The Effect of the Clock on Diet and Health

Pavel Jelnov

Abstract

Let there be light? This paper is concerned with the causal effect of the clock on diet, health, and health-related time use. To this end, I utilize a unique natural experiment: twenty years of clock reforms in Russia. The borders between the eleven Russian time zones have been frequently moved. Differently from existing papers, which focus on the transition to and from daylight saving time, I utilize permanent shifts in time zones. Analyzing the 1994-2015 period, I estimate both immediate and lagged effects of clock reforms, using both regional and individual data. The results are not uniform. On the one hand, Russians, especially in the south of the country, improve their habits with a later daylight: their diet is healthier, they lose weight, and are more physically active. Children are more likely to do sports every day and spend less time playing at home. Furthermore, Russians' weekly sleep is 25 minutes shorter for a one-hour shift toward a later daylight and almost 40 minutes shorter in the southern half of the country. However, the major problem with a later clock arises when its effect on disease and health problems is considered. In particular, in the north of the country, several diseases are more common with the later clock. Individual data reconfirms the positive relationship between the later clock and disease. Finally, I compare Russia with the United States, using the 2007 extension of the daylight saving time in America. Even though the two countries are not fully comparable in terms of the natural experiment they experienced, I construct a difference-in-differences setup in the United States. The results show that in the U.S., the later daylight is associated with a lower expenditure on fast food but with a higher expenditure on meat and baked goods. The American time use shifts with a later daylight toward more socializing and less relaxation.

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Pavel Jelnov Leibniz Universität Hannover

Institut für Arbeitsökonomik

Königsworther Platz 1 D-30167 Hannover, Germany

e-mail: jelnov@aoek.uni-hannover.de

1 Introduction

Managing the clock is an important issue in political economy. Time zones and daylight saving time are differently managed around the globe and discussions around the "best" clock do not seize in many countries. Spain lives in the Central European Time Zone, making travelers surprised by how late the locals go out for dinner. Historically, the reasons for such unnatural time zone in Spain are political. But what are the consequences for the economy and the people? The clock as a factor of economic growth is related to the discussions around the relationship between geography and development (Acemoglu et al. (2001)). By managing the clock, politicians sometimes face the trade-off between nature and politics. Shifting the clock may have political consequences but may also affect the fit between the humans and the nature, altering the socio-economic outcomes.

I take an advantage of an ideal natural experiment to directly measure the effect of clock reforms on the socio-economic outcomes. I explore the variation in the time zones of Russian administrative regions. Not only that Russia, differently from any other country in the world, covers eleven time zones, but its frequent reforms with regards to the time zones allow a unique quasi-experimental setup for a precise investigation. The identification of the causal effect of the clock on the economy relies on the fact that Russia is a large but centralized country. The clock reforms are exogenous in the sense that they are generally initiated by the federal government and not by the treated regions. For example, the reform of 2010 reduced the number of time zones in Russia from eleven to nine. The declared purpose was to improve the governability of the country. As a result, five Russian regions had to move to a different time zone.

The existing literature mostly uses the Daylight Saving Time (DST) transitions to test the effect of the clock on the economy. In DST, the clock is shifted by one hour twice a year, in the spring and in the autumn. The disadvantage in using the DST transitions in empirical design is that by nature the discontinuity event occurs in two specific seasons, similarly every year. Thus, it is impossible to estimate the effect of additional daylight time in other seasons. The current study overcomes this shortcoming because the exogenous variation in Russian time zones is not seasonal. An additional advantage of the current study is that in Russia, time zones may be shifted up to two hours ahead the natural ones. Thus, we can test the monotonicity and linearity of the daylight effect by comparing the effects of the first and the second additional hours of daylight. This is not possible with the DST transitions, which are single hour shifts.

This paper is innovate as it is the first study to use exogenous variation in time zones other than daylight saving temporal shifts. I estimate the effect of a later clock (a later sunrise and sunset) on diet, disease, and health-related time use. The utilized data is both aggregated and individual. The aggregated data is the “Regions of Russia” annual report of the central Russian bureau of statistics, Rosstat. The individual-level data is the Russian Longitudinal Monitoring Survey, managed by the Higher School of Economics. Both datasets track back to the mid 1990s.

The results show that a later clock is associated with ambiguous effects. In particular, the regional data allows consideration of aggregated consumption of food ingredients. Consumption of most ingredients, with an exception of sugar, decreases by a few percents when the clock is later. From individual-level data follows that Russians have a 0.07 lower BMI with a one-hour later clock, addtional one percentage point report that they lost weight during the last year and additional one percentage point report being physically active. Their daily walk for pleasure is 6 minutes longer. On the other hand, adults sleep weekly 25 minutes less and almost 40 minutes less in the southern half of the country. Children are two percentage points more likely to do sports every day and spend weekly 18 minutes less playing at home, similarly in the northern and southern halfs of the country.

However, the problem arises when disease and health problems are considered. By contrast to the effects mentioned above, certain types of disease are more common with the later clock, especially when the clock that was in power a few years earlier or during the last years is the explanatory variable. In particular, from both regional and individual data follows that most chronical deseases are more common with a later clock, especially in the northern half of Russia. Furthermore, respondents in the Russian Longitudinal Monitoring Survey report reduced ease of daily activities, such as walking and getting up from bed. Finally, depression and reporting a family member being sick also increase with a later clock.

The results in the north of the country are somewhat different from the results in the south. It is important to note the difference between the south and the north. The effect of the time zone on economy is sometimes referred in the literature as "longitude matters" (Stein and Daude (2007)), which is an extension of the well-known discussion of development economists whether "latitude matters" (Acemoglu et al. (2001)). The north-south difference in the time zone effect, documented in the current paper, means that "longitude matters" and "latitude matters" are not necessary two separate discussions. The daylight timing may be related to longitude (for example, when the time zone equalization is supposed to make two places "closer" to each other despite the longitude difference) but the importance of daylight differs across latitudes.

I compare the results in Russia to difference-in-differences results in the United States, where the 2007 reform extended the daylight saving time. The American natural experiment is not identical to the Russian one because the dayligh saving time extension affects only a few weeks every year. Thus, to obtain exogenous variation in the clock, I focus on the weeks around the DST transition. By contrast, Russian reforms constitute permanent shifts of the clock. Nevertheless, I compare the effects in Russia with the ones in the U.S.. Using the consumer expenditure data collected by the Bureau of Labor Statistics, I find that in the U.S., the later clock is associated with larger expenditures on food, and in particular on meat. On the other hand, the expenditure on fastfood drops by 7% in spring. Using the American Time Use Survey, I find that the one-hour-later clock is associated with additional 10 minutes spent on socializing at the expense of relaxation time which shortens by 22.5 minutes in autumn.

The public discussion over time zones in Russia raises arguments in favor of better governability when the clock in certain regions is equalized versus issues of health and crime raised by opposers of the low sunrise and sunset sometimes caused by these equalizations. The public opinion is generally on the side of longer daylight. The observed in the current paper effects are related not only to the immediate well-being but also to human and social capitals' formation. The outlined above results imply that the clock reforms that moved Russian regions "closer" to Europe or "squeezed" the country into a smaller number of time zones, did not do a good job for many of the socio-economic outcomes. The policy of gradually drifting the country "to the west" started in 1957 but no steady state has been reached. Disputes on clock do not cease in Russia but also in other countries, especially around the daylight saving. Particularly, as currently about 70 countries implement the Daylight Saving Time (DST), while other countries do not (in the U.S. and Canada most regions implement DST but some do not), the issue of daylight remains actual in political economy around the world. Hopefully, this paper sheds some light on the consquences of the time zones policy and can be helpful in further discussions on the optimal clock.

1.1 Related literature

The existing literature on time zones is divided into three groups while two of them are not directly related to the current study.[1] The first group of papers is concerned with the difference between time zones of two locations. On the left hand side, there appear mutual trade (Kikuchi (2006), Kikuchi and Marjit (2010), Kikuchi and Van Long (2010), Christen (2015)), foreign direct investment (Stein and Daude (2007), Hattari and Rajan (2012)), or time use activities affected by watching live television shows (Hamermesh et al. (2008)). The second group of studies considers the Daylight Saving Time (DST) transitions as a discontinuity quazi-experiment where the treatment is sleep deprivation. They establish a short-run effect of sleep deprivation on happiness (Kountouris and Remoundou (2014), Kuehnle and Wunder (2014)), health (Jin and Zebarth (2015), Toro et al. (2015); see footnote 2 in Jin and Zebarth (2015) for a list of references for medical studies linking DST transitions with short-run health changes), and performance of stock markets (Kamstra (2000)). The estimated effects last for no more than few days and, mostly, are observed only in the "bad" DST transition in spring but not in the "good" transition in autumn (Kuehnle and Wunder (2014), Kuehnle and Wunder (2014), Jin and Zebarth (2015)).

The bunch of literature mostly related to the current paper is the small third group of papers which consider the effect of daylight. A few studies in this group use geographical variation in daylight to estimate the effect of daylight on health (Markusen and Røed (2015)) and productivity (Figueiro et al. (2002), Gibson and Shrader (2014)). Using Norwegian data, Markusen and Røed (2015) report that longer daylight is associated with increased entry rate to absenteeism but also a higher recovery rate. The overall effect is positive (less absenteeism) but small (0.3%). Figueiro et al. (2002) collect data from a software development company located in NewYork and find that workers in offices with windows spend more time working on

[1] In addition, White (2005) provides an intersting discussion on the establishment of time zones in the United States and Canada in 1883. He explains why this is a beautiful example of economic theory in action. The American time standardization was a private initiative, driven by economic interests of a small group of people (railroad managers), which had no legal force until 1918, and nevertheless changed a centuries-old social norm of local time.

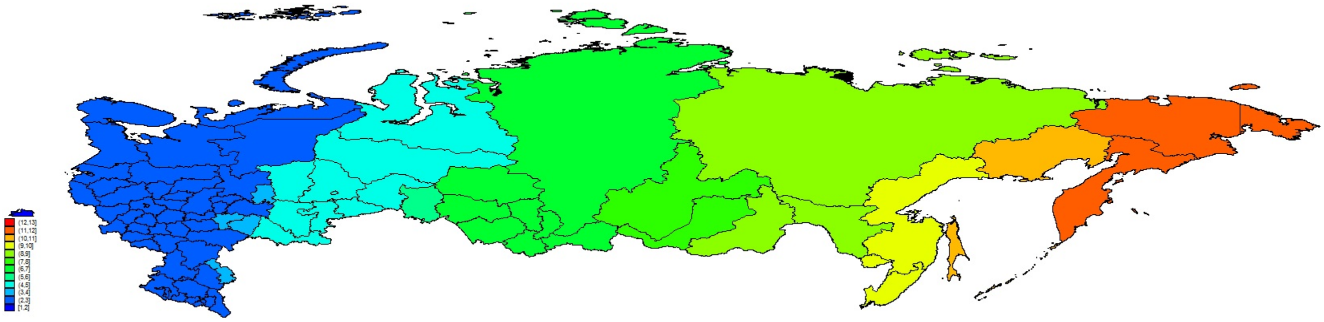
computers than workers in offices without natural light. Because the visual system performs similarly well in both environments, the authors suggest that the reason for the observed difference is a better circadian regulation when a human is exposed to daylight. Gibson and Shrader (2014) estimate the wage retutns to sleep, instrumented by sunset time, and find that a one-hour-later sunset decreases the short-run wages by 0.5% and long-run wages by 4.5%. The authors conclude from two-stage regressions that a later sunset leads to a shorter sleep which in turn harms wages. Recently, Doleac and Sanders (2015), Dmonguez and Asahi (2016), and Toro et al. (2016) use regression discontinuity around the day of DST transition to establish the effect of longer daylight on crime. Doleac and Sanders (2015) find a 7% decrease in robberies in the U.S. as a result of the additional hour of daylight, Dmonguez and Asahi (2016) report a large 18% decrease in overall crime in Chile, driven by decrease in robbery, and Toro et al. (2016) find a 14% decrease in homicide in Brasil.

The remainder of this paper proceeds as follows. Section 2 provides background on the reforms in the Russian time zones since 1995. Section 3 presents the empirical strategy and data. Section 4 is dedicated to the empirical results in Russia. Section 6 analyzes the extension of the daylight saving time in the United States in order to compare the effect of a later clock in the U.S. to the effect in Russia. Section 7 analyzes the policy-oriented empirical approach to the time zones in Russia. Section 8 focuses on identification tests. Section 9 concludes.

2 Clock Reforms in Russia

Russia differs from any other country in the world by the very long distance between its eastern and western ends. The longitude of the capital of the most western of the Russian 85 regions, Kaliningrad Oblast, is 20.5° E. The longitude of the capital of the most eastern region, Chukotka, is 177.5° E. The difference is 157° which corresponds to 11 natural (nautical) time zones (each nautical time zone is 15° width). However, as many other countries do, Russia does not strictly implement its natural time zones. In fact, in the period between 1990 and 2015, out of 2,162 region-year cases, only in 196 (9%) the actual time zone in power during most of the year was equal to the natural one. Between 1995 and 2014, the number is only 20 out of 1,662, which constitutes 1% of the cases. Almost in all of the other cases the actual time zone was higher than the natural

Figure 1: Actual times zones in Russia as of August 1st, 2016



one. Between 1990 and 2015, in 52% of the cases the time zone was higher by one hour than the natural one, and in 38% of the cases it was higher by two hours (see Table 1; more details about the table compilation are provided in Section 3). To visually imagine the Russian actual time zones devision, Figure 1 shows the actual time zones as of August 1st, 2016.

Russia differs from other countries also in the relatively frequent reforms with regard to its time zones. The time zones were introduced in 1919 and were expanded to the whole territory of the Soviet Union in 1924. The introduction of the time zones was followed by a long list of reforms which continues until the present. For example, in 1930, the Soviet government introduced "decree time". By this decree, all clocks in the Soviet Union were permanently shifted one hour ahead of standard time for each time zone. The daylight saving time was introduced only in 1981 and existed until 2011. Between 1981 and 1991, the Soviet government gradually eliminated the decree time but de-facto reintroduced it already in the end of 1991. The considerations in these and other reforms have been always a mix of geogrpahical and political ones. One example of political reasons is the 1995 time zone change in Altai Repuplic and Altai Krai, which was reasoned by economic dependence on a strong neighbor, Novosibirsk Oblast. Some reforms, such as the ones of 1919, 1930, 1991, 2011, and 2014 affected the whole country, while other reforms (such as the ones of 1947, 1957, 1981, 1995, 2010, and 2016) affected only a subset of regions.

Starting with 1957, many regions moved “back in time”, adopting a lower time zone. This policy change coincides with destalinization and may be related to a gradual withdraw from the "Stalin's" decree time. Especially, the wish to have a more "western" clock was strong in 1991 when the Soviet Union collapsed following its democratization. One should remember that despite its definition as a federation, Russia is a very centralized country. Particularly, at any point in time, about 50 regions out of 85 have the same time zone as Moscow. Moreover, as stated in the president's annual address to the parliament in 2009, the goal of the 2010 reform was to make the Russian distant regions "closer" to Moscow, which should improve the coordination between the local and the central governments. As a result of the reform, the number of regions with the Moscow time zone raised from 50 to 52 (and raised to 54 in 2014). The implementation of the 2010 reform led to some popular protest. Already in the following 2011, the reform was recognized as a failure and a different reform was initiated. This latter reform of 2011 moved the whole country one time zone up and eliminated the daylight saving time. The further reform of 2014 actually cancelled the one of 2011. Later, the reform of 2016 attempted to "correct" the one of 2014.

The current paper focuses on the period between 1995 and 2014. The following is the list of the clock reforms that took place during this period:

1. May 28, 1995 - Altai Krai and Altai Republic move from UTC+7 to UTC+6.

2. March 30, 1997 - Sakhalin Oblast moves from UTC+11 to UTC+10.

3. May 1, 2002 - Tomsk Oblast moves from UTC+7 to UTC+6.

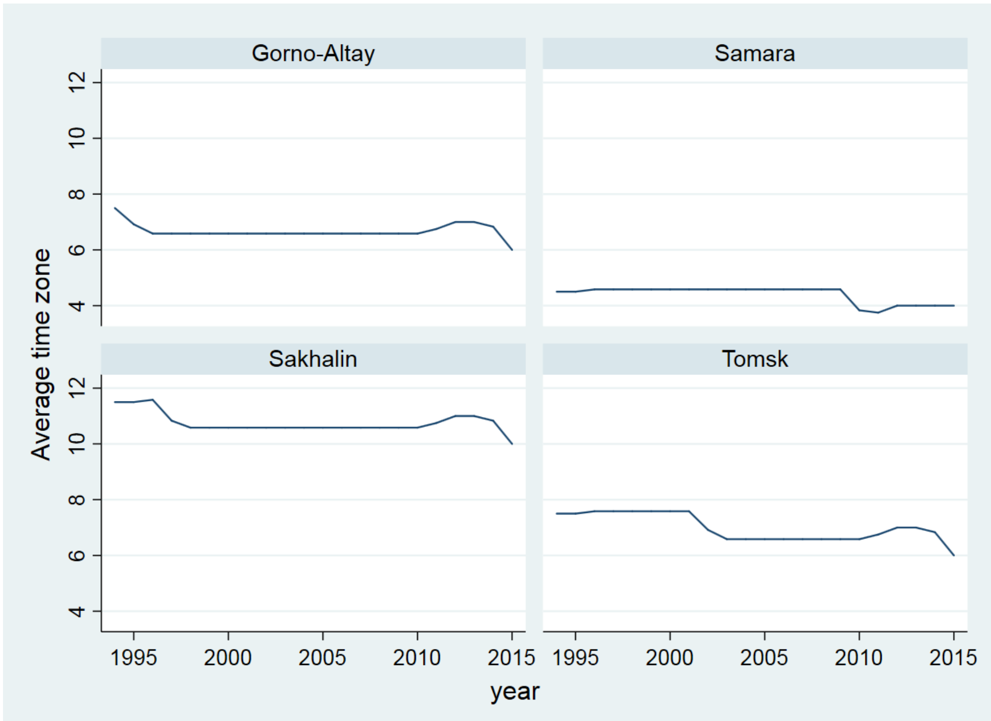
4. March 28, 2010 - Russia reduces the number of its time zones from 11 to 9. Udmurt Republic and Samara Oblast move from UTC+4 to UTC+3. Kemerovo Oblast moves from UTC+7 to UTC+6. Chukotka and Kamchatka Krai move from UTC+12 to UTC+11.

5. August 31, 2011 - Russia eliminates the daylight saving time. The summer time that was in power in the summer of 2011 was declared to be the permanent time which means shifting one time zone up.

6. October 26, 2014 - The whole country except of seven regions moves one time zone down. Magadan Oblast and Zabaykalsky Krai move two time zones down. The five regions affected by the 2010 reform do not move.

7. March 27 to July 24, 2016 - a period which is not covered in the empirical analysis of the current paper - 9 regions move to a higher time zone: Astrakhan Oblast and Ulyanovsk Oblast move from UTC+3 to UTC+4. Altai Krai, Altai Republic, Novosibirsk Oblast, and Tomsk Oblast move from UTC+6 to UTC+7. Zabaykalsky Krai moves from UTC+8 to UTC+9. Magadan Oblast and Sakhalin Oblast move from UTC+10

Figure 2: Examples of average time zone time series between 1994 and 2016



to UTC+11.

In addition to these changes, on March 30, 2014, few days after annexation of Crimea and Sevastopol to Russia, the time zone in these two regions was changed from UTC+2 to UTC+4.[2]

Figure 2 plots, as an example, the time zone of four regions, starting with 1994. The figure illustrates the cross-region variation in the time zones reforms.

The time zones in power most of the year in the 85 Russian federal subjects and the listed above changes are summarized in a table in Appendix. Note that the time zone in power most of the year is not always the official time zone. In particular, until 2011 the daylight saving time was in power for most of the year. In the table in Appenix, the columns represent the changes. Bold numbers show the regions affected by the reform (the time zone is different from the column to the left). Note that in some cases, the region shifts by two

[2]During the considered period, also minor changes in the administrative division of Russia took place.

Table 1: The distribution of the time zone bias (number of regions), 1990-2015

Year	-1	0	1	2	Total
1990	0	2	40	41	83
1991	2	38	39	4	83
1992	1	37	40	5	83
1993	0	1	41	41	83
1994	1	41	41	0	83
1995	0	1	43	39	83
1996	0	1	43	39	83
1997	0	1	44	38	83
1998	0	1	44	38	83
1999	0	1	44	38	83
2000	0	1	44	38	83
2001	0	1	44	38	83
2002	0	1	45	37	83
2003	0	1	45	37	83
2004	0	1	45	37	83
2005	0	1	45	37	83
2006	0	1	45	37	83
2007	0	1	45	37	83
2008	0	1	45	37	83
2009	0	1	45	37	83
2010	0	3	46	34	83
2011	0	3	46	34	83
2012	0	3	46	34	83
2013	0	3	46	34	83
2014	0	3	46	36	85
2015	1	47	37	0	85
Total	5	196	1,134	827	2,162
	0.2%	9.1%	52.5%	38.3%	100%

time zones. This happened in 2014 in Crimea and Sevastopol and later the same year in Magadan Oblast and Zabaykalsky Krai. In all other cases, the region shifts by one time zone.

3 Empirical Model and Data

3.1 Econometric model

3.1.1 Clock as a continuous variable

The explanatory variable used in the empirical analysis is the bias of the actual zone from the natural (nautical) time zone. It means the deviation of sun's zenith (up to small deviations because of the Earth's uneven speed) from 12 am. That is

$$TZB_{it} = ATZ_{it} - NTZ_i$$

where TZB is the average time zone bias of region (federal subject) i in year t, ATZ is the actual time zone and NTZ is the nautical time zone. Because the whole Russia lies in the eastern hemisphere, the nautical time zone (relative to UTC) for Russian regions is defined as

$$NTZ_i = (longitute_i - 7.5)/15$$

where I consider, as the region's longitute, the longitute of the region's capital city (which is almost always the region's by far largest city).

The regression specification using region-level data is

$$Y_{it} = \beta_0 + \beta_1 TZB_{it} + \beta_2 TZB_{i,t-j} + \beta_3 long_i + \beta_4 lat_i + \gamma_t + \delta_i + \varepsilon_{it} \quad (1)$$

where Y_{it} is the outcome in region i in year t, . $long$ and lat are, respectivelly, longitude and latitude of the region's capital. The lagged TZB effect after j years is captured by $TZB_{i,t-j}$. The year fixed effect is γ_t and δ_i are, respectfuly, year and regional fixed effects.

For individual data, the specification is

$$Y_{ijt} = \beta_0 + \beta_1 TZB_{j\tau} + \gamma_t + \mu_i + \varepsilon_{it} \quad (2)$$

where the equation considers individual i who was interviewed in region j in year t on date τ. The individual fixed effects are μ_i. For individual-level data the lagged TZB is not considered because in this data the TZB is specific for the date of the interview. There is little sense in considering the TZB at exactly the same date several years earlier because the TZB may change during the year.

The standard errors are clustered by region. The reason for clustering on the yearly level and not, let us say, use spatial correlation, is that in Russia correlation between regional economies is not neccessarily a decreasing function of the geographic distance. For example, economy of industrial centers (Russia is very strong in arms, and relatively strong in aircraft and cars industries) may depend on the energy prices which also affect the economy of mining-dominated regions. These relationships are not always related to the geographical distance between the regions.

3.1.2 Difference-in-difference

I further directly utilize the reforms in a difference-in-difference setup. The reforms 2, 3, and 4 in the list in Section 2 considered only a few regions. In all cases, the shift in the time zone was downward. I estimate the following specification:

$$Y_{it} = \beta_0 + \beta_1 Before_{it} + \beta_2 long_i + \beta_3 lat_i + \gamma_t + \delta_i + \varepsilon_{it} \tag{3}$$

where $Before_{it}$ is a dummy variable which receives 1 for years before the reform. I estimate the model twice: first, only the seven regions involved in the reforms are considered. Second, I consider all of Russia, setting $Before = 1$ to all other regions, but restricting the data to 1995-2011, to exclude the years when all regions experienced clock reforms up and down.

3.2 Data

3.2.1 Regional data

The data source in this research is the annual reports "Regions of Russia: socio-economic outcomes" published by the Federal State Statistics Service of Russian Federation (Rosstat). The annual reports cover a wide range of topics and data is aggregated on the regional level. The considered perios is 1995-2015. I select a list of variables of interest: gross regional product (GRP) per capita, agricultural product, number of homicide cases, consumption of different types of food, health outcomes (rate of new cases of different diseases), labor force participation, and leisure (rate of visits to museums).

Because the Rosstat data is annual, the considered time zone is the average time zone in the case of a continuous variables and the one which was in force during most of the year in the case of a descrete variable. In other words, in absence of the dayligh saving time, if a reform took place before June 1st of a year, I consider the post-reform time zone for this year. Similarly, if a reform took place after June 1st, I consider the pre-reform time zone. Furthermore, until 2011, Russia used to have the daylight saving time. The time zone was changed twice a year - on the last Sunday of March (a shift of one time zone up) and October (a shift of one time zone down; the last Sunday of September until 1996). Thus, seven months a year the country lived in a summer time. Summary statistics of the Rosstat data are found in Table 2.

3.2.2 Individual data

The utilized individual data is the Russian Longitudinal Monitoring Survey (RLMS). This is a panel that started in 1994. It covers individuals from 41 locations in 34 Russian regions and until 2015 accumulated almost 300,000 observations. I use the continuous time zone bias at the location as the explanatory variable. Importantly, the Rosstat and the RLMS are two completely independeny datasets. The former is collected by the state and the latter is collected by an academic body. This independence makes an agreement of the clock effects between the two datasets to be a more convincing result.

4 Analysis with Russian regional data

The first results to be reported are the ones obtained with the Rosstat regional data. Tables 3 and 5 report the results of the difference-in-differences estimation (Equation 3) and Tables 5 and 6 report the results of the estimation of Equation 1. The difference-in-differences regressions consider the reforms of 1997, 2002, and 2010 when only a few regions were affected. The main explanatory variable $Before$ corresponds to the years before the reform when the time zone is higher than after the reform. In the first panel, I consider all the regions setting $Before = 1$ to the regions not affected by any of the three reforms. I exclude the post-2011 years because of the 2011 and 2014 reforms that affected almost all regions. In the first panel, I

Table 2: Summary statistics

variable		N	mean	st. dev.	min	max
year		1785			1995	2015
longitude of the region's capital		1785	60.73842	34.57395	20.5	177.5167
latitude of the region's capital		1785	53.75259	5.856476	42.98491	68.96957
log of consumption per capita in kg	bread	1580	4.77769	0.1396036	4.077538	5.141664
	eggs	1585	5.403442	0.2953713	3.135494	5.996452
	meat	1589	4.013108	0.2574669	3.044523	4.736198
	milk	1583	5.412141	0.2587714	4.060443	5.976351
	oil	1584	2.335849	0.2822611	1.458615	3.242592
	potato	1585	4.776481	0.3674355	3.091043	5.746203
	sugar	1586	3.576031	0.2078433	2.995732	4.094345
log of new cases per 1000 of population	birth defects	1214	0.5411331	0.5431624	-1.203973	2.397895
	endocrine system deseases	1373	2.256102	0.4157219	0.3364722	4.021774
	eye deseases	1214	3.49949	0.3274428	1.88707	4.561218
	nervous system deseases	1373	2.877043	0.5641608	1.308333	4.530447
	skin deseases	1373	3.859617	0.253835	2.433613	4.689511
	total disease	1601	6.599674	0.2214197	5.004617	7.468513

consider only the regions affected by the three reforms and all years. Tables 4 and 6 consider the time zone bias (the timing of zenith relatively to the noon in hours) in the region's capital city. For health outcomes, I consider not only the current time zone bias but also the time zone bias three years earlier to account for lagged effects of the later daylight on health. All regressions are estimated separately for the whole country, for regions with capitals to the north of the median, which is 54.5°, and for regions with capitals to the south of the median.

4.1 Diet

The results in Tables 3 and 4 indicate that a higher time zone is associated with a lower consumption of all ingredients, except of eggs and sugar. The statitically significant effects constitute a decrease of between 4 and 8 percents. An exception are regressions with only affected regions and only in the north. The effects in these regressions are stronger but the sample is small.

4.2 Health

Tables 5 and 6 show ambiguous results. In the south of Russia, all statistically significant coefficients and most not statistically significant coefficients are negative, indicating a lower rate of new cases of the deseases when the clock is later. However, in the north, all statistically significant coefficients are positive and large. These results, if indicate a true effect and not a spurious correlation, imply that a later daylight in the north of Russia is problematic for health. We should remember that the north of Russia has a very short daylight in winter and a long daylight in summer. Thus, a one-hour shift of the clock in the north makes a small difference in the summer but a big difference in the winter. This senstivity to the clock in the winter may help to explain the estimated effects. Further evidence of a positive relationship between the later clock and desease and other health problems in the north is discussed in Section 5, where individual data is analyzed.

5 Analysis with Russian individual data

In this section, I explore the health and health-related time use changes as a function of the time zone bias using the RLMS individual-level panel data. The regressions follow the specification given in Equation 2.

Table 3: The effect of clock reforms on diet (log og of annual per-capita consumption in kg) - difference in differences

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
		bread	eggs	meat	milk	oil	potato	sugar
		All regions are used in regressions						
All Russia	before the reform	-0.0412*	0.0253	-0.0722*	-0.107	-0.0410	-0.0178	0.0335
		(0.0217)	(0.0287)	(0.0400)	(0.0658)	(0.0613)	(0.0467)	(0.0343)
	Observations	1,338	1,343	1,347	1,341	1,342	1,343	1,344
North	before the reform	-0.0332	0.00815	-0.0846*	-0.129	-0.0821	-0.0509	0.0866**
		(0.0299)	(0.0357)	(0.0419)	(0.0983)	(0.0755)	(0.0516)	(0.0372)
	Observations	670	675	679	673	674	675	676
South	before the reform	-0.0619*	0.0364	-0.0512	-0.0839**	0.0275	-0.0101	-0.0417
		(0.0344)	(0.0398)	(0.0806)	(0.0379)	(0.0255)	(0.0918)	(0.0550)
	Observations	668	668	668	668	668	668	668
		Only involved regions are used in regressions						
All Russia	before the reform	-0.0315	0.0880	-0.0813*	-0.156*	-0.0736*	0.0176	0.0362*
		(0.0296)	(0.0483)	(0.0338)	(0.0706)	(0.0346)	(0.0444)	(0.0157)
	Observations	130	135	139	133	134	135	136
North	before the reform	0.00458	0.0274*	-0.134**	-0.247**	-0.104**	-0.0480	0.0434*
		(0.0214)	(0.00909)	(0.0313)	(0.0461)	(0.0287)	(0.0779)	(0.0140)
	Observations	70	75	79	73	74	75	76
South	before the reform	-0.0890**	0.0915	-0.0257	-0.0996	0.00197	0.0474	-0.0136
		(0.0153)	(0.0686)	(0.0370)	(0.0945)	(0.0290)	(0.0332)	(0.0152)
	Observations	60	60	60	60	60	60	60

*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents estimates of difference-in-difference regressions described by Equation (3). All regression control for the region capital city longitude and latitude as well as for the year and region fixed effects. The standard errors are clustered by region. The variable "before" corresponds to the pre-reform years when the time zone is higher than in the post-reform years. When all regions are used in the regression (the top panel), the post-2011 years are excluded because of the 2011 and 2014 reforms in all regions of the country.

Table 4: The effect of clock reforms on diet (log og of annual consumption in kg) - clock as a continuous variable

	All Russia						
	bread	eggs	meat	milk	oil	potato	sugar
time zone bias (tzb)	-0.0403	0.00522	-0.0351	-0.0972*	0.00306	-0.00726	0.00369
	(0.0306)	(0.0323)	(0.0399)	(0.0552)	(0.0590)	(0.0496)	(0.0313)
Observations	1,580	1,585	1,589	1,583	1,584	1,585	1,586
Number of region_id	82	82	82	82	82	82	82

	North						
	bread	eggs	meat	milk	oil	potato	sugar
time zone bias (tzb)	-0.0207	0.00399	-0.0617	-0.110	-0.0393	-0.0395	0.0656**
	(0.0428)	(0.0365)	(0.0451)	(0.0845)	(0.0836)	(0.0584)	(0.0307)
Observations	790	795	799	793	794	795	796
R-squared	0.043	0.483	0.814	0.208	0.792	0.301	0.488
Number of region_id	40	40	40	40	40	40	40

	South						
	bread	eggs	meat	milk	oil	potato	sugar
time zone bias (tzb)	-0.0733*	-0.00570	0.00374	-0.0917*	0.0563**	0.0129	-0.0791*
	(0.0417)	(0.0442)	(0.0690)	(0.0522)	(0.0276)	(0.0968)	(0.0432)
Observations	790	790	790	790	790	790	790
R-squared	0.084	0.412	0.806	0.295	0.807	0.128	0.310
Number of region_id	42	42	42	42	42	42	42

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents estimates of regressions described by Equation (1). All regression control for the region capital city longitude and latitude as well as for the year and region fixed effects. The standard errors are clustered by region.

Table 5: The effect of clock reforms on health (log of of annual new cases of disease per 1000 of population) - difference in differences

		birth defects	endocrine system disease	eye disease	nervous system disease	skin desease	total desease
		All regions are used in regressions					
All Russia	before the reform	-0.0532	0.0686	0.0145	0.0472	-0.00666	0.0411
		(0.113)	(0.115)	(0.0845)	(0.0633)	(0.0701)	(0.0570)
	Observations	963	1,122	963	1,122	1,122	1,350
North	before the reform	0.0500	0.158	-0.0593	0.0362	0.0183	0.0676
		(0.131)	(0.148)	(0.0932)	(0.0697)	(0.101)	(0.0672)
	Observations	489	569	489	569	569	680
South	before the reform	-0.275***	-0.0947	0.152	0.0514	-0.0458	-0.0229
		(0.0518)	(0.0595)	(0.108)	(0.111)	(0.0551)	(0.0320)
	Observations	474	553	474	553	553	670
		Only involved regions are used in regressions					
All Russia	before the reform	0.0494	0.247	-0.0167	0.119	0.0247	-0.0132
		(0.205)	(0.153)	(0.0830)	(0.108)	(0.0593)	(0.0885)
	Observations	105	119	105	119	119	140
North	before the reform	0.325*	0.428**	-0.0943	0.186	0.123**	0.112*
		(0.126)	(0.115)	(0.156)	(0.171)	(0.0297)	(0.0393)
	Observations	60	68	60	68	68	80
South	before the reform	-0.302	0.0194	0.175	0.121	-0.0930***	-0.152*
		(0.124)	(0.122)	(0.184)	(0.207)	(0.00180)	(0.0496)
	Observations	45	51	45	51	51	60

*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents estimates of difference-in-difference regressions described by Equation (3). All regression control for the region capital city longitude and latitude as well as for the year and region fixed effects. The standard errors are clustered by region. The variable "before" corresponds to the pre-reform years when the time zone is higher than in the post-reform years. When all regions are used in the regression (the top panel), the post-2011 years are excluded because of the 2011 and 2014 reforms in all regions of the country.

Table 6: The effect of clock reforms on health (log of of annual new cases of disease per 1000 of population) - clock as a continuous variable

	All Russia					
	birth defects	endocrine system disease	eye disease	nervous system disease	skin desease	total desease
time zone bias (tzb)	-0.0922	0.00893	-0.0183	0.0294	-0.0674	0.0203
	(0.0703)	(0.0911)	(0.0894)	(0.0811)	(0.0613)	(0.0383)
tzb 3 years ago	0.245**	-0.0659	0.190*	-0.0463	0.0696	0.0342
	(0.0969)	(0.107)	(0.110)	(0.0521)	(0.0523)	(0.0470)
Observations	1,212	1,371	1,212	1,371	1,371	1,599
Number of region_id	83	83	83	83	83	83

	North					
	birth defects	endocrine system disease	eye disease	nervous system disease	skin desease	total desease
time zone bias (tzb)	-0.0462	0.0110	-0.146**	-0.0371	-0.0614	-0.00181
	(0.0869)	(0.132)	(0.0632)	(0.0599)	(0.0929)	(0.0330)
tzb 3 years ago	0.276**	0.0826	0.255*	-0.0491	0.170***	0.129**
	(0.114)	(0.143)	(0.139)	(0.0910)	(0.0536)	(0.0508)
Observations	618	698	618	698	698	809
Number of region_id	43	43	43	43	43	43

	South					
	birth defects	endocrine system disease	eye disease	nervous system disease	skin desease	total desease
time zone bias (tzb)	-0.175*	-0.0188	0.196	0.110	-0.0857**	-0.00760
	(0.0921)	(0.102)	(0.119)	(0.174)	(0.0410)	(0.0526)
tzb 3 years ago	0.157	-0.220***	0.0484	-2.51e-05	-0.0510	-0.0120
	(0.0934)	(0.0771)	(0.0515)	(0.0694)	(0.0590)	(0.0482)
Observations	594	673	594	673	673	790
Number of region_id	40	40	40	40	40	40

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents estimates of regressions described by Equation (1). All regression control for the region capital city longitude and latitude as well as for the year and region fixed effects. The standard errors are clustered by region.

In particular, they control for individual fixed effects. Tables 7-10 consider adults and Table 11 reports the results for children of ages 7 to 14. Because the respondents are interviewed on a specific date, there is little sense to consider the time zone bias three years earlier. Thus, the lagged time zone is the average time zone over the past three years.[3]

Table 7 reports the effects on chronical desease. Clearly, the current and the lagged tzb are positively and significantly related to many chronical deseases. Exceptions are the neurological desease, allergies, and varicose veins. Considering the daily activities, such as walking, getting up, sitting, and lifting 5 kg, the time zone bias is again negatively related to the ease of performing these activities. These effects are reported in Table 8. Even thought not all effects are statistically significant, there is ambiguity in the results: the effect of the time zone bias on the ease of performing is negative or negligble for all activities. The effect for the old people, for whom the difficulty of daily activities is a more acute problem, are much higher. Table 9 reports the effect of the clock on specific health problems. Most coefficients are very small but some are notable. A one-hour later clock, averaged over the three years, is associated with a 12 percentage points higher rate of respondents who report their family member is sick. Furthermore, there is a 8 percentage points higher rate of respondents who report depression. However, the proportion of people who missed work in the past year is lower with a later clock.

Table 10 shows the effect of the clock on health-related time use. The results show that Russians sleep weekly 25 minutes less with a one-hour-later clock, and the effect is stronger, 37 minutes, in the southern half of the country. However, not all results are negative. Daily pleasure walking time increases by 6 minutes.BMI, the weight-to-height ratio, decreases by 0.06. An additional one percentage point of respondents report loss of weight within past twelve months. However, there is no effect on the proportion of respondent who respond being phisically active.

Finally, Table 11 reports the effect of the later clock on time use of children in ages 7 to 14. The effects are clearly positive: children are two percentage-points more likely to report that they do sports every day,

[3]The problem with averaging the time zone bias over a long period of time is that the variance of the average is mechanically lower the longer the period is. Thus, the regression coefficients are artificially inflated. For this reason, I do not use average time zone bias in the aggregated-data analysis but I use it when the data is individual-level.

Table 7: Regression results with individual data - chronical disease (age 18+)

	heart	lung	liver	kidney	stomach	spinal	endocrine	hypertension	joints
time zone	-0.00177	-0.00120	-0.000897	0.000496	0.00205	0.00142	0.000988	0.00288	-0.00267
bias (tzb)	(0.00193)	(0.00129)	(0.00161)	(0.00160)	(0.00213)	(0.00218)	(0.00442)	(0.00740)	(0.00782)
average tzb	0.0368***	0.0198***	0.0315***	0.0285***	0.0148	0.0371***	-0.0249	0.0176	0.0511
over last 3 years	(0.0113)	(0.00761)	(0.0107)	(0.00921)	(0.0133)	(0.0137)	(0.0235)	(0.0411)	(0.0424)
Observations	198,301	198,606	198,228	198,058	198,036	198,272	63,115	63,170	63,224
Number of ind	37,434	37,443	37,434	37,431	37,432	37,439	22,756	22,755	22,759

	neurol.	eye	gyno	allergies	varicose veins	skin	cancer	urogenital	upper resp.
time zone	0.00391	0.0187***	-0.000382	0.0142***	0.0167***	0.00319	-0.00217	0.00864*	0.0142***
bias (tzb)	(0.00543)	(0.00661)	(0.00783)	(0.00498)	(0.00520)	(0.00291)	(0.00238)	(0.00502)	(0.00540)
average tzb	-0.0918***	-0.0616	0.0986**	-0.0605**	-0.00831	-0.00786	-0.00802	0.0270	0.0316
over last 3 years	(0.0300)	(0.0389)	(0.0459)	(0.0284)	(0.0340)	(0.0206)	(0.0110)	(0.0275)	(0.0367)
Observations	63,174	63,283	43,811	63,327	63,280	63,339	63,124	45,395	63,247
Number of ind	22,757	22,768	20,351	22,768	22,757	22,767	22,754	20,129	22,763

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

with no effect on average time of sports conditional on doing sports. Playing at home shortens by 18 minutes a week, without any change in time dedicated to reading, drawing, and playing music.

6 Analysis in the United States

6.1 The daylight saving time extension

I compare the results in Russia to estimates in the United States. In the U.S., no similar to Russian reform where borders between time zones are shifted took place. However, the daylight saving time experienced a reform in 2007. The start of the daylight saving time moved from the first Sunday of April to the second Sunday of March. The end of the daylight saving time moved from the last Sunday of October to the first Sunday of November. I use the reform in a design described in Table 12. The explanatory variable is DST which receives one when the considered week experiences the daylight saving time and zero otherwise.

Table 8: Regression results with individual data - ease of daily activities, 1 = easy, 0 = difficult (age 18+)

	running 1 km	walking 1 km	walking 200 m	walking in room	sitting 2 h	getting up from sitting	getting up from bed	lifting 5 kg
time zone	-0.00554	-0.00344	0.0138	-0.00459	-0.0344***	-0.0176	-0.0164	-0.0281**
bias (tzb)	(0.00579)	(0.0125)	(0.0171)	(0.0220)	(0.0133)	(0.0121)	(0.0114)	(0.0115)
average tzb	-0.0230	-0.0464	-0.0958*	-0.125*	-0.0821*	-0.0845**	-0.192***	-0.0521
over last 3 years	(0.0141)	(0.0373)	(0.0558)	(0.0727)	(0.0433)	(0.0371)	(0.0430)	(0.0357)
Observations	22,302	15,622	10,684	7,686	15,781	15,821	15,855	22,533
Number of ind	11,489	6,624	4,409	4,032	4,860	4,865	4,866	11,574

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Regression results with individual data - health problems (age 18+)

	nervous	family member sick	eyesight	missed work in the past year	hospitalized	high blood pressure
time zone	0.00152	0.000601	-0.00743*	-0.0197***	-0.00195	-0.00549**
bias (tzb)	(0.00214)	(0.0105)	(0.00442)	(0.00755)	(0.00148)	(0.00253)
average tzb	-0.0118	0.122***	-0.00161	-0.0736**	0.00353	0.0252
over last 3 years	(0.0500)	(0.0296)	(0.0182)	(0.0355)	(0.00617)	(0.0167)
Observations	39,084	31,518	59,093	79,716	231,326	197,748
Number of ind	19,364	12,158	16,612	25,015	42,024	37,420
	(7) depression	(8) sleep disturbances	(9) stroke	(10) called ambulance	(11) health problems in 12 months	(12) good health
time zone	-0.00440	0.0185*	0.000705	-0.00146	0.00460	-0.0118***
bias (tzb)	(0.00532)	(0.0108)	(0.000740)	(0.00707)	(0.00286)	(0.00245)
average tzb	0.0690***	-0.136	0.000899	0.0119	0.00609	-0.00941
over last 3 years	(0.0234)	(0.272)	(0.00498)	(0.0265)	(0.0133)	(0.0113)
Observations	98,046	18,818	231,100	80,533	230,978	230,244
Number of ind	30,028	10,870	42,013	25,119	42,004	41,965

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Regression results with individual data - Time use, loss of weight, and BMI (age 18+)

	All Russia				
	sleep (minutes in a week)	pleasure walking (minutes in a day)	BMI	lost weight within 12 months	physically active (yes/no)
time zone bias (tzb)	-24.94*	5.800***	-0.0619***	0.0128***	0.00557**
	(13.10)	(1.339)	(0.0153)	(0.00281)	(0.00250)
average tzb over last 3 years			-0.160*	-0.00894	0.00352
			(0.0955)	(0.0136)	(0.0113)
Observations	31,193	91,359	209,565	192,152	209,369
Number of ind	12,136	28,882	40,829	38,397	40,323

	North				
	sleep (min.)	pleasure walking (min.)	BMI	lost weight within 12 months	physically active (yes/no)
time zone bias (tzb)	-18.78	4.448***	-0.0354*	0.0179***	0.00654*
	(19.21)	(1.627)	(0.0199)	(0.00379)	(0.00348)
average tzb over last 3 years			-0.0561	-0.0112	0.00700
			(0.117)	(0.0144)	(0.0141)
Observations	17,054	50,837	116,018	107,071	115,593
Number of ind	6,761	17,050	24,039	22,624	23,713

	South				
	sleep (min.)	pleasure walking (min.)	BMI	lost weight within 12 months	physically active (yes/no)
time zone bias (tzb)	-37.09**	9.257***	-0.0897***	0.00617	0.00578
	(18.18)	(2.348)	(0.0240)	(0.00425)	(0.00363)
average tzb over last 3 years			-0.358**	-0.0159	-0.0157
			(0.177)	(0.0498)	(0.0182)
Observations	14,139	40,522	93,547	85,081	93,776
Number of ind	5,375	11,832	16,790	15,773	16,610

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 11: Regression results with individual data - Children's time use (age 7-14)

	All Russia			
	sports beside school every day (yes/no)	sports beside school minutes in a week	reading/music/draw minutes in a week	playing at home minutes in a week
time zone bias (tzb)	0.0216*	-0.446	-4.080	-17.30***
	(0.0127)	(16.45)	(6.628)	(4.993)
Observations	15,340	7,759	9,466	14,746
Number of ind	5,906	3,159	3,585	6,085

	North			
	sports beside school every day (yes/no)	sports beside school minutes in a week	reading/music/draw minutes in a week	playing at home minutes in a week
time zone bias (tzb)	0.0187	-0.446	0.740	-18.13***
	(0.0176)	(16.45)	(9.576)	(6.824)
Observations	8,245	7,759	5,401	8,230
Number of ind	3,293	3,159	2,070	3,466

	South			
	sports beside school every day (yes/no)	sports beside school minutes in a week	reading/music/draw minutes in a week	playing at home minutes in a week
time zone bias (tzb)	0.0245	-8.605	-9.236	-15.30**
	(0.0186)	(17.07)	(8.783)	(7.591)
Observations	7,095	6,476	4,065	6,516
Number of idind	2,613	2,482	1,515	2,619

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12: The use of the 2007 reform in the U.S. in a difference-in-difference setup

	First week of March	Second week of March	One week before the last of October	Last week of October	First week of November
1996-2006	No DST	No DST	DST	No DST	No DST
2007-2012	No DST	DST	DST	DST	No DST

Note: by "week", I consider seven days starting with Sunday. For example, the first week of March are seven days starting with the first Sunday of March.

I estimate separately the effects in spring and in autumn. The considered outcomes are expenditures on different types of food, available in the consumer expenditures collected by the Bureau of Labour Statistics (1996-2012), and the different types of time use, available in the American Time Use Survey (2003-2016).

The use of the American case in a difference-in-differences estimation is according to the following empirical model:

$$Y_{ijt} = \beta_0 + \beta_1 DST_{it} + \mu_{it} + \gamma_t + \delta_i + \varepsilon_{ijt} \tag{4}$$

where DST is the observation of dayligh saving time (see Table 12) by respondent j who lives in state i and whose data corresponds to date t. The fixed effects are μ, δ, and ε, corresponding, respectivelly, to the week (for example, the first week of March), year, and state. The considered weeks are the ones reported in Table 12 and the regressions are estimated separately for autumn and for spring.

Table 13 reports the results for expenditures and Table 14 reports the results for time use. The effects show a pattern of lower expenditure on fast food but a higher expenditure on meat and baked products in autumn. In spring, the effect is only on meat. The total expenditure on food increases, by 7% in autumn and by 4.5% in spring.

The effects on the time use, reported in Table 14, show a statistically significant 5 percentage points higher likelihood to do sports in autumn and daily 9 more minutes spent on events and 23 less minutes spent on relaxation in spring. Overall, the results are consistent and are not contradicting the intuition of the effect of a later daylight.

Table 13: Expenditure of food in the U.S (log of dollars), difference-in-differences

	Autumn					
	food	alcohol	fastfood	sweet	meat	baked goods
DST	0.0667***	0.037	-0.071**	0.0127	0.180***	0.086***
	(0.00798)	(0.074)	(0.0308)	(0.0283)	(0.0283)	(0.0261)
Observations	256,404	6,519	23,680	23,121	23,456	25,348

	Spring					
	food	alcohol	fastfood	sweet	meat	baked goods
DST	0.0448***	0.107	0.0466	-0.00110	0.0839**	-0.0345
	(0.00909)	(0.0712)	(0.0348)	(0.0332)	(0.0330)	(0.0319)
Observations	167,893	4,028	16,048	14,945	15,228	16,293

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 14: Time use in the U.S (daily minutes, except of sport variable)., difference-in-difference

	Autumn								
	eating	sleep	sport (yes/no)	work	working	sport	socializing	events	relaxation
DST	-2.334	-4.174	0.0530**	-1.179	-0.007	2.838	-0.854	-5.187	17.85
	(2.961)	(8.642)	(0.0232)	(17.15)	(0.032)	(3.556)	(4.319)	(3.163)	(11.36)
N	8,905	8,905	8,905	8,905	8,905	8,905	8,905	8,905	8,905

	Spring								
	eating	sleep	sport (yes/no)	work	working	sport	socializing	events	relaxation
DST	3.045	0.240	-0.00767	4.840	0.00400	-0.722	9.559*	-0.669	-22.50*
	(3.609)	(9.463)	(0.0276)	(18.59)	(0.0355)	(2.794)	(5.368)	(2.220)	(13.41)
N	6,082	6,082	6,082	6,082	6,082	6,082	6,082	6,082	6,082

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: All regressions control for year fixed effects, week in the year (first/second of March, one before last/last in October, first in November) effect, and state fixed effects. The regressions are weighted by the ATUS weights.

7 Policy-oriented analysis

The time zone bias considered in the regression above is a continuous variable. Practically, we are interested in a time zones policy. The time zones in Russia are descrete. Thus, in addition to the exact time zone bias, I define a descrete time zone bias

$$TZB_{it}^{D} = \lceil ATZ_{it} \rceil - \lceil NTZ_i \rceil$$

The descrete time zone bias is the deviation of the time zone in power most of the year from the rounded natural time zone. The rounded natural zone is the most "natural" policy.

Empirically, this variable receives the values of either -1, 0, 1, or 2 (see Table 1). The descrete time zone bias is useful not only as a policy-oriented variable but also because it allows estimation of the linearity and mononocity of the effect of the time zone bias on the outcomes, when the effect of the time zone bias of one hour is compared to the effect of the time zone bias of two hours. using the following specification:

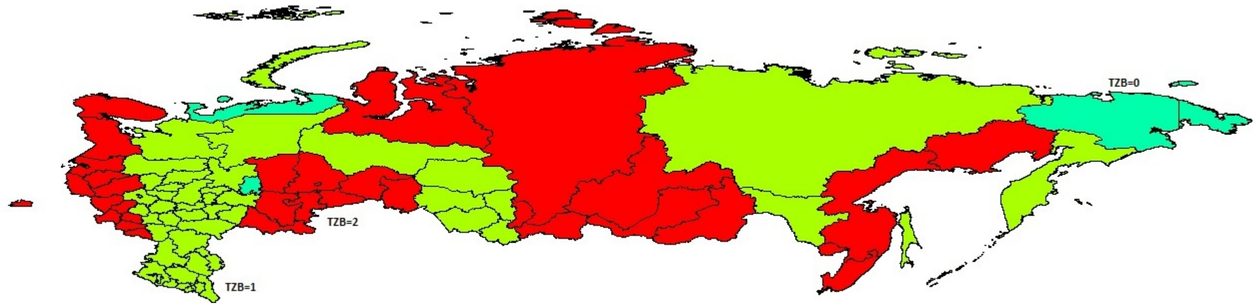
$$Y_{it} = \beta_0 + \beta_1 D_{it}^1 + \beta_2 D_{it}^2 + \beta_3 D_{i,t-j}^1 + \beta_4 D_{i,t-j}^2 + \beta_5 long_i + \beta_6 lat_i + \gamma_t + \delta_{it} + \varepsilon_{it} \qquad (5)$$

where D^1 is a dummy for $TZB^D = 1$ and D^2 is a dummy for $TZB^D = 2$.

Note that the case of TZB^D=-1 is unified with the case of TZB^D=0 and together these two cathegories constitute the reference group in the regressions. The reason for this unificaiton is that the case of TZB^D=-1 is extremely rare, as follows from Table 1.

Figure 3 presents the map of TZB^D in 2014. It is noticable that the southern regions of Russia do not provide the same level of variation in TZB as the northern regions. Table 15 shows the distribution of time zone bias across regions to the south and to the north of the median region during the 1990-2015 period. The median latitude is 54.5°. The case of zero TZB is similarly rare in both the south and the north. TZB of two hours is less prevalent in the south than in the north, but even in the south it accounts for one third of the cases. The problem is, however, that in southern regions there is not enough variation along time to identify all parameters of equation 5. To observe difference between the regions, the regressions are estimated for the whole country as well as separately for regions northern to the median one. The comparison between the

Figure 3: The Time Zone Bias in Russia, 2014



"whole country" coefficients and "north" coefficients provides some evidence of the south-north differences. The estimation results can be sent by request.

8 Identification tests

8.1 Balance regression

Are the clock reforms in Russia indeed exogenous to the analyzed above outcomes? In Table 16, I regress the dummy for change in TZB versus previous year on the outcomes (one by one) one and two years earlier. Because all shifts in TZB during the 1995-2015 period are downward (see the table in Appendix A) there is no need to separate reforms into "upward" and "downward" ones. All regressions include year and region fixed effects. Out of 2x21=42 coefficients only 3 are statistically significant (on 10% level). Thus, the hypothesis that the reforms are not correlated with the outcomes can not be rejected.

8.2 Distance and time difference from Moscow

But perhaps TZB is just a function of longitude? In this case, the results are not driven by the TZB but by the correlated with TZB distance or time difference from some geographical location. To rule out this concern, all regressions in the results section control for longitude and latitude as follows from Equation 5. Furthermore, estimating the regressions separately for "east" and "west" does not show major differences between coefficients (differently from estimating for "north" versus the whole country). But to finally rule out

Table 15: The distribution of the time zone bias (number of regions), south and north of Russia (the threshold latitude is 54.5°)

	South				North				
Year	0	1	2	Total	-1	0	1	2	Total
1990	0	23	18	41	0	2	17	23	42
1991	21	17	3	41	2	17	22	1	42
1992	20	17	4	41	1	17	23	1	42
1993	0	22	19	41	0	1	19	22	42
1994	22	19	0	41	1	19	22	0	42
1995	0	24	17	41	0	1	19	22	42
1996	0	24	17	41	0	1	19	22	42
1997	0	25	16	41	0	1	19	22	42
1998	0	25	16	41	0	1	19	22	42
1999	0	25	16	41	0	1	19	22	42
2000	0	25	16	41	0	1	19	22	42
2001	0	25	16	41	0	1	19	22	42
2002	0	25	16	41	0	1	20	21	42
2003	0	25	16	41	0	1	20	21	42
2004	0	25	16	41	0	1	20	21	42
2005	0	25	16	41	0	1	20	21	42
2006	0	25	16	41	0	1	20	21	42
2007	0	25	16	41	0	1	20	21	42
2008	0	25	16	41	0	1	20	21	42
2009	0	25	16	41	0	1	20	21	42
2010	0	27	14	41	0	3	19	20	42
2011	0	27	14	41	0	3	19	20	42
2012	0	27	14	41	0	3	19	20	42
2013	0	27	14	41	0	3	19	20	42
2014	0	27	16	43	0	3	19	20	42
2015	26	17	0	43	1	21	20	0	42
Total	89	623	358	1,070	5	107	511	469	1,092
	8.3%	58.2%	33.5%	100%	0.5%	9.8%	46.8%	42.9%	100%

Table 16: Balance test

	Dependent variable: a dummy for time zone change					
	(1)	(2)	(3)	(4)	(5)	
	log agr. product	log GRP per cap.	log homicide	log bread	log eggs	
x (year - 1)	-0.0213	0.0156	0.00301	-0.00468	-0.0249	
	(0.0158)	(0.0242)	(0.0147)	(0.0662)	(0.0355)	
x (year - 2)	0.0222	-0.0520**	-0.00130	-0.0347	0.0225	
	(0.0155)	(0.0233)	(0.0147)	(0.0641)	(0.0327)	
Observations	1,532	1,436	1,573	1,498	1,503	
	(6)	(7)	(8)	(9)	(10)	
	log meat	log milk	log oil	log potato	log sugar	
x (year - 1)	0.0227	-0.0271	0.00265	-0.0152	0.0100	
	(0.0589)	(0.0457)	(0.0396)	(0.0267)	(0.0527)	
x (year - 2)	-0.0381	-0.0392	0.0141	0.0204	-0.0157	
	(0.0589)	(0.0454)	(0.0395)	(0.0256)	(0.0512)	
Observations	1,507	1,500	1,502	1,503	1,504	
	(11)	(12)	(13)	(14)	(15)	(16)
	log birth defects	log endocrine	log eye	log nervous	log skin	log total disease
x (year - 1)	-0.00219	-0.00384	0.00526	-0.0326*	-0.00972	0.0527
	(0.0160)	(0.0219)	(0.0185)	(0.0189)	(0.0337)	(0.0400)
x (year - 2)	0.0232	0.0135	0.0143	0.0479***	0.0129	-0.0449
	(0.0156)	(0.0210)	(0.0183)	(0.0181)	(0.0333)	(0.0402)
Observations	1,126	1,126	1,126	1,126	1,126	1,515
	(17)	(18)	(19)	(20)	(21)	
	log museums	log beer	log likeurs	log wine	lfp	
x (year - 1)	0.00717	-0.0331**	-0.0149	-0.00578	0.0527	
	(0.0114)	(0.0153)	(0.0176)	(0.0139)	(0.0400)	
x (year - 2)	-0.00838	0.0190	0.0172	0.0100	-0.0449	
	(0.0115)	(0.0148)	(0.0179)	(0.0136)	(0.0402)	
Observations	1,571	1,236	1,264	1,263	1,515	

The regressions are linear probability models.
All regressions include year and region fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 17: Correlation of the time zone bias with geographical distance from Moscow and time difference from Moscow

	TZB=-1	TZB=0	TZB=1	TZB=2
Distance from Moscow	-0.0058	0.0185	-0.1959	0.1905
Time difference from Moscow	-0.0152	-0.0296	-0.2613	0.2770

the concern, I consider the distance from a single location as an alternative channel. The natural location to consider is Moscow. Table 17 reports the correlation coefficients of the different time zone bias dummies with geogrpahical distance and time difference from Moscow. The close-to-zero correlation of TZB=-1 dummy can be ignored as it is driven by a single data point. The correlation of TZB=0 dummy is also close to zero. It implies that regions where the actual time zone equals the natural one are randomly located on the map (at least for the 1995-2015 period). The correlation coefficients of TZB=1 and TZB=2 with the distance and time difference from Moscow are not negligible but have an opposite sign. The TZB=1 dummy is negatively correlated with distance and time difference from Moscow. It implies that regions close to Moscow tend to have a one hour time zone bias. However, the TZB=2 dummy has positive correlation with distance and time difference from Moscow, of the same magnitude as the opposite correlation of TZB=1. Would the regression results be driven by distance or time difference from Moscow, the signs of the regression coefficients should be non-monotonic in TZB. But they are monotonic as this is one of the robustness requirements mentioned in Section **??** - to be reported, the effect for TZB=2 should be with the same sign and not weaker than the effects for TZB=1. Thus, the concern is turned out.

9 Concluding remarks

This is an empirical study providing evidence of the relationship between the clock and the economy. Let us summarize the main results and figure out possible links suggesting directions for future investigation.

First, clock matters and it matters for a wide spectrum of health-related outcomes. Second, the effects on health and diet are ambigious. The results imply that the consumption of unhealthy foods (eggs, sugar) decreases with a later daylight. However, some health problems become more frequent and the ease of daily activities increases. Especially disturbing are the health effects of a later clock in the north of Russia. The time use is more healthy with a later clock when it comes to physical activity of adults and children but the sleep shortens. The comparison with the effects in the U.S. show that also in America the diet and the time use are different when the clock is later. However, strictly speaking, the comparison of the effects should be done with caution because the natural experiments in the two countries are different.

To recall what the paper starts with, understanding the consequences of the decision to set a specific time zone should ease (but may also complicate) the public discussion of what is the optimal clock for the country.

Appendix

Changes in time zones, in power most of the year, in Russian federal subjects, 1995-2015

Region (Federal Subject)	natural time zone	1995	1997	2002	2010	2014	2015
Altay Kray		7	7	7	7	7	**6**
Amur Oblast		10	10	10	10	10	**9**
Arkhangelsk Oblast		4	4	4	4	4	**3**
Astrakhan Oblast		4	4	4	4	4	**3**
Belgorod Oblast		4	4	4	4	4	**3**
Bryansk Oblast		4	4	4	4	4	**3**
Vladimir Oblast		4	4	4	4	4	**3**
Volgograd Oblast		4	4	4	4	4	**3**
Vologda Oblast		4	4	4	4	4	**3**
Voronezh Oblast		4	4	4	4	4	**3**
Jewish Autonomous Oblast		11	11	11	11	11	**10**
Zabaykalsky Kray		10	10	10	10	10	**8**
Ivanovo Oblast		4	4	4	4	4	**3**
Irkutsk Oblast		9	9	9	9	9	**8**
Kabardin-Balkar Republic		4	4	4	4	4	**3**
Kaliningrad Oblast		3	3	3	3	3	**2**
Kaluga Oblast		4	4	4	4	4	**3**
Kamchatka Kray		13	13	13	**12**	12	12
Karachay-Cherkess Republic		4	4	4	4	4	**3**
Kemerovo Oblast		8	8	8	**7**	7	7
Kirov Oblast		4	4	4	4	4	**3**
Kostroma Oblast		4	4	4	4	4	**3**
Krasnodar Kray		4	4	4	4	4	**3**
Krasnoyarsk Kray		8	8	8	8	8	**7**
Kurgan Oblast		6	6	6	6	6	**5**
Kursk Oblast		4	4	4	4	4	**3**
Leningrad Oblast		4	4	4	4	4	**3**
Lipetsk Oblast		4	4	4	4	4	**3**
Magadan Oblast		12	12	12	12	12	**10**
Moscow City		4	4	4	4	4	**3**
Moskva Oblast		4	4	4	4	4	**3**
Murmansk Oblast		4	4	4	4	4	**3**
Nenets Avtonomnyy Okrug		4	4	4	4	4	**3**
Nizhegorod Oblast		4	4	4	4	4	**3**
Novgorod Oblast		4	4	4	4	4	**3**
Novosibirsk Oblast		7	7	7	7	7	**6**
Omsk Oblast		7	7	7	7	7	**6**
Orenburg Oblast		6	6	6	6	6	**5**
Orel Oblast		4	4	4	4	4	**3**
Penza Oblast		4	4	4	4	4	**3**
Perm Kray		6	6	6	6	6	**5**
Primorye Kray		11	11	11	11	11	**10**
Pskov Oblast		4	4	4	4	4	**3**

Region (Federal Subject)	1995	1997	2002	2010	2014	2015
Adygey Republic	4	4	4	4	4	**3**
Altay Republic	7	7	7	7	7	**6**
Bashkortostan Republiclika	6	6	6	6	6	**5**
Buryat Republic	9	9	9	9	9	**8**
Dagestan Republic	4	4	4	4	4	**3**
Ingush Republiclika	4	4	4	4	4	**3**
Kalmyk Republic	4	4	4	4	4	**3**
Karelia Republic	4	4	4	4	4	**3**
Komi Republic	4	4	4	4	4	**3**
Crimea					**4**	**3**
Mariy-El Republic	4	4	4	4	4	**3**
Mordovia Republic	4	4	4	4	4	**3**
Sakha Republic	10	10	10	10	10	**9**
North Ossetia Republic	4	4	4	4	4	**3**
Tatarstan Republic	4	4	4	4	4	**3**
Tuva Republic	8	8	8	8	8	**7**
Khakass Republic	8	8	8	8	8	**7**
Rostov Oblast	4	4	4	4	4	**3**
Ryazan Oblast	4	4	4	4	4	**3**
Samara Oblast	5	5	5	**4**	4	**4**
St. Petersburg	4	4	4	4	4	**3**
Saratov Oblast	4	4	4	4	4	**3**
Sakhalin Oblast	12	**11**	11	11	11	**10**
Sverdlovsk Oblast	6	6	6	6	6	**5**
Sevastopol					**4**	**3**
Smolensk Oblast	4	4	4	4	4	**3**
Stavropol Kray	4	4	4	4	4	**3**
Tambov Oblast	4	4	4	4	4	**3**
Tver Oblast	4	4	4	4	4	**3**
Tomsk Oblast	8	8	**7**	7	7	**6**
Tula Oblast	4	4	4	4	4	**3**
Tyumen Oblast	6	6	6	6	6	**5**
Udmurt Republic	5	5	5	**4**	4	**4**
Ulyanovsk Oblast	4	4	4	4	4	**3**
Khabarovsk Kray	11	11	11	11	11	**10**
Khanty-Mansiy Avtonomnyy Okrug	6	6	6	6	6	**5**
Chelyabinsk Oblast	6	6	6	6	6	**5**
Chechnya Republic	4	4	4	4	4	**3**
Chuvash Republic	4	4	4	4	4	**3**
Chukot Avtonomnyy Okrug	13	13	13	12	12	12
Yamal-Nenets Avtonomnyy Okrug	6	6	6	6	6	**5**
Yaroslavl Oblast	4	4	4	4	4	**3**

Notes:
1. The table shows the actual time zone in power most of the year relatively to UTC.
2. Bold numbers represent the reforms (time zone different from the column to the left).
3. Crimea and Sevastopol were annexed to Russia in March, 2014. On March 30, 2014, the time zone (winter time) in these two regions was changed from UTC+2, as it used to be since 1996, to UTC+4.

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