An econometric evaluation of daylight saving time in Mexico

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Abstract

This paper evaluates the impact of daylight saving time (DST) on households' consumption of electricity in Mexico. Differences-in-differences estimates suggest that current savings in households' electricity consumption due to DST account for almost 0.6% of total electricity consumption in the country. Nevertheless, the effect of DST is not homogeneous along the whole period in which it is in effect (from April to October). Savings are larger toward the end of the period.

Keywords: Daylight saving time; time series, Mexico

JEL Classification codes: Q48

1. Introduction

Daylight saving time (DST) is a common practice in several countries around the world. Although Benjamin Franklin is acknowledged as the promoter of the idea at the end of the 18th century, it was actually implemented by some countries in Europe and the United States (US) until the First World War. Since then, several countries have been using it intermittently. According to the information in the web page of Fideicomiso para el Ahorro de Energia Electrica (FIDE),[1] DST is currently used in 86 countries around the world. Among other things, this is due to the idea that it saves energy and, consequently, reduces the use of natural resources.

DST is supposed to generate two main types of savings (Maqueda and Rebolledo, 2008). On the one hand, it changes the consumption pattern in households by reducing electricity consumption in the evening, during the peak of demand, and increasing it early in the morning (Kellogg and Wolff, 2008). Hence, DST helps to smooth consumption during the day generating efficiency gains in the production of electricity. On the other hand, DST is assumed to reduce

[1] FIDE is a trust fund created by the Mexican government to promote savings in electricity usage. http://www.fide.org.mx/index.php?option=com_content&view=article&id=102&Itemid=190

overall electricity consumption. That is, reduced consumption during the evening –attributed to DST– is larger than increased consumption during the morning.

There are some recent studies arguing that DST, or an extension of its duration, does not necessarily generate energy savings. For example, the works of Kellogg and Wolff (2008), Kotchen and Grant (2011), and Marshall (2010), based on natural experiments in Australia, the US, and Chile, respectively, claim that implementing DST or extending its duration actually increases overall electricity consumption. Similarly, Shimoda et al. (2007), using simulation techniques, find that DST would increase residential electricity consumption in Osaka; while Kandel and Sheridan (2007), using a time series approach, find that DST has an ambiguous effect on electricity consumption in California. However, many other recent studies find the opposite (Maqueda and Rebolledo, 2008; Mirza and Bergland, 2011; Ahuja and SenGupta, 2012; Verdejo et al., 2016).

Mexico is an interesting place to evaluate DST for several reasons. First, while the US and other developed countries have a long experience using DST, Mexico has been using it only for a few years.[2] Therefore, there is recent and reliable information on household consumption both before and after DST was implemented. Second, the DST is used only during part of the year. In particular, individuals in Mexico adjust their clocks one hour forward the first Sunday of April and adjust them backward the last Sunday of October. Hence, some months of the year (those not affected by DST) can be used as a control group in order to evaluate DST using a differences-in-differences (DD) approach. Third, the price of electricity for household consumption in Mexico is regulated (fixed by the government). Therefore, price is not an endogenous variable in Mexico as it is in other places.[3] Fourth, the most recent evaluation of DST in Mexico –conducted by Maqueda and Rebolledo (2008)– took place about 10 years ago.

In this paper, we evaluate empirically whether DST reduces or not overall household electricity consumption in Mexico. Moreover, we evaluate the effect of DST for each of the months included in the program. Our results, based on publicly available data gathered from the

[2] Choi, Pellen and Masson (2017) make a similar argument to motivate their study about the effects of DST in Western Australia (WA). They explain that DST was adopted in WA at the end of 2006 and then repealed at the beginning of 2009.

[3] Mexico is not the only country in which electricity prices are fixed by the government. For instance, Kellogg and Wolff (2008) say that end-use electricity prices in Australia are regulated.

national statistics agency in Mexico (INEGI), indicate that DST reduces consumption. We estimate that household electricity consumption savings generated by DST are about 1,545 Gigawatts/hour (GWh) on a yearly basis. These savings account for almost 0.6% of total electricity consumption in the country. Nevertheless, DST does not reduce consumption uniformly during the whole period. In particular, we find that DST has smaller effects during the first months of the period (that is, April, May, June and July) and larger effects towards the last months (that is, August, September, and October).

The rest of the paper is organized as follows. In Section 2, we explain the basic characteristics of the Mexican electricity industry. In Section 3, we make simple DD calculations around the point in which DST was implemented for the first time in order to have a first approximation of the impact of this policy. In Section 4, we estimate the effects of DST econometrically. In Section 5, we conduct robustness tests. Finally, in the last section, we present the main conclusions if this study.

2. Background

The electricity industry has been subject to several regulatory changes in Mexico. These changes point slowly towards the creation of a private wholesale market for electricity. For many years, the state-owned public utility Comisión Federal de Electricidad (CFE) was by law the unique producer and distributor of electricity in the country. At the beginning of the 90s, there was a change in the law allowing private firms to generate electricity for own-consumption or to sell it to CFE. The most recent reform –approved in the year 2013– allowed private firms to generate and distribute electricity in the country.

In spite of creating a wholesale electricity market in Mexico, the recent energy reform maintained CFE as a monopoly in the distribution of electricity for household consumption. Moreover, the prices of electricity for households are still fixed by the Ministry of Finance (SHCP), taking into account the opinion of other ministries as well as CFE proposals. It follows that these prices are not driven by market conditions, but by an authority that takes into account economic, social, and political issues.

Electricity prices for households vary with the season, the geographical region of the country in which the house is located, and the particular level of consumption of each household.

Prices are lower during the summer semester when temperatures are relatively high in most of the country. In addition, prices vary from region to region depending on historical temperature records. Prices are lower in the regions where the average minimum temperature has been higher in the last years. The idea behind this pricing policy is to compensate households that face warmer summers and, consequently, need to spend more on air conditioning (AC). Finally, households face an increasing block tariff. That is, the marginal price of electricity increases when consumption reaches certain thresholds. This pricing policy is intended to have the following effects. On the one hand, it charges higher prices at the margin to higher income households because they tend to consume more electricity. On the other hand, it promotes energy savings.

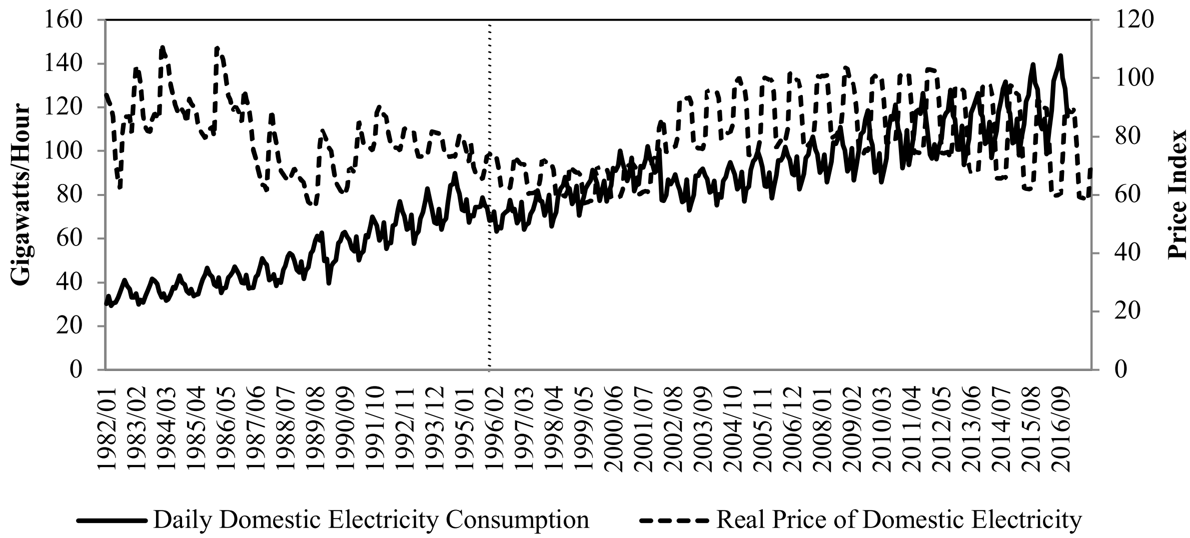

Fig. 1. Daily domestic consumption and real prices of electricity in Mexico. *Data source*: www.inegi.org.mx

Figure 1 illustrates the evolution of the monthly average of households' daily electricity consumption in Mexico and its real average price. Consumption is measured in GWh, while the real price of electricity is an index of domestic electricity prices divided by the national consumer price index. Electricity consumption exhibits a clear increasing trend over the whole period. In contrast, the real price of electricity has been relatively stable if we ignore seasonal variations. This occurs because the SHCP adjusts prices periodically to keep up with the inflation rate. However, there are several subtle but clear shifts in the price trend. That is, electricity prices tended to fall during the 90s, to increase at the beginning of the next decade, and to fall again at the beginning of the last decade. Now, if we consider seasonal variations in consumption, it is easy to note that peaks take place during the summer mainly for two reasons: need for AC and low electricity prices.

The thin vertical dotted line in Figure 1 divides the timeline into two parts: before and after the implementation of DST in the country. The Mexican government started implementing DST in 1996, while prices and consumption of electricity were moving mainly due to seasonal adjustments. In addition, the country suffered a deep economic crisis in the middle of the 90s, a small one at the beginning of the next decade, and a large one again after the 2008 World Financial Crisis. It follows that it is not straightforward to separate the effect of DST on electricity consumption from that of other variables.

3. Differences-in-differences comparisons

In this section, we make simple differences-in-differences (DD) comparisons to have an initial approximation of the impact of DST on domestic consumption of electricity. It is important to explain that we will evaluate the effect of DST econometrically in the next section. At this point, we will simply compare domestic consumption during different months of the year before and after the implementation of DST for illustration purposes. Given that DST started in 1996, we compare average consumption in years 1993, 1994 and 1995 with the average in years 1996, 1997 and 1998. Similarly, given that DST takes place only during part of the year, we use months to build control and treatment groups. The control group includes the months of January, February, March, November and December, while the treatment group includes the remaining 7 months. That is, the treatment group includes only the months where DST is applied.

The idea of using months as controls to estimate the effect of DST is not new. Kellogg and Wolff (2008) tried using months adjacent to DST in Australia (that is, August and November) as controls. However, they decided not to rely on the estimates they obtained using this approach because monthly demand in Australia is not stable. We try to avoid this problem, at least partially, by using a three-year average of monthly consumption for these comparisons. Later on, in the econometric model, we will avoid this problem by using an average of all non-

DST months in a given year as controls. Again, this idea is not completely new. Choi, Pellen and Masson (2017) use non-DST months as controls in their econometric analysis.

We believe that using months to construct the treatment and control groups is appropriate for several reasons. First, the choice of months where DST applies is arbitrary to some extent. It is clear that DST generates more savings in the summer than during the rest of the year. However, some countries have discussed and implemented year round DST or extensions of DST.[4] Second, households' electricity consumption seemed to be growing homogenously around those years. Third, this approach produces a reasonable and simple first approximation to the effects of DST on electricity consumption.

Table 1. Average household electricity consumption in Mexico (GWh)

	Before	After	Change	% Change	DST
January	2,111.33	2,179.33	68.00	3.22	No
February	2,073.33	2,160.33	87.00	4.20	No
March	1,956.00	1,992.67	36.67	1.87	No
April	2,001.67	2,006.33	4.67	0.23	Yes
May	2,093.33	2,107.67	14.33	0.68	Yes
June	2,200.67	2,212.00	11.33	0.51	Yes
July	2,382.00	2,357.33	-24.67	-1.04	Yes
August	2,452.00	2,421.67	-30.33	-1.24	Yes
September	2,517.00	2,473.67	-43.33	-1.72	Yes
October	2,435.00	2,411.00	-24.00	-0.99	Yes
November	2,283.33	2,332.00	48.67	2.13	No
December	2,159.00	2,204.67	45.67	2.12	No
	Average	Average	Difference	%	
Non DST months	2,116.60	2,173.80	57.20	2.70	
DST months	2,297.38	2,284.24	-13.14	-0.57	
Differences-in-differences			70.34	3.27	

Table 1 suggests that DST was effective to reduce domestic electricity consumption in Mexico, or at least to make it grow at a slower rate. The first two columns of data in the table are three-year averages of domestic consumption before and after, respectively, the implementation of DST. The third column in the table is the percentage change when comparing average consumption before and after DST for a given month. The last column specifies whether DST applies or not in the corresponding month. Note that consumption increases between 1.87% and

[4] See HMSO (1970), Ebersale et al. (1974), Kellogg and Wolff (2008), Hill et al. (2010), and Ahuja and SenGupta (2012).

4.2% in the months that belong to the control group (that is, the five months in which DST is not implemented in Mexico). In contrast, consumption decreases (or increases a little bit) in the months that belong to the treatment group.

In order to calculate an overall DD estimate of the effect of DST, we compare the rates of growth of the treatment and control groups. In this case, the growth of average domestic consumption in DST months is -0.57% while its counterpart is 2.7%. This simple DD comparison suggests then that DST reduced average domestic consumption about 70 GWh monthly. If this number is correct, the DST allowed saving about 490 GWh per year. Total electricity use in Mexico, at that time, was about 135 thousand GWh. Therefore, savings represented about 0.36% of total electricity consumption in the country when DST was implemented for the first time. This number is clearly lower than previous estimates. For instance, Ramos et al. (1998) calculated that DST reduced total electricity use in Mexico between 0.65% and 1.1%.

4. Econometric estimate of the effect of DST

In this section, we use monthly time series data to estimate econometrically the effect of DST on household electricity consumption.[5] The database covers the period from 1982 to 2016 and is published by INEGI. The main variable of interest in our study is average (daily) households' consumption of electricity during the month.[6] We choose to use household consumption data because most savings from DST are expected to take place in households' electricity consumption for illumination (Aries and Newsham, 2008; Momani, Yatim and Ali, 2009).

Assume that daily average household consumption of electricity (Q) during month i of year t is given by the following expression:

(1) $Q_{it} = \alpha + \beta \cdot PR_{it} + \delta \cdot Y_t + \phi \cdot W_i + \gamma \cdot DST_{it} + \varepsilon_{it}.$

[5] CFE classifies consumers in three types: residential, commercial and industrial. Household consumption corresponds to consumers classified as residential.

[6] We consider April and October as part of treatment months because more than 75% of the days in the month are DST days.

The variables that explain household consumption of electricity are: real price of electricity (*PR*), households' permanent income (*Y*) during the year, weather conditions (*W*) during the month, whether *DST* is in effect or not, and an error term.

We will use the sub-index letter *o* to denote that a variable belongs to the control group (that is, a month or set of months in which *DST* is not implemented). Therefore, we can calculate the difference between consumption in a given treatment month i and the control period as follows

$$(2)\ Q_{it} - Q_{ot} = \beta \cdot \left(PR_{it} - PR_{ot}\right) + \phi \cdot \left(W_i - W_o\right) + \gamma \cdot DST_{it} + \varepsilon_{it}.$$

Variables that adjust every year like households' permanent income (Y) disappear once we calculate differences in household consumption of energy. Similarly, seasonal differences (such as daylight hours or weather conditions) between a particular month and the control month(s) become a constant. We can rewrite (2) in terms of percentage changes as follows

$$(3)\quad \frac{Q_{it} - Q_{ot}}{Q_{ot}} \cdot 100 = \frac{\beta \cdot PR_{ot}}{Q_{ot}} \left(\frac{PR_{it} - PR_{ot}}{PR_{ot}} \cdot 100 \right) + \frac{100\phi}{Q_{ot}} \left(W_i - W_o\right) + \frac{100\gamma}{Q_{ot}} DST_{it} + \frac{100}{Q_{ot}} \varepsilon_{it}.$$

We can define $\Delta\%Q_{it} \equiv 100 \cdot \frac{Q_{it} - Q_{ot}}{Q_{ot}}$ as the difference between average daily consumption during month i and the month or set of months used as controls. Similarly, we can also define $\Delta\%PR_{it} \equiv 100 \cdot \frac{PR_{it} - PR_{ot}}{PR_{ot}}$. Finally, we can simplify (3) to obtain

$$(4)\ \Delta\%Q_{it} = a + b \cdot \Delta\%PR_{it} + c \cdot DST_{it} + \eta_{it}.$$

We estimate this equation pooling together all the months in which DST is implemented. Note that DST_{it} is zero from years 1982 to 1995 and one afterwards. It is reasonable to argue that differences in weather conditions between summer and winter months have been changing over time. In particular, summers are becoming hotter and winters colder. If this is the case, our estimates will be biased. However, we can include a time trend to control for this effect. Therefore, as suggested by Angrist and Pischke (2009), we will estimate (4) with a time trend.

The variable TREND takes the values 1, 2, 3… 35, respectively, for each of the years in the time series.

Table 2 shows the results of two DD regression models of household electricity consumption. Both models are based on equation (4), they include a time trend, and dummies to control for month effects. In the first model, we assume that the effect of DST on electricity consumption is the same for all DST months. In the second model, we include interactions between the month dummies and DST. Therefore, we can test whether DST has different effects on different months.

Table 2. Domestic Electricity Consumption Results (pooled regression)

Variable	**Month Dummy Regression**	**Month Dummy Interaction Regression**
Constant	-7.61***	-9.20**
Trend	0.28***	0.30***
PR	-0.23 ***	-0.20***
DST	-6.49***	-4.13***
May	0.00	-0.65
June	9.52***	9.59***
July	11.91***	12.60***
August	16.61***	20.08***
September	22.38***	26.54***
October	16.95***	21.50***
May*DST		1.68
June*DST		0.50
July*DST		-0.50
August*DST		-5.14***
September*DST		-6.31***
October*DST		-7.25***
R^2	0.83	0.86

*,** and *** indicate that the coefficient associated with the DLS dummy variable is significant at 10% , 5% and 1%, respectively.

All the coefficients in the regressions have the expected signs. First, the trend coefficient is positive. This means that DST consumption of electricity is growing faster than non-DST consumption. As mentioned before, this is probably explained by warmer summers; as well as an increase in the availability and use of air conditioning (AC) with time. Second, the price coefficient is negative. That is, an increase in the price difference between treatment and control months, reduces the difference in consumption of electricity. However, the effect of this variable is small; suggesting that household demand for electricity is relatively price inelastic. Third, the DST coefficient is negative. That is, DST reduces consumption of electricity. Nevertheless, it is important to highlight that DST has a smaller effect on consumption during the first four months of the period (that is, April, May, June, and July) in comparison with the last three months (August, September, and October).

We can use the model to calculate electricity savings due to DST. Note that γ is the effect of DST on electricity consumption. However, the DST coefficient that we estimate in the regressions is $c = \gamma \frac{100}{Q_o}$. Given that Q_o (that is, average daily consumption in non-DST months) was about 113.6 GWh during year 2016, the effect of DST in a given month is $\gamma = c \times 1.136$. Finally, we should multiply the corresponding figure by the number of DST days in the month to estimate monthly savings.

Table 3. Estimated DST electricity savings in year 2016

	April	May	June	July	August	September	October
DST Days (2016)	30	31	30	31	31	30	27
DST Coefficient	-4.13	-2.45	-3.63	-4.63	-9.27	-10.44	-11.38
Savings (GWh)	140.8	86.3	123.7	163.1	326.5	355.8	349

Table 3 shows estimated electricity savings for each month in year 2016. The DST coefficients that we use come from the pooled regression with interaction terms. Therefore, DST coefficients vary with the month. Electricity savings due to DST in the whole period are 1,545.1 GWh. Given that total electricity consumption in the country was about 260 thousand GWh in year 2016, DST savings in residential electricity consumption represent almost 0.6% of total electricity consumption in Mexico.

We use the same procedure to estimate electricity savings due to DST both in the middle of the 90s (when DST was introduced in Mexico) and about ten years later. These estimates can be compared to previous estimates obtained by Ramos et al. (1998) and Maqueda and Rebolledo (2008), respectively. Average daily consumption by households was about 68.9 GWh in the 1996. Therefore, yearly savings generated by DST were about 937.1 GWh. This number was approximately 0.7% of total electricity consumption in the country at that time. Note that it is almost twice the savings we calculated with a simple DD comparison in the previous section. Moreover, this number is in line with the estimates obtained by Ramos et al. (1998). Similarly, considering that daily household consumption was about 93.4 GWh in 2008, we can estimate that savings generated by DST were around 1,270 GWh at that time. This figure is about 14% larger than the 1,115 GWh savings estimated by Maqueda and Rebolledo (2008).

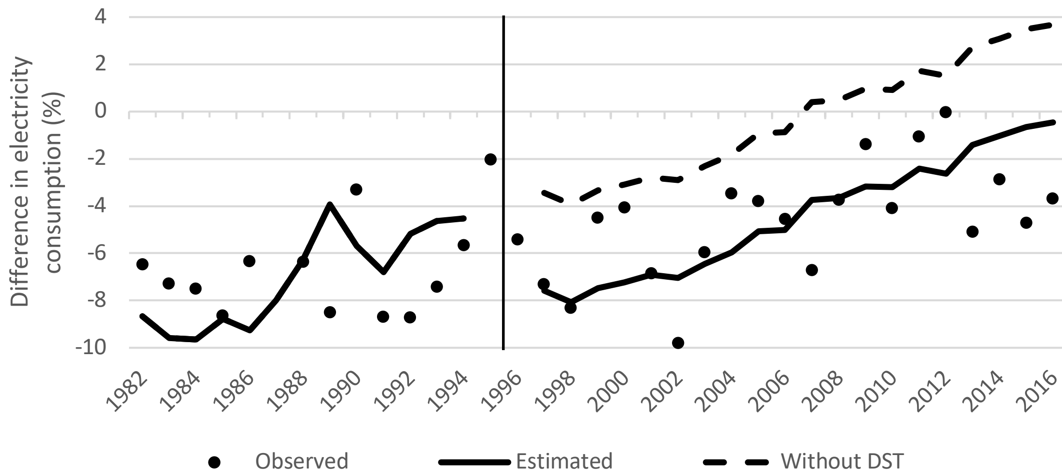

Fig. 2A. Effect of DST on electricity consumption: April vs. Non-DST months

Figure 2A illustrates the effect of DST in a particular month. The dispersed square-dots in this figure are observed differences in daily consumption between April and the average of non-DST months at different points in time. Daily electricity consumption in this month is usually smaller than the average of non-DST months. Nevertheless, it is clear that this difference is becoming smaller over time. That is, this difference has a positive trend. The thin vertical line indicates the moment in which DST started in Mexico. The increasing solid line is the difference in electricity consumption (between April and non-DST months) predicted by the model. The dotted line is what the model predicts without DST. Although DST reduces consumption in April, this effect is relatively small.

Although we are using essentially a DD approach, it is worth mentioning that Figure 2A resembles the ones that are typically obtained with regression discontinuity (RD) analysis. As explained by Thistlewaite and Campbell (1960), who used RD originally to measure the effects of an award on student attitudes toward intellectualism, the treatment must cause a jump in the regression line plots at the cutting point. In Thistlewaite and Campbell (1960), the cutting point is the arbitrary minimum test score required to obtained the award. In this case, the cutting point is the year in which the Mexican government decided to start implementing DST in the country.

It is worth mentioning that regression discontinuity analysis is used by Toro, Tigre and Sampaio (2015) to evaluate the effects of DST on myocardial infarction.

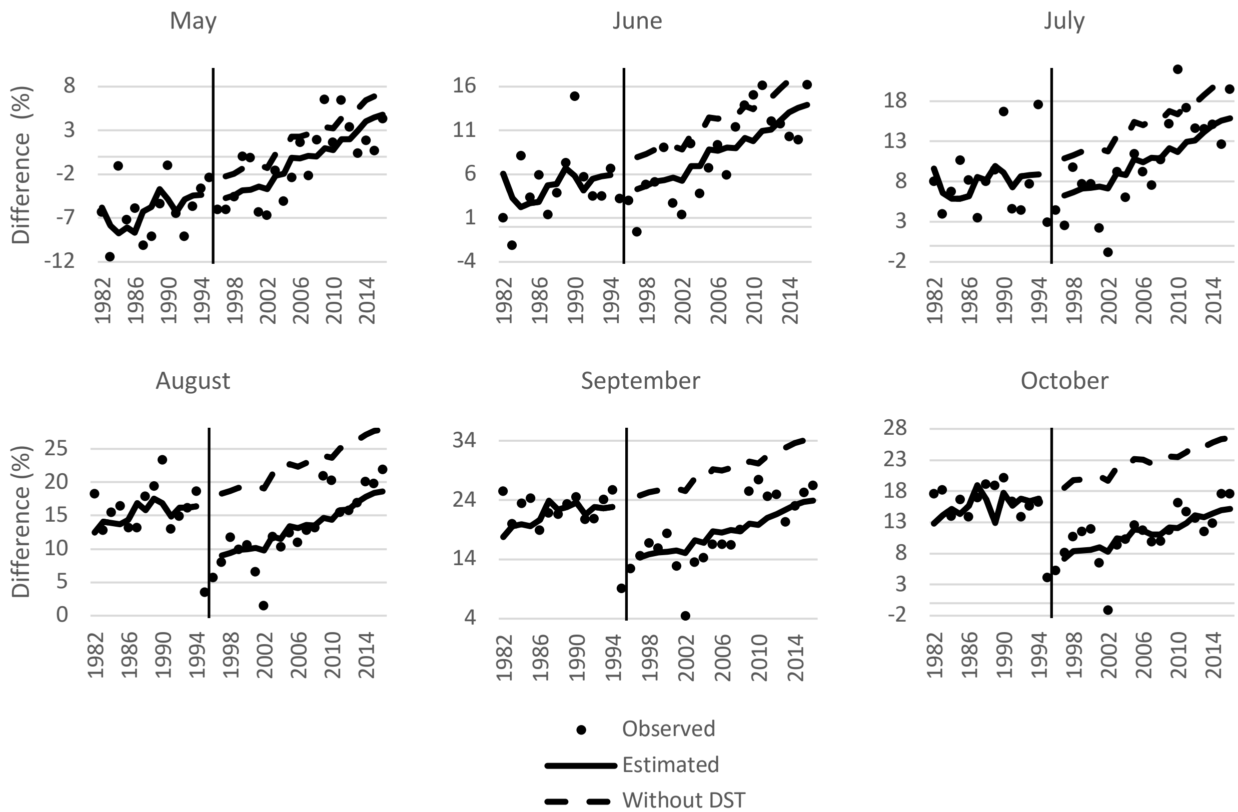

Fig. 2B. Effect of DST on electricity consumption for different DST months vs. Non-DST months

The effect of DST on electricity consumption varies throughout the months in which the program is in effect. Figure 2B shows the effect of DST from May to October. It is worth making a couple of comments about these graphs. First, daily electricity consumption during most DST months has been larger than consumption during non-DST months both before and after DST started. Second, there is a positive trend in the difference between consumption in each DST month and average consumption in non-DST months. That is, electricity consumption in DST months has been growing faster than consumption in non-DST months. Finally, the effects of DST seem to be substantially larger in the last three months of DST (that is, August, September, and October) in comparison with the first three months (that is, May, June, and July).

5. Robustness checks

In this section, we present the results of four robustness checks. First, we include dummies to control for the four large economic crises that took place in Mexico during the period under study. Second, we introduce placebo beginnings of DST. That is, we arbitrarily move the beginning of DST to the middle of the periods before and after it was actually implemented. Third, we run separate regressions for DST months, using the average of the non-DST months as the control group. Fourth, we run again separate regressions for DST months, using now electricity consumption in a single non-DST month as a control instead of an average of all non-DST months.

5.1. Controlling for large economic crises

In principle, the method that we use to estimate the effects of DST on residential electricity consumption should be immune to economic cycles. We are using an average of electricity consumption during non-DST months as controls. It is unlikely that only DST months or non-DST months, in a given year, are affected by an economic expansion or a recession. Moreover, transitory changes in income should have small effects on consumption. Nevertheless, it is worth checking whether large economic crises –like the ones that occurred in Mexico during the period of study– affect the main results of the paper.

The four large economic crises that we are considering in this exercise took place in 1983, 1986, 1995, and 2009, respectively. The Mexican GDP fell at least 3% in each of these years. We are particularly concerned by the large economic crisis that occurred just one year before the implementation of DST (that is, the crisis of 1995). The GDP fell more than 6% in that year. Therefore, it is reasonable to believe that DST may be capturing, at least partially, the effect of this event.

Table 4. Domestic Electricity Consumption Results (pooled regression with recession dummies)

Variable	**Month Dummy Interaction Regression**
Constant	-8.98**
Trend	0.37***
PR	-0.14***
DST	-5.85***
May	-0.17
June	10.24***
July	13.34***

August	20.78***
September	27.18***
October	21.88***
May*DST	2.14
June*DST	0.78
July*DST	-0.38
August*DST	-4.97***
September*DST	-6.05***
October*DST	-7.19***
1983	-1.09
1986	0.18
1995	-7.56***
2009	3.77***
R^2	0.88

*,** and *** indicate that the coefficient associated with the DLS dummy variable is significant at 10% , 5% and 1%, respectively.

Table 4 shows the results of a pooled regression that includes dummies for the years in which Mexico suffered large economic crisis. Only the crises of 1995 and 2009 have a significant effect on the difference in electricity consumption between DST months and non-DST months. However, they have opposite signs. More importantly, including these controls does not change qualitatively the main results of the paper. We estimate that DST savings with these controls are 1,908.7 GWh. This represents 0.73% of total electricity consumption in the country.

5.2. Placebo effects

Another way to check that our results are robust is to run pooled regressions with placebo beginnings of DST. With this idea in mind, we create dummies as if DST started in 1989 and 2006, respectively. It is important to say that 1989 is in the middle of the period 1982-1996 and 2006 in the middle of the period 1996-2016. We run two regression using these dummies, respectively, instead of the dummy for 1996, when DST was actually introduced in Mexico.

Table 5. Placebo Test Regressions

Variable	**DST dummy 1989**	**DST dummy 2006**
Constant	-6.41***	-5.37***
Trend	0.04	-0.17***
PR	-0.25***	-0.18***
DST	-1.41[i]	5.80***[ii]
May	-0.20	0.64
June	9.29***	10.21***
July	11.68***	12.62***
August	16.39***	17.30***

September	22.17***	23-06***
October	16-83***	17.30***
R^2	0.80	0.83

*,** and *** indicate that the coefficient associated with the DLS dummy variable is significant at 10% , 5% and 1%, respectively.

i DST is zero from years 1982 to 1988 and one afterwards. ii DST is zero from years 1996 to 2005 and one afterwards.

Table 5 shows the results of placebo tests. As expected, the coefficient of the fictitious DST beginning in 1989 –that is, before the actual beginning of DST– is negative but not statistically significant. In contrast, the coefficient of the fictitious DST beginning in 2006 –that is, after the actual beginning of DST– is positive and statistically significant. However, it is important to note the small negative trend in this regression. This suggests that the fictitious DST is taking the effect of fast growing electricity consumption in DST months (compared to non-DST months) that we observe in the data. Finally, we should mention that none of the placebo DST tests produce electricity savings as the actual DST test.

5.3. Separate regressions for DST months

We can also check the robustness of our results by running separate regressions for each DST month instead of a pooled regression. The advantage of separate regressions is that each model may adjust better to the data of the corresponding month. However, the big disadvantage of separating DST months is that we run regressions with small number of observations. Therefore, it is harder to find significant effects.

Table 5 shows the results of the separate regressions of household electricity consumption for the different DST months. Most of the coefficients have the expected signs. However, some of them are no longer significant. In particular, note that DST has no effect on consumption during the first two months of DST (that is, April and May). This is not surprising given that we have a small number of observations; and we know from previous regressions that DST has a small effect at the beginning of the period.

Table 5. Domestic electricity consumption regressions results for DST months

Variable	April	May	June	July	August	September	October
Constant	-8.40***	-9.04***	0.61	2.05	8.32***	16.59***	12.99***
PR	0.06	-0.04	-0.07	-0.23*	-0.48***	-0.32*	-0.20
TREND	0.24***	0.39***	0.49***	0.44***	0.14	0.19	0.18
DST	-1.55	-2.06	-5.75**	-7.45**	-8.99***	-9.84***	-9.45***
R^2	0.40	0.6	0.52	0.46	0.51	0.38	0.40

*,** and *** indicate that the coefficient associated with the DLS dummy variable is significant at 10% , 5% and 1%, respectively.

We can use the estimates obtained in this model to calculate again domestic electricity savings due to DST in year 2016. According to these results, yearly savings generated by DST are about 1,525.5 GWh. These savings are slightly lower than our initial estimate. However, they still represent about 0.6% of total electricity consumption in the country.

5.4. Single months as controls

We run again separate regressions for DST months. However, we now use electricity consumption in a single non-DST month as a control instead of an average of all non-DST months. The most natural controls for this robustness check are months adjacent to the treatment months (that is, March and November). In particular, we believe that March is a better control than November. In several ways, March is closer to summer months than November. Karasu (2010) points out that the change in the average temperature in Turkey from March (without DST) to April (with DST) is marginal (it increases 2.2 degrees C), while the change in temperature from October (with DST) to November (without DST) is large (it decreases 7.6 degrees C). Something similar occurs in Mexico. For instance, there are about 11:45 hours of sunlight in Mexico at the beginning of March. In contrast, there are only about 11:00 hours of sunlight at the end of November. Nevertheless, we will use each of the non-DST months as control and show all the results.

Table 6. DST effect on treatment months using different months as controls

Treatment Month	**Control Month**				
	January	**February**	**March**	**November**	**December**
April	-	-	- *	+ *	+
May	- *	-	- *	+ *	+
June	- ***	- *	- ***	+	-
July	- ***	- **	- ***	-	- *
August	- ***	- **	- ***	- *	- ***
September	- ***	- **	- ***	- **	- ***
October	- ***	- **	- ***	-	- ***

*,** and *** indicate that the coefficient associated with the DLS dummy variable is significant at 10% , 5% and 1%, respectively.

We summarize the main results of this last robustness check in Table 6. Basically, we specify the sign of the DST coefficient (whether it resulted positive or negative) for each combination of months; and its level of significance. Regardless of the month that we use as control, we cannot reject –with a 5% level of significance– the null hypothesis that DST has no effect on electricity consumption in April and May. Moreover, only if we consider March as the control month, we find that DST reduces consumption in these two months at a 10% level of significance. However, we obtain the exact opposite result (that is, that DST increases electricity consumption) if we use November as the control month. Therefore, these results suggest that DST generates small savings –if any– in electricity consumption during the beginning of DST. On the other hand, we reject the null hypothesis that DST has no effect on consumption –with a 1% level of significance– for each month from June to October if we use the months of January and March as controls. Similarly, we reject the null hypothesis that DST has no effect on consumption –with a 5% level of significance– from July to October if we use February as control; or with a 1% level of significance from August to October if we use December as control. Hence, there is sufficient evidence to say that that DST reduces consumption of electricity towards the end of the DST period.

6. Conclusion

In this paper, we evaluate econometrically whether DST reduces or not household electricity consumption in Mexico. We use time series data and a DD approach in order to estimate savings generated by DST at different points in time. According to our estimates, DST has been reducing domestic electricity consumption in Mexico since the program started in 1996. Moreover, we find that DST reduces electricity consumption nowadays by 1,545.1 GWh on a yearly basis. These savings account for 0.6% of total electricity consumption in the country. It is important to mention that this figure is in line with previous estimates in Mexico; and large in comparison to the 0.34% mean of the literature reported in the meta-analysis elaborated by Havranek, Herman and Irsova (2018).

We also find that DST does not reduce consumption homogeneously during the whole period in which this energy saving practice takes place (from April to October). Interestingly, DST generates larger savings towards the last months (August, September, and October) of the period. This result contrasts with the previous findings of Momani, Yatim and Ali (2009) for Jordan. They recommend not implementing the DST in September (that is, towards the end of the DST period in Jordan).

The fact that we find some evidence that DST has relatively smaller effect on household electricity consumption during the first months of the period, is not sufficient to conclude that the authority should shorten the duration of DST in Mexico. There are several reasons not to do it. First, there is no strong evidence to say that DST increases electricity consumption in any particular month. Second, even if DST does not reduce residential electricity consumption in a given month, it may still smooth consumption during the day generating savings in the production of electricity. Third, given the commercial links between Mexico and the US, it benefits to coordinate on the DST as much as possible.

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