The Impact of Observing Daylight Saving Time in Indiana: Was Economic Prosperity Only an Hour Away?

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I. Introduction

The state of Indiana has a long, controversial history over the choice of time zone and whether to observe daylight saving time. Between 1918 and 1961, The Standard Time Act of 1918 stipulated that the entire state of Indiana was in the Central Time Zone and it was to observe daylight saving time. However, some communities chose not to comply with these regulations. Over the years, both regulators and regulations changed. Some Indiana counties observed Central Time while others followed Eastern Time. A vast majority of the state did not observe daylight saving time, while a small number of counties chose to do so.

By 2005, the five northwest Indiana counties next to Chicago followed Central Time and observed daylight saving time.[1] The five southwest Indiana near Evansville by the Kentucky and Illinois borders also followed Central Tome and observed daylight saving time.[2] The three Indiana counties next to Louisville, Kentucky were on Eastern Time and observed daylight saving time.[3] Finally, the two Indiana counties neighboring Cincinnati, Dearborn and Ohio counties, also followed Eastern Time and observed daylight saving time. While these 16 counties had to spring forward and fall back with daylight saving time, the other 76 Indiana counties were on Eastern Time; but, they did not observe daylight saving time. When out-of-state businesses asked during transactions whether a given time was Eastern, Central or daylight saving time, an often-heard, common reply was “it is Indiana time.”

[1] These include Jasper, Lake, LaPorte, Newton, and Porter counties.
[2] These include Gibson, Posey, Spencer, Vanderburgh and Warrick counties.
[3] These include Clark, Floyd and Harrison counties.

In 2005, newly-elected, Republican Governor Mitch Daniels made Indiana state-wide observance of daylight saving time a key component of his economic development plan. Avoiding the more controversial debate on whether Indiana should observe Central or Eastern Time, Daniels argued that "Indiana time" was bad for the state's economy because out-of-state businesses did not know with certainty what the time was in a given city in Indiana at given moment. According to The Indianapolis Star, Daniels argued:

> The issue is a jobs issue. It costs us good will, and it cost us business in dealing with other states. The critical matter for putting Hoosiers to work, attracting more businesses and more dollars, is to end the confusion elsewhere about what the heck time it is in Indiana now.[4]

In his economic forecast for 2006, Professor Robert Guell, an economist at Indiana State University, commented the governor thought "economic prosperity was only an hour away." The legislation was passed and on April 2, 2006, the entire state of Indiana began observing daylight saving time.[5]

This paper is a first attempt of measuring the impact of observing daylight saving time on employment in Indiana counties. This study uses monthly data from all the 92 Indiana counties between January 1990 and November 2010. Using the "difference in differences" technique found in other research in labor economics, the regression results using this panel data indicate that those counties that began observing daylight saving time saw an average increase in monthly employment of 170 workers.

Following this introduction, the paper is organized as follows. The next section contains a brief review of the literature. The third section of the paper describes a theoretical model of a

[4] See Schneider (2005).

[5] Indiana became the forty-eighth state to observe daylight saving time. Hawaii and Arizona are now the only states that do not observe daylight saving time. Because the Navajo Indian Reservation spreads over portions of three states - - Arizona, New Mexico and Utah - - the portion of the reservation in Arizona does observe daylight saving time.

perfectly competitive firm where the adoption of daylight saving time leads to a reduction in marginal cost and an increase in employment. The panel data, the regression model and the estimation results are described in the fourth section of the paper. The final section of the paper summarizes and critiques the results while suggesting future research that needs to be done.

II. Literature review

Much of the research over the economic impact of daylight saving time deals with its impact on energy use. Kotchen and Grant (2010) measured the effect that observing daylight saving time in Indiana had on the consumption of residential electricity. They found observing daylight saving time increased the demand for electricity. While the demand for electricity for lighting decreased, Indiana households used more electricity for heating and cooling. Kotchen and Grant estimated that observing daylight saving time cost Indiana households an additional $9 million per year in higher electricity bills. Most of the electricity in Indiana is produced by coal-fired power plants, and Kotchen and Grant also estimated that the increased use of electricity resulted in increased pollution emissions, resulting in an additional social cost between $1.7 and $5.5 million per year.

In their review of the literature, Aries and Newsham (2008) find the impact of daylight saving time on the use of energy for lighting in uncertain. Some studies show a reduction in energy demand, others show no effect and some show an increase in energy demand if gasoline consumption is included. They report there is general consensus that daylight saving time leads to a reduction in the peak demand for electricity in the evening; but, this decrease may be offset by an increase in lighting use in the morning. They stress that synthesizing the results of the various studies is complicated by population growth, changes in the patterns of energy use and the increased energy efficiency of new buildings and machineries.

In the area of automobile safety, previous research has found daylight saving time may result in more fatal automobile crashes in the short run; however, observing daylight saving time will reduce the risks of fatal crashes in the long run. In studying the impact of changing time on vehicular fatalities, Sood and Ghosh (2007) used 28 years of automobile crash data from the United States between 1976 and 2003. They find switching to daylight saving time has no statistically significant effect on automobile crashes in the short run. However, they found that in the long run, observance of daylight saving time lead to a fall between 8 and 11 percent in accidents involving pedestrians and a decline in accidents with other automobiles between 6 and 10 percent.

Calandrillo and Buehler (2008) argue that daylight saving time should be used year round. They contend this would save hundreds of lives from reductions in car and pedestrian accidents. The additional daylight in the evening reduces criminal activity and decreases the peak demand for electricity. Finally, they argue that year-round observance of daylight saving time would negate the cost encountered in changing time in the fall and spring. They contend the aggregate benefits outweigh the cost of observing daylight saving time during the winter.

Several studies have argued changing the clocks every fall and spring because of daylight saving time leads to increased economic inefficiency. Analyzing the cost changing time imposes on the U.S. stock exchanges, Kamstra, Kramer, and Levi (2000) estimated the "daylight saving time" effect resulted in a one-day loss of $31 billion. However, Lamb, Zuber and Gander (2004) dispute these results, finding the estimated loss depends on the methodology used.

III. Theoretical model

To show that differences in the observance of daylight saving time may adversely affect a firm's profits, assume that a perfectly competitive, profit-maximizing firm sells its product at market price P in two different markets. In the first market, there is complete certainty on what the time is and the firm sells q_1 units of output. However, in the second market, there is uncertainty over the proper time and whether the region observes daylight saving time and the firm sells q_2 units of output. Assume the firm's short-run production function is a function of labor (L) and a fixed supply of capital ($\bar{K}$). Given the firm is a price taker in both the output and input markets, its profits (π) are

$$\pi = Pq_1(L_1,\bar{K}) + Pq_2(L_2,\bar{K}) - w(L_1+L_2) - \theta q_2(L_2,\bar{K}) - r\bar{K} . \tag{1}$$

In equation (1) L_1 is the hours of labor a firm needs to produce q_1, L_2 is the hours of labor to produce q_2, w is the hourly wage, and r is the interest rate. The variable of interest, θ, is the variable per unit cost the firm encounters in selling output in the second market where the time of day varies across the region depending on whether daylight saving time is observed. The common neoclassical assumptions are made about the production function. Labor is assumed to have a positive marginal product but exhibit diminishing returns. This implies $\partial q_1/\partial L_1 > 0$ and $\partial q_2/\partial L_2 > 0$ but $\partial^2 q_1/\partial L_1^2 < 0$ and $\partial^2 q_2/\partial L_2^2 < 0$.

The first-order conditions for profit maximization are

$$\pi_1 = \frac{\partial \pi}{\partial L_1} = P\frac{\partial q_1}{\partial L_1} - w = 0 \tag{2}$$

and

$$\pi_2 = \frac{\partial \pi}{\partial L_2} = (P - \theta)\frac{\partial q_2}{\partial L_2} - w = 0 . \tag{3}$$

Both equations (2) and (3) give the standard result that a profit-maximizing firm will hire labor in given market up to that point where the value of the marginal product of the last worker hired is equal to the marginal cost of hiring that worker. The sufficient second-order conditions guaranteeing a maximum are $\pi_{11} = P(\partial^2 q_1/\partial L_1^2) < 0$, $\pi_{22} = (P - \theta)(\partial^2 q_2/\partial L_2^2) < 0$ and $\pi_{11}\pi_{22} > 0$.[6]

Given the sufficient second-order conditions are met, the implicit function theorem can be invoked and the profit-maximizing levels of the endogenous variables, L_1^* and L_2^*, are functions of the exogenous variables P, r, w, θ and $\bar{K}$ or $L_1^* = L_1^*(P,w,r,\theta,\bar{K})$ and $L_2^* = L_2^*(P,w,r,\theta,\bar{K})$. To find $\partial L_2^*/\partial\theta$, both the first-order conditions in equations (2) and (3) are evaluated at the solutions and differentiated with respect to θ. The resulting system of equations is

$$\begin{bmatrix} \pi_{11} & 0 \\ 0 & \pi_{22} \end{bmatrix} \begin{bmatrix} \partial L_1^*/\partial\theta \\ \partial L_2^*/\partial\theta \end{bmatrix} = \begin{bmatrix} 0 \\ \partial q_2^*/\partial L_2^* \end{bmatrix}. \tag{4}$$

A simple exercise in comparative statics reveals that

$$\partial L_2^*/\partial\theta = \frac{\overset{+}{\partial q_2^*/\partial L_2}}{\underset{-}{\pi_{22}}} < 0. \tag{5}$$

Thus, if policy makers can reduce the ambiguity over the actual time in the second market, the marginal cost of selling output to that market is reduced. If θ falls, the profit-maximizing firm will respond by increasing both L_2 and q_2.

IV. The panel data, the regression model and estimation results

Given there is some theoretical evidence that observing daylight saving time and the associated reduction in marginal cost may lead to an increase in employment, this hypothesis is

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[6] Note $\pi_{12} = \dfrac{\partial^2\pi}{\partial L_1 \partial L_2} = 0$.

statistically tested using a pooled cross-section and time-series data set of employment from Indiana counties. Using Local Area Unemployment Statistics (LAUS) from the Bureau of Labor Statistics (BLS), monthly data for the 92 counties in Indiana was obtained for the time period between January 1990 and November 2010.[7] The data set consists of 23,092 observations. Of the 92 counties, 16 always observed daylight saving time and there are 4,016 monthly observations on employment in these counties. The other 76 Indiana counties began observing daylight saving time after April 2006 and there are a total of 19,076 monthly observations of employment in these counties. Descriptive, summary statistics of the county data is reported in Table 1.

This initial attempt of measuring the impact of the entire state observing daylight saving time uses the difference-in-differences technique that has been used in other labor economics research such as Card and Krueger (1994). A dummy, binary variable was used to distinguish the counties that always observed daylight saving time from those counties that began observing daylight saving time after April 2006. Let $D_{it} = 1$ if county i initially did not observe daylight saving time. In this case D_{it} will equal 1 for all time periods. Conversely, $D_{it} = 0$ if county i always observed daylight saving time for all time periods. The dummy variable D_{it} identifies those counties that changed time and those that did not.

Another dummy variable, T_{it}, identifies those months when the entire state of Indiana observed daylight saving time. Therefore, $T_{it} = 0$ for all counties before April 2006 and $T_{it} = 1$ for all counties after March 2006. The regression model becomes

$$E_{it} = \beta_o + \beta_1 D_{it} + \beta_2 T_{it} + \beta_3 (D_{it} T_{it}) + \varepsilon_{it} \quad (6)$$

where E_{it} is the employment in county i at time t, the β_i are the unknown parameters that have to be estimated and ε_{it} is the random error. The regression model in equation (6) includes an

[7] See http://www.bls.gov/lau/home.htm .

interactive term, $D_{it}T_{it}$, that captures the effect of observing daylight saving time in those counties that initially did not observe the change in time.

After the model is estimated, it is possible to estimate the expected value of employment in a given region for a given period of time. Let $\hat{\beta}_i$ be the estimate for the regression parameter β_i. The following equations list the expected value of employment in a given region during a given period:

$$E(E_{it} | D_{it} = 0 \text{ and } T_{it} = 0) = \hat{\beta}_0$$

$$E(E_{it} | D_{it} = 0 \text{ and } T_{it} = 1) = \hat{\beta}_0 + \hat{\beta}_2$$

$$E(E_{it} | D_{it} = 1 \text{ and } T_{it} = 0) = \hat{\beta}_0 + \hat{\beta}_1$$

$$E(E_{it} | D_{it} = 1 \text{ and } T_{it} = 1) = \hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3 \; . \qquad (7)$$

To isolate the effect of how observing daylight saving time affected employment, the difference-in-differences procedure analyzes the change in average employment. For those counties that always observed daylight saving time ($D_{it} = 0$), the interesting question is what was the change in average employment before and after the state-wide change. This difference equals $\hat{\beta}_0 + \hat{\beta}_2 - \hat{\beta}_0 = \hat{\beta}_2$ and it shows the change in employment due to other national and state effects other than the policy of observing daylight saving time state wide.

For those counties that did not initially observe daylight saving time, the change in average employment before and after the state wide change equals $(\hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3) - (\hat{\beta}_0 + \hat{\beta}_1) = \hat{\beta}_2 + \hat{\beta}_3$. However, this change in employment is also affected by the same other state and national effects that impacted the change in employment in the counties that had always observed daylight saving time. To net out these other effects, one takes the difference in differences or $(\hat{\beta}_2 + \hat{\beta}_3) - \hat{\beta}_2 = \hat{\beta}_3$. These results are summarized in Table 2.

The panel data estimation results are listed in Table 3. The generalized least squares regression procedure corrects both the parameter estimates and the parameters' covariances for both cross-section heteroscedasticity and contemporaneous correlation. The weighted statistics indicate an R^2 over 99 percent and all the estimates are statistically different from zero at the one-percent level. More importantly, the estimates reported in Table 3 indicate that, after correcting for other state and national effects, switching to daylight saving time increased employment in those counties that initially did not observe the time change an average of 170 workers. So there is some statistical evidence that Governor Daniels was correct in arguing that state-wide observance of daylight saving time was a jobs issue in Indiana.

V. Summarizing and critiquing thee results and suggestions for future research

Before 2006, 83% of the 92 counties in Indiana did not observe daylight saving time. This paper presents a case study of how a policy change requiring the entire state to observe daylight saving time affected average employment in Indiana counties. The paper presents a simple model of a perfectly competitive firm selling output to two markets, where the uncertainty of what the actual time is in one market imposes an additional variable cost on the firm. Comparative statics shows that if that uncertainty over the correct time is reduced, the firm's marginal cost of production declines, and it will hire more labor. Using a difference-in-differences regression model and panel-data estimation techniques, statistical evidence indicates that uniform observance of daylight saving time increased average monthly employment in those counties that initially did not observe the time change by 170 workers.

The first attempt of analyzing this case study can be improved. The division of counties between 16 counties that observed daylight saving time and 76 counties that did not may offer too little differences across the cross sections. In the future, county data from Illinois, Ohio, Kentucky and Michigan can be added to the sample. These states border Indiana and the difference-in-differences technique may do a better job measuring the extraneous national and state events that affect county employment but were not related to solely the time change. Kentucky has both counties in the Central Time zone and the Eastern Time zone and its inclusion in the sample may do a better job controlling for the differences across time zones.

In addition, other covariates may be added to the model's specification that are also related to a county's employment in a given month. These monthly variables could include lagged wages or unemployment rates.

Duflo and Mullainathan (2004) argue papers using the difference-in-differences technique have data sets consisting of many years that ignore possible serial correlation. Consequently these papers report results based on inconsistent standard errors leading to large t-statistics and small p-values. They argue for corrections in the estimation of the variance-covariance matrix. The panel estimation techniques used here may address some of these concerns; but, these questions need more thorough analysis. But the simple statistical model presented here shows that even in the midst of the longest recession since World War II, the policy change requiring statewide observance of daylight saving time in Indiana led to a small but statistically significant increase in the monthly employment levels in those counties that initially refused to spring forward and fall back every year.

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Table 1
Descriptive Statistics: Employment in Indiana Counties, January 1990 – November 2010

	Indiana Counties that Always Observed Daylight Saving Time		Indiana Counties that Began Observed Daylight Saving Time after April 2006	
	January 1990 to March 2006	April 2006 to November 2010	January 1990 to March 2006	April 2006 to November 2010
Mean	40,259	40,594	30,127	30,630
Median	18,400	20,705	15,582	15,161
Minimum	2,295	2,573	3,074	3,075
Maximum	227,319	219,888	453,728	448,759
Standard Deviation	50,593	49,600	54,099	54,631
Number of Counties	16	16	76	76
Number of Observations	3120	896	14,820	4256

Table 2
Difference in Differences

	Counties that Always Observed Daylight Saving Time	Counties that Only Observed Daylight Saving time after March 2006
Average Monthly County Employment between January 1990 and March 2006	$\hat{\beta}_0 + \hat{\beta}_2$	$\hat{\beta}_0 + \hat{\beta}_1$
Average Monthly County Employment between April 2006 and November 2010	$\hat{\beta}_0 + \hat{\beta}_2$	$\hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3$
Differences	$(\hat{\beta}_0 + \hat{\beta}_2) - \hat{\beta}_0 = \hat{\beta}_2$	$(\hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3) - (\hat{\beta}_0 + \hat{\beta}_1) = \hat{\beta}_2 + \hat{\beta}_3$
Difference in Differences	$(\hat{\beta}_2 + \hat{\beta}_3) - (\hat{\beta}_2) = \hat{\beta}_3$	

Table 3
Regression Results

Parameter	Estimate
β_0	40,259.96* (3,206.97)
β_1	-10,131.96* (-3,056.14)
β_2	325.48* (26.53)
β_3	170.43* (7.00)
Weighted Statistics	
R^2	0.998
$\bar{R}^2$	0.998
F-Test	3,969,407†
Durbin-Watson Statistic	1.186
Observations	23,092

* indicates the null hypothesis that the estimate is equal to zero is rejected at the one-percent level.
† indicates the null hypothesis that all the slopes coefficients simultaneously equal 0 is rejected at the one-percent level.