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The economic implications of later school start times in the United States

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ABSTRACT

Numerous studies have shown that later school start times (SST) are associated with positive student outcomes, including improvements in academic performance, mental and physical health, and public safety. While the benefits of later SST are very well documented in the literature, in practice there is opposition against delaying SST. A major argument against later SST is the claim that delaying SST will result in significant additional costs for schools due to changes in bussing strategies. However, to date, there has only been one published study that has quantified the potential economic benefits of later SST in relation to potential costs. The current study investigates the economic implications of later school start times by examining a policy experiment and its subsequent state-wide economic effects of a state-wide universal shift in school start times to 8.30 AM. Using a novel macroeconomic modeling approach, the study estimates changes in the economic performance of 47 US states following a delayed school start time, which includes the benefits of higher academic performance of students and reduced car crash rates. The benefit–cost projections of this study suggest that delaying school start times is a cost-effective, population-level strategy, which could have a significant impact on public health and the US economy. From a policy perspective, these findings are crucial as they demonstrate that significant economic gains resulting from the delay in SST accrue over a relatively short period of time following the adoption of the policy shift.

Introduction

Inadequate sleep among adolescents has emerged as a public health epidemic.[1] Even though teens need an average of 8 to 10 hours of sleep each night, about 60 percent of middle school students report weeknight sleep duration of less than nine hours and only about 7 per cent of high school students report 9 hours or more of sleep per night.[1] The existing literature has shown that a lack of sleep among adolescents is associated with numerous adverse outcomes, including poor physical and mental health, behavioral problems, suicidal ideation and attempts, attention and concentration problems, and suboptimal academic performance.[2–9] In addition, insufficient sleep is associated with motor vehicle crashes, the leading cause of death of teenagers.[10]

Many factors have been found to be associated with adolescent sleep loss, including busy social lives, school work, participation in afterschool activities, and use of technology in the bedroom.[11] Furthermore, known biological changes in adolescent sleep–wake cycles contribute to delayed sleep–wake cycle.[12] Rise times are primarily determined by a factor of public policy, and that factor is school start times (SST).[13] In order to accommodate the known biological shift in adolescent sleep–wake cycles leading to later bedtimes and later wake-times, major medical organizations recommend that middle and high schools start no earlier than 8:30 AM.[14,15] Despite these recommendations, a Centers for Disease Control and Prevention (CDC) study estimated that 82% of middle and high schools start before 8:30 AM, with an average start time at 8:03 AM, showing significant variance of SST across different states.[16] While the benefits of later SST are well-documented in the literature, in practice there is often opposition against delaying SST. A major argument against later SST is the claim that delaying SST will result in significant additional costs for schools due to changes in bussing strategies.

To our knowledge, however, there has only one been one published study to date that has aimed to quantify the potential benefits of later SST in relation to potential costs. Specifically, the analysis by the Brookings Institution[17] examined the cost-benefits of delaying school start times and found a benefit–cost ratio of 9:1 for a 1hour

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later start time among middle and upper grades. In other words, for every $1 spent, the return is $9. Costs were estimated to be $150 per year per student, based on data from a single district in North Carolina[18] and were determined by a change in the school bus system, from a three-tiered bus system to a single-tier system. Cumulatively, the study estimated an average $17,500 gain per student in terms of lifetime earnings compared to $1950 in costs per student over his/her school career. While the Brookings Institution analysis shows a high benefit to cost-ratio, it is important to highlight that the time horizon for the potential benefits is protracted over the average working life of an individual (e.g., about 45 years). However, from a policymaker's perspective, it is important to have a more granular understanding of the timeframe for when these benefits are likely to accrue.

Against this background, the current study examines the potential economic impact from delaying SST for middle and high schools to 8:30 AM. That is, the main research question this study aims to answer is: *what are the economic implications of a state-wide universal shift in start times to at least 8:30 AM and how do they vary regionally by state and what is the expected time horizon for the benefits to occur?*

Specifically, this study runs a hypothetical policy experiment in order to estimate the potential year-by-year state-wide economic changes for several US states which may occur from a state-wide universal shift to 8.30 AM SST compared to the current start times in each of the states [cross-state average of 8:03 AM, as reported by the CDC[16]]. The analysis departs from the approach taken in the Brookings Institution study in several ways. First, instead of assuming a one hour later school start time, the current distribution of school start times across different states is taken into account and the impact of an 8:30 AM SST is modeled. Second, when calculating the benefits of SST, this study takes into account the effects on student lifetime earnings as well as the potential impact of reduced car crashes among adolescents, which can have a negative impact on future labor supply of an economy if young adults die prematurely. Third, the Brookings analysis focused only on a general potential gain per student, whereas this study looks at potential economic effects for different regions, taking into account the variation of school start times and economic factors across different US States. Finally, this study also takes into account potential multiplier effects of increased lifetime earnings of individuals. For instance, at any given point in time the additional money these individuals save or consume will create further opportunities through further income for other agents in the economy.

Methods

General modeling approach

The analysis is based on a theoretical dynamic general equilibrium model related to a system of mathematical equations to characterize the economic interaction of different agents in an economy such as households, firms, or the government. The economic model builds on the long tradition of computable general equilibrium (CGE) models, which have been extensively applied for economic policy analysis.[19–21] CGE models are based on a detailed theoretical framework simulating the behavior of various agents and depicting relationships between subjects in an economy described by a set of parameters, equations and conditions that are to be satisfied simultaneously. The equations are then evaluated using mathematical software,[22] giving a set of numerical results representing, for example, the levels of labor or capital in a simulated economy. CGE models explicitly allow for the analysis of multiple comparable scenarios which differ only in the selected set of parameters, for example by creating both a baseline (or status quo) and a 'what if' situation showing how the economy would evolve under different policy scenarios. The specific model applied in this study is a so-called 'Overlapping Generations (OLG) model, which simulates the behavior of different cohorts of individuals over their lifecycle (see a more detailed description of the model in Appendix A).

Estimates of potential benefits and costs associated with a state-wide shift in SST

As a first step, the model simulates the economic forecast of each of the states under consideration in the baseline scenario, using the current distribution of SST across middle and high schools in 47 US states which is provided by the CDC.[16] In a second step, under a different 'what if' scenario (compared to current start times), the model predicts how the economic output (e.g. measured as gross domestic product) of each state would change if the state implemented a universal shift to 8:30 AM SST. The population affected by the policy change are students from grade 6 to grade 12. In the applied economic model, it is assumed that delaying SST leads to extended sleep duration for adolescents,[14] which subsequently could impact the economy in a given state through different "channels". Specifically, we only included effects for which there were sufficient and robust parameters from the existing literature. In particular, this study focuses on two specific beneficial channels that could be derived from later SST:

The first channel is mortality from motor vehicle crashes. The data for car crash mortality includes the underlying cause of death data provided by the CDC[23] on weekday motor vehicle fatalities among teenagers age 16 to 18, combined with parameters from a study by the AAA Foundation for Traffic Safety, which revealed that about one fifth of fatal motor vehicle crashes involved a driver impaired by sleepiness, drowsiness or fatigue.[24] Together with the estimate by Danner & Phillips,[25] which suggests that the car crash rate decreases by 16.5 percent due to an hour delay in SST, the potential reduction of car crash mortality rates for each state is calculated. Note that in the model, reduced mortality levels among adolescents increase the potential future labor population and therefore has a positive effect on the economy. Thus, the labor supply effect derived from motor vehicle mortality data consists of two factors: (1) the direct impact of the individual being alive and productive; and (2) the impact on the individual's potential future offspring, which will subsequently be missing and hence will not contribute to the economy in the future.[26]

The second channel potentially contributing to the benefits of later SST is the impact on academic performance. Using data on the effect of adolescent sleep on academic performance and graduation rates from Wang et al.,[9] the model predicts that longer sleep will lead to increased high-school and college graduation rates.[9] Specifically, Wang et al.[9] estimate that one additional hour of sleep is estimated to increase the probability of high school graduation on an average by about 8.6% and the college attendance rate by 13.4%, both with decreasing marginal returns for each hour of additional sleep. Due to the non-linear effect of sleep duration, Wang et al.'s findings suggest that later school start times may create longer-run human capital benefits especially for those adolescents that sleep on average below seven hours a night, which has been estimated to affect more than 40 per cent of the adolescent population.[1] The positive effect on adolescents' academic performance and likelihood of high school graduation, in turn, impacts the jobs they are able to obtain in the future. This in turn, has a direct effect on how much a particular person contributes towards the economy in future financial earnings. Due to the dynamic nature of the model, at any given point in time, the increased income these individuals save or consume will create further opportunities through additional income for other agents in the economy and hence increase overall economic output of each of the states.[127] In essence, the effects of changes in

[1] In economics this is referred to as a 'multiplier effect', which is when extra income leads to more spending in the economy which subsequently can create more income.

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