (diary). This file covers summary time in a simplified range of 25 time use activity categories. Activities are recorded in minutes, so the sum of the variables for each row are 1440 (24*60). To transform variables from minutes to hours, we just divide each one by 60: $variable/60$. In the next table we summarize the variables we used:

Table 15: Definition Variabels

Variables	Definition
Working	1 if individual is full-time or part-time worker, or if he is working but do not remember the number of hours he worked; 0 in other case
Full	1 if individual is full-time worker (worked 30 or more hours last week

Continued on next page...

... Continuation Table 15

	according to MTUS definition); 0 in other case
Sleep Hours	Number of sleep hours
Travelling	Number of hours travelling to/from work or education
Childcare	Number of hours taking care of the child: homework, physical or medical care, play sports, read, talk and travels related to child.
Spouse	Number of hours with the spouse or partner
Home Production	Number of hours allocated to: childcare, food preparation, clean, wash-up, gardening, maintain home, odd jobs, pet care, adult care, purchasing household goods.
Private Leisure	Number of hours allocated to: sports, exercise, tv, radio, read, email, computer games, web, go out, restaurants, pubs or cafes, other leisure.
Leisure (with Home Production)	24 hours less hours of work, travelling and sleeping
Leisure (without Home Production)	24 hours less hours of work, travelling, sleeping and home production
Urban	1 if individual lives in a urban area; 0 in other case
Couple	1 if individual has a couple; 0 in other case
Household size	Number of people in the household
Age youngest child	Age of the youngest child in the household
Children younger than 18 years	Number of children younger than 18 years
Education	Higher level of education: 1 if less than secondary education; 2 if secondary education and 3 if above secondary education.
Low Education	1 if less than secondary education; 0 in other case.
High Education	1 if above secondary education; 0 in other case
Income	Level of household income: 1 if belongs to the 25% lowest income; 2 if belongs to the middle 50% and 3 if belongs to the 25% highest income.
Poor	1 if belongs to the 25% lowest income; 0 in other case.
Rich	1 if belongs to the 25% highest income; 0 in other case.

Countries that have all the variables from table are the ones included in the final panel:

HARMONISED AGGREGATE FILES

Like the simple file, these files cover summary time but a wider range of 69 activity categories, including total time with a spouse or partner for diarists in couples, and a wider range of survey, household and person-level variables. Each row represents a 24-hour diary, although the number of surveys included in these data is smaller. Countries from the table are the ones included in the final panel: Spain and United States.

Activities in this case are also recorded in minutes, so the sum of the variables for each row are 1440 (24*60). To transform variables from minutes to hours, we just divide each one by 60: $variable/60$. In the next table we summarize the variables we used:

Table 16: Definition Variables

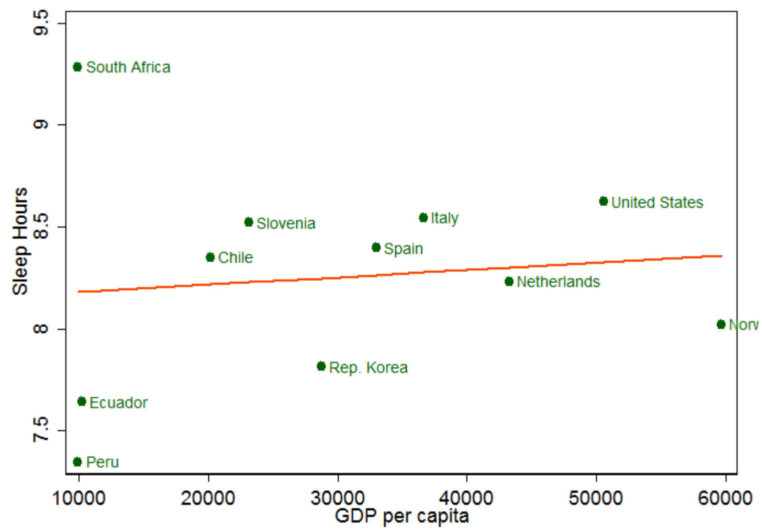
Variables	Definition
Working	1 if individudal is full-time or part-time worker, or if he is working but do not remember the number of hours he worked; 0 in other case
Full	1 if individual is full-time worker (worked 30 or more hours last week according to MTUS definition); 0 in other case
Sleep Hours	Number of sleep hours
Travelling	Number of hours travelling to/from work or education
Childcare	Number of hours taking care of the child: homework, physical or medical care, play sports, read, talk and travels related to child.
Spouse	Number of hours with the spouse or partner
Home Production	Number of hours allocated to: childcare, food preparation, clean, wash-up, gardening, maintain home, odd jobs, pet care, adult care, purchasing household goods.
Private Leisure	Number of hours allocated to: sports, exercise, tv, radio, read, email, computer games, web, go out, restaurants, pubs or cafes, other leisure.
Leisure	24 hours less hours of work, travelling, sleeping and home production
Urban	1 if individual lives in a urban area; 0 in other case
Couple	1 if individual has a couple; 0 in other case
Household size	Number of people in the household
Children younger than 18 years	Number of children younger than 18 years
Education	Higher level of education: 1 if less than secondary education; 2 if secondary education and 3 if above secondary education.
Low Education	1 if less than secondary education; 0 in other case.
High Education	1 if above secondary education; 0 in other case
Income	Level of household income: 1 if belongs to the 25% lowest income; 2 if belongs to the middle 50% and 3 if belongs to the 25% highest income.
Poor	1 if belongs to the 25% lowest income; 0 in other case.
Rich	1 if belongs to the 25% highest income; 0 in other case.

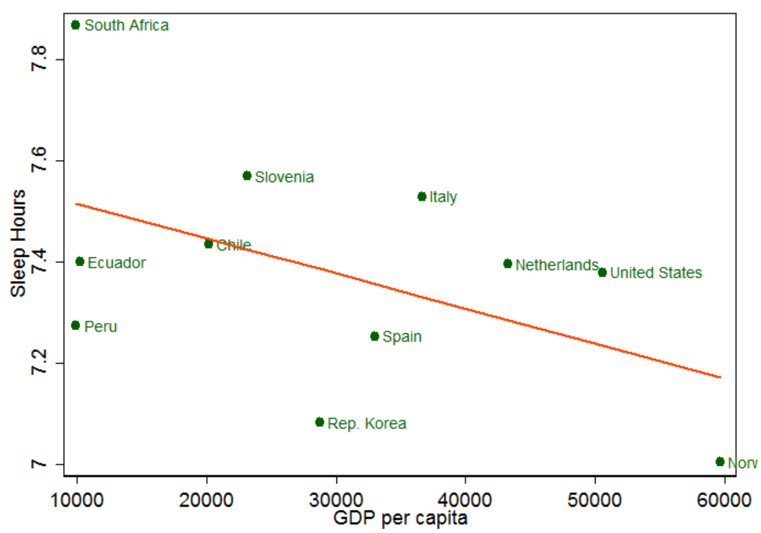
APPENDIX B: ROBUSTNESS CHECKS (TABLES AND FIGURES)

SLEEP HOURS VS. GDP IN IN URBAN AREAS

Figure 3: Sleep Hours vs GDP per capita in urban areas

(a)





Note: Author calculations using: EUT-Chile, EUT-Ecuador, ENUT-Peru, MTUS and WDI. When multiple surveys are available, for this plot we use the last round available (see Appendix). Panel (a) displays the relationship between average sleeping time in the sample and GDP per capita (PPP) of men between 25 and 65 years old who live in urban areas in the country. In contrast, panel (b) displays sleeping time only for full-time male workers between 25 and 65 years old who live in urban areas (This is not a gender bias in our focus but simply a way to focus on a more homogeneous group across countries.). GDP per capita (PPP) is US dollars from 2011.

WITHIN-COUNTRY INEQUALITY: WOMEN

In this section we present the results of within countries regressions using changing the sample to full-time female workers between 25 and 65 years old, and using the level of education instead of the level of income as the main regressor. Results are presented on tables 17, 18 and 19 respectively.

Table 17: Sleep Hours vs. Household Income Within Country (Women)

Country	Lowest 25%	Highest 25%	$H_{25\%} - L_{25\%}$	N	Adj. R^2
Denmark	0.144	-0.029	-0.173	209	0.031
	(0.221)	(0.172)	[0.482]	-	-
Germany	0.217	-0.226	-0.444	267	0.006
	(0.303)	(0.199)	[0.221]	-	-
*Italy**	0.419	-0.205	-0.624*	267	0.032
	(0.261)	(0.248)	[0.079]	-	-
Netherlands	0.108	-0.125	-0.233	607	0.043
	(0.149)	(0.099)	[0.153]	-	-
Norway	-0.267	-0.221	0.046	69	0.040
	(0.564)	(0.245)	[0.943]	-	-
South Korea	0.103	-0.189***	-0.292***	1,465	0.084
	(0.076)	(0.067)	[0.001]	-	-
Slovenia	0.014	0.403	0.388	54	0.065
	(0.726)	(0.361)	[0.571]	-	-
South Africa	0.639***	-0.399***	-1.038***	532	0.173
	(0.172)	(0.128)	[0.000]	-	-
Spain	0.055	-0.297*	-0.351	346	0.104
	(0.233)	(0.169)	[0.183]	-	-
United Kingdom	0.268	-0.167	-0.435	119	0.137
	(0.255)	(0.202)	[0.121]	-	-
United States	0.218	0.020	-0.198	691	0.075
	(0.210)	(0.120)	[0.363]	-	-
Chile	-0.043	1.003	1.047	92	0.057
	(0.353)	(0.718)	[0.114]	-	-
*Ecuador***	-0.191**	-0.146**	0.045	1,717	0.018
	(0.094)	(0.059)	[0.611]	-	-
*Peru***	0.174***	-0.109*	-0.283	1,785	0.060
	(0.067)	(0.063)	[0.000]	-	-

Significance Level: * 10%; ** 5%; *** 1%. The table reports OLS regression estimates where the dependent variable corresponds to the number of sleep hours. The equation we estimate is: $s_i = \alpha + \beta_1 Income_i^{Low25} + \beta_2 Income_i^{Top25} + \gamma' X_i + \epsilon_i$. Bottom 25% and Top 25% columns correspond to the coefficients of each income dummy in each regression. *Diff.* correspond to an F test of the difference between the coefficients. P-values of the F test are in brackets. In each regression we use: age, age squared, marital status, working hours, household size and the number of children as covariates. We use robust standard-errors.

*We use the level of education as the main regressor because income variables were not available. The level of education is divided in three categories: *less than secondary*, *complete secondary* and *above secondary*. We omitted the *complete secondary* dummy in the regression.

**We do not include household size and the number of children as covariates in these regressions because this variables were not available on these databases.

BETWEEN-COUNTRY INEQUALITY: ROBUSTNESS CHECKS

Tables 20 to **??** presents panel regressions estimates using additional covariates, modifying the income definition and also modifying the sample. Particularly, in the first place we present estimates using full-time female workers between 25 and 65 years old. Then we present estimates including education covariates and finally we present estimates using the level of education instead of the level of income as the main regressor for men and women.

WOMEN

Table 18: Sleep Hours vs. Household Income

Variable	Sleep Hours		Log Sleep Hours	
Level of Income	(1)	(2)	(1)	(2)
Lowest 25 %	0.063	0.166**	0.006	0.021**
	(0.060)	(0.055)	(0.008)	(0.007)
Highest 25 %	-0.139***	-0.173***	-0.019***	-0.023**
	(0.032)	(0.054)	(0.005)	(0.008)
$High_{25\%} - Low_{25\%}$	-0.201**	-0.339***	-0.025**	-0.044***
	[0.017]	[0.005]	[0.023]	[0.008]
Country fixed Effects	✓	✓	✓	✓
Couple	✓	✓	✓	✓
Age	✓	✓	✓	✓
Age2	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓
Number of people in the household		✓		✓
Number of child <18 in the household		✓		✓
N	7,953	4,451	7,951	4,449
Adj. R^2	0.025	0.073	0.021	0.079
N. Countries	13	11	13	11

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. We report resuls using sleep hours and the logarithm of sleep hours as the dependent variable. The equation we estimate is: $s_{ic} = \alpha_c + \beta_1 Income_{ic}^{Low25} + \beta_2 Income_{ic}^{Top25} + \gamma' X_{ic} + \epsilon_{ic}$. In column (1) of each regression we use: age, age squared marital status and the level of working hours as covariates; in column (2) of each regression we use: age, age squared, marital status, level of work hours, household size, the number of children and the age of the youngest child as covariates. $High_{25\%} - Low_{25\%}$ corresponds to an F test of the difference between the coefficients of $Highest25\%$ and $Lowest25\%$. We report p-values of the test in brackets. Countries included are: Denmark, Germany, Netherlands, Norway, South Korea, Slovenia, South Africa, Spain, United Kingdom, United States, Chile, Ecuador and Peru. Standard errors are clustered at the country level.

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Table 19: Sleep Hours vs. Level of Education

Variable	Sleep Hours		Log Sleep Hours	
Level of Education	(1)	(2)	(1)	(2)
Incomplete Secondary	0.231**	0.163	0.032**	0.025*
	(0.097)	(0.100)	(0.13)	(0.013)
Above Secondary	-0.123**	-0.098	-0.015	-0.011
	(0.056)	(0.081)	(0.009)	(0.012)
Inc. Sec.-Above Sec.	-0.354**	-0.261*	-0.048**	-0.036*
	[0.013]	[0.077]	[0.012]	[0.066]
Country fixed Effects	✓	✓	✓	✓
Couple	✓	✓	✓	✓
Age	✓	✓	✓	✓
Age2	✓	✓	✓	✓
Work Hours	✓	✓	✓	✓
Number of people in the household		✓		✓
Number of child <18 in the household		✓		✓
N	17,961	11,102	17,955	11,096
Adj. R^2	0.031	0.086	0.026	0.090
N. Countries	14	12	14	12

Significance Level: * 10%; ** 5%; *** 1%. The table reports panel fixed effects regression estimates. We report results using sleep hours and the logarithm of sleep hours as the dependent variable. The equation we estimate is: $s_{ic} = \alpha_c + \beta_1 Inc.Sec_{ic} + \beta_2 AboveSec_{ic} + \gamma' X_{ic} + \epsilon_{ic}$. In column (1) of each regression we use: age, age squared marital status and the level of working hours as covariates; in column (2) of each regression we use: age, age squared, marital status, level of work hours, household size, the number of children and the age of the youngest child as covariates. $Inc.Sec. - AboveSec.$ corresponds to an F test of the difference between the coefficients of $IncompleteSecondary$ and $AboveSecondary$. We report p-values of the test in brackets. Countries included are: Denmark, Germany, Italy, Netherlands, Norway, South Korea, Slovenia, South Africa, Spain, United Kingdom, United States, Chile, Ecuador and Peru. Standard errors are clustered at the country level.

TIME USE ACTIVITIES AND SLEEP TIME

Table 20: Leisure Definition

Cook, Wash up	Meals and snacks	Listen to records, tapes, cds
Housework	Visit friends at their homes	Active sports participation
Odd Jobs	Listen to radio	Study, homework
Gardening	Free time travel	Passive sports participation
Shopping	Watch television or video	Read books
Childcare	Excursions	Walking
Read papers, magazines	Entertain friends at home	
Religious activities	Dances or parties	
Relax	Knit, sew	
Civic activities	Social clubs	
Conversation	Other leisure	
Cinema or theatre	Pubs	
Restaurants		