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Did Spending Cuts During the Great Recession Really Cause Student Outcomes to Decline?

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Abstract
Understanding the impact of K-12 spending on student outcomes has become increasingly important as our nation deals with the economic and social cost of COVID 19. A forthcoming Jackson, Wigger, and Xiong (2020a, JWX) paper provides evidence that education spending reductions during the Great Recession had widespread negative impacts on student achievement and attainment. We replicate JWX as a first step in modeling the potential effects of the pandemic on K-12 spending and outcomes. This paper describes our process of duplicating the JWX study and highlights a variety of tests we employ to check the robustness of the JWX findings. We find the JWX results are not robust to reasonable specification changes and that the estimated impact of K-12 spending on college-going rates is likely confounded with contemporaneous higher education trends. While we believe that spending reductions may have negative impacts on student outcomes, this paper provides evidence that the JWX results are unlikely to represent the true causal impact of spending changes on educational outcomes.

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I. Introduction

Since Coleman et al. (1966), researchers have sought to understand the relationship between school expenditures and educational outcomes. Early studies cast doubt on the idea that school spending is strongly linked with student performance (Clark, 2003; Hanushek, 2003; Papke, 2008; Roy, 2011). More recently, however, researchers have used causal identification strategies to provide evidence that overall spending plays a more influential role than previously thought (Jackson et al., 2016; Candelaria & Shores, 2017; Hyman, 2017; Miller, 2017; Gigliotti & Sorensen, 2018; Lee & Polachek, 2018; LaFortune et al., 2018; Jackson et al., 2020). The extent to which school expenditures impact student outcomes is of particular interest today as the COVID-19 pandemic creates significant state budget shortfalls while simultaneously increasing fiscal demands on schools.

Evidence from previous recessions may provide pertinent information that can be used to ease the impact of the COVID-19 pandemic on schools and students. Prior studies have claimed to uncover significant causal relationships between recessionary changes and important educational factors such as teacher quality and retention (Nagler, Piopiunik, & West, 2017; Fuchsman & Zamarro, 2019). The focus of this paper is one such study, a forthcoming *American Economic Journal: Economic Policy* article titled "Do School Spending Cuts Matter? Evidence from The Great Recession," that investigates the impact of spending cuts related to the Great Recession on test scores and college-going rates (Jackson, Wigger, and Xiong, 2020a; JWX hereafter). JWX exploits state-level variation in education spending using an instrumental variables (IV) approach to identify the causal effect of recessionary spending cuts on student outcomes. We replicate JWX as a first step in modeling the potential effects of the COVID-19 pandemic on K-12 spending and outcomes.

JWX uses pre-recession (i.e., 2008) K-12 state revenue share to instrument for the effect of expenditures on educational outcomes. This approach relies on the assumption that states which depend more heavily on state-generated education funding are more vulnerable to recessionary changes. The authors argue state-share captures recession vulnerability because it is subject to crowd-out from other more-pressing budgetary demands, such as Medicare and unemployment benefits, and because state income and sales tax revenues are more susceptible to the business cycle than local revenue, namely property taxes.

On the surface, pre-recession state revenue share is a plausibly exogenous instrument. JWX fails, however, to test the robustness of their results to small, reasonable changes in modeling choices around how the study groups states for the analysis and controls for year-specific shocks. They also do not investigate whether their model can disentangle the effect of K-12 spending vs. higher education spending on college enrollment. This paper describes our process of duplicating the JWX study and highlights a variety of tests we employ to check the robustness of the JWX findings.

While we are able to reproduce the JWX findings, we do not find consistent evidence that spending cuts resulting from the Great Recession had a causal effect on student outcomes. Instead, our results show:

- the JWX group IV results depend on categorizing very few states as having low-reliance (***three*** states) or high-reliance (***four*** states) on state revenue to fund K-12 education, and the results are sensitive to small changes in group composition;
- the JWX linear IV results rely on a non-standard specification for year fixed effects, and the results are sensitive to using other reasonable specifications to control for year-specific effects; and

- K-12 and higher education funding trends are highly correlated, and as a result, the JWX finding that K-12 spending reductions impacted state college-going rates is likely confounded with contemporaneous higher education funding trends.

The rest of the paper proceeds as follows. First, we briefly describe the JWX study and findings. Section II describes the data used to reproduce JWX. Section III motivates our robustness checks. Our analytical approach is described in Section IV. Results are outlined in Section V and Section VI concludes the paper, providing implications of our findings.

Description of "Do School Spending Cuts Matter? Evidence from The Great Recession"

JWX uses an instrumental variables (IV) analysis to causally link spending reductions resulting from the Great Recession to student outcomes. Since unobserved factors influence both per-pupil expenditures (PPE) and student outcomes, PPE is considered an endogenous variable. Therefore, researchers cannot directly investigate the causal impact of PPE on student outcomes. Isolating the effect of changes in PPE requires finding an instrument that is causally linked to PPE, has no impact on the outcome measure except through PPE, and is not caused by any factors that also impact student outcomes. Figure 1 depicts the relationship between PPE, student outcomes, and an exogenous instrument, using a directed acyclic graph (DAG).

JWX exploits variation in state-appropriations to public education as an instrument for per-pupil spending. Specifically, JWX utilizes the share of a state's public-school revenues generated from state sources just prior to the Great Recession in place of per-pupil spending (i.e., 2008 state share of K-12 revenue). This identification strategy relies on the fact that state-level taxes are more susceptible to the business cycle than either local property taxes or federal funding. Therefore, states who are more reliant on state funding are likely to experience larger recession-induced cuts to school spending.

JWX presents evidence that spending reductions cause declines in both student achievement and college matriculation rates. The authors find that for every $1,000 cut in per-pupil spending attributed to the recession, scores on the National Assessment of Educational Progress (NAEP) exam decline by 3.85 percent of a standard deviation. Results are similar for college-going rates, where a $1,000 reduction in per-pupil expenditures results in a decrease in college enrollment of 1.24 percentage-points. In addition to the main analysis, JWX finds that spending reductions also increased achievement gaps by both race and socioeconomic status, and that states that cut K-12 spending hired fewer personnel and reduced capital expenditures rather than core K-12 expense categories.

The JWX findings suggest that both student achievement and attainment may be broadly responsive to fluctuations in education spending. Moreover, their results imply that high-poverty districts – where state aid makes up a larger proportion of revenues – may be the most at-risk to changes in school funding. Naturally, these findings have important implications for policymakers interested in understanding the relationship between education finance and student outcomes.

II. Data

Our dataset, which mirrors the sources and strategies employed in JWX, contains data on all 50 states and the District of Columbia spanning years between 2001 to 2019. We closely match the mean, standard

deviation, and number of observations for all data elements used in JWX's main analyses. Table 1 provides summary statistics for our data and compares it to the JWX data.[2]

Unadjusted test scores for National Assessment of Educational Progress (NAEP) were obtained from publicly-available data aggregated and hosted by the Urban Institute.[3] To match the JWX data we use public school state-year average scores for 4th and 8th grade math and reading assessments between 2002 and 2017. All scores are standardized to a base year of 2003 using the national public school NAEP test means and standard deviations.[4]

College-going data comes from the Integrated Postsecondary Education Data System (IPEDS). The data includes information reported by institutions on the number of first-time college freshmen who graduated high school in the past 12 months, aggregated by state of origin.[5] This portion of the survey is only administered in even years. To compute a college-going rate, we obtain population estimates from the US Census for the number of 17-year-olds in each state the year prior to enrollment.[6] Our college-going rate divides the number of enrollees from each state in even numbered year divided by the number of 17-year-olds in the state the previous year.[7] This rate is then associated with the odd number year which matches the 17-year-old observation.

High school graduation rates are obtained from the National Center for Education Statistics (NCES). NCES changed its high school graduation rate measure in 2014. As a result, data from 2001-2013 represent Average Freshman Graduation Rate (AFGR) values and data from 2014-2019 are Adjusted Cohort Graduation Rates (ACGR).[8]

We obtain school finance data from the Census (F33) School District Finance Survey available at the Common Core of Data (CCD) . Data contains information on school revenue and expenditures, as well as the number of students enrolled in each district and state. To obtain per-pupil expenditures, spending variables were CPI-adjusted to 2015 dollars and divided by total district membership in each year.[9]

We also retrieve data on economic conditions in each state and year from the Bureau of Labor Statistics (BLS). Following JWX, we use these data to construct Bartik economic control variables for unemployment and average wage. This process is described in A.2 of the online appendix for JWX. We obtain state employment shares for 2007 – the first year of the recession – using BLS "CSVs By Industry" and "Annual

[2] See JWX Table 1 for summary statistics.
[3] Five states do not have 2002 NAEP scores: AK, CO, NH, NJ, and SD. To generate a balanced panel of data, we impute the mean reading z-score for those same states in 2003. Results are consistent both including and excluding these observations.
[4]Data obtained from the NAEP Data Tool (https://www.nationsreportcard.gov/ndecore/landing). 2003 National NAEP Exam Statistics: 4th grade reading – Mean = 216, SD = 37; 8th grade reading – Mean = 261, SD = 35; 4th grade mathematics – Mean = 234, SD = 28; 8th grade mathematics – Mean = 276, SD = 36
[5] We use files labeled "Residence and migration of first-time freshmen: Fall 2018" and use the associated downloadable STATA .do file provided by IPEDS to organize and summarize the data.
[6] Data from 2000-2010 come from the State Intercensel Estimates (https://www.census.gov/data/datasets/time-series/demo/popest/intercensal-2000-2010-state.html) and data from 2010-2019 come from the Vintage 2019 Estimates (https://www.census.gov/data/tables/time-series/demo/popest/2010s-state-detail.html).
[7] JWX report using the number of 17 and 18-year-olds in their Data Appendix, but the means do not match when we use both age groups. Our mean college-going rate does match when computed using only 17-year-olds. Previous working paper versions of JWX used 17-year-olds.
[8] NCES reports a summary of the difference here: https://nces.ed.gov/blogs/nces/post/what-is-the-difference-between-the-acgr-and-the-afgr.
[9] JWX winsorizes extreme values for per-pupil expenditures by capping values of districts with expenditures great that 200 percent the 99th percentile of per-pupil revenues or less than 50 percent of the first percentile. Our analysis shows that the mean and standard deviation of spending data are not significantly changed because of winsorizing, therefore we utilize the non-winsorized data in our study. Our non-winsorized spending data is not statistically different from JWX winsorized data.

Averages."[10][11] Average wage by industry is obtained from BLS Occupational Employment Statistics data. Unemployment data by industry and year is obtained from the BLS Economic News Release.[12][13]

Information on higher education finance is obtained from two sources. State share of higher education funding comes from the IPEDS finance surveys. Data on state and local appropriations per FTE and tuition and fees per FTE are obtained from the State Higher Education Executive Officers Association (SHEEO, 2019).

III. Motivation for Robustness Checks

While replicating JWX, we encountered several circumstances that led us to question the robustness of its findings. Econometric models can be constructed in a variety of ways, and many modeling choices may be somewhat arbitrary or theoretically unimportant. However, if the statistical model's estimates represent the true causal impact, they should be consistent across many different reasonable ways of constructing the model. JWX presents several robustness checks but fails to test the sensitivity of their results around a few important modeling choices. The remainder of this section describes both the data that led us to question the JWX results and the specific areas where we test the robustness of the JWX findings.

K-12 Spending and Outcomes Trends

To motivate their analysis, JWX compares trends over time for PPE and student outcomes, demonstrating that they seemingly move together. We follow suit, graphing trends in PPE, NAEP scores, and the college-going rate. Figures 1-3 depict these trends. Our figures show that PPE declined during the Great Recession but increased sharply after 2013. We also include NCES's projections for 2018 and 2019 (dashed blue lines), which show that PPE has likely continued to climb in the years after the JWX study period.

As indicated in our graphs, both NAEP scores and the college-going rate increased with PPE in the years leading up to the recession. However, since the outset of the recession, it is less apparent whether PPE and student outcomes have been moving together. Figure 2 shows that while PPE rebounded a few years after the recession, NAEP scores have continued to decline. The national college-going rate for 17-year-olds, depicted in Figure 3, leveled off following the recession and has remained flat even as PPE increased. The recent divergence between PPE and student outcomes, especially NAEP scores, raises the question of whether the seeming correlation between the variables in earlier years was simply a coincidence. Sections IV and V more rigorously investigate the relationship between PPE and student outcomes.

Instrument Data

Both the U.S. Census Bureau and NCES provide data on K-12 revenue by source. JWX uses Census data to define their instrument.[14] These two institutions make their own unique determinations regarding what is state versus local revenue, leading to significant differences in revenues attributed to each category

[10] https://www.bls.gov/cew/downloadable-data-files.htm
[11] Census industry code crosswalk used for the BLS unemployment rate can be found here: https://www.census.gov/topics/employment/industry-occupation/guidance/code-lists.html
[12] For example, data for 2019 and 2020 can be found at: https://www.bls.gov/news.release/empsit.t14.htm.
[13] While JWX does not provide any summary statistics for these Bartik control variables, the 2019 NBER working paper version (Jackson et al., 2019) does provide Figure A4 depicting yearly averages for the unemployment rate Bartik. The figure is not well labeled but our values generally match this figure. Our average Bartik control for the unemployment rate is: 2001-4.74, 2002-5.82, 2003-5.97, 2005-4.99, 2007-4.49, 2009-9.15, 2011-8.56, 2013-6.94, 2015-4.97, 2017-4.09.
[14] The JWX data can be found in Table A2 of the online appendix for the forthcoming version (Jackson et al., 2020a). The 2008 Census state share data can be downloaded at https://www.census.gov/data/tables/2008/econ/school-finances/secondary-education-finance.html. There are some differences between JWX's data and Census that likely stem from Census data updates.

for some states. For example, Census lists Arkansas' state revenue share as 76 percent, counting the state mandated minimum local property tax effort as state revenue (see note on page B-1 of the Census 2008 survey documentation). On the other hand, NCES data for 2008 show Arkansas' state revenue share at 56.7 percent, nearly 20 percentage points lower than Census. Given the purpose of the instrument is to capture recession vulnerability, the NCES data for state share is likely, at least for Arkansas, a better fit for the analysis.

Table 2 summarizes the 2008 state revenue share data from JWX, Census, and NCES.[15] In total, there are 13 states where JWX and NCES data for state revenue share differ by more than 2 percentage points. Six states differ by more than 5 percentage points and three states vary by more than 15 percentage points.[16] These differences are potentially important given how few observations are included in the analysis (i.e., the 50 states and Washington D.C.).

For certain analyses, JWX groups states into high, medium, and low reliance categories. Because of the differences in the data, applying the same categorization rules to different data sources yields different groupings. Table 2 includes color coding to indicate high- and low-reliance groups across data sources. Cells colored green are states that are below the 0.33 threshold JWX uses to define low-reliance, and cells colored red are above the 0.67 threshold JWX uses to define high-reliance. We will discuss these thresholds in more detail in the next section. Simply changing data sources from JWX to NCES results in three states changing categories. While this only represents 6 percent of observations, as we will show in the next section, these three states represent very high proportion of the high- and low-reliance groups.

State-Group Definitions

The primary analysis in JWX relies on grouping states into high-, medium-, and low-reliance categories. In addition to the data issue outlined in the previous section, the thresholds JWX use to categorize states result in very few states being placed in the high- and low-reliance categories. JWX does not provide a theoretical or empirical justification for the thresholds used to categorize states and does not test different groupings.

As noted in the previous section, JWX defines high-reliance states as those who depend on state appropriations for more than 67 percent of total revenue and low-reliance as less than 33 percent. Of the 51 jurisdictions included in the analysis (i.e., 50 states and Washington D.C.), the JWX categorization rules result in only ***three*** states being placed in the low-reliance group and ***four*** in the high reliance group. All other states are relegated to the middle-reliance category. Outlier jurisdictions Washington D.C. (low-reliance with zero percent state share) and Hawaii (high-reliance with 85 percent state share) are among the few states in the top or bottom categories.

The small number of states in the high- and low-reliance groups and the presence of outliers in both groups raises the question of how sensitive the JWX results are to state-group definitions. We test the impact of state-group definitions in three ways, as depicted in the columns of Table 3. First, we apply the JWX assignment rules for high- and low-reliance using NCES state share data instead of Census (Column 3). States highlighted in red text are those which are different from the JWX grouping (Column 2). States not listed in either the low- or high-reliance groups are in the medium-reliance category. Changing the data source to NCES removes Arkansas from the high-reliance category and adds one state each to the high- and low-reliance groups.

[15] NCES also collects information property tax revenue, which is a plausible substitute for the JWX instrument. The 2008 state-level property tax share calculated using NCES data only has a 0.67 correlation with the state revenue share documented in table A2 of JWX.
[16] In addition to how state mandated local tax effort is categorized, Census and NCES also handle pension payments somewhat differently.

Next, we group states using the top and bottom decile of NCES state share (Column 4). Under these assignment rules two states are added to the low-reliance group and three join the high-reliance category. Finally, we apply top and bottom quartile thresholds for high- and low-reliance to categorize states (Column 5). With this organization, nine states are added to the low reliance category and ten to the high reliance group.

Given the variation in group composition with different threshold rules and data sources, our empirical approach investigates how state group definitions influence the JWX results. We believe using percentiles to define state groups is more empirically justifiable than the JWX assignment rules and testing more inclusive groupings will help us better understand the influence of the groupings on the robustness of the results. Sections IV and V outline our analytical approach and present findings for different specifications using each grouping included in Table 3.

Controlling for Year-Specific Shocks

The Great Recession was a complex event with multiyear impacts on many aspects of our society. Given the nature of the identifying event, annual stochasitc shocks may influence both the outcome measures and the instrument. In circumstances such as these it is common practice to implement individual year fixed effects in empirical models to control for potential annual shocks.

JWX employs the full set of year fixed effects in models that group states into reliance categories. However, as the previous section outlines, we have reason to believe the results of those models may be sensitive to state-group definitions. Other versions of JWX also present models that do not rely on state groupings, but instead include 2008 state revenue share as a continuous variable. JWX does not include the full set of year fixed effects in these models, electing to group specific years together for controls. The authors note that including the full set of year fixed effects would be ideal, but doing so results in a "weak first stage" (footnote 18 on p. 11 of JWX, 2019). We test this claim and find that when the full set of year fixed effects is included the instrument's first-stage, the coefficient estimate is close to zero and the Kleibergen-Paap Wald F-statistic is lower than the critical value, validating that the instrument is weak in the precence of full year fixed effects.

Rather than using full year fixed effects, JWX groups years into three period controls representing pre-recession (2001/02-2007), during-recession (2009-2011), and post-recession (2013-2017). Grouping years in this way is a debatable modeling choice, especially since we have reason to believe that there may be significant year-specific effects. There are at least two motivations to test for sensitivity to different specifications of year fixed effects. First, there could be factors related to the recession that vary with year and affect the outcomes through channels other than school spending. Grouping years will not fully account for these factors. We believe that is why JWX says the "ideal" is full year fixed effects.

Second, JWX's year groups do not neatly align with official estimates of recession timing. The National Bureau of Economic Research (NBER) estimates that the Great Recession began in December of 2007 and ended in June of 2009.[17] Of course, in most states, the budget implications of the downturn lasted beyond the official end of the recession. Imprecision around the timing of the recession and its impacts recommends caution when grouping years together over this timeframe. JWX, however, only presents models using a single, specific year grouping. Given the uncertainty around how best to control for year-specific shocks, we test different configurations of the year fixed effects in our analysis. Our approach is outlined in section IV.

[17] See https://www.nber.org/cycles.html.

Potential Confounding of the JWX College-Going Result

For K-12 state revenue share to be a valid instrument for PPE, it must not affect the college-going rate through any other pathway except through PPE and it must not be influenced by any other factors which are also causally linked to college-going. We believe that the exclusion restriction is potentially violated for the JWX college-going result because of confounding between K-12 and higher education funding trends. We also believe there may be economic, political, and institutional factors that influence both pre-recession K-12 state revenue share and post-recession college-going rate. Figure 4 provides DAGs illustrating our concerns.

To investigate confounding, we examine time trends to see if K-12 and higher education funding measures move in tandem. Figure 5 depicts the relationship between PPE, state and local higher education appropriations per full-time equivalent (FTE) student, and tuition revenue per FTE. Per-pupil expenditures and higher education appropriations move closely together, both falling sharply between 2008 and 2012, while tuition revenue steadily increases over time. Figure 6 shows these same three variables indexed to their 2002 values to display percentage change. The magnitude of the changes in higher education appropriations and tuition dwarf those for PPE, raising the prospect that higher education finance might have greater potential to influence college-going rates.

These graphs lead us to believe that K-12 and higher education spending may be confounded and even if a relationship between K-12 PPE and college-going rates exists, it may be overshadowed by the impact of changing higher education appropriations and tuition revenue. It is reasonable to theorize that higher education funding may influence college-going more than K-12 appropriations. Recent studies have shown that college outcomes, including enrollment, are responsive to higher education funding changes (Deming and Walters, 2017 and Bond et al., 2019). While we do not attempt to identify the true effect of higher education spending on college enrollment, we investigate the possibility that higher education appropriations and tuition confound the JWX college-going findings. Section IV provides additional details regarding our approach.

IV. Empirical Approach

Our empirical methods follow JWX closely, with variable definitions matching those described in the Identification Strategy section of JWX. To our knowledge, we deviate only in areas where we test the robustness of the JWX results. The sections below present our empirical approach for four different analyses: 1) event study graphs, 2) group IV, 3) linear IV, and 4) tests for higher education confounding. Each section describes our methods and approach for robustness checks.[18]

Event Study Graphs

JWX presents event study graphs as suggestive evidence that per pupil expenditures, NAEP scores, and the college-going rates declined more in states with a high reliance on state revenues relative to states with a low reliance on state revenue. Equation 1 describes the event study estimating equation.

$$Y_{st} = \sum_{t=2003}^{2017} \beta_t \left(I_{\Omega_s > q(50),s} \times I_{T=t}\right) + \alpha_s + \theta_t + (\tau_s \times T) + \upsilon_{st} \quad (1)$$

Subscripts *s* and *t* indicate state and year, respectively. The outcome variable, Y_{st}, is either PPE, average NAEP scores, college-going rates, or high school graduation rates. $I_{\Omega_s > q(50),s}$ is an indicator for states where the 2008 K-12 state share is above the national median of 0.48. $I_{T=t}$ are year-specific indicators. The

[18] Errors are clustered at the state level in all models.

α_s are state fixed effects, and the θ_t are year fixed effects. τ_s is the pre-recession, state specific linear trend for the left-hand side variable in each equation.[19] β_t is the coefficient of interest and represents the year-specific difference between states above vs below the median. Two thousand and seven is the omitted year, so the differences are relative to that year.

Instrumental Variables Models

Following JWX, we estimate two different sets of IV models. The first is a group IV in which states are categorized as being high-, medium-, or low-reliance based on state share of K-12 revenue. These category variables are then used to define the instrument. The second model is a linear IV in which state share of education revenue is treated as a continuous variable. While the forthcoming version (Jackson et al., 2020a) focuses exclusively on the group specification, the Northwestern University working paper version of JWX (Jackson et al., 2020b) includes both the linear and group IV specifications. We include both to test the robustness of the results across multiple dimensions.

Group IV: For the group IV analysis, we estimate the equations below using two stage least squares (2SLS).

$$PPE_{st} = \sum_{g=2}^{3}\left[\pi_{1g}\left(I_{gs} \times I_{post} \times (T - 2008)\right)\right] + \sum_{g=2}^{3}\left[\emptyset_{1g}\left(I_{gs} \times I_{post}\right)\right] + \rho_{12}\left(I_{post}\right) + \delta \boldsymbol{C}_{st} + \alpha_{1s} + \theta_t + (\tau_{1s} \times T) + \varepsilon \quad (2)$$

$$Y_{st} = \beta\left(\widehat{PPE}_{st}\right) + \sum_{g=2}^{3}\left[\emptyset_{1g}\left(I_{gs} \times I_{post}\right)\right] + \rho_{22}\left(I_{post}\right) + \delta \boldsymbol{C}_{st} + \alpha_{2s} + \theta_t + (\tau_{2s} \times T) + \varepsilon \quad (3)$$

The subscript g refers to the reliance categories, with 1 representing low-reliance, 2 representing medium-reliance, and 3 representing high-reliance. I_{gs} is a state specific indicator for group membership, I_{post} is an indicator for years after 2008, and $(T - 2008)$ indicates current year, T, relative to 2008. $\boldsymbol{C}_{st}$ is a vector of state and year-specific Bartik economic controls for the unemployment rate and average annual wage, which are defined in JWX. State (α_{*s}) and year (θ_{*t}) fixed effects are including, along with the pre-recession, state-specific linear trend for the left-hand-side variables (τ_{*s}). The second stage outcome variable, Y_{st}, is either a) average standardized NAEP scores, b) college-going rates, or c) high school graduation rates.[20] β, the coefficient on the predicted values from the first stage, $\widehat{PPE}_{st}$, is the coefficient of interest.

To test the impact of state group definitions on the results, we vary state-reliance group membership as described in the motivation section above and outlined in Table 3.

Linear IV: For the linear IV, we estimated the model described below using 2SLS.

$$PPE_{st} = \pi_1\left(\Omega_s \times I_{post} \times (T - 2008)\right) + \rho_{11}\left(\Omega_s \times I_{post}\right) + \rho_{12}\left(I_{post}\right) + \delta \boldsymbol{C}_{st} + \alpha_{1s} + \theta_{1t} + (\tau_{1s} \times T) + \varepsilon \quad (4)$$

$$Y_{st} = \beta\left(\widehat{PPE}_{st}\right) + \rho_{21}\left(\Omega_s \times I_{post}\right) + \rho_{22}\left(I_{post}\right) + \delta \boldsymbol{C}_{st} + \alpha_{2s} + \theta_{2t} + (\tau_{2s} \times T) + \varepsilon \quad (5)$$

All variable definitions are the same as in the group IV described above. However, in this model the reliance group indicators are replaced with the continuous variable Ω_s, which is 2008 K-12 state revenue share.

Because there is uncertainty about how best to control for year-specific shocks, we test the linear model using eight different specifications for year fixed effects. Table 5 describes each of the specifications we test. Column 2 provides the number of year indicator variables included in the model in each specification.

[19] These linear trends are equal to the slope of the left-hand-side variable between 2001/2002 and 2007. We also ran models where we instead used regression to predict the left-hand-side variables based on pre-recession data with similar results.
[20] High school graduation rate models include an indicator for the change from AFGR to ACGR.

We concentrate our robustness tests on years around (2007-2009) and those after the Great Recession (2011-2017).

Higher Education Confounding: We test for confounding in three ways using the linear IV model described above.[21] First, we replace the K-12 instrument with pre-recession state share of higher education revenue. If pre-recession state share of higher education revenue has similar predictive power to K-12 state revenue share, then state funding for K-12 and higher education may be confounded.

Next, we estimate the linear IV described above, but replace the dependent variable with state and local higher education appropriations per FTE and tuition and fees per FTE. If instrumented PPE predicts these higher education funding variables, then the exclusion restriction may be violated in the JWX model.

Finally, we estimate a JWX-style linear IV predicting college-going using state share of higher education to instrument for state and local higher education appropriations per FTE and tuition and fees per FTE. If a similarly specified IV model using higher education variables can predict college-going, then it indicates that higher education is a potential alternative pathway influencing college-going.

V. Results

Event Study Graphs

Figures 7-10 provide the event study graphs from our analysis. These figures include a dot indicating the point estimate for the year-specific difference between states that are above vs below the median for 2008 K-12 state revenue share, as well as 95 percent confidence intervals around the point estimates. Point estimates are relative to 2007, the omitted year in the model.

We find evidence that PPE declined more in states where pre-recession K-12 state revenue share was above the median following the recession (Figure 7). However, for NAEP scores (Figure 8), college-going rates (Figure 9), and high school graduation rates (Figure 10) we find no statistically significant differences between states that are above vs below median K-12 state revenue share.

Our event study results are different from JWX, which finds significant differences after 2007 in NAEP scores and college going rates for states that are above vs. below the median for state revenue share. The threshold used in JWX for the event study graphs has changed significantly across different versions of the paper (i.e., from 0.33 to 0.39 to 0.48). Based on our analysis, we believe that the latest version of JWX may present results for a lower cutoff (i.e., 0.39) than is stated in the paper (i.e., 0.48 - the national median).[22]

Group IV

Tables 5A through 5C present the results of our group IV estimation. The letters A-C in the table names correspond to our three outcome variables: A) NAEP scores, B) college-going rates, and C) high school graduation rates. We estimate results both without (Columns 1-5) and with (Columns 6-10) Bartik economic controls. Columns 1 and 6 provide results from JWX for comparison. We model each of the four state categorization frameworks presented in Table 3: JWX categorization (Columns 2 and 7), NCES data using

[21] We also tested adding state and local higher education appropriations per FTE and tuition and fees per FTE in the linear IV. The variation inflation factors (VIFs) for both variables were well above recommended levels in these models, indicating significant multicollinearity with other included variables.

[22] The change in the cutoff from 0.39 to 0.48 moves 16 states from one group to the other.

JWX assignment rules (Columns 3 and 8), NCES data using top and bottom decile for assignment (Columns 4 and 9), and NCES data using top and bottom quartile for assignment (Columns 5 and 10).[23]

For both NAEP and college-going, our estimates using the JWX categorization are similar in magnitude and significance to the JWX results. Changing data sources for the instrument from Census to NCES appears to make little difference to the estimates. However, when we apply categorizations based on top and bottom decile/quartile, point estimates shrink toward zero, going negative in the case of NAEP, and lose significance. We also provide results for high school graduation rates, which are insignificant across all specifications.

Our estimates indicate that the JWX group IV results are highly sensitive to state group definitions. Using the top and bottom decile of pre-recession K-12 state revenue share only modestly changes the low- and high- reliance group composition, adding 2 and 3 states to those groups, respectively. However, even this relatively minor change yields insignificant results for both NAEP and college-going.

Linear IV

As noted in the motivation section, a key component of JWX's linear specification is how year fixed effects are modeled. Instead of including the full set year fixed effects, JWX groups years into three indicator variables for pre-, during-, and post-recession. We test eight different specifications for year fixed effects to better understand the model's robustness around this choice. Table 4 describes each of the specifications we employ.

Tables 6A-C present the results of our linear IV. As in the previous section, the letters in the table names correspond to our outcomes: A) NAEP scores, B) college-going rates, C) high school graduation rates. Column 1 provides the JWX results for comparison. The remaining columns in Tables 6A-C correspond to rows in Table 4, which outline the various year fixed effect specifications.

We replicate similar magnitudes and significance levels for the impact of instrumented PPE on both NAEP and the college-going rate when using the JWX specification (Columns 1 and 3). For NAEP scores all other specifications for the year fixed effects yield insignificant results and point estimates that shrink toward zero (Table 6A). On the other hand, the findings for college-going rate appear to be robust to changes in year fixed effects specification as all specifications yield positive and significant results of roughly the same magnitude (Table 6B). The point estimates for high school graduation are very close to zero, not consistent in sign, and insignificant in all but one specification.

These findings indicate that the NAEP results are highly sensitive to different specifications of the year fixed effects. While the college-going results appear more robust, the sensitivity of the NAEP results and lack of statistically significant effects on high school graduation rates call into question the pathway by which PPE affects college-going. If PPE did not have a consistent effect on student test scores and did not impact graduation rates, then how did it affect the college-going rate? The next section provides one potential answer to that question.

Higher Education Confounding

While the JWX college-going results appears to be robust in the linear IV models above, there is reason to believe that it is confounded with contemporaneous higher education trends. Section III describes why

[23] For NCES state share, we use average state share from 2005-2007 instead of 2008 state revenue share. This ensures that the instrument is measured pre-recession and captures persistent state share.

we believe this is the case and section IV lays out our three-pronged approach for empirically demonstrating that confounding likely exists between K-12 and higher education spending.

First, we replace the K-12 state share instrument with pre-recession state share of higher education revenue. Table 8 presents the results of this exercise for both NAEP and college-going. The first two columns in each panel provide the JWX findings and our replicated results from Table 6. Results using the higher education state share instrument are found in the final two columns of Table 8. Replacing the instrument with higher education revenue yields point estimates that are of similar magnitude and significance to those obtained using K-12 state share. This indicates that state shares of K-12 and higher education revenue are likely confounded.

Next, we estimate linear IV models replacing the dependent variable with state and local higher education appropriations per FTE and tuition and fees per FTE. Tables 9A and 9B present the results of those models. As in the linear IV section we provide results across all year fixed effect specifications outlined in Table 4. For all 16 specifications except the model including full year fixed effects for tuition and fees, we find that instrumented PPE is statistically significant and positively related to state and local higher education appropriations per FTE and tuition and fees per FTE. The ability of instrumented PPE to predict higher education funding variables indicates that the IV exclusion restriction may be violated in the JWX college-going model.

Finally, we estimate JWX-style IV models to predict college-going rates using pre-recession state share of higher education revenue to instrument for state and local higher education appropriations per FTE and tuition and fees per FTE. We also estimate these models substituting K-12 state share as the instrument in place of higher education revenue. This investigates whether the confounding of the instrument is also apparent when higher education spending is treated as the endogenous variable. We estimate these models using the natural log of appropriations and tuition and fees per FTE. Table 10 provides the results for those models. All specifications yield statistically significant, positive point estimates, indicating that higher education spending is a viable alternative pathway for impacting college-going rates.

Based on the results of the three tests, we believe that the JWX college-going finding is confounded with contemporaneous higher education trends. While it may be feasible that both K-12 spending and higher education spending impact college-going, we do not think it is possible to disentangle those impacts using a JWX-style IV approach.

VI. Conclusions

As states face looming budget shortfalls and schools grapple with the effects of COVID-19, it has become increasingly important to understand the potential impact of education funding reductions on student outcomes. Using data from the years around the Great Recession, JWX suggests that K-12 spending reductions have widespread negative impacts on both student achievement and attainment. While we believe that spending reductions may have negative impacts on student outcomes, our analysis provides evidence that the JWX results are not robust and are unlikely to represent the true causal impact of spending changes on educational outcomes. Instead, our results show:

- the JWX group IV results depend on categorizing very few states as having low-reliance (***three*** states) or high-reliance (***four*** states) on state revenue to fund K-12 education, and the results are sensitive to small changes in group composition;

- the JWX linear IV results rely on a non-standard specification for year fixed effects, and the results are sensitive to using other reasonable specifications to control for year-specific effects; and
- K-12 and higher education funding trends are highly correlated, and as a result, the JWX finding that K-12 spending reductions impacted state college-going rates is likely confounded with contemporaneous higher education funding trends.

Our results highlight the challenges of estimating causal effects for loosely defined interventions (e.g., funding changes) at the level of states and the importance in exercising caution when making policy recommendations based on such studies. It is not surprising that it is difficult to empirically estimate the impact of school funding on student outcomes. K-12 education is a complex system and how schools deal with funding changes varies widely both within and across states. Unless those changes are substantial and have a direct, sizeable impact on classrooms, student outcomes are unlikely to respond quickly enough to be captured in short timeframes. Therefore, it is questionable whether rigorous research can consistently show that school spending matters for educational outcomes on such a broad scale.

Research that digs deeper into the into the specific context of how spending changes have been implemented within states and districts is more likely to uncover meaningful connections between how money is spent and how schools and students fare. These questions are of deep policy relevance as states and districts struggle to deal with the COVID-19 era challenges and beyond.

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Tables and Figures

Figure 1: IV Directed Acyclic Graph (DAG)

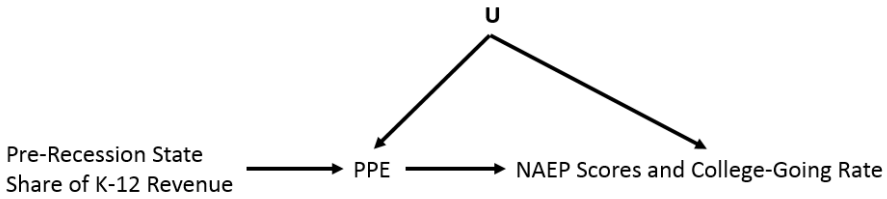
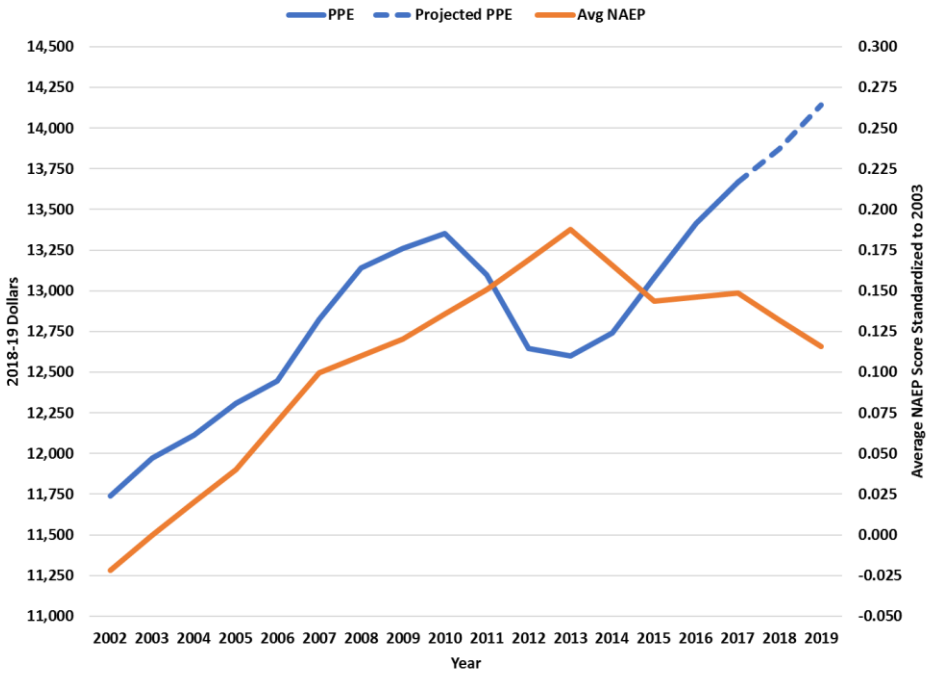
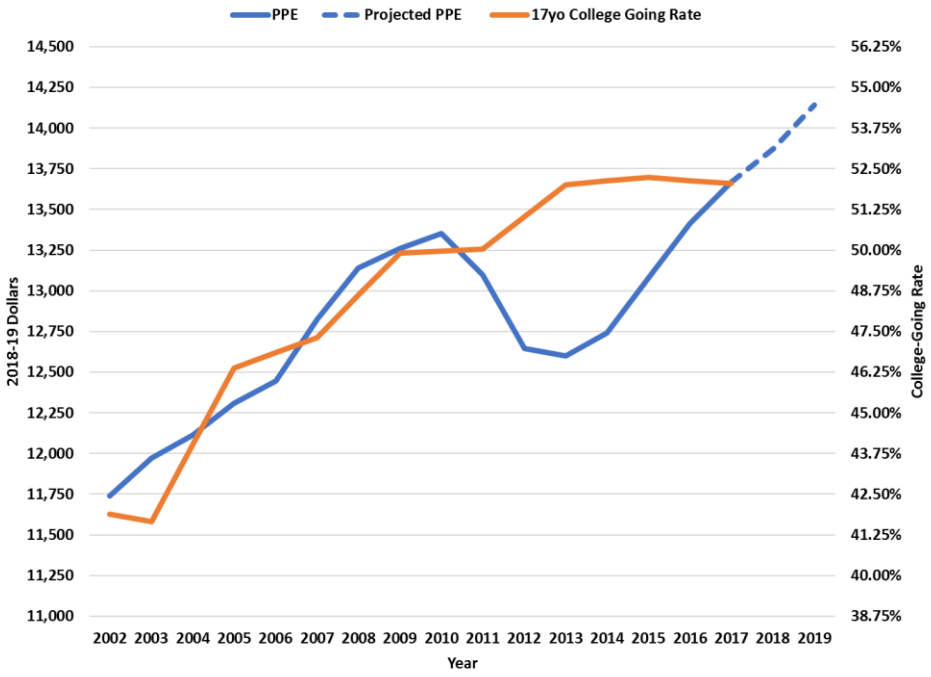


Figure 2: Per-Pupil Current Expenditures (PPE) and Average NAEP Scores



Notes: PPE was collected from the 2019 NCES Digest of Education Statistics table 236.55. Average NAEP is the national public average score on reading and mathematics tests standardized to 2003. NAEP data were collected from the NAEP Data Explorer. Only the reading test was administered in 2002. Mathematics test scores for that year were imputed using linear interpolation.

Figure 3: Per-Pupil Current Expenditures (PPE) and College-Going Rate



Notes: PPE was collected from the 2019 NCES Digest of Education Statistics table 236.55. The college-going rate is the number of first-time enrollees in the fall semester who graduated high school in the past 12 months divided by the Census estimate for the number of 17-year-olds in the previous year. The national rate was calculated by summing the numerator and denominator across states in each year. See the Data section for more details on the data and calculation.

Figure 4: College-Going IV Directed Acyclic Graphs (DAGs)

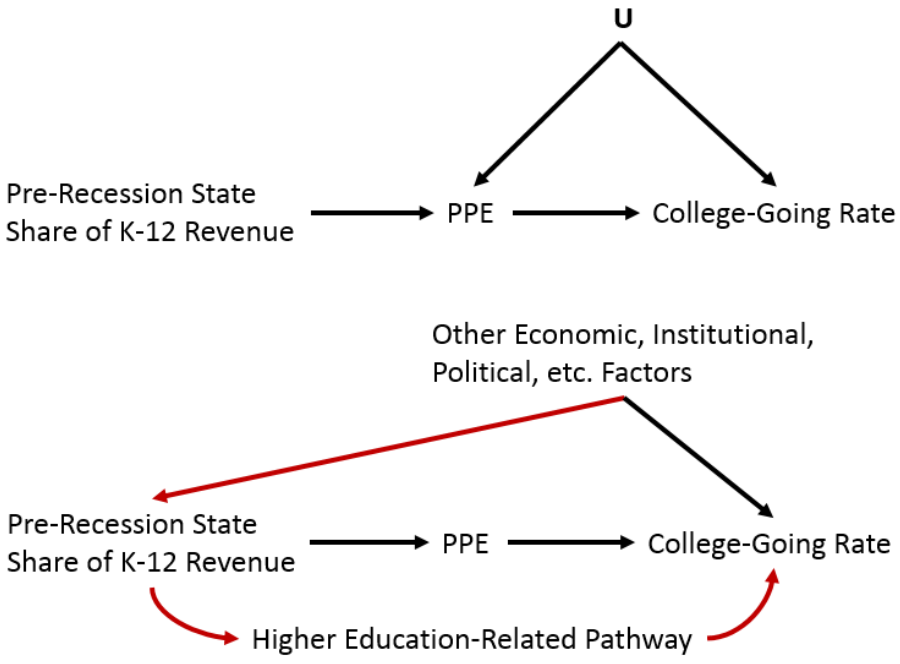
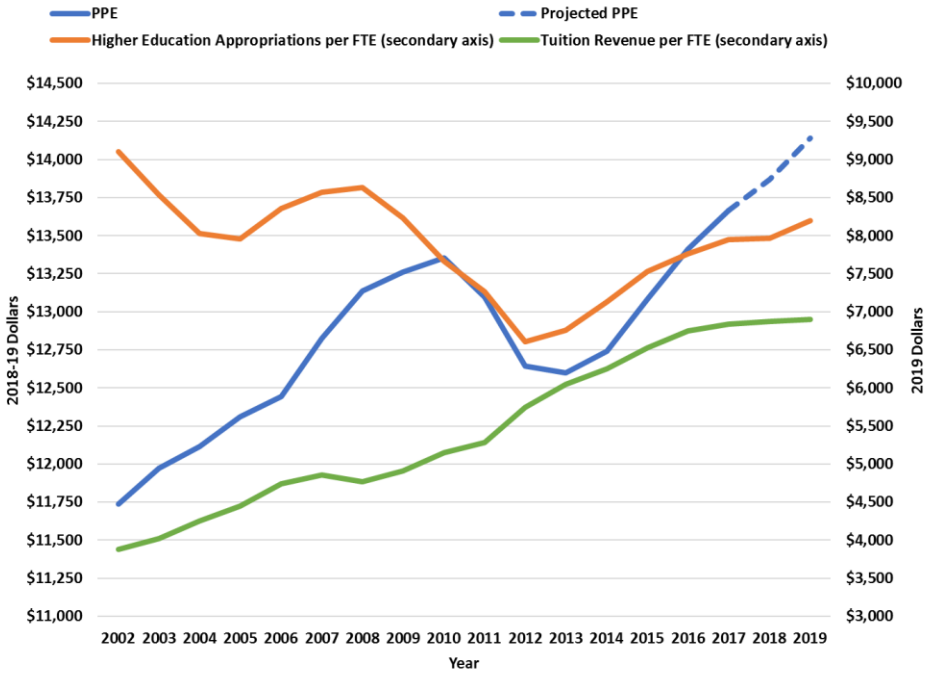
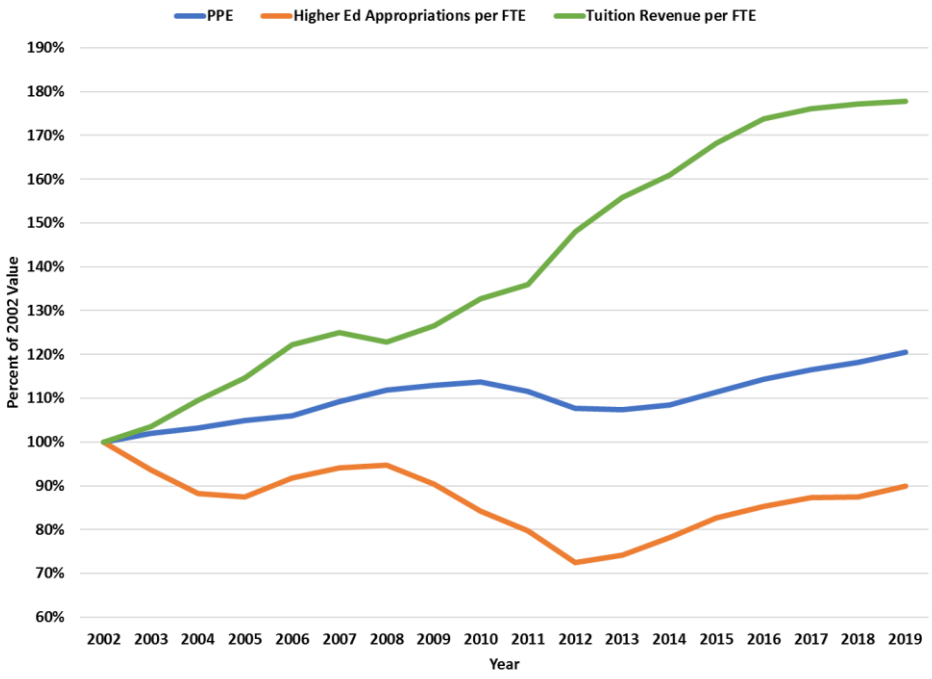


Figure 5: Per-Pupil Current Expenditures (PPE) and Higher Education Funding Trends



Notes: PPE was collected from the 2019 NCES Digest of Education Statistics table 236.55. State and local appropriations per FTE and tuition and fees per FTE are obtained from the State Higher Education Executive Officers Association (SHEEO, 2019).

Figure 6: 2002 Indexed Per-Pupil Current Expenditures (PPE) and Higher Education Funding Trends



Notes: PPE was collected from the 2019 NCES Digest of Education Statistics table 236.55. State and local appropriations per FTE and tuition and fees per FTE are obtained from the State Higher Education Executive Officers Association (SHEEO, 2019).

Figure 7: Per-Pupil Expenditures Event Study Graph
Using 48 Percent Threshold for High-Reliance

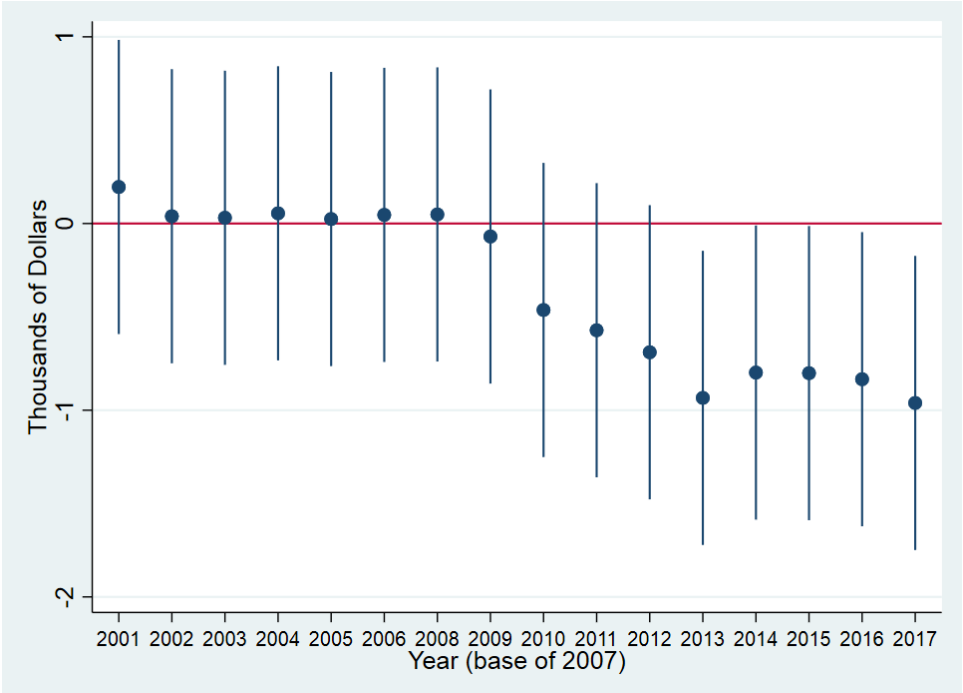


Figure 8: NAEP Scores Event Study Graph
Using 48 Percent Threshold for High-Reliance

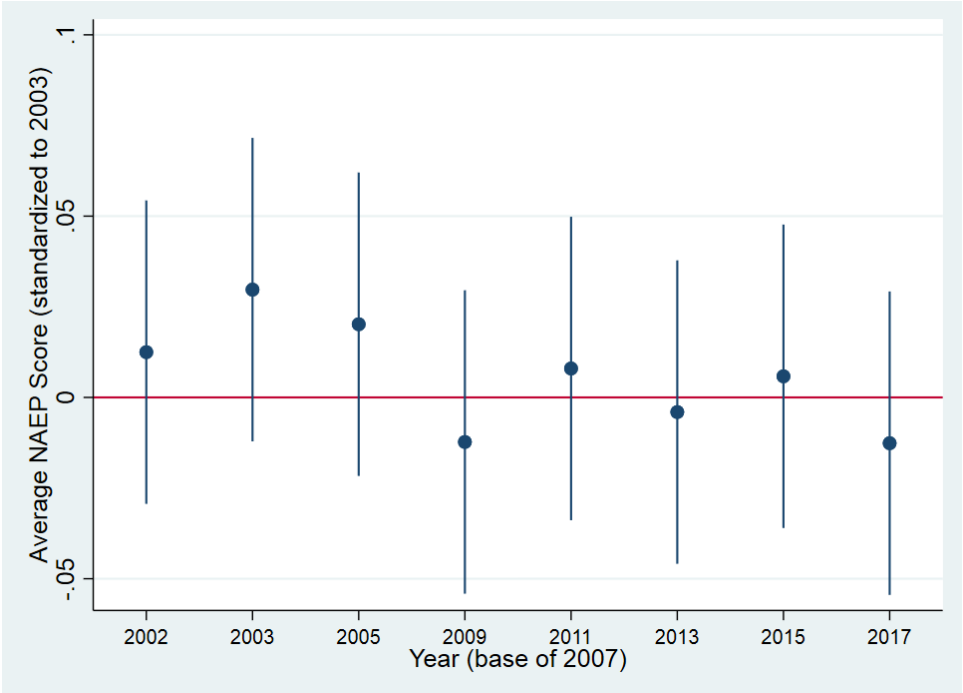


Figure 9: College-Going Rate Event Study Graph
Using 48 Percent Threshold for High-Reliance

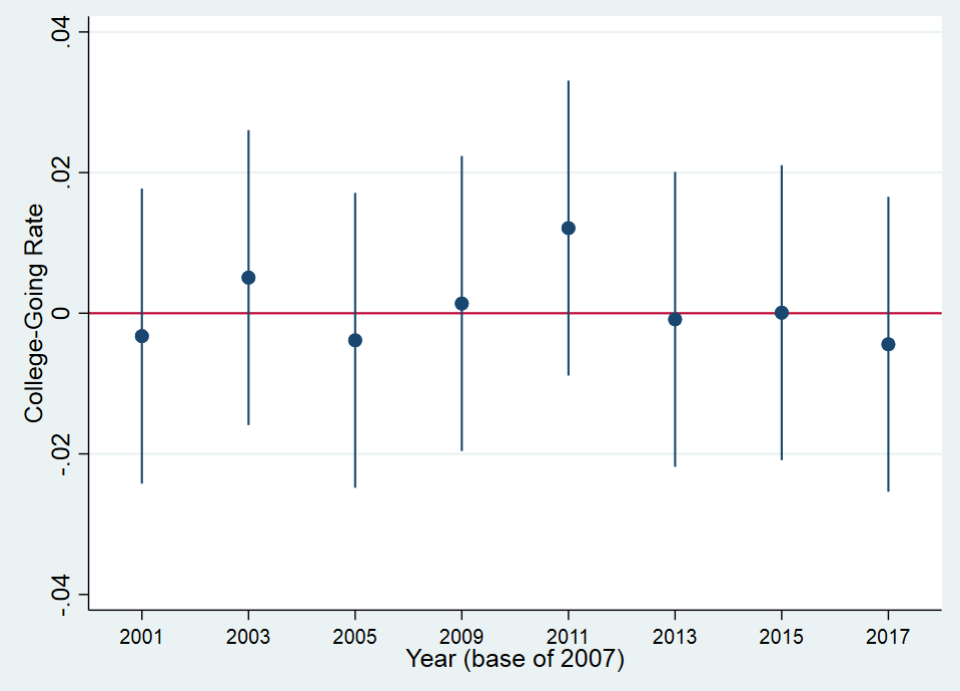


Figure 10: High School Graduation Rate Event Study Graph
Using 48 Percent Threshold for High-Reliance

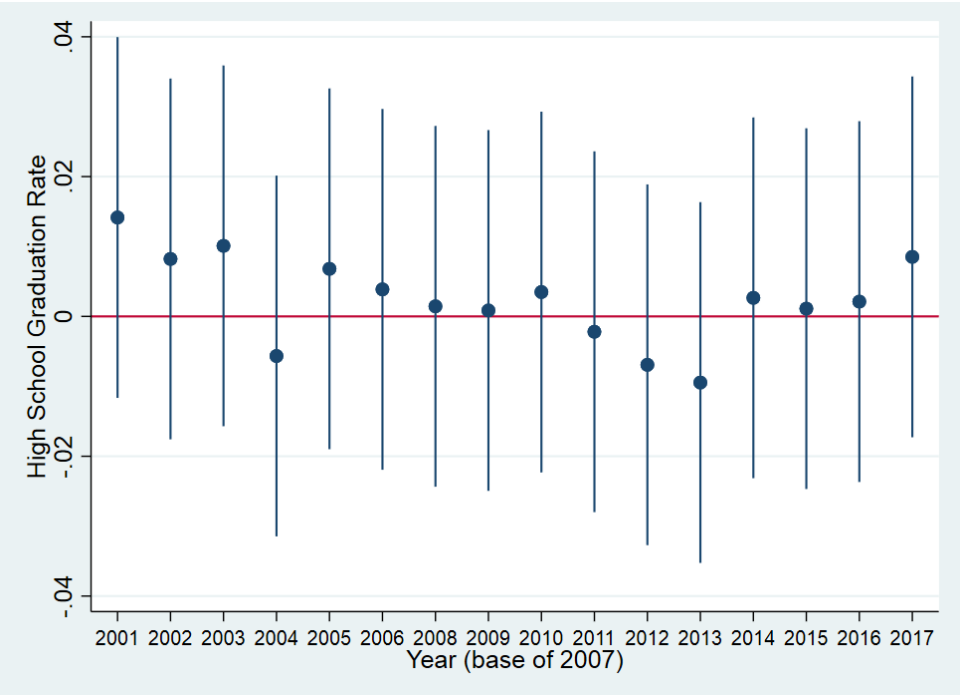


Table 1: Study Data Summary Statistics

	JWX Values			Replication Values			P-Value for t-test of Difference in Means
	N	Mean	SD	N	Mean	SD	
Per-pupil spending (2015 dollars)	510	13,208	3,807	510	13,203	3,699	0.98
Share of revenue from state sources in 2008 (Jackson)	51	0.493	0.137	51	0.493	0.137	
Share of revenue from state sources in 2008 (Census)				51	0.502	0.144	
Share of revenue from state sources in 2008 (NCES)				51	0.496	0.144	
Share of revenue from property taxes in 2008 (NCES)				51	0.300	0.131	
Average NAEP Z-Score (standardized to 2003)	459	0.125	0.211	459[24]	0.120	0.200	0.71
College Enrollment Rate (17-year-olds)[25]	459	0.475	0.078	459	0.480	0.079	0.33
College Enrollment Rate (18-year-olds)				459	0.471	0.080	
College Enrollment Rate (17 & 18-year-olds)				459	0.237	0.039	
High School Graduation Rate[26]				510	0.773	0.081	
Unemployment Rate	510	5.777	1.965	510	5.742	1.955	0.78
Annual Average Employment (thousands)	510	2,603.81	2,820.57	510	2,600.10	2,822.63	0.98
Average Annual Wage (2015 dollars)				510	53,052.66	10,744.91	
Bartik Unemployment Rate				510	5.972	1.659	
Bartik Average Annual Wage (2015 dollars)				510	46,807.09	1,496.35	

Notes: Variables were collected for each state and the District of Columbia for the following years: 2001, 2002, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. College-going variables are available for odd numbered years starting in 2001. We use NAEP from 2002 matching JWX. NAEP test scores are standardized to 2003, and then averaged for each state and year.

[24] Only the reading test was administered in 2002, and five states do not have 2002 NAEP scores: AK, CO, NH, NJ, and SD. We used 2003 average reading z-score as the 2002 value for these five states.

[25] We model the college-going rate as the number of first-time college enrollees divided by the number of 17-year-olds in a state. JWX says that they use the number of 17 and 18-year-olds, but the means do not match when we use the larger group. Previous working paper versions of JWX used 17-year-olds.

[26] Data from 2001-2013 represent Average Freshman Graduation Rate (AFGR) values and data from 2014-2019 are Adjusted Cohort Graduation Rates (ACGR).

Table 2: Data on 2008 State and Property Tax K-12 Revenue Share

	Census[27]	JWX	NCES	NCES
State	State Revenue as a Percentage of Total Revenue			Property Tax Revenue as a Percentage of Total Revenue
ALABAMA	60.2%	60.2%	60.6%	13.1%
ALASKA	64.9%	64.9%	66.3%	8.9%
ARIZONA	48.5%	48.1%	51.7%	29.6%
ARKANSAS	76.0%	75.7%	56.7%	26.5%
CALIFORNIA	59.9%	57.9%	61.3%	21.8%
COLORADO	42.4%	42.1%	42.2%	39.8%
CONNECTICUT	38.5%	37.8%	39.6%	54.2%
DELAWARE	63.0%	61.2%	62.0%	25.0%
D.C.	0.0%	0.0%	0.0%	25.3%
FLORIDA	39.4%	39.4%	38.8%	43.0%
GEORGIA	45.2%	45.1%	45.4%	31.4%
HAWAII	84.8%	84.8%	84.8%	0.0%
IDAHO	65.5%	65.5%	67.1%	17.5%
ILLINOIS	33.8%	32.9%	31.2%	51.2%
INDIANA	48.5%	47.3%	53.5%	26.4%
IOWA	46.5%	44.8%	46.5%	30.1%
KANSAS	58.4%	58.4%	57.5%	25.9%
KENTUCKY	57.9%	57.9%	57.3%	21.3%
LOUISIANA	43.9%	43.6%	44.8%	13.8%
MAINE	44.5%	43.2%	44.9%	43.1%
MARYLAND	42.0%	42.0%	42.1%	24.8%
MASSACHUSETTS	42.1%	41.8%	41.9%	48.4%
MICHIGAN	57.3%	54.6%	57.5%	28.9%
MINNESOTA	65.8%	64.4%	65.9%	16.2%
MISSISSIPPI	53.8%	53.7%	54.5%	22.4%
MISSOURI	41.1%	40.8%	33.3%	44.2%
MONTANA	49.4%	49.0%	49.7%	22.9%
NEBRASKA	33.0%	32.3%	33.1%	49.6%
NEVADA	57.5%	57.5%	30.8%	29.4%
NEW HAMPSHIRE	38.6%	37.1%	38.6%	52.7%
NEW JERSEY	41.3%	40.0%	42.1%	50.3%
NEW MEXICO	71.2%	71.2%	70.8%	11.1%
NEW YORK	45.4%	45.2%	44.8%	44.0%
NORTH CAROLINA	58.8%	58.8%	65.7%	18.6%
NORTH DAKOTA	36.1%	34.7%	36.3%	39.1%
OHIO	44.1%	43.0%	45.6%	37.7%
OKLAHOMA	51.2%	51.2%	54.2%	23.8%
OREGON	52.8%	52.4%	52.3%	28.9%
PENNSYLVANIA	35.8%	34.3%	36.5%	41.9%
RHODE ISLAND	38.7%	38.5%	39.9%	50.6%
SOUTH CAROLINA	50.7%	50.6%	50.8%	29.6%
SOUTH DAKOTA	33.2%	33.1%	33.9%	41.6%
TENNESSEE	46.1%	45.9%	45.6%	20.5%
TEXAS	43.2%	43.1%	44.8%	38.7%
UTAH	56.3%	56.3%	56.7%	24.7%
VERMONT	88.5%	68.3%	85.9%	0.1%
VIRGINIA	41.0%	40.3%	41.0%	25.6%
WASHINGTON	62.4%	61.9%	62.5%	23.2%
WEST VIRGINIA	58.1%	58.1%	59.1%	25.9%
WISCONSIN	50.1%	49.2%	50.0%	39.0%
WYOMING	52.9%	52.8%	52.8%	27.2%

Note: Across the various data sources, green is used to highlight states that have 2008 state revenue share less than 0.33 and red is used to highlight states that have 2008 state revenue share greater than 0.67.

[27] Census values are provided because JWX differs from the Census data.

Table 3: Categorization for Group IV

	JWX Groups[28]	NCES State Revenue Share Data Using JWX Assignment Rules	NCES State Revenue Share Data Using Top and Bottom Decile	NCES State Revenue Share Data Using Top and Bottom Quartile
Low-Reliance	***D.C.*** IL NE	***D.C.*** IL NE **NV**	***D.C.*** IL NE **NV** **SD**	**CT** ***D.C.*** **FL** IL **MO** NE **NV** **NH** **ND** **PA** **RI** **SD**
High-Reliance	AR ***HI*** NM VT	***HI*** **MN** NM VT	**DE** ***HI*** **MN** NM **NC** VT	**AL** **AK** **CA** **DE** ***HI*** **ID** **MI** **MN** NM **NC** VT **WA** **WV**

Notes: States that are highlighted in red are different from the JWX categorization. D.C. and Hawaii are in bold and italics because their education funding systems are fundamentally different from other states. D.C. is a city and single school district, and it relies heavily on federal funding. Because of its peculiar setup, D.C. has zero state revenue share in the data. The entire state of Hawaii is a single district managed by the state, making any attempt to separate state vs. local revenue somewhat moot.

Table 4: Year Groupings for Fixed Effects

	Number of Year Fixed Effects	2001/2002	2003	2005	2007	2009	2011	2013	2015	2017
No Year Fixed Effects	0	-	-	-	-	-	-	-	-	-
JWX Grouping	3	P	P	P	P	D	D	A	A	A
Grouping 2	3	P	P	P	P	D	D	A	A	A
Grouping 3	4	P	P	P	X	D	D	A	A	A
Grouping 4	5	P	P	P	X	D	X	A	A	A
Grouping 5	5	P	P	P	P	D	D	X	X	X
Grouping 6	6	P	P	P	P	D	X	X	X	X
Full Year Fixed Effects	9	X	X	X	X	X	X	X	X	X

Notes: Colors are used to indicate year groupings for fixed effects. P indicates pre-recession group. D indicates during recession group. A indicates after recession group. X indicates individual year fixed effect. The rows correspond to the different estimation results in columns 2-9 of tables 4A-C.

[28] Based on the text of JWX the group cutoffs are state share less than 1/3 for low reliance and state share greater than 2/3 for high reliance. When implementing these rules, JWX appears to have simplified to 0.33 and 0.66. If the 1/3 rule had been applied strictly, South Dakota should also have been included in the low-reliance group.

Table 5A: Group IV – NAEP[29]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No Economic Controls					Bartik Economic Controls				
	JWX Result[30]	JWX Categorization	NCES, JWX rules	NCES, Top & Bottom Decile	NCES, Top & Bottom Quartile	JWX Result[31]	JWX Categorization	NCES, JWX rules	NCES, Top & Bottom Decile	NCES, Top and Bottom Quartile
Per-Pupil Spending (thousands)	0.0365***	0.0394**	0.0456**	0.0327*	-0.0167	0.0385***	0.0472**	0.0524*	0.0389	-0.0197
	(0.0103)	(0.0122)	(0.0160)	(0.0164)	(0.0247)	(0.0110)	(0.0172)	(0.0233)	(0.0218)	(0.0327)
Pre-Recession State Trends	X	X	X	X	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X	X	X	X	X
Bartik Economic Controls						X	X	X	X	X
Observations	459	459	459	459	459	459	459	459	459	459

Table 5B: Group IV – College-Going Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No Economic Controls					Bartik Economic Controls				
	JWX Result[32]	JWX Categorization	NCES, JWX rules	NCES, Top & Bottom Decile	NCES, Top & Bottom Quartile	JWX Result[33]	JWX Categorization	NCES, JWX rules	NCES, Top & Bottom Decile	NCES, Top and Bottom Quartile
Per-Pupil Spending (thousands)	0.0127***	0.0135***	0.0227**	0.0152	0.0075	0.0124***	0.0203**	0.0299**	0.0212	0.0148
	(0.0030)	(0.0032)	(0.0084)	(0.0090)	(0.0083)	(0.00387)	(0.0066)	(0.0111)	(0.0122)	(0.0137)
Pre-Recession State Trends	X	X	X	X	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X	X	X	X	X
Bartik Economic Controls						X	X	X	X	X
Observations	459	459	459	459	459	459	459	459	459	459

[29] In all results tables, stars represent the following significance levels: 1 percent (***), 5 percent, (**), and 10 percent (*).
[30] Table 3 column 3 from JWX
[31] Table 3 column 4 from JWX
[32] Table 3 column 7 from JWX
[33] Table 3 column 8 from JWX

Table 5C: Group IV – High School Graduation Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No Economic Controls					Bartik Economic Controls				
	JWX Result	JWX Categorization	NCES, JWX rules	NCES, Top & Bottom Decile	NCES, Top & Bottom Quartile	JWX Result	JWX Categorization	NCES, JWX rules	NCES, Top & Bottom Decile	NCES, Top and Bottom Quartile
Per-Pupil Spending (thousands)	-	0.0079	0.0433	0.0338	-0.0000	-	0.0132	0.0481	0.0424	0.0081
	-	(0.0082)	(0.0325)	(0.0304)	(0.0174)	-	(0.0094)	(0.0341)	(0.0345)	(0.0258)
Pre-Recession State Trends	-	X	X	X	X	-	X	X	X	X
Year Fixed Effects	-	X	X	X	X	-	X	X	X	X
Bartik Economic Controls	-					-	X	X	X	X
Observations	-	867	867	867	867	-	867	867	867	867

Table 6A: Linear IV – NAEP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	JWX Results[34]	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	0.0552***	0.0357***	0.0304***	0.0294	-0.0049	0.0094	0.0071	0.0147	0.0291
	(0.0152)	(0.0133)	(0.0095)	(0.0252)	(0.0196)	(0.0221)	(0.0148)	(0.0193)	(0.0272)
Pre-Recession State Trends	X	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X	X
Observations	459	459	459	459	459	459	459	459	459

Table 6B: Linear IV – College-Going Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	JWX Results[35]	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	0.0377***	0.0231***	0.0146***	0.0306***	0.0240***	0.0159***	0.0140***	0.0101***	0.0237*
	(0.00969)	(0.0033)	(0.0020)	(0.0069)	(0.0042)	(0.0037)	(0.0020)	(0.0021)	(0.0123)
Pre-Recession State Trends	X	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X	X
Observations	459	459	459	459	459	459	459	459	459

[34] Table 3 column 3 from the Northwestern University working paper version of JWX (2020b).
[35] Table 3 column 9 from the Northwestern University working paper version of JWX (2020b).

Table 6C: Linear IV – High School Graduation Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	JWX Results	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	-	-0.0038	-0.0054	0.0134**	0.0044	0.0086	-0.0050	-0.0019	0.0040
	-	(0.0042)	(0.0045)	(0.0066)	(0.0069)	(0.0068)	(0.0045)	(0.0044)	(0.0131)
Pre-Recession State Trends	-	X	X	X	X	X	X	X	X
Bartik Economic Controls	-	X	X	X	X	X	X	X	X
Observations	-	867	867	867	867	867	867	867	867

Table 7A: Linear IV using Property Tax Share – NAEP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	JWX Results[36]	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	0.0552***	0.0313**	0.0306***	-0.0360	-0.0195	-0.0181	-0.0190	-0.0254	-0.0377
	(0.0152)	(0.0127)	(0.0100)	(0.0272)	(0.0226)	(0.0227)	(0.0149)	(0.0195)	(0.0565)
Pre-Recession State Trends	X	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X	X
Observations	459	459	459	459	459	459	459	459	459

Table 7B: Linear IV using Property Tax Share – College-Going Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	JWX Results[37]	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	0.0377***	0.0164***	0.0116***	0.0130**	0.0156***	0.0149***	0.0095***	0.0077***	0.0039
	(0.00969)	(0.0038)	(0.0026)	(0.0051)	(0.0048)	(0.0048)	(0.0024)	(0.0023)	(0.0159)
Pre-Recession State Trends	X	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X	X
Observations	459	459	459	459	459	459	459	459	459

[36] Table 3 column 3 from the Northwestern University working paper version of JWX (2020b).
[37] Table 3 column 9 from the Northwestern University working paper version of JWX (2020b).

Table 7C: Linear IV using Property Tax Share – High School Graduation Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	JWX Results	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	-	0.0024	0.0005	0.0171**	0.0249***	0.0214***	0.0006	0.0020	-0.0070
	-	(0.0033)	(0.0032)	(0.0082)	(0.0081)	(0.0080)	(0.0032)	(0.0033)	(0.0255)
Pre-Recession State Trends	-	X	X	X	X	X	X	X	X
Bartik Economic Controls	-	X	X	X	X	X	X	X	X
Observations	-	510	510	510	510	510	510	510	510

Table 8: Replace Instrument with State Share of Higher Education Revenue

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	NAEP Scores				College-Going Rate			
	JWX Result[38]	JWX Grouping from Table 6A	No Year Fixed Effects	JWX Grouping	JWX Result[39]	JWX Grouping from Table 6B	No Year Fixed Effects	JWX Grouping
Per-Pupil Spending (thousands)	0.0552***	0.0304***	0.0325***	0.0293***	0.0377***	0.0146***	0.0196***	0.0116***
	(0.0152)	(0.0095)	(0.0123)	(0.0093)	(0.00969)	(0.0020)	(0.0040)	(0.0024)
Pre-Recession State Trends	X	X	X	X	X	X	X	X
Year-Group Fixed Effects	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X
Observations	459	459	459	459	459	459	459	459

Table 9A: Predict State Appropriations Per FTE for Higher Education

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	530.16***	399.46***	225.30	567.66***	332.17*	377.20***	255.56**	701.59**
	(136.71)	(109.28)	(254.78)	(164.12)	(181.94)	(111.81)	(119.91)	(326.25)
Pre-Recession State Trends	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X
Observations	850	850	850	850	850	850	850	850

[38] Table 3 column 3 from the Northwestern University working paper version of JWX (2020b).
[39] Table 3 column 9 from the Northwestern University working paper version of JWX (2020b).

Table 9B: Predict Tuition and Fees Per FTE for Higher Education

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	No Year Fixed Effects	JWX Grouping	Grouping 2	Grouping 3	Grouping 4	Grouping 5	Grouping 6	Full Year Fixed Effects
Per-Pupil Spending (thousands)	336.35***	257.58***	476.16**	227.28**	285.38**	258.02***	285.75***	199.13
	(104.69)	(71.29)	(236.66)	(112.03)	(144.14)	(75.31)	(86.84)	(281.88)
Pre-Recession State Trends	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X
Observations	850	850	850	850	850	850	850	850

Table 10: Linear IV for College-Going using Log State Appropriations Per FTE and Log Tuition Per FTE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Higher Education Share				JWX K-12 State Share			
	State Appropriations		Tuition		State Appropriations		Tuition	
	No Year Fixed Effects	JWX Grouping	No Year Fixed Effects	JWX Grouping	No Year Fixed Effects	JWX Grouping	No Year Fixed Effects	JWX Grouping
Ln (State Approps or Tuition)	0.1831***	0.1185**	0.1884***	0.1321***	0.2441***	0.1883***	0.2269***	0.1596***
	(0.0616)	(0.0543)	(0.0587)	(0.0506)	(0.0589)	(0.0582)	(0.0630)	(0.0487)
Pre-Recession State Trends	X	X	X	X	X	X	X	X
Bartik Economic Controls	X	X	X	X	X	X	X	X
Observations	450	450	450	450	450	450	450	450