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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.

lower car crash rates and higher educational attainment are translated into economic benefits the moment an individual enters the labor market and continues to progress throughout his/her career until retirement.

Note that a shift to 8:30 AM SST is likely to come with some costs, and hence it is relevant to compare the economic benefits of the delayed SST to its potential costs. As mentioned, one of the most important factors driving costs is a change in the bus system from a three-tier to a one- or two-tier system, which would incur additional costs. The Brookings Institution analysis uses a cost estimate of $150 per student per year for the cost–benefit analysis, based on estimates from a school district in Wake County, North Carolina.[18] Obviously, the cost will depend on the local circumstances of each state, and even at the more granular school district level it is impossible to representatively estimate them across the USA. Hence, for the purpose of illustration of the potential benefit–cost ratios four different cost estimates are used in the present analyses to provide a more comprehensive range of potential costs: $150, $350, $500 and $700. We assume that the cost per student will occur in perpetuity after the policy shift to 8:30 AM SST. This is likely overestimating the actual costs as the majority of the costs would probably accrue at the beginning of the policy shift in the form of upfront investments for new bus routes.

Calibrating the economic model with data from different sources

In the simulated model, the economic output of each state is produced using different production factors including capital and so called 'effective labor', which combines physical labor units (e.g. number of workers) with labor efficiency units (e.g. productivity of each unit of labor), where the latter includes units of human capital (e.g. level of education). To address the first component, physical labor, a cohort-component model is applied to predict the size of the future populations in each state using current base population estimates from the Census Bureau,[28–31] as well as mortality and fertility rates data provided by the CDC.[23,32] In essence, the base population evolves over time by applying assumptions on mortality and fertility so that the state population changes according to a 'natural' increase (births minus deaths), providing a projection of a state's population by one-year cohort groups into the future. In order to address the second component, labor efficiency, several sources of data from the US Census Bureau are utilized. First, in order to inform what share of the total population belongs to each one-year cohort group, we determine, the proportions of individuals in each state according to their age, gender and ethnicity[33] and complement this data with detailed information on school and college attainment. Second, in order to translate the changes in SST into potential personal financial gains of potentially higher academic performance data on the average earnings by the highest educational attainment level is used, which is collected by United States Census Bureau.[34] In addition, a variety of parameters were used to calibrate the model, including, among others, the hours of work, capital-labor ratios, capital stock depreciation rates and the growth rate of technological change. A full model specification and a complete description of model parameters is reported in Hafner et al. (2017).[34]

Results

This study illuminates the link between a state-wide universal delay in SST to 8:30 AM and economic gains to different US states. In what follows, the predicted cumulative gains in present-day values (2016 $ figures) aggregated across all 47 states are presented, followed by a breakdown of the benefits by student and the comparison against the potential costs per student. Finally, the overall benefit–cost ratios by state are presented.

Predicted cumulative gains and benefit–cost ratios across the USA

Fig. 1 depicts the cumulative economic gains from delayed SST in present-day value across the 47 US states included in the analysis. The economic gains are displayed as higher levels of economic output that would occur if SST would be delayed compared to the status quo. Economic output is measured as gross state product (GSP), which is the equivalent of gross domestic product (GDP) at country level.

In the first year of the shift to 8:30 AM SST, the model projects no immediate economic gain, given that the first cohort of students graduating from high school is only experiencing one-year of change in the SST policy before graduation. However, as more students will benefit over time from the delayed SST as they enter the labor market, the gains are increasing over time. For instance, after year two of the policy shift, the model projects an economic gain of about $8.6 billion which represents about 0.04% of total US Gross Domestic Product (GDP). After five years, the economic gain increases to about $37 billion, and to $83 billion and about $140 billion after 10 and 15 years, respectively. On average, this corresponds to an annual gain of about $9.3 billion, which is roughly the annual revenue of Major League Baseball.[35]

Furthermore, Fig. 2 reports the average benefit–cost ratio per student across the 47 US states using four different estimates for costs in order to capture a range of relevant scenarios for different school districts: $150, $350, $500, and $700.[2] Under the assumption that the costs per student are $150, as in the Brookings Institution analysis, the benefits are predicted to outweigh the costs per student (e.g. benefit–cost ratio is larger than 1) after about 2 years of delaying SST to 8:30 AM. After 13 years, the benefit–cost ratio would reach 3:1, meaning that every $1 invested would yield a return of $3. The ratio increases annually, reaching 4:1 after 20 years. Assuming a higher cost of $350 per student per year, a universal state-wide delay in SST to 8:30 AM on average is predicted to outweigh the cost after 7 years. Remarkably, assuming a high cost of $500, the "break-even" point would be 16 years. Even when assuming an extremely high cost of $700 per student per year, which is more than four times larger than the suggested cost per student used in the Brookings study, the economic benefits of delaying SST would outweigh the cost per student after 25 years.

Variation across states: Gains per student and benefit–cost ratios

The findings presented thus far represent average figures across the 47 US states, but a state-by-state analysis reveals significant regional variation in the effects. For instance, Table 1 reports the gains per student across 47 states after the policy change to delay SST to 8:30 AM.

For instance, in Alabama, the economic gain per student after 2 years is estimated to be about $31 per student. This is significantly lower than the average of $346 per student across the 47 states. Other states with relatively low gains per student are Arkansas, Idaho and Mississippi (between $177 and $190). On the other hand, states such as Delaware and Massachusetts would proportionally gain more than $700 per student after 2 years. Other states with relatively large gains per student are Connecticut, New Jersey, Ohio, Rode Island and Virginia. Note that the difference is mainly driven by variation in the state-wide initial average SST and underlying economic factors which also vary significantly by state (e.g. the industrial composition or average productivity levels).

Table 2 reports the benefit–cost ratios by state assuming the cost per student to implement the delayed SST to 8:30 AM would be $150

[2] Both benefits and costs per student are discounted and presented in present-day values. The future benefits and costs have been discounted by a rate of 4% which is common among the macroeconomic literature.

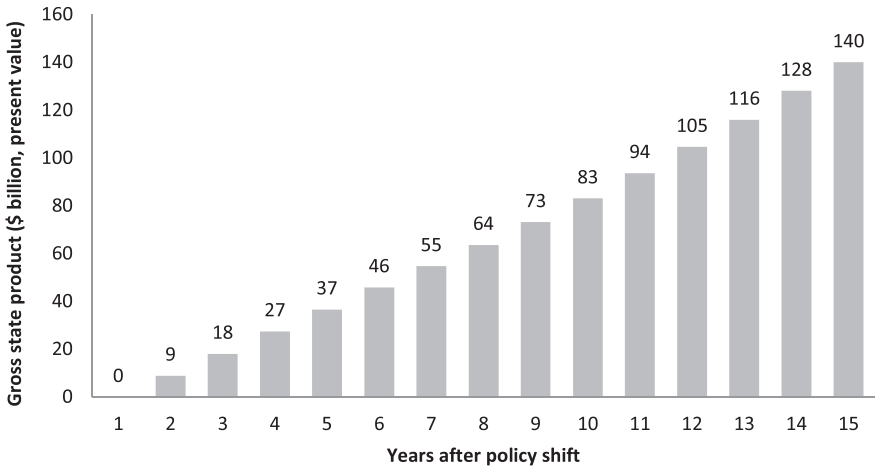

Fig. 1. Predicted cumulative economic gains from delayed SST to 8:30 AM across 47 US States. *Note: The figure plots the predicted discounted cumulative gains of delayed SST to 8:30 AM aggregated across 47 US states since the change of policy (from one to fifteen years).*

per student per year. The findings suggest that with the exception of Alabama, in every other state, the economic benefits for delaying SST would outweigh the costs within 5 years after the change. The predicted benefit–cost ratio after five years varies from 0.4 (Alabama) to 4.4 (Delaware). Even after two years, a majority of states are predicted to reach a benefit–cost ratio of at least 1:1, meaning that for every $1 spent, there is a $1 return on investment.

Discussion

The current study is the first to measure the economic gains associated with delaying school start times in states across the US. Using a novel macroeconomic modeling approach, the findings suggest that delaying SST to 8:30 AM could lead to significant economic gains over a relatively short period of time in the form of increased overall economic performance. Departing from the previous cost–benefit analysis provided by the Brookings Institution, this study reports the estimated year-by-year and state-by-state changes in benefits from delaying SST which average across the states from 1.2 (after 2 years) to 3.2 (after 15 years). 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. In comparison, the Brookings Institution estimated a benefit–cost ratio of 9:1 per student, but calculated the benefits and costs over the working life of an individual, which is about 45 years on average, and hence the benefit–cost ratio cannot directly be compared to the ratios predicted in this study, which are year-on-year. However, if we apply the annual cost in perpetuity assumption of $150 per student per year to the Brookings Institution analysis, which found that the overall lifetime

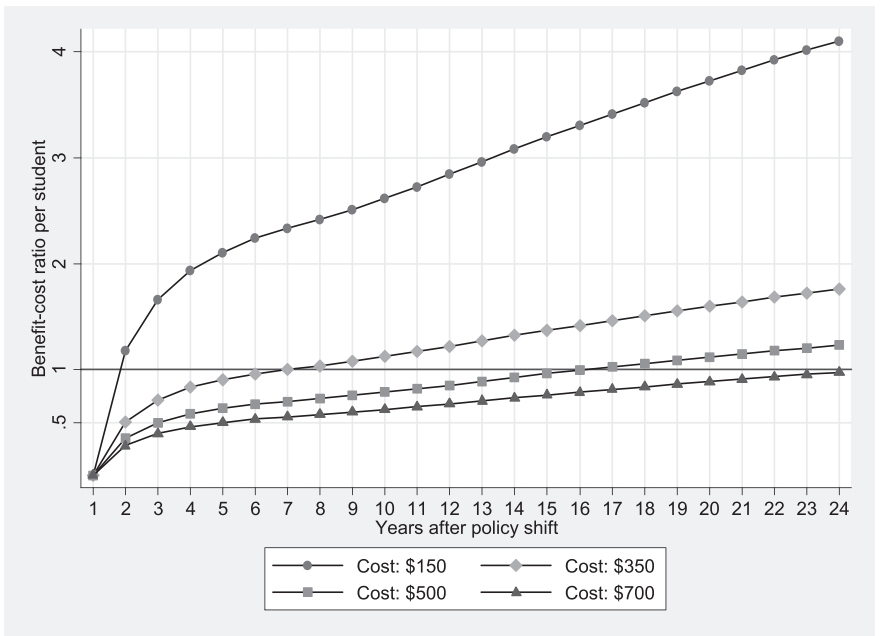

Fig. 2. Predicted average Benefit–Cost Ratios of Delayed SST to 8.30 AM across 47 US States. *Note: The figure plots the predicted benefit–cost (B-C) ratios of delayed SST to 8:30 AM across 47 U.S states after the change of policy).*

Table 1
Predicted cumulative economic gain

State	Years after policy change (gain $ per student)				
	2	*5*	*10*	*15*	*20*
Alabama	31	246	953	2220	3712
Arizona	374	1498	3325	5440	7619
Arkansas	190	904	1908	3349	4867
California	335	1357	3097	5216	7523
Colorado	294	1199	2876	5158	7515
Connecticut	517	2209	5193	8863	12,639
Delaware	733	3061	7242	12,278	17,275
Florida	456	1783	3943	6525	9145
Georgia	269	1098	2485	4109	5835
Hawaii	476	2295	4688	7553	10,653
Idaho	180	735	1676	2802	4044
Illinois	259	1082	2539	4499	6700
Indiana	273	1273	2824	5097	7459
Iowa	395	1625	3681	5756	7983
Kansas	289	1478	3117	5215	7500
Kentucky	263	1442	3043	4916	6850
Louisiana	381	1587	3723	6422	9232
Maine	275	1148	2748	4702	6740
Massachusetts	704	2693	5673	9050	12,535
Michigan	331	1367	3248	5381	7551
Minnesota	360	1443	3395	5671	8046
Mississippi	177	856	1844	3112	4452
Missouri	341	1396	3302	5877	8468
Montana	338	1366	2942	4656	6473
Nebraska	258	1096	2527	4358	6433
Nevada	191	795	1897	3330	4896
New Hampshire	286	1343	3117	5416	7801
New Jersey	551	2207	5112	8482	11,886
New Mexico	373	1469	3268	5204	7226
New York	295	1244	2970	5298	7862
North Carolina	342	1411	3215	5413	7717
Ohio	410	1646	3510	5665	7879
Oklahoma	291	1153	2568	4226	5989
Oregon	294	1198	2758	4810	7088
Pennsylvania	276	1212	2987	5381	7900
Rhode Island	537	2406	5358	8703	12,081
South Carolina	317	1380	3050	4747	6513
South Dakota	296	1300	2744	4438	6287
Tennessee	225	967	2286	3998	5858
Texas	333	1335	3007	5022	7162
Utah	228	931	2327	3956	5654
Vermont	365	1523	3464	5876	8365
Virginia	595	2129	4774	7706	10,765
Washington	503	2308	4786	7664	10,662
West Virginia	235	972	2263	3813	5443
Wisconsin	360	1498	3572	6034	8610
Wyoming	461	1982	4497	7553	10,702
Average	**346**	**1461**	**3309**	**5552**	**7906**

Notes: The table reports the predicted discounted cumulative economic gains per student of delayed SST to 8:30 AM across all 47 US states, compared to the status quo with current distribution of SST.

gain of a student is $17,500 for a one-hour shift in SST, and further assume a 45 year time horizon, then the predicted adjusted benefit–cost ratio of the Brookings Institution analysis is approximately 6:1, instead of 9:1. By taking a more comprehensive and more detailed national approach, the figures presented in Table 2 suggest that after only 15 years (about a third of the working life of an individual), the benefit–cost ratio across the 47 states is about half of the benefit–cost ratio of the Brookings analysis. If the estimates reported in Table 2 would be extended to 45 years, the ratio is predicted to increase to about 7.5:1, which is about 1.2 times larger than the estimated adjusted benefit–cost ratio by Brookings Institution (of 6:1), even though the current analysis implies generally a net increase in SST of less than an hour (approximately 30 minutes).

Overall, this study only applies parameters in the calibration process of the model for which robust empirical evidence is available concerning the impact of sleep loss on affects adolescents' health and academic performance. Specifically, we utilized available data on car crash mortality and impaired academic performance. Therefore, our models are conservative in nature, as we did not take into account other potential impacts of insufficient sleep, such as the effects on mental health, including depression and suicide, or other potential negative effects related to obesity or other morbidities that are also associated with insufficient sleep. Hence, the reported benefits in this study are likely an underestimation of the full benefits related to delaying SST.

On the cost side, this study uses a previous estimate of $150 per student per year but also uses higher cost estimates to assess the effectiveness of the policy change at a broader range of costs. Since costs will vary by school district, the costs applied in the current model serve for illustration purposes, but represent ostensible ranges. Furthermore, beyond increased transportation costs, it is possible that there could be other costs which are not included in our model calculations, such as the costs of having to reschedule after-school activities. In addition, due to later school start time costs, parents could incur costs associated with having to go to work later or before-or after school childcare and there could be a potential loss of income associated with a reduction in after-school employment for adolescents. However, in our analysis, on average, the delay SST to 8:30 AM only reflected an average delay of 30 minutes. In reality, given that many schools start before 8 AM, it is also possible that a greater "dose" of the intervention (i.e., more than a 30 minute change) could result in even greater benefits to outweigh the costs. Nevertheless, even if higher cost estimates (e.g. $500 per student per year) are applied, which likely would cover some of these difficult to quantify additional potential costs to parents and the wider society, the benefits from delaying SST would still outweigh the costs after fifteen years. Moreover, in conjunction with the highly consistent and robust data showing the widespread consequences of adolescent sleep loss on health, safety, and academic performance,[36–42] these benefit–cost projections 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.

These findings must be interpreted within the constraints of the study and the specific modeling approach. First, our model is a simulated or hypothetical "natural experiment" that presupposes a statewide universal shift in school start times to 8:30 AM or later. This presupposition may seem unjustified given that start times are generally determined at the local district level. However, there are several examples of proposed policy initiatives in states across the country, including a bill in California that mandates that California middle and high school start no earlier than 8:30 AM.[43] Thus, the hypothetical policy shift modeled in the current analysis is potentially a conceivable strategy. Second, we focused on the cost-benefits of later SST for the 47 states for which there was available data from the CDC on SST and the average start time was before 8:30 AM, and therefore do not have estimates for Maryland, District of Columbia, North Dakota, and Alaska. Third, the specific modeling approach taken in this study is in part based on assumptions that may influence the modeling outcome. It is important to emphasize that whenever an assumption had to be made, we aimed to make sure that the specific assumption would be conservative, hence leading to a potential underestimation of the potential true effect. Finally, as mentioned, our model focuses on two specific factors that drive costs: the impact of sleep insufficiency on motor vehicle crashes/mortality and academic achievement/high school graduation rates. These factors were chosen because we were able to collect and derive robust estimates from the literature. However, as mentioned, there are numerous other costs associated with mental and physical morbidity that were not included in our model. For instance, the combined public health costs of the obesity epidemic in children and adolescents and its associated cardiovascular morbidities are estimated at $45

Table 2
Predicted benefit–cost ratio by state: cost $150 per student per year

State	Years after policy shift				
	2 years	*5 years*	*10 years*	*15 years*	*20 years*
Alabama	0.1	0.4	0.8	1.3	1.8
Arizona	1.3	2.2	2.6	3.1	3.6
Arkansas	0.7	1.3	1.5	1.9	2.3
California	1.1	2.0	2.5	3.0	3.6
Colorado	1.0	1.7	2.3	3.0	3.5
Connecticut	1.8	3.2	4.1	5.1	6.0
Delaware	2.5	4.4	5.7	7.1	8.2
Florida	1.6	2.6	3.1	3.8	4.3
Georgia	0.9	1.6	2.0	2.4	2.8
Hawaii	1.6	3.3	3.7	4.4	5.0
Idaho	0.6	1.1	1.3	1.6	1.9
Illinois	0.9	1.6	2.0	2.6	3.2
Indiana	0.9	1.8	2.2	2.9	3.5
Iowa	1.3	2.3	2.9	3.3	3.8
Kansas	1.0	2.1	2.5	3.0	3.5
Kentucky	0.9	2.1	2.4	2.8	3.2
Louisiana	1.3	2.3	2.9	3.7	4.4
Maine	0.9	1.7	2.2	2.7	3.2
Massachusetts	2.4	3.9	4.5	5.2	5.9
Michigan	1.1	2.0	2.6	3.1	3.6
Minnesota	1.2	2.1	2.7	3.3	3.8
Mississippi	0.6	1.2	1.5	1.8	2.1
Missouri	1.2	2.0	2.6	3.4	4.0
Montana	1.2	2.0	2.3	2.7	3.1
Nebraska	0.9	1.6	2.0	2.5	3.0
Nevada	0.7	1.1	1.5	1.9	2.3
New Hampshire	1.0	1.9	2.5	3.1	3.7
New Jersey	1.9	3.2	4.0	4.9	5.6
New Mexico	1.3	2.1	2.6	3.0	3.4
New York	1.0	1.8	2.4	3.1	3.7
North Carolina	1.2	2.0	2.5	3.1	3.6
Ohio	1.4	2.4	2.8	3.3	3.7
Oklahoma	1.0	1.7	2.0	2.4	2.8
Oregon	1.0	1.7	2.2	2.8	3.3
Pennsylvania	0.9	1.8	2.4	3.1	3.7
Rhode Island	1.8	3.5	4.2	5.0	5.7
South Carolina	1.1	2.0	2.4	2.7	3.1
South Dakota	1.0	1.9	2.2	2.6	3.0
Tennessee	0.8	1.4	1.8	2.3	2.8
Texas	1.1	1.9	2.4	2.9	3.4
Utah	0.8	1.3	1.8	2.3	2.7
Vermont	1.2	2.2	2.7	3.4	4.0
Virginia	2.0	3.1	3.8	4.4	5.1
Washington	1.7	3.3	3.8	4.4	5.0
West Virginia	0.8	1.4	1.8	2.2	2.6
Wisconsin	1.2	2.2	2.8	3.5	4.1
Wyoming	1.6	2.9	3.6	4.4	5.1
Average	**1.2**	**2.1**	**2.6**	**3.2**	**3.7**

billion a year, and sleep loss is longitudinally associated with increased risk of obesity in children and adolescents.[38] Further, insufficient sleep among teens is associated with an increased risk of engaging in property and violent crime.[40] The direct and indirect costs of crime, including direct economic losses, increased insurance rates, loss of productivity, and various aspects of the criminal justice system, from police, to courts, to juvenile facilities and prisons are estimated in the billions of dollars.[44] In addition, the robust association between insufficient sleep and poor sleep quality and adolescent risk for mental health problems and other risk-taking behaviors, including substance use, could also contribute to substantial societal costs. Taken together, our estimates suggest substantial benefits relative to costs on a state-wide basis related to a universal change in SST and, if anything, these estimates are likely conservative estimates of the true cost savings.

In summary, it is important to put this economic data in context. The findings of this study, as well as the Brookings Institution findings, suggest that the benefits of later start times far out-weigh the immediate costs. Moreover, when paired with the substantial literature demonstrating the dire public health consequences of insufficient sleep among adolescents, the multitude of health and academic benefits associated with later start times, and the lack of any scientific evidence to suggest that there are benefits to having adolescents start school earlier, these data provide a strong case to counter the argument that changing school start times is too costly to endeavor a change. Policymakers, educators, and community members should shift from the narrow and often short-sighted focus on the costs of shifting to healthy start times to a focus on the significant benefits associated with later SST, including demonstrable long-term public health and economic benefits.

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