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Privatization and Cost Inefficiency at U.S. Public Research Universities

Abstract

This study examines the relationship between cost efficiency and privatization at 163 public research institutions in the United States between 2005 and 2015. We employ a spatial autoregressive (SAR) random-effects model and stochastic frontier analysis (SFA) to estimate the relationship between costs and four privatization variables: auxiliary enterprises as a percentage of total revenue, tuition and fees as a percentage of total revenue, private grants/contracts as a percentage of total revenue, and out-of-state first year enrollment. Results showed cost inefficiency at public research universities increased between 2005 and 2015, even as reliance on private sources of revenue increased. Public research universities exhibit 28.5% overall cost inefficiency over the time period studied, 85.6% of which is short-run cost inefficiency. This suggests that most of the cost inefficiency varies across years and may be the result of challenges that institutional leaders face adapting to short-term fluctuations in market-oriented sources of revenue. The results also show a nonlinear relationship between cost inefficiency and three of the privatization variables. Given the expectation of little to no increase in state support for public research universities, this study has implications for policy, institutional management, and future research.

Keywords: educational finance; public research universities; privatization; cost efficiency; stochastic frontier analysis; spatial analysis

JEL Classification: I22, I23, I29, H52

Declarations of interest: none

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Economic recessions and associated reductions in state tax revenues have had a significant impact on the finances of public universities and the students who attend them. Public universities have been pushed by policy makers to improve performance (Ortagus et al., 2020), often with fewer state resources, even as the costs of providing higher education have increased (Archibald & Feldman, 2008). State appropriations on a per-student basis have decreased for the average public university by 30% over the past 30 years (Webber, 2017). Although state appropriations per student have increased for eight consecutive years, the increases have not made up for steep budget cuts enacted during the last two recessions, and per-student appropriations in 12 states are still below 2008 levels (State Higher Education Executive Officers [SHEEO], 2021).

State disinvestment has led to greater tuition dependence and calls from some public universities for greater autonomy from the state to determine tuition prices (McClure, et al., 2020). The costs of providing higher education have increasingly been pushed to students and families, through hikes in tuition and fees. Net tuition revenue as a percentage of total revenue increased from 29% to 46% between 1992 and 2017 (SHEEO, 2018), while inflation-adjusted student fees increased by 95% between 1999 and 2012 (Kelchen, 2016). This shift in finances has been conceptualized as de facto privatization, raising concerns about public universities' mission, accessibility, and financial sustainability over time (Lyall & Sell, 2006).

The transition in public higher education towards privatization has been explicitly advocated by some policy analysts (e.g., Garrett & Poole, 2006), who have contended that privatizing public universities' operations would result in cost efficiencies. However, there has been no systematic examination of the relationship between privatization and cost inefficiency in public higher education. This study investigates how cost inefficiency is related to privatization at U.S. public research universities between 2005 and 2015. We examine two types of inefficiency: short-run/residual and long-run/persistent. Residual inefficiency captures singular management errors or incorrect responses to changes in market conditions and factor prices at one point in time. By contrast, persistent inefficiency reveals recurring management errors and repeated misallocation of resources that may be due to long-term management problems.

This study employs stochastic frontier analysis (SFA) to analyze costs and cost inefficiency of public research universities. Following Titus et al. (2017), we employ spatial econometrics to account for the possibility that universities across state borders or those located in rural versus metropolitan settings face differing costs. We use panel data analysis to evaluate the cost inefficiency of 163 public research universities over an 11-year period. The empirical results inform campus leaders, researchers, and policy makers about how privatization has affected the finances of public research universities.

Literature Review

Research has examined the origins, manifestations, and consequences of privatization in U.S. public higher education (McClure et al., 2020). Priest et al. (2006) defined privatization as "the process of transforming low-tuition institutions that are largely dependent on state funding to provide mass enrollment opportunities at low prices into institutions dependent on tuition revenues and other types of earned income as central sources of operating revenue" (p. 2). Research points to tuition dependence, nonresident enrollment, philanthropic donations, and auxiliary services as variables tied to privatization in public higher education (McClure et al., 2020). Despite research showing growth in alternative revenues, we located few studies examining the relationship between these variables and cost efficiency. In a related study, Sav (2017) estimated the impacts of decreases in state funding support on the operating efficiency of public colleges and universities in the U.S. using panel data for 378 institutions spanning 10 years. The results showed decreases in state funding was associated with production inefficiency.

Privatization has been a response to declining state appropriations to public universities (McClure et al., 2020). Lyall and Sell (2006) documented this pattern in state appropriations: "whether measured by [inflation-adjusted] state appropriations per student, by the share of state budgets spent on higher education, or by the investment per $1,000 of state income devoted to higher education, state investment in public higher education has been shrinking" (p. 8). As of 2017, for the first time in U.S. history, most states' public universities relied upon tuition revenue more than state appropriations to cover expenses (SHEEO, 2018). On a per student basis, net tuition revenue increased 96% in constant dollars over the last 25 years (SHEEO, 2018). Webber (2017) found that for every $1,000 reduction in per-student state appropriations to public universities, the average student would pay $275 more per year in tuition. Researchers have concluded that the financial profiles of many public research universities have come to more closely resemble those of private nonprofit research universities (Hearn, 2006). Accordingly, tuition dependence due to state funding cuts has been studied as a manifestation of privatization (McClure et al., 2020).

Increased reliance on tuition revenue has affected the recruitment goals of public research institutions, which have pursued out-of-state, first-year students. Out-of-state students tend to pay more in tuition, score better on standardized tests, are wealthier, and are less likely to be Black or Latinx (Jaquette et al., 2016). According to Jaquette (2017), in 11 states the public flagship university enrolls more than 50% of its first-year student body from out-of-state. While the immediate impact on revenue of such a strategy can be positive, Jaquette et al. (2016) found that an increase in the proportion of out-of-state students was associated with a decrease in the share of low-income and underrepresented minority students, particularly at highly selective public research universities. Han et al. (2019) showed that one mechanism driving these patterns is that public research universities were more likely to visit out-of-state high schools in affluent communities within major metropolitan areas where the students were predominantly white. Consequently, research points to recruiting out-of-state students with the goal of generating net tuition revenue as a form of privatization.

Public universities have explored additional sources of revenue to complement tuition and enrollment strategies. Two of the most common are philanthropic donations and auxiliary services (e.g., residence halls, dining halls, and bookstores) (Priest et al., 2006). Public research universities have increasingly invested in fundraising capacity, and both the size of major gifts and comprehensive fundraising campaigns have grown over time (McClure & Anderson, 2020). Cheslock and Gianneschi (2008) found that between 1994 and 2004, as state appropriations fell, donations to public universities' current fund grew by 50%. Stalowski (2021) found that at public doctoral universities decreasing state appropriations was associated with increasing philanthropic funding between 2011 and 2018. The prioritization of philanthropic donations has been conceptualized as a turn towards private sources of funding and a manifestation of privatization (McClure et al., 2020).

In addition to private giving, many public universities have turned to auxiliary services for revenue (Priest et al., 2006). These services include campus housing, dining, parking, conferences, and athletic events. The price of on-campus room and board increased by 25% at public universities between 2008 and 2018 (Ma et al., 2018). Many recent campus housing projects have been debt-financed and/or constructed through public-private partnerships because state governments have refused to appropriate state funds for these facilities (McClure et al., 2017). The importance of auxiliary services as a revenue stream became clear during the pandemic, when many public universities needed federal stimulus money to cover revenue shortfalls caused by campus closures and some institutions continued to house students, despite public health warnings (Whitford, 2021). Although auxiliary services typically represent a small share of a public university's total revenues, it has been discussed as a private revenue source whose importance to public universities' finances has increased and a form of privatization (Priest et al., 2006).

Theoretical Framework

The research design for this study is built around (i) the revenue theory of costs (Bowen, 1980) and (ii) multi-product costs functions (Baumol et al., 1982). The revenue theory of costs is one of the most widely used theories to explain cost escalation in higher education. In a market economy, economic forces and competitive pressures incentivize firms to maximize profits by producing efficiently. Bowen (1980) argued that universities do not operate with the goal of producing efficiently (i.e., maximizing profits/minimizing costs) but instead aim to maximize income and spending in an effort to increase their prestige, excellence, and influence. Since total costs are only constrained by total revenue, he argues that rising costs reflect the common institutional strategy of maximizing revenue in pursuit of excellence/prestige.

Using Bowen's theory, we examine how decreases in state funding are associated with the maximization of other revenue sources: (i) tuition, (ii) auxiliary enterprises, (iii) private grants/contracts, and (iv) the fraction of full-time, first-year students paying non-resident tuition, and whether these shifts influenced cost inefficiency at public research universities between 2005 and 2015. It is possible that the replacement of state funds with revenue sources earned through competition in a market will compel public research universities to be more cost conscious and manage resources to maximize return on investment. Alternatively, the privatization of public research institutions may, as Bowen (1980) posited, encourage the competitive pursuit of prestige and produce increased spending. As an example of this latter relationship, McClure and Titus (2018) found that as public universities sought to be classified as research universities, an organizational behavior tied to prestige-seeking, they spent more on administration.

The second theoretical framework is based on microeconomic theory detailing the relationship between costs of production and the producer's outputs, inputs, input prices, and other exogenous factors. Baumol et al.'s (1982) work on multi-product cost functions has been adapted to higher education (Cohn et al., 1989) by measuring university outputs via undergraduate and graduate full-time equivalent (FTE) enrollment in a specific year. The most commonly used measure for research output is research expenditures. The higher education teaching-research output mix is "produced" with a key input: faculty. The price or cost of this input is quantified by average full-time faculty salaries[5] (Kuo & Ho, 2008).

The cost function associated with multiple products has been studied (Baumol et al., 1982) in multiple mathematical forms (Johnes, 1997). The translog functional form is known for its flexibility (Christensen et al., 1973), and since we are not restricted by zero values, we choose it with all variables natural log transformed. The translog form depicts a second-order approximation to a cost function, facilitating the estimation of the cost frontier and permitting coefficients to be interpreted, after geometric mean normalization, as elasticities of output estimated at the means of the data (Kumbhakar et al., 2014). Our translog total cost (*TC*) function of producing *k* outputs at each of the *n* public research universities across multiple years *t* is:

$$lnTC_{nt} = \sum_{i=1}^{k} a_i lnQ_{int} + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} b_{ij} lnQ_{int} lnQ_{jnt} + \frac{1}{2}\sum_{i=1}^{k} c_i lnQ_{int} lnFSal_{nt}$$

$$+ \frac{1}{2}\sum_{i=1}^{k} d_i lnQ_{int} lnFtFac_{nt} + \frac{1}{2} f_1 lnFSal_{nt} lnFtFac_{nt} + f_2 lnFSal_{nt}$$

$$+ f_3 lnFtFac_{nt} + \frac{1}{2} f_4 lnFSal_{nt}^2 + \frac{1}{2} f_5 lnFtFac_{nt}^2 + g_1 lnX_{nt} + g_2 Y_{nt} + a_n + v_t$$

$$+ u_{nt} + (\gamma_{nt} + \delta_n) \qquad (1)$$

[5] The authors looked for reliable and complete data on part-time faculty salaries. We investigated *The Chronicle of Higher Education*'s crowd-sourced data on salaries for instructors and adjuncts, but few institutions were present in the database for multiple years and our study spans 15 years.

where n represents the nth institution; t is the tth time period; i is the ith output. Q is a vector of outputs (undergraduate/graduate education and research), *FtFac* is an input (number of full-time faculty), *FSal* is the input prices (faculty salary), X is a vector of measures of the degree of privatization and Y is a vector of institutional characteristics.

Some higher institutions in the same geographic area may view each other as competitors with respect to expenditures, namely salaries, which represent a major expenditure for universities. Therefore, institutional expenditures in the same geographic area may be more alike than institutions in different areas. To further investigate if this cost correlation exists, we introduce a spatial component to the analysis, by accounting for the distance between any two research institutions as described by their longitude and latitude coordinates. This spatial econometrics approach captures cost dependencies due to localized labor costs and market conditions among institutions that are in close geographical proximity. This spatial consideration allows us to reduce the bias in the estimation and better explain the variation in costs across institutions and years

Research Design

Data and Variables

This study uses data from the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS) on 163 public research universities covering the fiscal years 2005 through 2015 (for a total of 1,793 cases). This sample of 163 institutions includes all the US universities that have the 2015 Carnegie classifications of Doctoral Universities: Highest Research Activity (R1), Doctoral Universities: Higher Research Activity (R2) and Doctoral Universities: Moderate Research Activity (R3). We removed private institutions and the public institutions that did not have consistent data for the eleven years studied.

The Office of Postsecondary Education identity (OPEID) number is used to establish the institutional unit of analysis.[6] Total operating costs is the dependent variable in this study and is calculated as the sum of expenditures on administration (academic and institutional support), instruction, and student services. Per IPEDS, depreciation is included in the calculations. We excluded data on plant maintenance and public service because their numerous missing values for multiple institutions and years.

The independent variables depicting *inputs and outputs* are: the number of full-time faculty; FTE undergraduate and FTE graduate enrollment; and research expenditures as a percentage of total expenditures. The latter has been used as a proxy for research output to better capture the differences in research activity among universities relative to other institutional priorities. The Max Planck Institute runs a database of publications/citations for Germany's academia, an alternative measure for research output (Gralka et al., 2019), but such a database does not exist in the U.S. Two benefits of using the current measure of research output are (i) being able to compare our results with previous work and (ii) avoiding the multiple counting of publications for coauthors from multiple institutions (Gralka et al., 2019, p. 330). We considered support staff as an input; however, in 2012, there was a major reclassification of occupations in IPEDS, which does not allow a consistent count across jobs before and after.

The key variables are those capturing manifestations of *privatization* at public research institutions over the 11 year period studied. Consistent with the literature review, we considered four measures of privatization: the percentage of revenue derived from tuition; the percentage of revenue from auxiliary services; the percentage of revenue from private gifts/contracts; and the percentage of full-time, first-year students paying out-of-state tuition.

[6] See Jaquette and Parra (2014) regarding why the OPEID is preferred to the IPEDS UNITID when establishing the institution unit of analysis.

We *control* for other factors related to costs: whether the institution is part of a state system of institutions, has an affiliated hospital, is located in a large urban/suburban area, or is a historically black college or university. The 2010 Carnegie classification identifies the level of research activity of each institution (R1- very high, R2 - high, R3 - moderate). To alleviate potential bias, we omitted any institution that changed tiers in the Carnegie Classification during 2005/2010/2015 (McClure & Titus, 2018). Time fixed-effects are included to capture yearly shocks impacting all institutions (changes in federal postsecondary education policies or economic indicators). All continuous variables are adjusted for inflation, normalized (divided by their respective geometric means) and log transformed.

Descriptive Statistics

Table 1 provides descriptive statistics for the variables in the study.

[Insert Table 1]

[Insert Figure 1]

Table 1 shows costs have increased by 55% over the 11-year period, while revenue increased by 36%. State support declined from 30.3% of revenue (2005) to 21.6% (2015). Figure 1 gives a breakdown of costs per FTE. With respect to the privatization measures (Table 1), tuition and fees as a percent of revenue increased by 9%, from 29.6% (2005) to 38.6% (2015); revenue generated from auxiliary services accounted for 11.8% and had a modest increase, while revenue from private gifts/contracts accounted for nearly 3% of total revenue with a 0.4% increase over time. First-time full-time undergraduate enrollment, the fourth measure for privatization, increased from 16.8% (2005) to 22.8% (2015).

Analytical Techniques

Spatial econometrics uses statistical techniques designed to consider dependence among observations that are in close geographical proximity as measured by their latitude/longitude coordinates. The results of the Pesaran test for panel data cross-sectional dependence indicate spatial autocorrelation with respect to costs and unobserved common shocks with heterogeneous impact across, or spillover effects between, public research universities. Therefore, we employed a spatial autoregressive (SAR) model to estimate the translog cost function. The SAR model is based on a row standardized inverse distance weighted matrix, which depicts both the spatial arrangement of the universities and the intensity of the interaction between institutions. SAR models take into account spatially lagged correlation of the errors, compared to non-spatial random-effects models with no spatially correlated error component (Lee & Yu, 2010), therefore controlling for heterogeneity among public universities with similar but unobserved characteristics within a given geographic area. Furthermore, we test for heteroskedasticity and the need for time fixed-effects and account for both. We used the Stata user-written program *xsmle* to estimate the SAR random-effects model (Belotti et al., 2017).

Incorporating the spatial analysis, the Eq. 1 total cost function becomes:

$$
\begin{aligned}
lnTC_{nt} = {} & \sum_{i=1}^{k} a_i lnQ_{int} + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} b_{ij} lnQ_{int} lnQ_{jnt} + \frac{1}{2}\sum_{i=1}^{k} c_i lnQ_{int} lnFSal_{nt} \\
& + \frac{1}{2}\sum_{i=1}^{k} d_i lnQ_{int} lnFtFac_{nt} + \frac{1}{2} f_1 lnFSal_{nt} lnFtFac_{nt} + f_2 lnFSal_{nt} \\
& + f_3 lnFtFac_{nt} + \frac{1}{2} f_4 lnFSal_{nt}^2 + \frac{1}{2} f_5 lnFtFac_{nt}^2 + g_1 lnX_{nt} + g_2 Y_{nt} \\
& + \rho \sum_{m=1}^{n} w_{nm} lnTC_{mt} + a_n + v_t + u_{nt} + (\gamma_{nt} + \delta_n) \qquad (2)
\end{aligned}
$$

Where $\sum_{m=1}^{n} w_{nm} lnTC_{mt}$ is the spatial lag of the dependent variable and ρ is the SAR parameter. γ_{nt} captures the residual/short-run institution-level efficiency, δ_n captures the persistent/long-run institution level efficiency, a_n represents the random institution effects, v_t captures the time fixed-effects, and u_{nt} is the typical idiosyncratic and normally distributed error.

Institution Efficiency Estimation

Stochastic frontier analysis (SFA) is a widely used statistical method to evaluate efficiency (Agasisti & Salerno, 2007). Tsionas's (2002) and Greene's (2005) work allow for a cost function to be estimated for each institution while acknowledging heterogeneity in universities based on specific characteristics (e.g., size, research versus teaching intensity).

Tests for normality (Chen & Shapiro, 1995) of the u_{nt} idiosyncratic and $a_n$random effects errors from the SAR random effects model indicate non-normal distributions of both, further justifying use of SFA to generate estimates of cost inefficiency. The SFA employed in this research is a modified version of the multi-step approach developed by Kumbhakar et al. (2014) and previously adapted to higher education by Titus et al. (2017). Following Badunenko and Kumbhakar's (2017) application examining cost efficiency in the Indian banking industry, the KLH-SFA generated estimates of cost inefficiency are regressed against the measures of privatization.[7]

Short-run/residual inefficiency captures singular management errors or incorrect responses to changes in market conditions, isolated mismanagement of resources and changes in factor prices such as salaries, rents, and interest rates at one point in time. Long-run/persistent inefficiency reveals recurring management errors and repeated misallocation of resources that may be due to long-term management problems. Therefore, unlike persistent cost inefficiency, residual cost

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[7] More specifically, the Stata user-written program *sfmodel* by Kumbhakar and Lovell (2000) is used to regress estimates of short-term (residual) and long-term (persistent) cost inefficiency on measures on privatization.

inefficiency varies over time (Filippini et al., 2018). Consequently, this study focuses on how residual cost inefficiency is influenced by privatization at public research universities.

Results

The main results of our analysis show overall cost inefficiency is 28.5% over the 11-year period, with 85.6% of cost inefficiency being short-term/residual. Auxiliary services and tuition revenue, both measured as a percent of total revenue, are negatively related to costs. Furthermore, some of the privatization variables have a nonlinear relationship with residual cost inefficiency. We detail these below.

Cost Function Parameters

The spatial random effects model explains 82% of the variance in costs within and 91% across public universities (Table 2). The spatial rho of the SAR random effects model is positive and statistically significant, indicating positive spatial autocorrelation in costs at public universities.

Total costs are positively associated with FTE undergraduate (beta = 0.448, $p < 0.001$) and FTE graduate (beta = 0.073, $p < 0.01$) enrollment. Costs are also positively associated with the number of full-time faculty (beta = 0.558, $p < 0001$) and average faculty salaries (beta = 0.636, $p < 0.001$). Costs are negatively related to the percentage of expenditures on research (beta = -0.203, $p < 0.001$). The coefficients on the quadratic values of the outputs are only significant for the research variable (beta = -0.045, $p < 0.001$), indicating that as research output increases at high levels, costs decrease, holding all else constant. Table 2 shows that research expenditures as a percent of total expenditures and the number of full-time faculty exhibit cost complementarities (beta = -0.515, $p<0.001$).

Looking specifically at the privatization variables, costs decline as the percent of revenue from auxiliary services (beta = -0.085, $p < 0.01$) and tuition revenue (beta = -0.215, $p < 0.001$)

increase. Costs are not statistically related to the percentage of revenue from private gifts/contracts and the percent of first-time, full-time out-of-state undergraduate students.

For control variables, compared to a public research university with moderate research activity, higher costs are incurred at R1 institutions (beta = 0.720, $p < 0.001$) and R2 (beta = 0.290, $p < 0.001$) universities. The most research-intensive institutions may have lower teaching loads for tenured and tenure-track faculty, thus requiring more spending on other instructional faculty. Additionally, they likely spend more on research facilities, faculty salaries, and sponsored research management. Costs are also higher at public research universities with affiliated hospitals (beta = 0.246, $p < 0.001$).

[Insert Table 2]

Cost Inefficiency Indices

Overall inefficiency at public research universities over the 11-year period averages 28.5%. This metric is far less informative than each of its components (i.e., short-run and long-run inefficiency). As defined previously, short-run/residual inefficiency captures singular management errors or incorrect responses to changes in market conditions and factor prices at one point in time. There is a non-linear increase over the 11-year period, from an average short-run cost inefficiency index of 14.6% in 2005 to 32.7% in 2015 (Table 3). Figure 3 shows the R3 institutions have the lowest level of short-run inefficiency (mean 10.3%), followed by R2s (16%) and R1s (36.8%). The R3s also have the lowest increase in inefficiency over time (from 5.3% in 2005 to 13.5% in 2015), followed by the R2s (9% to 21.7%) and R1s (22.8% to 49.1%).

[Insert Table 3]

[Insert Figure 2]

[Insert Figure 3]

Persistent/long-run cost inefficiency reveals recurring management errors/repeated misallocation of resources due to long-term management problems. Results show persistent/long-run cost inefficiency is low (mean 4.1%). A lower mean is expected, since in the long-run, all inputs are variable and, therefore, the institution is less constrained in determining the optimal input mix than in the short-run, where fixed factors are present. However, there is a wider range of values across institutions, with a 0.9% index at the low end and 44.4% at the high end (Table 3). Figure 4 shows the histogram/kernel density of the persistent cost inefficiency indices by type of research activity, revealing a smaller difference across the three categories than in the residual/short-run cost inefficiency.

[Insert Figure 4]

Long-term cost inefficiency is a sign of a consistent issue, with the 4.1% persistent cost inefficiency revealing that, on average, public research institutions could reduce their costs by 4.3% (1/(1-0.041)-1). This number varies greatly, with those in the 10th percentile only needing a 1% reduction in cost, while those in the 99th percentile benefiting from a 30.1% reduction.

Privatization and Cost Inefficiency

We regressed short-run inefficiency against the variables reflecting privatization and time fixed-effects. Table 4 demonstrates that short-run cost inefficiency is quadratic. Revenue from auxiliary services are associated with an increase in residual inefficiency when below 2.5% and decreases thereafter. The mean of auxiliary services as a percent of revenue is 11.9%, past the 2.5% value, indicating that residual inefficiency is continuously decreasing in this privatization variable. Private grants/contracts revenues lead to an increase in residual inefficiency when under 2% and decrease thereafter. The mean of private grants/contracts as a percent of revenue is 2.9%, higher than the 2% critical value, indicating that residual inefficiency is continuously decreasing in this privatization variable. The percentage of out-of-state, first-year students is linked to an increase in residual inefficiency when below 2.6% and decreases thereafter. The mean for out-of-state first-year enrollment is 19.4%, significantly higher than the 2.6% turning point value, indicating that residual inefficiency is continuously decreasing in this privatization variable.

Residual inefficiency decreases linearly (squared term not statistically significant) as the percent of revenue from tuition increases (beta = -6.01, $p < 0.05$); then, increases in tuition as a percentage of total revenue always reduce cost inefficiency. Furthermore, the time fixed-effects show short-run inefficiency increases over time, after considering the influence of the privatization variables.

Robustness Check

We investigated if our estimates are sensitive to changes in the output measures by repeating the analysis with student credit hours at the undergraduate and graduate level as an output (Sav, 2004). Tables A1 and A2 in the Appendix show the two regression results side-by-side. The new inefficiency scores are roughly within 0.007 or 0.7% of our original results, suggesting the results are valid even with changes in the output measure.

Discussion

Lyall and Sell (2006) argued that privatization in higher education has some positive impacts, such as "incentives for increased operating efficiency and greater attention to consumer preferences imposed by the necessity to operate with the discipline of the competitive marketplace" (p. 9). The present study investigated the relationship between privatization and cost inefficiency at public research universities. There are three main results.

First, results revealed cost inefficiency at public research universities increased between 2005 and 2015, even as reliance on private sources of revenue increased. Out of the 28.5% overall cost inefficiency, 85.6% is residual. This suggests that most of the cost inefficiency varies across years and may be the result of challenges institutional leaders face adapting to short-term fluctuations in market-oriented sources of revenue. Short-run inefficiency increased drastically (18.1%) and exhibited a nonlinear time trend. The R3s were the least cost inefficient and R1s were the most cost inefficient, possibly because R1s require more spending to achieve and maintain that designation (McClure & Titus, 2018). Specifically, these institutions must free up more faculty time and use more staff/facilities to support research activities. This can be achieved by reducing enrollment in both the undergraduate and graduate programs and by further hiring graduate students or adjunct faculty to teach, which may be a sub-optimal mix of labor inputs to minimize costs. Compared to less research-intensive institutions, R1s may also have to invest more in labs/research facilities and face higher overhead costs not covered by research grants.

Second, all measures of privatization were significant in understanding cost inefficiency. The percentage of revenue from auxiliary services and private gifts/contracts, and the percentage of out-of-state students, are associated with an increase in cost inefficiency up to 2.5%, 2%, and 2.6% of their values. The literature suggests that out-of-state students tend to be wealthier, pay more in tuition, and score better on standardized tests (Jaquette et al., 2016). Therefore, these students can bring certain benefits to institutions in terms of tuition revenue and prestige. Consistent with the revenue theory of costs (Bowen 1980), recruiting out-of-state students may require additional spending on admissions staff for out-of-state travel and establishing relationships with a larger out-of-state network of high schools (Han et al., 2019). Consequently, an increase in out-of-state students initially may result in a less than optimal mix of inputs and resources required to minimize costs. Public research institutions have already passed the period of initial increase in inefficiency attributed to out-of-state enrollment (16.8% in 2005, 22.8% in 2015), thus consistently reducing short-run cost inefficiency.

Third, increases in tuition as a percent of revenue reduce cost inefficiency. Tuition has become the most important revenue source to public universities as state appropriations have declined (SHEEO, 2018). It is possible that an increase in tuition revenue is associated with optimal levels of output, via increases in the retention of existing students rather than the recruitment of new students, thereby realizing lower cost per student. Earlier research (Titus, 2006) suggested that student persistence at four-year institutions is positively related to the percent of revenue derived from tuition. A more recent study (Fowles, 2014) contended that an increased reliance on tuition leads to more student-related expenditures. However, more research is recommended on the relationship between tuition revenue and cost inefficiency.

Policy makers should be heartened that, on average, public research universities demonstrated low persistent cost inefficiency. This means that public research universities are not generally experiencing repeated misallocation of resources or management problems. Nevertheless, residual cost inefficiency, on average, was increasing over the time period, indicating difficulties managing economic shocks and fluctuations from market-oriented revenues. This makes a strong case for state support to allow for successful operations during periods of economic instability. While not captured in the cost inefficiency indices, the reduced state support also raises the issue of what the policymakers prioritize in terms of access and equity. Specifically, the active recruitment of out-of-state students paying out-of-state tuition could reduce in-state students' access to public research institutions. Many states have established statewide college attainment goals (Lumina Foundation, 2021), and reaching those goals often relies on closing completion gaps between white, affluent students and underserved student populations. If public research institutions have financial incentives to prioritize recruitment of out-of-state students, it may be harder to serve in-state students that are the target of state attainment goals. Policy makers should also prepare for the possibility that permitting/incentivizing out-of-state recruitment may initially mean institutions spend more than they would for in-state recruitment.

The methodology and results employed allow for the identification of those public research universities that are operating cost-efficiently. Policy makers should take note of the higher costs/cost inefficiency of R1s. This does not mean states should forgo investment in these institutions, but rather recognize that R1s may face greater challenges in terms of correctly responding to market fluctuations. Some states (e.g., Texas) have enacted policies to encourage the creation of more research-focused universities through dedicated funds for emerging research universities (Texas Higher Education Coordinating Board, 2021). Such a policy may dramatically improve the research productivity of universities, but may not be the best use of state funds, especially given the demonstrated cost efficiency of master's institutions (Titus et al., 2017). Overall, figuring out how to improve cost efficiency may require looking closely at specific practices. Within a given state or state system, there may be examples of cost efficiency that guide practices/policies at both the state and institution level.

This study revealed avenues for future research. While the results sheds light on how various variables linked to privatization influence cost inefficiency, this study does not provide causal explanations. Future research could involve qualitative case studies of cost-efficient institutions and/or quantitative studies employing causal models.

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APPENDIX (see separate document)

APPENDIX

Table A1 (Table 2 equivalent): SAR Random Effects Model of Total Operating Costs at Public Research Universities, FTE (fulltime equivalent) vs SCH (student credit hours)

VARIABLES	Total Effects (*FTE*)	Total Effects (*Stud Credit Hours*)
FTE Ug (col 1) / SCH Ug (col 2)	0.448***	0.354***
	(0.063)	(0.060)
FTE Grad (col 1) / SCH G (col 2)	0.073***	0.063**
	(0.026)	(0.027)
Research expenditure as a percent of total expenditures	-0.203***	-0.203***
	(0.038)	(0.038)
Full-time faculty	0.558***	0.577***
	(0.074)	(0.073)
Avg. full-time faculty salary	0.636***	0.596***
	(0.124)	(0.122)
FTE Ug*FTE G (col 1) / SCH Ug*SCH G (col 2)	0.034	0.014
	(0.146)	(0.134)
FTE Ug (col 1) / SCH Ug (col 2) * Research expenditure as a percent of total expenditures	0.255	0.210
	(0.187)	(0.160)
FTE Ug (col 1) / SCH Ug (col 2) * Full-time faculty	-0.430	-0.752**
	(0.468)	(0.348)
FTE Ug (col 1) / SCH Ug (col 2) * Avg. full-time faculty salary	1.073*	0.846
	(0.628)	(0.534)
FTE G (col 1) / SCH G (col 2) * Research expenditure as a percent of total expenditures	-0.011	-0.004
	(0.063)	(0.062)
FTE G (col 1) / SCH G (col 2) * Full-time faculty	0.111	0.006
	(0.193)	(0.160)
FTE G (col 1) / SCH G (col 2) * Avg. full-time faculty salary	-0.119	0.073
	(0.337)	(0.307)
Research expenditure as a percent of total expenditures * Full-time faculty	-0.515***	0.039
	(0.143)	(0.176)
Research expenditure as a percent of total expenditures * Avg. full-time faculty salary	0.149	0.050
	(0.256)	(0.055)
Full-time faculty * Avg. full-time faculty salary	-0.144	-0.503***
	(0.636)	(0.124)
FTE Ug (col 1) / SCH Ug (col 2) – Squared	-0.013	0.111
	(0.221)	(0.245)
FTE G (col 1) / SCH G (col 2) – Squared	0.032	-0.189

	(0.056)	(0.531)
Research expenditure as a percent of total expenditures – Squared	-0.045***	-0.046***
	(0.012)	(0.011)
Full-time faculty – Squared	0.230	0.524**
	(0.326)	(0.243)
Avg. full-time faculty salary – Squared	-0.066	-0.059
	(0.738)	(0.731)
Auxiliary enterprises – percent of revenue	-0.085***	-0.085***
	(0.027)	(0.025)
Private grants and contracts – percent of revenue	0.012	0.008
	(0.009)	(0.009)
Tuition – percent of revenue	-0.215***	-0.201***
	(0.056)	(0.057)
Out-of-state first-time full-time first-years – percent	-0.000	-0.000
	(0.006)	(0.006)
Highest research activity (reference group – moderate research activity)	0.720***	0.705***
	(0.118)	(0.122)
Higher research activity (reference group – moderate research activity)	0.290***	0.277***
	(0.073)	(0.074)
Part of a System	0.028	0.013
	(0.043)	(0.042)
HBCU	-0.012	-0.010
	(0.081)	(0.083)
Affiliated Hospital	0.246***	0.209**
	(0.087)	(0.083)
Located in a large urban/suburban area	0.024	0.022
	(0.045)	(0.046)
Spatial rho	.238***	0.206***
	(.056)	(0.058)
Year fixed-effects	Yes	Yes
Number of observations	1,793	1,793
Number of institutions	163	163
R^2 – within	0.820	0.820
R^2 – between	0.915	0.906

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2 (Table 3 equivalent). Regression, Via Maximum Likelihood, of the Effects of Privatization on Cost Inefficiency

VARIABLES	Short-Run (Residual) Beta Coeff – FTE	Short-Run (Residual) Beta Coeff – Stud Credit Hours
Auxiliary enterprises – percent of revenue	7.66***	7.61***
	(1.346)	(1.411)
Auxiliary enterprises – percent of revenue Squared	-1.51***	-1.48***
	(0.270)	(0.283)
Private grants and contracts – percent of revenue	3.64***	3.71***
	(0.618)	(0.616)
Private grants and contracts – percent of revenue Squared	-0.89***	-0.89***
	(0.225)	(0.221)
Tuition – percent of revenue	-6.01**	-5.71**
	(2.663)	(2.782)
Tuition – percent of revenue Squared	0.49	0.42
	(0.408)	(0.428)
Out-of-state first-time full-time first-years - percent	2.74***	2.33***
	(0.653)	(0.633)
Out-of-state first-time full-time first-years – percent Squared	-0.53***	-0.48***
	(0.122)	(0.119)
2006	0.12	0.13
	(0.476)	(0.474)
2007	0.46	0.46
	(0.462)	(0.461)
2008	0.81*	0.79*
	(0.456)	(0.459)
2009	1.34***	1.34***
	(0.439)	(0.440)
2010	1.92***	1.94***
	(0.434)	(0.435)
2011	2.01***	2.04***
	(0.441)	(0.442)
2012	2.18***	2.24***
	(0.440)	(0.442)
2013	2.36***	2.43***
	(0.443)	(0.444)
2014	2.49***	2.57***
	(0.445)	(0.446)
2015	2.65***	2.74***
	(0.444)	(0.446)
Constant	-4.17	-3.92
	(3.923)	(4.130)
Observations	1,793	1,793
Log Likelihood	-1547.93	-1532.34

Wald $\chi 2$	111.49***	104.34***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3 (Table 4 equivalent): Residual/Short-Run Cost Inefficiency Indices by Year – Student Credit Hours as output

Cost Inefficiency	Year	Mean	Min	P10	P25	P50	P75	P99	Max
Residual	2005	0.142	0.014	0.031	0.055	0.109	0.198	0.607	0.737
Residual	2006	0.152	0.008	0.036	0.063	0.115	0.21	0.599	0.747
Residual	2007	0.176	0.012	0.045	0.076	0.135	0.241	0.641	0.766
Residual	2008	0.198	0.012	0.048	0.095	0.158	0.279	0.608	0.766
Residual	2009	0.23	0.014	0.06	0.11	0.185	0.333	0.638	0.786
Residual	2010	0.267	0.02	0.079	0.123	0.22	0.392	0.693	0.809
Residual	2011	0.263	0.023	0.073	0.129	0.222	0.39	0.699	0.792
Residual	2012	0.269	0.033	0.08	0.133	0.229	0.392	0.769	0.793
Residual	2013	0.288	0.025	0.089	0.152	0.254	0.415	0.746	0.795
Residual	2014	0.302	0.016	0.102	0.154	0.269	0.442	0.76	0.806
Residual	2015	0.319	0.018	0.107	0.152	0.29	0.467	0.778	0.826
Residual	Overall	0.237	0.008	0.06	0.105	0.19	0.335	0.688	0.826

TABLES 1-4

Table 1. Descriptive Statistics

Variables	Mean 2005	Mean 2015	Mean all years	SD	Min	Max
Total Operating Cost (million $)	345.9	535.2	440.5	357.5	39.5	2,940
Total Gross Tuition & Fee Revenue (in million $)	203.3	363.1	278.3	227.8	11.3	1,833
Total Revenue (in million $)	817.2	1,108	955.7	924	64	6,345
Research Expenditures (million $)	138.3	180.8	163.3	193.5	0.2	992.7
FTE Graduate Enrollment	3,693	4,047	4,114	2,977	305	20,423
FTE Undergraduate Enrollment	16,592	19,345	17,995	9,954	1,400	76,144
FTE Full-Time Faculty	919.7	1,083	1,006	589.7	107	4,319
Avg. Faculty Salary	85,747	89,435	87,206	14,747	56,583	147,134
Part of a System	0.712	0.712	0.712	0.453	0	1
HBCU	0.0368	0.0368	0.0368	0.188	0	1
Hospital Affiliated	0.153	0.153	0.153	0.360	0	1
Urban	0.368	0.368	0.368	0.482	0	1
Pct. Of Revenue from Auxiliary Enterprises	11.89	12.20	11.88	5.588	1.189	34.14
Pct. Of Revenue from Private Grants & Contracts	2.704	3.110	2.883	2.486	0	25.44
Pct. Of Revenue from Tuition & Fees	29.63	38.59	33.85	11.67	5.929	65.85
Pct. Of Full-Time Out-Of-State Freshmen	16.81	22.80	19.40	14.94	0	77.13
Highest Research Activity Univs (RI1)	0.442	0.442	0.442	0.497	0	1
Higher Research Activity Univs (RI2)	0.423	0.423	0.423	0.494	0	1
Moderate Research Activity Univs (RI3)	0.135	0.135	0.135	0.342	0	1
No of observations	163	163	1793 (163 institutions x 11 years)			

Table 2: SAR Random Effects Model of Total Operating Costs at Public Research Universities

VARIABLES	Total Effects
FTE undergraduate enrollment	0.448***
	(0.063)
FTE graduate enrollment	0.073***
	(0.026)
Research expenditure as a percent of total expenditures	-0.203***
	(0.038)
Full-time faculty	0.558***
	(0.074)
Avg. full-time faculty salary	0.636***
	(0.124)
FTE undergraduate enrollment*FTE graduate enrollment	0.034
	(0.146)
FTE undergraduate enrollment * Research expenditure as a percent of total expenditures	0.255
	(0.187)
FTE undergraduate enrollment * Full-time faculty	-0.430
	(0.468)
FTE undergraduate enrollment * Avg. full-time faculty salary	1.073*
	(0.628)
FTE graduate enrollment * Research expenditure as a percent of total expenditures	-0.011
	(0.063)
FTE graduate enrollment * Full-time faculty	0.111
	(0.193)
FTE graduate enrollment * Avg. full-time faculty salary	-0.119
	(0.337)
Research expenditure as a percent of total expenditures * Full-time faculty	-0.515***
	(0.143)
Research expenditure as a percent of total expenditures * Avg. full-time faculty salary	0.149
	(0.256)
Full-time faculty * Avg. full-time faculty salary	-0.144
	(0.636)
FTE undergraduate enrollment Squared	-0.013
	(0.221)
FTE graduate enrollment Squared	0.032
	(0.056)
Research expenditure as a percent of total expenditures Squared	-0.045***
	(0.012)
Full-time faculty Squared	0.230
	(0.326)
Avg. full-time faculty salary Squared	-0.066

	(0.738)
Auxiliary enterprises – percent of revenue	-0.085***
	(0.027)
Private grants and contracts – percent of revenue	0.012
	(0.009)
Tuition – percent of revenue	-0.215***
	(0.056)
Out-of-state first-time full-time first-years – percent	-0.000
	(0.006)
Highest research activity (reference group – moderate research activity)	0.720***
	(0.118)
Higher research activity (reference group – moderate research activity)	0.290***
	(0.073)
Part of a System	0.028
	(0.043)
HBCU	-0.012
	(0.081)
Affiliated Hospital	0.246***
	(0.087)
Located in a large urban/suburban area	0.024
	(0.045)
Spatial rho	.238***
	(.056)
Year fixed-effects	Yes
Number of observations	1,793
Number of institutions	163
R^2 – within	0.820
R^2 – between	0.915

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Residual/Short-Run and Persistent/Long-Run Cost Inefficiency Indices by Year

Cost Inefficiency	Year	Mean	Min	P10	P25	P50	P75	P99	Max
Residual	2005	0.146	0.011	0.034	0.055	0.115	0.201	0.563	0.710
Residual	2006	0.156	0.006	0.037	0.064	0.119	0.218	0.539	0.721
Residual	2007	0.181	0.010	0.047	0.078	0.142	0.256	0.592	0.744
Residual	2008	0.206	0.010	0.051	0.099	0.164	0.294	0.587	0.745
Residual	2009	0.238	0.012	0.063	0.114	0.192	0.344	0.611	0.766
Residual	2010	0.276	0.017	0.081	0.120	0.229	0.406	0.706	0.788
Residual	2011	0.271	0.020	0.080	0.131	0.224	0.409	0.719	0.769
Residual	2012	0.278	0.030	0.085	0.136	0.239	0.408	0.772	0.782
Residual	2013	0.296	0.021	0.093	0.158	0.263	0.435	0.773	0.776
Residual	2014	0.310	0.013	0.104	0.160	0.278	0.458	0.787	0.790
Residual	2015	0.327	0.014	0.109	0.156	0.299	0.479	0.806	0.807
Residual	Overall	0.244	0.006	0.063	0.110	0.198	0.346	0.696	0.807
Persistent	Overall	0.041	0.009	0.012	0.015	0.023	0.048	0.236	0.444

Table 4. Regression, Via Maximum Likelihood, of the Effects of Privatization on Cost Inefficiency

VARIABLES	Short-Run (Residual) Beta Coeff
Auxiliary enterprises – percent of revenue	7.66***
	(1.346)
Auxiliary enterprises – percent of revenue Squared	-1.51***
	(0.270)
Private grants and contracts – percent of revenue	3.64***
	(0.618)
Private grants and contracts – percent of revenue Squared	-0.89***
	(0.225)
Tuition – percent of revenue	-6.01**
	(2.663)
Tuition – percent of revenue Squared	0.49
	(0.408)
Out-of-state first-time full-time first-years - percent	2.74***
	(0.653)
Out-of-state first-time full-time first-years – percent Squared	-0.53***
	(0.122)
2006	0.12
	(0.476)
2007	0.46
	(0.462)
2008	0.81*
	(0.456)
2009	1.34***
	(0.439)
2010	1.92***
	(0.434)
2011	2.01***
	(0.441)
2012	2.18***
	(0.440)
2013	2.36***
	(0.443)
2014	2.49***
	(0.445)
2015	2.65***
	(0.444)
Constant	-4.17
	(3.923)
Observations	1,793
Log Likelihood	-1547.93
Wald $\chi 2$	111.49***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

FIGURES 1-4

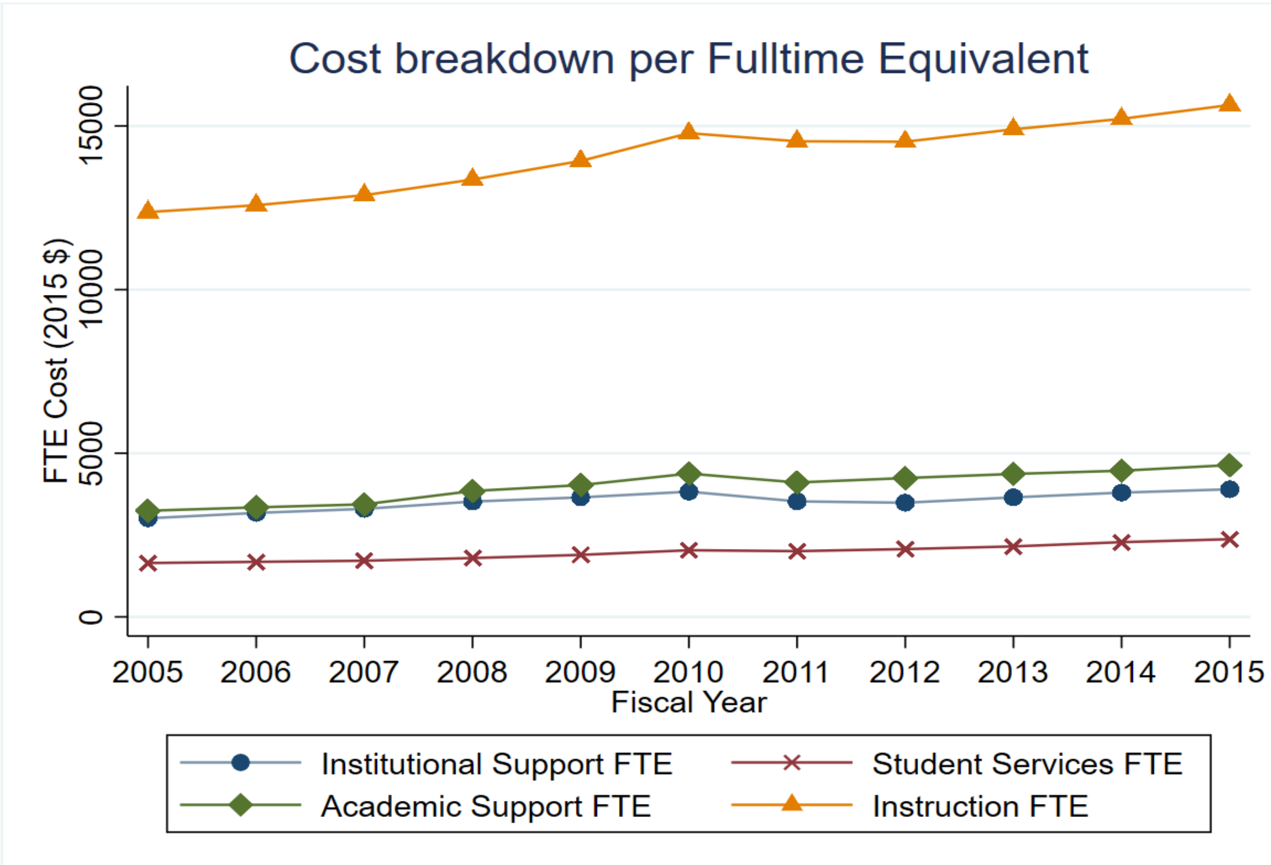

Figure 1: Operating Costs per FTE by Year

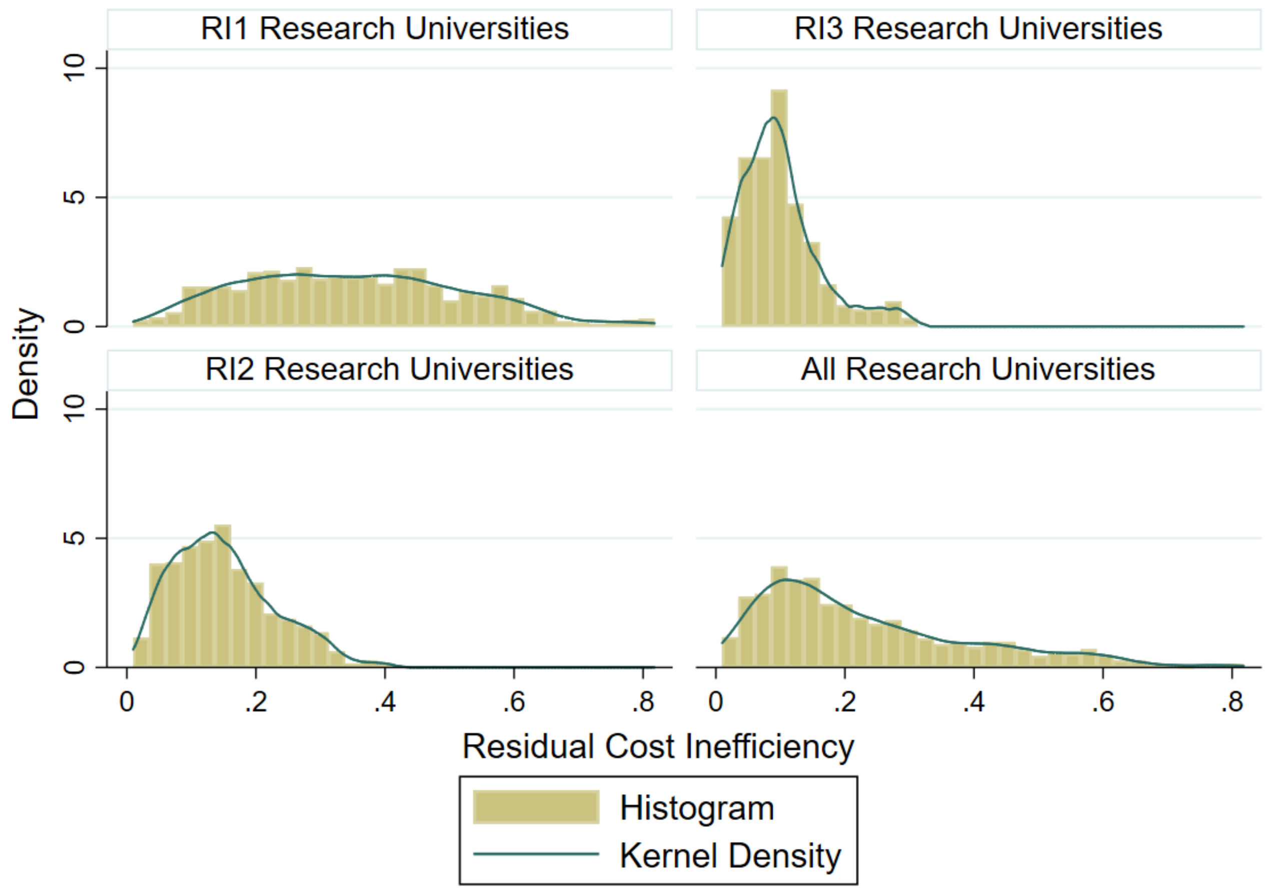

Figure 2: Kernel Density of the Residual/Short-Run Cost Inefficiency Indices

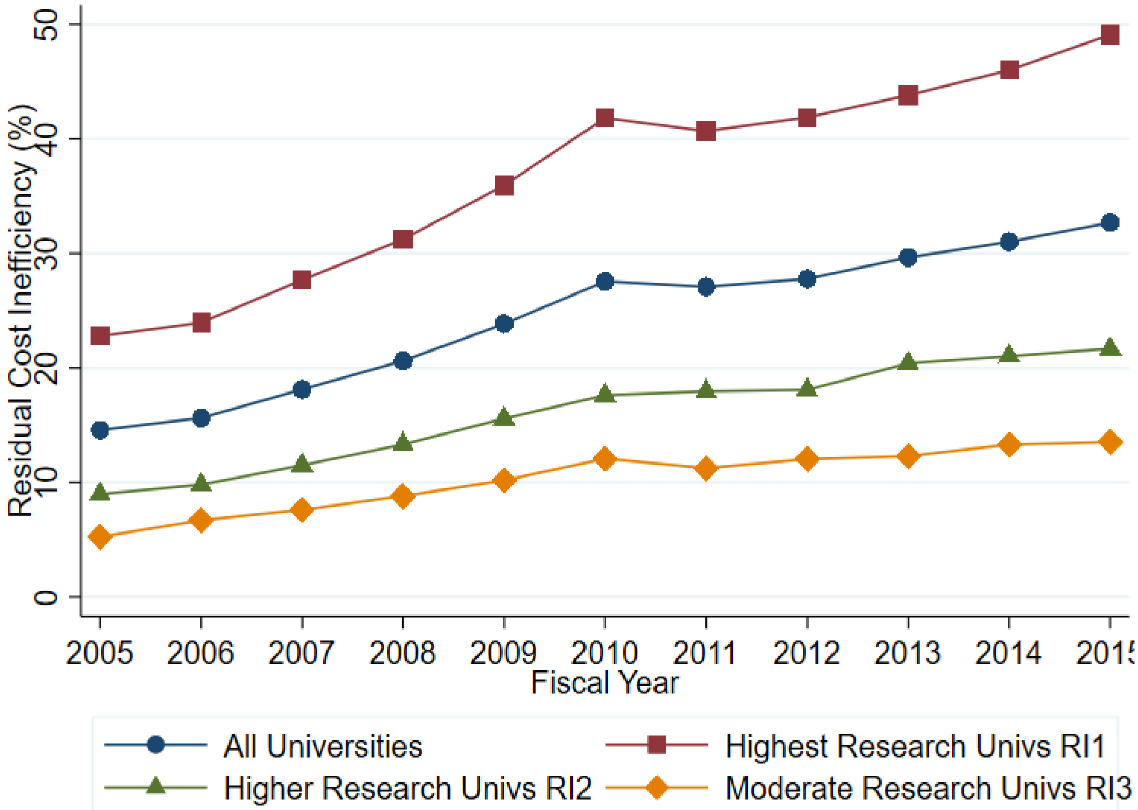

Figure 3 Residual/Short-Run Cost Inefficiency Indices by Year and research activity

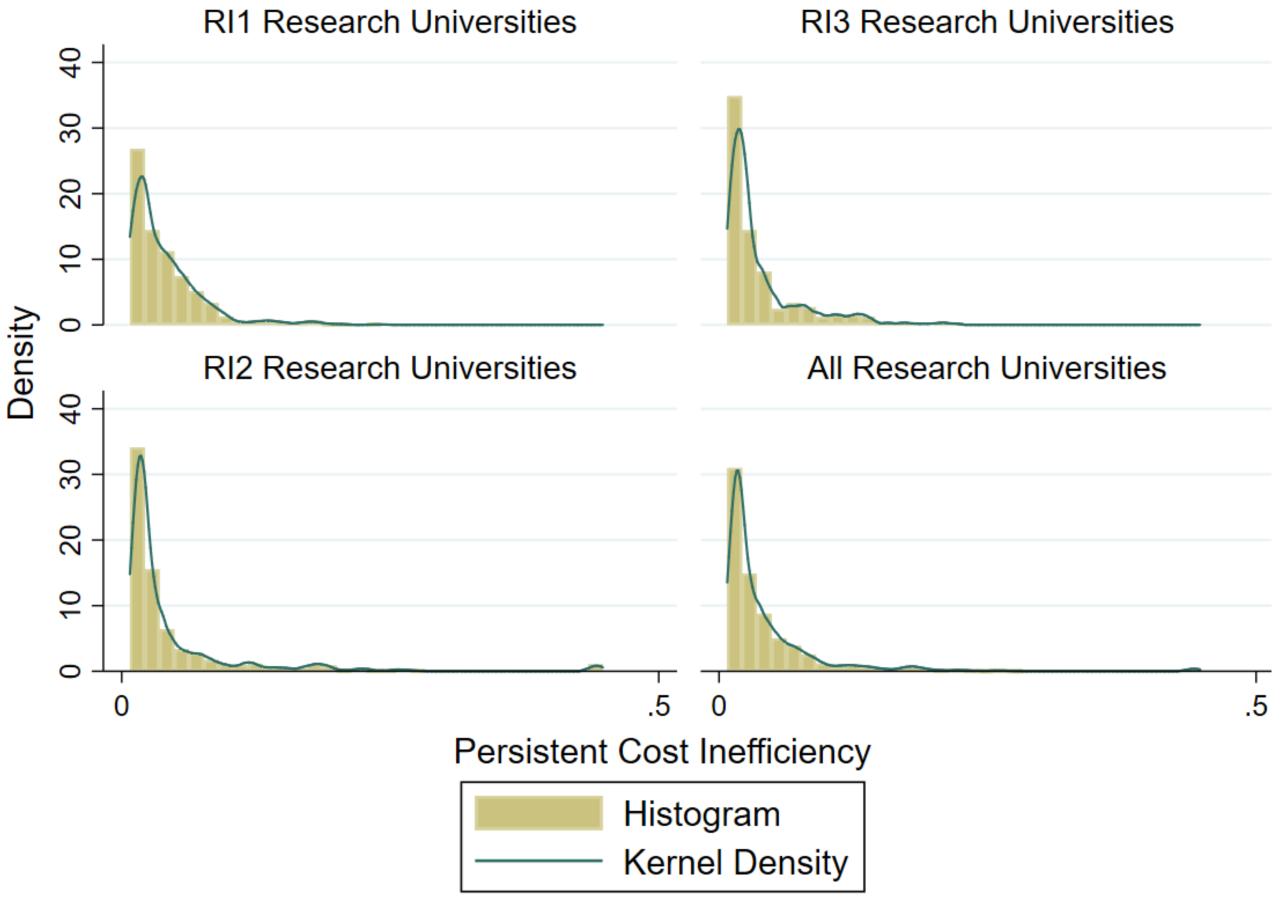

Figure 4: Kernel Density of the Persistent/Long-Run Cost Inefficiency Indices