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Economic Consequences of Daylight-Saving Time: Evidence from Turkey[1]

Yaz Saati Uygulamasının Ekonomik Sonuçları: Türkiye Örneği

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Abstract

For last years, the consequences of the implication of daylight saving time has been discussed frequently, daylight saving time has effects on many field of the daily routine such as electricity consumption, human health, performance, behavior and well-being of individuals. Since the cabinet decision in 2016, Turkey has been implementing the summertime throughout the whole year in order to save energy. Therefore, the main aim of this study is to analyze the effects of this change on economic growth and labor productivity by employing quarterly data for the time period 2006:Q1 and 2018:Q1 for Turkey and Threshold AR model in order to incorporate the nonlinear behavior in considered time series. The results show significant effect of this policy change on economic growth and labor productivity as well as nonlinear behavior in the time series due to continuous fluctuations in the data throughout time which can be classified into at least two regimes as recession and expansion. As a conclusion, the policy makers should evaluate the effects of daylight saving time (DST) on different indicators before the changes in the implementation.

Keywords: *Daylight Saving Time, Turkey, Nonlinear Model, Economic Growth, Labor Productivity.*

Öz

Son yıllarda, gün ışığından faydalanmak amacıyla, yaz saati uygulamasına geçişin etkileri sıklıkla tartışılmaktadır. Yaz saati uygulamasına geçişin, günlük rutinde, elektrik tüketimi, insan sağlığı, performans, bireylerin refahı ve davranışı gibi birçok alanda etkileri bulunmaktadır. 2016 Bakanlar Kurulu kararından bu yana, Türkiye, enerji tasarrufu sebebiyle, tüm yıl boyunca yaz saati uygulamasında kalmayı tercih etmiştir. Bu durumda, bu çalışmanın temel amacı, bu değişikliğin etkilerinin, ekonomik büyüme ve işgücü verimliliği üzerindeki etkilerini, Türkiye için 2006:01 ve 2018:1 dönemlerine ait çeyreklik verileri kullanarak, Eşik AR modeli ile doğrusal olmayan ilişkileri göz önüne alarak analiz etmektir. Sonuçlar, bu politika değişikliğinin, zaman içinde verilerde meydana gelen dalgalanmalardan dolayı oluşabilecek durgunluk ve genişleme zamanlarına göre 2 ayrı rejimdeki önemli etkilerinin olabileceğini göstermektedir. Sonuç olarak, politika yapıcıların, uygulamada herhangi bir değişiklik yapmadan önce, yaz saati uygulaması politikasının etkilerini, farklı belirleyiciler açısından, iyi analiz etmeleri önerilmektedir.

Anahtar Kelimeler: *Yaz Saati Uygulaması, Türkiye, Doğrusal Olmayan Modeller, Ekonomik Büyüme, İşgücü Verimliliği.*

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Introduction

Following the idea of energy conservation using day light saving time (DST) transition proposed by Benjamin Franklin in 1784 and the first attempts for the introduction of legislation for it in the beginnings of 1900s, although there are some periods in which the DST was not adopted, there has been wide implementation among the countries (Choi, Pellen and Masson, 2017: 247; Harrison, 2013: 285). DST was implemented first in 1916 by Germany following the discussions on the use of DST for saving energy through the times of World War I (Karasu, 2010: 3774; Mirza and Bergland, 2011: 3559). In the world, 33% of countries have used DST in various forms as a policy (Robb and Barnes, 2018: 193). In 2017, 77 countries implemented DST which corresponds to a population of more than 1.5 billion (Havranek et al., 2018). However, some countries, such as, Bangladesh, China, Iraq, Japan, Kazakhstan, Kyrgyzstan, Malaysia, Pakistan, Philippines, South Korea and Taiwan, abolished the transition to DST while China, Kyrgyzstan, Malaysia, and South Korea fixed their time at DST (Ahuja and SenGupta, 2012: 667-668). Another example is Russia which ended the implementation of switching to summer time officially in 2011 because of its negative consequences claimed for individual well-being (Kountouris and Remoundou, 2014: 100). Also, European Union discusses the possible abolishment of switching between winter and summer time.

Therefore, Turkey is also among the countries which ended the transition to summer and winter times. After the switching between winter and summer time twice a year on the predetermined dates (on the last Sunday in September/October and last Sunday in March, respectively) during the period starting from 1923 to 2016 but with interruption of DST adoption in some years and with the implementation of double DST in some other years (Karasu, 2010: 3774-3775), by the cabinet decision (No. 2016/9154) in 2016, Turkey has been implementing the summer time throughout the whole year in order to save energy starting by taking the clocks one hour forward at 03:00 on Sunday, 27th March 2016. It is not the first time in the history of Republic of Turkey for such an implementation. During the years between 1978 and 1982, the clocks were set fixed at DST/summer time (Karasu, 2010:3775). However, there are different aspects and studies showing conflicting results about the energy saving resulted from this change for Turkey such as the study performed by Istanbul Technical University and the study by Chamber of Electrical Engineering (TEPAV, 2017). Cabinet decision (No. 2017/10921) published in the Official Gazette in 2017 introduced the winter time again in which it was stated that the clocks will be taken one hour backward on Sunday, 28th October 2018. However, this decision was cancelled by the President's decision (No. 139, Date: 01.10.2018) on the continuous implementation of summer time (GMT+3) throughout the year.

In the literature, the studies discussed and found significant effects of transition to DST on electricity consumption (see for example, Ebersole, 1974; Choi, Pellen and Masson, 2017 and see also Reincke and van den Broek, 1999 and Aries and Newsham, 2008 for survey as well as Havranek et al., 2018 for meta-analysis), financial markets (Kamstra et al., 2000), human well-being and health (Kantermann et al., 2007; Janszky and Ljung, 2008; Jin and Ziebarth, 2015; Gaski and Sagarin, 2011; Janszky et al., 2012; Jiddou et al., 2013), sleep (see Harrison, 2013 for review of studies), academic success (Hicks et al., 1980; Garrison and Christakis, 2011; Gaski and Sagarin, 2011; Herber et al. 2017), home and community accidents (Robb and Barnes, 2018), road accidents and fatalities (Monk, 1980; Hicks et al., 1983; Ferguson et al., 1995; Coren, 1996 (a), 1996b, 1998; Varughese and Allen, 2001; Coate and Markowitz, 2004; Lahti et al., 2010; Robb and Barnes, 2018), work accidents (Barnes and Wagner, 2009), productivity (Wagner et al., 2012), crime rate (Felson and Poulsen, 2003), behavior and many other consequences of DST. One can refer to Reincke and van den Broek (1999), Aries and Newsham (2008) and Harrison (2013) for the review of the studies. Below, a brief review can be found including some selected recent studies.

Kountouris and Remoundou (2014) investigated the effect of transition to day light saving time on life satisfaction and mood of individuals using survey data for Germany over the period from 1986 to 2010 and found the negative impacts of DST on individual well-being especially for people under full time employment and for males. In the model, daylight saving time, demographic variables (age, gender, marital status, education level, employment status), household income, individual fixed effects, day of week, month, year and region dummies are included as factors affecting the individual life satisfaction and mood. The further results show the positive effects of household income but negative impacts of being out of work force and the effect of switch to DST does not last for more than one week. In addition, Jin and Ziebarth (2015) also documented the adverse health impacts of DST transition in the United States.

The study by Choi, Pellen and Masson (2017) examined the effect of DST on electricity demand and electricity generation cost considering the period from September 2006 to March 2013 for Western Australia using difference-in-differences method but found only negligible effect. However, their results indicate the importance of re-distributional effect of DST, thus its effectiveness to reduce peak electricity demand and marginal cost of electricity not to provide conservation of energy and reduction in total generation costs. Moreover, other factors (weather, seasonality, school and public holidays, day light and time trend) are found to affect electricity demand significantly with expected signs. Lastly, findings show the reducing effect of solar power incentives. Mirza and Bergland (2011) also examined the impact of DST on electricity consumption but for Southern Norway and Sweden over the period between June 2003 and December 2009 controlling for seasonal factors, temperature, day length, economic activity, electricity price and employing hourly electricity consumption data and difference-in-difference method. They found that DST transition leads to at least 1% decline in electricity consumption in both countries but more effect during holidays and weekends compared to working days corresponding to the 16.1 and 30.1 million Euros savings annually in Norway and Sweden, in order. Verdejo et al. (2016) made a similar analysis for Chilean residential electricity consumption using both heuristic and differences-in-differences methods. Their result suggests that there is evidence of very small decrease in residential electricity consumption, but for the effectiveness of DST transition, there are regional differences in the country. Karasu (2010) evaluated different alternatives of DST forms for Turkey and the optimal choice was found to be the 30-minutes forward shift starting from April and ending in October which provides 0.7% energy saving in lighting.

Lastly, Havranek et al. (2018) performed meta-analysis in order to analyze the studies investigating the effect of DST on electricity consumption and found that the results indicated the slight energy saving but there are differences among the studies based on frequency of data, estimation method and geographical location of the country. Countries away from equator seem to benefit more from DST transition.

On the other hand, Robb and Barnes (2018) explored the effects of DST switch to various types of accidents ranging from road, work, falls to home and community for New Zealand covering the period from 2005 to 2016 and found significant effect which have important policy implications. Start of DST was found to have significant positive effects on road accidents, whereas, significant negative effects on falls, home and community accidents. But in contrast, end of DST significantly increased the falls, home and community accidents with a relatively smaller impact compared to the start of DST. In addition, the findings showed the significant effects of public holidays, long weekends, day of week, school and holiday period and seasonality. The results indicated that road and work accidents has declined over time, however, for falls, home and community accidents, this result was not found. The impact of DST change on road accidents was analyzed also by Huang and Levinson (2010) considering weather conditions and traffic volumes for Minnesota between 2001 and 2007. Their findings showed decrease in the number of accidents after DST transition.

Another study performed by Schaffner et al. (2018) found that in general DST transition does not affect cognitive performance and risk taking behavior significantly in New South Wales before, after and after one week based on experimental economics methods and controlling for individual heterogeneity such as, gender, marital status, number of children at home, income, age and also time period of day (early morning, morning, afternoon, evening) with one exception. On the day of transition, cognitive performance is higher than Queensland in which DST transition is not implemented.

In order to assess the effect of DST transition on students' performance, Herber et al. (2017) employed the data on performance assessment of 22000 elementary school students in 6 European countries made by the evaluation of math, science and reading test scores before and after DST switch and found insignificant effects. Sexton and Beatty (2014) analyzed the effect of DST start on the time use of individuals using American Time Use Survey covering the period from 2003 to 2011 controlling for day of week effect, month effect, year effect, number of days before and after DST transition, weather, 2007 DST extension, gender, demographic conditions, educational level, employment and marital status and found behavioral change in such a way that individuals shift their activities which necessitate high amount of energy usage to the earlier periods of the day, however, this behavioral change is associated with increase in energy consumption which is a result contrary to the aim of DST shift implementation.

Ahuja and SenGupta (2012) found that year-round 30-minutes advancement of Indian Standard Time (IST) which they called YRDST will be the best option considering all the costs and benefits when compared with different options, such as, IST, two time zones and DST switching for India.

The morning and evening daylight amounts are affected by DST switch (Sexton and Beatty, 2014: 293). Moreover, DST transition, i.e., switching between winter and summer time, may cause decline in the quality and quantity of sleep because of the time lag for the adjustment of circadian clocks leading decrease in awareness and increase in accidents, and associated with many adverse effects related to health, labor market and academic success (Robb and Barnes, 2018: 193-194; Baert et al., 2015; Jennum et al., 2014) although the DST transition is anticipated and the residents may adapt to it (Schaffner et al., 2018: 391). Milne (1911) discussed that DST switch may affect the workers' efficiency (Harrison, 2013: 285). In the literature, some studies mentioned the productivity increase in office by the DST implementation as discussed by Ahuja and SenGupta (2012). Productivity increase can also lead to economic output increase (see for example, Su and Heshmati, 2011; Mahmud and Rashid, 2006; Auzina-Emsina, 2014; Huyuguzel Kısla and Delıktas, 2015; Karaalp-Orhan, 2016; Nakamura, Kaihatsu, and Yogi, 2018). Mahmud and Rashid (2006) provided a brief literature review of the studies for the relation between productivity and economic growth. In the literature, based on Young (1928), Kaldor (1966) discussed that as a result of dynamic increasing returns to scale, economic growth increases following productivity increase (Magacho, 2017: 44). Mahmud and Rashid (2006) analyzed the relation between output growth and labor productivity growth for Pakistan over the period from 1972 to 2005 using Johansen Full Information Maximum Likelihood

Method and their findings showed that there is evidence of cointegration between them and also unidirectional long run causality from labor productivity growth to economic growth in addition to the short run bidirectional causality. Auzina-Emsina (2014) also examined the effect of labor productivity increase on economic growth for Latvia, Lithuania and Estonia considering three different periods over the years between 2004 and 2012 such as pre-crisis (2004-2008), crisis (2008-2010) and post-crisis (2011-2012) periods. This study found that although there is not any evidence of the effect of productivity increase on economic growth during pre-crisis; in the post-crisis period, the labor productivity improvements increase economic growth but with lag in time. Moreover, based on Kaldor-Verdoorn Law (Kaldor's second law on growth), Kaldor's first and third laws on growth, there can be relation in the opposite direction from economic growth to labor productivity growth (Lavoie, 2018: 313). The first, second and third Laws of Kaldor (1966, 1967) can be summarized as follows. According to the Laws, manufacturing sector's growth is essential for overall economic growth, manufacturing labor productivity growth and non-manufacturing labor productivity growth which can occur as a result of labor reallocation across sectors. Therefore, overall economic growth can lead to labor productivity growth. Previous studies followed by the first studies performed by Verdoorn (1949) and Kaldor (1966), have already proved the validity of Kaldor-Verdoorn Law (Deleidi, Meloni and Stirati, 2018: 16). The findings of some recent studies also validate this theoretical relation such as Korkmaz and Korkmaz (2017) and Deleidi, Meloni and Stirati (2018). Korkmaz and Korkmaz (2017) found that there is a long run relation between labor productivity and economic output and direction of causality runs from economic growth to labor productivity for seven OECD countries over the period from 2008 to 2014. Deleidi, Meloni and Stirati (2018) showed the validity of Kaldor-Verdoorn Law for European countries over the period between 1970 and 2015. The meta-analysis of List (2017) showed that the estimate of Kaldor-Verdoorn effect is 0.42 and in the range of the intervals found by McCombie (2002), Hein and Tarassow (2010) and Storm and Naastepad (2012) (Lavoie, 2018: 324). Therefore, this bidirectional relation was considered in our analysis.

In this context, this study aims to examine the effect of continuous summer time implementation on economic growth and labor productivity using quarterly data over the period from 2006: Q1 to 2018: Q1 for Turkey. In order to see the effect of summer time implementation on economic growth and labor productivity, two dummy variables are included into the model that d_policy (d1) covers the effect of policy change by taking the value of 1 by the policy change period (2016:4) and d_summer (d2) shows the effect of day light saving time by taking the value of 1 for summer time, 0 for winter time. The sign of the dummy variables show the positive or negative effect of implementation on economic growth and labor productivity. The main motivation of this paper is to see reducing or increasing effect of summer time implementation on economic growth and labor productivity. As can be seen from the brief literature review, the consequences of implementation of DST occur in many areas as well as economics and daily routines. To be specific, one of the best macroeconomic indicators of the economy, economic growth is included into the model. From the literature review, it is obvious that DST may affect labor productivity. Based on the possible bidirectional relationship between economic growth and labor productivity above, they are included into the application. To simplify the estimation, we didn't include any other variables into the model. This study will be the first to discuss this issue for Turkey in the empirical literature according to our knowledge. The model is estimated by linear and nonlinear framework. Threshold AR model was employed for possible asymmetry in these time series. There have been many studies considering the nonlinearity in economic time series based on rational expectations and assumptions related to preferences and technology in macroeconomic models (Brock and Potter, 1993). For example, Hamilton (1989) considered the evidence of asymmetry between expansion and recession (Potter, 1995). Moreover, Panagiotidis & Pelloni (2007) and Chang (2010) emphasized on the importance of considering nonlinearities in labor market. Chang (2010) found also that labor productivity is upward rigid. As stated, and summarized in Korucu-Gumusoglu (2013) that in a world with various economic crisis and shocks, economic literature shows that possible nonlinearity should not be neglected in empirical literature.[4] Especially, there are many studies that include GDP nonlinearity such as Pesaran and Potter (1997); Enders, Falk and Siklos (2007); Öcal (2000) and Öcal (2006). In this manner, the possible nonlinearity of the variables is taken into account in this study and findings indicate that significant effect of continuous summer time on economic variables. This paper is organized as follows. After the introduction, explanation on data is given and methodological issues are discussed. Then, empirical results are presented. Lastly, authors conclude.

1. Data

Labor productivity can be defined as "a measure of the efficiency with which one unit of labor input can produce goods and services" (Nakamura, Kaihatsu, and Yagi, 2018: 3). Although, there are many ways[5] to measure it, this study employs the output per worker as the measure of labor productivity. Therefore, data set includes the quarterly data on GDP per person employed (Index, seasonally adjusted, 2010=100) and Gross domestic product (volume estimates, expenditure

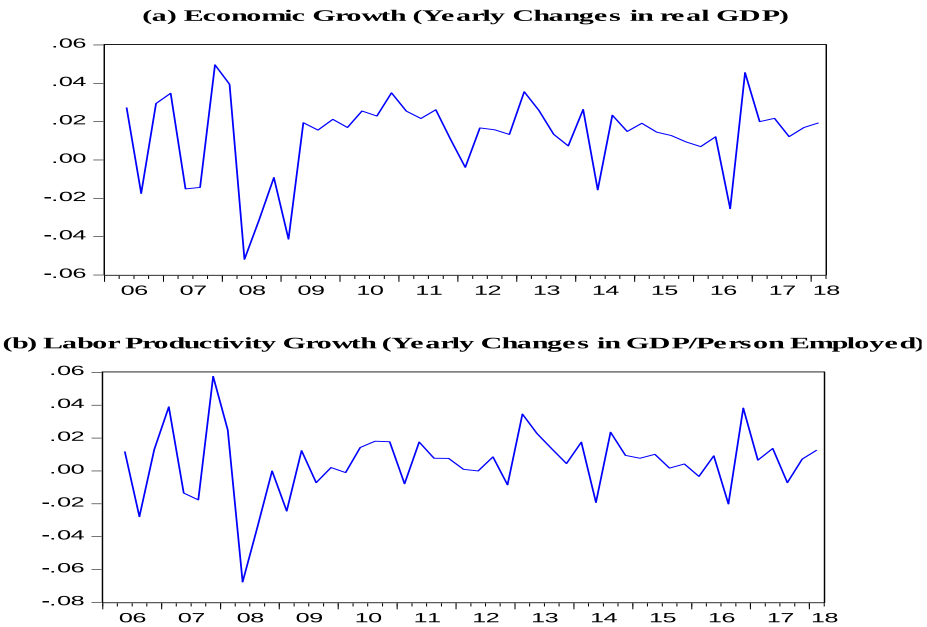
[4] The details of the nonlinear studies in economic literature can be found in Korucu-Gumusoglu (2013).

[5] Please see Nakamura et al. (2018) for other measures of labor productivity.

approach, Turkish Lira, Millions, OECD reference year=2010, annual levels, seasonally adjusted) over the years from 2006 to 2018. All the data were obtained from OECD Stat database. lbr and gdp represent labor productivity and Gross Domestic Product.

Table 1: Summary Statistics

	Economic Growth (Δgdp)	Labor Productivity Growth (Δlbr)
Mean	0.012455	0.004776
Median	0.016782	0.007645
Maximum	0.049565	0.057487
Minimum	-0.051880	-0.067631
Std. Dev.	0.021271	0.020538
Skewness	-1.108704	-0.675003
Kurtosis	4.123319	5.445472
Jarque-Bera	12.35749	15.60570
Probability	0.002073	0.000409
Sum	0.597858	0.229269
Sum Sq. Dev.	0.021265	0.019824
Observations	48	48



Graph 1: Economic Growth and Labor Productivity Growth

The series are in natural logarithmic form and as the unit root tests indicate that they are I (1), first differences of the series were taken.[6] Summary Statistics are presented in the following Table 1, while Figure 1 illustrates the economic and labor productivity growth series over the entire period starting from 2006: Q2 and ending in 2018: Q1. The quarterly economic growth and labor productivity growth realized at 1.3% and 0.4%, on average, throughout the period. As seen from Figure 1, there is a decline in both economic growth and labor productivity growth in 2008 at the second quarter reflecting the instantaneous but not continuous effect of 2008 Global Financial Crisis. There are fluctuations in both growth series over time.

2. Methodology

The effect of summer time implementation on economic growth and labor productivity is investigated by linear and nonlinear framework. The main motivation of this paper is to find out this effect by considering the possibility of asymmetry.

[6] The results of the unit root tests are given in Empirical Results section.

Therefore, in order to include the asymmetric relationship, Threshold Autoregressive (TAR) model is employed. There are 3 types of methods for nonlinear empirical literature. First one is Threshold Autoregressive models (TAR) by Tong (1978) and Tsay (1989). Second one is Smooth Transition Regression models (STAR) that allows smoothness between regimes. Third one is Markov Switching Model by Neftçi (1984) and Hamilton (1989). This paper uses TAR model. TAR model is able to capture both the periodicity and the asymmetric rise and fall of the data. TAR model allows sharp changes between regimes. The main problem in applying TAR models is to select delay parameter (d) and threshold value (c). There are 3 approaches in the literature to select these parameters namely Tsay, Bruce Hansen[7] and Chan Method.

In this paper, threshold value is determined by Chan (1993) method. Chan (1993) showed how to obtain a super consistent estimate of the threshold parameter so that this approach is commonly used in the literature while the main aim of Tsay (1989)'s study is to propose a procedure for testing threshold nonlinearity and building TAR. According to Chan (1993) method, first, the observations from smallest to largest are ordered such that: $y^1 < y^2 < y^3 \ldots < y^T$

For each value of y^j $\tau = y^j$,, set the indicator according to this potential threshold and estimate a TAR model. To choose the consistent estimate of the threshold, take the smallest residual sum of squares. In practice, the highest and lowest 15% of the $\{y^j\}$ values are excluded from the grid search to guarantee appropriate sample size for each side of the threshold that upper and lower regime. The method takes the threshold value which gives the minimum residual sum of squares.

Following Tsay (1989) and Hansen (1997), a basic TAR model can be formulated as:

$$y_t = \left(\varphi_{10} + \sum_{i=1}^{p} \varphi_{1i} y_{t-i}\right) I(q_{t-1} \le \gamma) + \left(\varphi_{20} + \sum_{i=1}^{p} \varphi_{2i} y_{t-i}\right) I(q_{t-1} > \gamma) + e_t \tag{1}$$

where (y_1, …, y_n) is observed data, I(.) denotes the indicator function, and $q_{t-1} = q(y_{t-1}, \ldots, y_{t-p})$ is a known function of data. The autoregressive order is $p \ge 1$, the threshold parameter is γ and e_t is *i.i.d.* $(0, \sigma^2)$. If the dependent variable is also chosen as threshold variable, then the model is called Self-Exciting Threshold Autoregressive (SETAR) models of Tong (1983).

In this paper, we followed basic TAR model and try to analyze the effect of daylight-saving time and policy change on productivity and growth. The empirical specification procedure for TAR model consists of following steps:

1. Test for the unit root, if the null hypothesis of stationarity (unit root) cannot be rejected, take the first difference of time series in the data.
2. Select threshold variable and threshold value.
3. Estimate the parameters in the selected TAR model.

To test for nonlinearity, Tsay (1989) test of linearity is used. The model with minimum p value is chosen as the lag of the threshold variable.

3. Empirical Results

In this section, we provide an empirical evidence of the effect of day light saving time and its policy change on economic growth and labor productivity over the period 2006:01-2018:01 for Turkey. We first take the natural log of the variables to reduce the probability of heterogeneity that can occur in the data set. Then, we test the null hypothesis of unit root for both variables by applying Augmented Dickey Fuller (ADF) test and nonlinear unit root tests developed by Kapetanios, Shin and Snell (2003) (KSS), Leybourne, Newbold, and Vougas (1998) (LNV), Sollis (2004) and Sollis (2009). Brief information related to nonlinear unit root tests can be given as follows focusing on the differences between them. In KSS test, the null of linear unit root is tested against ESTAR type nonlinear stationarity. LNV test allows for structural changes in addition to nonlinearity in time series employing Logistic Smooth Transition Regression Model. Based on both Enders and Granger (1998) Threshold AR unit root test and LNV (1998) test, Sollis (2004) developed a test which allows for symmetric or asymmetric adjustment and tests non-stationarity against smooth transition TAR stationarity. Lastly, Sollis (2009) proposed a test based on KSS (2003) and allowing for asymmetric adjustment employing exponential and logistic functions. Finally, Enders and Granger (1998) nonlinear unit root test is employed. Enders and Granger (1998) approach test the null hypothesis of a unit root against the alternative of stationarity with asymmetric adjustment. The test is based on TAR and momentum TAR models.

[7] For details of the methods, see Tsay (1989) and Hansen (1997).

According to the ADF unit root test results, the series are found to be I (1). This result is also supported by almost all of the nonlinear unit root tests. The first differences of the variables are taken for the stationarity of the series.

Table 2: Unit Root Tests

	gdp	Δgdp	lbr	Δlbr
Tests	Statistic	Statistic	Statistic	Statistic
ADF	-2.5374	-4.9139***	-2.0028	-6.2540***
Nonlinear Unit Root Tests				
KSS (2003)	-2.592	-1.955	-3.427**	-1.012
LNV (1998)				
Model B	-0.859	-6.934***	-0.238	-6.279***
Model C	0.122	-7.498***	0.155	-5.599**
Sollis (2004)				
Model B				
tmax	0.2271	-4.3473**	-0.0183	-4.5109**
F	0.5086	16.0858**	0.0365	19.3269***
Model C				
tmax	0.4591	-6.1304***	0.4500	-3.7962
F	0.1056	32.7978***	0.1013	15.4940**
Sollis (2009)	4.583	5.886**	2.667	1.259
Enders and Granger (1998)	10.32***	8.15**	13.92***	10.07***

Note: *In the unit root test equation, intercept and trend are added as the series are found to contain both intercept and trend based on graphical analysis. Lag length selection is based on BIC by taking maximum lag length as 10. *, **, *** shows the statistical significance of test statistics at 10%, 5%, and 1%, respectively. In LNV (1998) test, Model B allows for trend and nonlinearity in intercept, whereas, Model C allows for nonlinearity in intercept and trend. Critical values for KSS tests for series in level (first difference) are as follows; -3.93 (-3.48), -3.40 (-2.93) and -3.13 (-2.66) at 1%, 5%, and 10% significance levels. Critical values for LNV (1998), Sollis (2004) and Enders and Granger (1998) can be found from the articles of the authors. Critical values for Sollis (2009) are 8.711 (6.953), 6.593 (5.055) and 5.670 (4.194) for series in level (first difference) at 1%, 5%, and 10% significance levels. According to Enders and Granger (1998) test results, the series in level (first difference) seems stationary with asymmetric adjustment.*

Then we select p value, lag order for the Autoregressive model according to the model selection criteria (such as the Akaike Information criterion (AIC) and the Bayesian Information criterion (BIC)). One lagged model is selected according to the both AIC and BIC. Linear Johansen (1996) cointegration test results show no evidence of cointegration under the case of trend. Additionally, according to Engle-Granger (1987) cointegration test results, test statistic is found as -2.26, where MacKinnon critical values are -3.95 (1%), -3.36 (5%) and -3.06 (10%) so that the null hypothesis of no cointegration cannot be rejected. As stated in Enders and Siklos (2001), in the presence of nonlinearity, Enders and Siklos (2001) nonlinear cointegration procedure (especially Momentum-TAR method) is found to be more powerful compared to linear models. The Momentum-TAR (M-TAR) model, used by Enders and Granger (1998) and Caner and Hansen (1998), allows a variable to display differing amounts of autoregressive decay depending on whether it is increasing or decreasing (Enders and Siklos, 2001). Therefore, M-TAR procedure is found powerful to the alternative assumptions of symmetric adjustment and TAR models in Enders and Granger (1998) and Enders and Siklos (2001) studies. According to Enders and Siklos (2001) cointegration procedure in Table 3, that allows for either threshold autoregressive (TAR) or momentum-TAR (M-TAR) adjustment, the null hypothesis of no cointegration cannot be rejected. We can conclude that labor productivity and GDP are not cointegrated according to linear and nonlinear cointegration methods.

Table 3: Nonlinear Cointegration Results

	φ
TAR Model (threshold: 0)	2.78
M-TAR model (threshold: 0)	2.57
M-TAR model (threshold: -0.0068)	3.64

Moreover, we test for nonlinearity by using Tsay (1989) test. According to Tsay (1989) nonlinearity test, there seems evidence of nonlinearity as we reject the null hypothesis of linearity that is lower than 0.05 (p: 0.00). Therefore, the lag for threshold variable is chosen as 1 with the min p value that is 0.036 for GDP threshold model while the model with the min p value (0.00) is chosen as 3 for lbr threshold model. Moreover, two dummy variables are included into the model that d_policy (d1) covers the effect of policy change by taking the value of 1 by the policy change period (2016:4) and d_summer (d2) shows the effect of day light saving time by taking the value of 1 for summer time, 0 for winter time. To detect if there is problem of multicollinearity, we check for the correlation between the dummies. However, the correlation coefficient between two dummies are found as 0.3, thus, including two dummies separately into the model did not change the results significantly compared to the models that they are included together.

Moreover, the linear and nonlinear causality tests are applied to see the causal relationship. According to the linear granger causality test results, lbr can granger cause GDP (p: 0.084) while GDP does not granger cause lbr (p: 0.12). For the nonlinear pattern of the data set, Skalin and Terasvirta (1999) nonlinear causality test is applied. According to the nonlinear test results in Table 4, there seems no bidirectional relationship. According to the evidence of no bidirectional relationship, no cointegration and small sample reality, threshold vector error correction (TVEC) and threshold vector autoregressive (TVAR) models are not applied.

Table 4: Nonlinear Causality Test Results

Caused variable	Causing variable	p
GDP	Labor Productivity	0.8
Labor Productivity	GDP	0.06*

Note: *the results were obtained by RATS. only p values for lag 1 are given, the results are same for 5 lags, * p < 0.1, ** p<0.05.*

According to Table 4 nonlinear causality test, null hypothesis of *labor productivity does not linearly granger cause of GDP* cannot be rejected and secondly, null hypothesis of GDP *does not linearly granger cause of labor productivity* can be rejected at 90% confidence level (95% confidence level for higher lag values) therefore one can say that there is a nonlinear causality from GDP to labor productivity. Unidirectional relationship is found from GDP to labor productivity according to the nonlinear casual test.

To sum up, TAR model is employed to see the effect of summer time implementation on economic growth and labor productivity for 2 regimes (if GDP/labor productivity is lower than a specific threshold value and vice versa).

The estimated models are as follows:

$$\begin{aligned}\Delta gdp_t = {} & (\varphi_{10} + \textstyle\sum_{i=1}^{5} \varphi_{11i}\Delta gdp_{t-i} + \sum_{i=1}^{5} \varphi_{12i}\Delta lbr_{t-i} + \varphi_{13}d_1 + \varphi_{14}d_2) I(\Delta gdp_{t-1} \leq \gamma_1) \\ & +(\varphi_{20} + \textstyle\sum_{i=1}^{5} \varphi_{21i}\Delta gdp_{t-i} + \sum_{i=1}^{5} \varphi_{22i}\Delta lbr_{t-i} + \varphi_{23}d_1 + \varphi_{24}d_2) I(\Delta gdp_{t-1} > \gamma_1)\end{aligned} \tag{2}$$

$$\begin{aligned}\Delta gdp_t = {} & (\delta_{10} + \textstyle\sum_{i=1}^{5} \delta_{11i}\Delta gdp_{t-i} + \sum_{i=1}^{5} \delta_{12i}\Delta lbr_{t-i} + \delta_{13}d_1 + \delta_{14}d_2) I(\Delta \mathrm{lbr}_{t-3} \leq \gamma_2) \\ & +(\delta_{20} + \textstyle\sum_{i=1}^{5} \delta_{21i}\Delta gdp_{t-i} + \sum_{i=1}^{5} \delta_{22i}\Delta lbr_{t-i} + \delta_{23}d_1 + \varphi_{24}d_2) I(\Delta \mathrm{lbr}_{t-3} > \gamma_2)\end{aligned} \tag{3}$$

$$\begin{aligned}\Delta lbr_t = {} & \left(\beta_{10} + \sum_{i=1}^{5}\beta_{11i}\Delta gdp_{t-i} + \sum_{i=1}^{5}\beta_{12i}\Delta lbr_{t-i} + \beta_{13}d_1 + \beta_{14}d_2\right) I(\Delta gdp_{t-1} \leq \gamma_4) \\ & + \left(\beta_{20} + \sum_{i=1}^{5}\beta_{21i}\Delta gdp_{t-i} + \sum_{i=1}^{5}\beta_{22i}\Delta lbr_{t-i} + \beta_{23}d_1 + \beta_{24}d_2\right) I(\Delta gdp_{t-1} > \gamma_4)\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta lbr_t = {} & (\propto_{10} + \textstyle\sum_{i=1}^{5} \propto_{11i} \Delta gdp_{t-i} + \sum_{i=1}^{5} \propto_{12i} \Delta lbr_{t-i} + \propto_{13} d_1 + \propto_{14} d_2) I(\Delta \mathrm{lbr}_{t-3} \leq \gamma_3) \\ & +(\propto_{20} + \textstyle\sum_{i=1}^{5} \propto_{21i} \Delta gdp_{t-i} + \sum_{i=1}^{5} \propto_{22i} \Delta lbr_{t-i} + \propto_{23} d_1 + \propto_{24} d_2) I(\Delta \mathrm{lbr}_{t-3} > \gamma_3)\end{aligned} \tag{5}$$

According To Table 5, TAR model estimates can be analyzed. G denotes lower regime while R denotes upper regime in this nonlinear model. Model 2 and Model 5 can be considered as SETAR models as explained before. According to Model 2, the effect of summer time dummy seems negative but statistically insignificant while there seems positive and statistically significant policy change effect on GDP growth rate.

Table 5: TAR Model Estimates

	Dependent Variable: Δgdp		Dependent Variable: Δlbr	
Explanatory Variables:	**Model 2**	**Model 3**	**Model 4**	**Model 5**
R	0.013**	0.003	0.032*	0.002
	(0.018)	(0.7)	(0.09)	(0.8)
G	0.00	0.02***	0.012	0.012
		(0.003)	(0.08)	(0.04)
$Ggdp_{t-1}$	-1.06	0.08	-0.02	-0.002
	(0.62)	(0.82)	(0.96)	(0.99)
$Glbr_{t-1}$	1.59	0.13	-0.22	0.03
	(0.44)	(0.75)	(0.56)	(0.94)
$Rlbr_{t-1}$	-0.19	-1.052	1.17	0.59
	(0.59)	(0.17)	(0.14)	(0.33)
$Rgdp_{t-1}$	0.22	0.31	-0.51	-0.69
	(0.53)	(0.58)	(0.62)	(0.22)
d_summer	-0.011	**-0.01***	**-0.011***	**-0.013****
	(0.10)	(0.09)	(0.08)	(0.04)
d_policy	**0.018***	**0.016***	0.012	0.016
	(0.09)	(0.07)	(020)	(0.102)
Threshold variable	$\Delta gdp_{t-1} \leq 0.045$	$\Delta lbr_{t-3} \leq -0.014$	$\Delta gdp_{t-1} \leq -0.014$	$\Delta lbr_{t-3} \leq -0.008$

Note: *p values* are in parentheses; the results were obtained by RATS. * $p < 0.1$, ** $p < 0.05$.

According to Model 3 that threshold variable is taken as labor productivity, the effect of summer time dummy seems negative and significant while the effect of policy changes seems positive and significant on GDP growth rate. Labor productivity estimates can be seen from Model 4 and Model 5. In Model 4, threshold model is taken as growth rate while Model 5 takes threshold variables as lag value of labor productivity. However, the coefficients are found so close to each other that there seems negative and significant summer time effect on labor productivity. We can say that implementation of summer time may reduce labor productivity. To sum up the policy effect of summer time implementation, when the change in GDP is lower than some threshold value ($here, \Delta gdp_{t-1} \leq 0.045$), summer time dummy does not affect the growth rate while policy change seems to increase the growth. However, when the change in labor productivity is lower than some threshold value (here, $\Delta lbr_{t-3} \leq -0.014$). Implementation of summer time reduces the growth while policy change effect seems positive and significant. For the labor productivity models, when the change in GDP is lower than some threshold value (here, $\Delta gdp_{t-1} \leq -0.014$, negative growth), the implementation of summer time reduces the labor productivity, also for the lower rate of labor productivities (here, $\Delta lbr_{t-3} \leq -0.008$), the implementation of summer time reduces the labor productivity.

The linear model estimates are presented in Table 6 below to compare the linear and nonlinear models. According to the model 6, the implementation of summer time reduces the growth rate while policy change seems to increase the growth. However, according to model 7, the implementation of summer time reduces labor productivity while policy change has no significant effect.

Table 6: Linear Model Estimates

	Dependent Variable	
Explanatory Variables:	**Model 6: Δgdp**	**Model 7: Δlbr**
Constant	0.015***	0.011
	(0.006)	(0.04)
Δgdp_{t-1}	0.13	-0.11
	(0.68)	(0.72)
Δlbr_{t-1}	-0.06	0.06
	(0.86)	(0.84)
d_summer	-0.012*	-0.012*
	(0.06)	(0.06)
d_policy	0.018*	0.014
	(0.07)	(0.14)

* $p < 0.1$, ** $p < 0.05$.

Moreover, according to the diagnostics of the models in following Table 7, there seem no normality, autocorrelation and heteroscedasticity problems.

Table 7: Diagnostics of TAR Model Estimates

	Dependent Variable: Δgdp		Dependent Variable: Δlbr	
	Model 2	**Model 3**	**Model 4**	**Model 5**
$\hat{\sigma}$	0.02	0.02	0.02	0.02
R^2	0.19	0.31	0.18	0.18
Durbin-Watson	2.00	2.13	2.11	2.13
LM_{het}	3.71	11.75	2.47	11.70
χ_{nd}^{2s}	0.08	0.22	0.11	0.87
χ_{nd}^{2k}	0.43	0.57	0.02	0.69
χ_{nd}^{2j}	0.14	0.37	0.012	0.90

Note: *The significance levels are given for normality test results.*

Conclusion

This study analyzes the effect of year-round daily saving time implementation only focusing on labor productivity and economic growth by employing Threshold AR model to quarterly data for the time period 2006: Q1 and 2018: Q1 for Turkey to take into account the asymmetry. Moreover, it can be seen that the estimates of the nonlinear model seem to make more sense when compared with the linear AR model. However, one should be cautious about the result of this study and in order to evaluate the overall net benefit of implementing summer time or winter time over the whole year, one can perform social cost-benefit analysis. Because, the decision of switching or not switching to daylight saving time has many consequences including such as electricity consumption, financial markets and trade activities, human well-being and health, sleeping, academic success, home and community accidents, road accidents and fatalities, work accidents, productivity and security. Therefore, this decision should be analyzed by the policy makers deeply before implementing. There can be other factors that (are) affected (by) day light saving time. However, as literature focuses on one dimension of its effect, this study also restricts attention on only two important consequences of this implementation. Therefore, this paper takes into account this relationship in terms of growth and labor productivity framework. In this manner, the main motivation of this study is to be the first study in the empirical literature for Turkey. In the light of these issues, we found a positive and significant effect of policy change on GDP growth rate. Our second important finding is that there seems negative and significant effect of summer time on labor productivity.

Therefore, the implementation of *summer time may reduce the labor productivity* for both growth and labor productivity threshold models. While the change in growth rate is lower than some threshold value, policy change will increase the growth rate however the implementation of summer time has negative but insignificant effect on growth rate for this case. One can say that *policy change has positive effect on growth rate*. The contribution of this study may be to take into account the possible nonlinearity and secondly how the results can change according to different threshold values for growth and labor productivity. According to the aim of this study, we just consider the relationship between growth, labor productivity and summer time policy changes. These relationships can be widened including other factors by employing more complex econometric methods. This can be a subject for future studies. To conclude, policy makers should decide to implement day light saving time considering all effects such as electricity consumption, financial markets, trade activities and human well-being.

Moreover, as the focus of this study is to analyze the effect of all year round DST implementation on economic growth and labor productivity, other factors that can affect growth and labor productivity are not included into the analysis because of quarterly data unavailability. Based on data availability, future studies should also include other factors such as technological innovations, education, some macro-economic variables, social capital, labor market inflexibility, restrictions and rigidities, issues related to business management, quality of institutions and investment. Therefore, further research using more explanatory variables is certainly required.

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