

Postsecondary Education Structure

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States differ substantially in the structures of their public four-year university systems. This paper uses micro-level data to document the relationships between postsecondary education structure and individuals' educational and labor-market outcomes. Individuals who are exposed to more-fractionalized postsecondary education structures are more likely to attend universities overall (but no more likely to graduate), more likely to attend private universities instead of public universities, and mechanically, are more likely to attend small public universities instead of large public universities. More-fractionalized PSE structures are also associated with lower wages, and are more expensive to maintain. These findings suggest that states may benefit from consolidating their resources into fewer, larger universities.

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I. Introduction

In 1990, the state of Iowa had a population of approximately 2.8 million and funded three public four-year universities. Oregon, which also had a statewide population of approximately 2.8 million in 1990, funded eight public four-year universities. All three public universities in Iowa had enrollments above 12,000 students while in Oregon almost one in four students who attended a public university attended a university with an enrollment below 6,000 students.¹ This is just one example of the large differences across states in postsecondary education (PSE) structure. I refer to this aspect of PSE structure, where some states fund more, small universities and others fund fewer, large universities, as fractionalization.

States' PSE structures directly affect individuals by influencing their higher-education outcomes. I use micro-level data to show that increased fractionalization induces university attendance, pushes some individuals away from public universities and into private universities, greatly increases the probability that individuals obtain degrees from small public universities and greatly decreases the probability that individuals obtain degrees from large public universities.² I also link exposure to more-fractionalized PSE structures to wage outcomes later in life. Such exposure is negatively related to future earnings.

Two of these relationships borne out in the data particularly imply that more-fractionalized PSE structures produce less desirable outcomes. First is the negative relationship between individuals' earnings and their exposure to more-fractionalized PSE structures. Second, individuals who are on the margin between attending a public in-state university and a private university are more likely to move to the private sector when faced with a more-fractionalized in-state system, forgoing substantial in-state tuition subsidies. This suggests an increased willingness to pay for the outside option when the in-state system is more fractionalized.

¹ These calculations are based on data from the National Science Foundation (NSF) population of institutions in the Integrated Postsecondary Education Data System (IPEDS) enrollment survey. The university count in Oregon includes one health-sciences university with an enrollment of approximately 1,300 students in 1990.

² The direct effects of PSE structure need not be entirely realized in terms of educational outcomes at four-year universities. Outcomes for high-school and/or community-college students may also be affected. Some of the reduced form estimates in the analysis will pick up any such effects.

Alternatively, the only evidence that appears to favor more-fractionalized PSE structures is that these structures are associated with an increase in university attendance. This finding is consistent with the distance mechanism, whereby a more-fractionalized system places more universities within the state and reduces commuting costs for marginal attendees (see, for example, Card 1995, 1999; Frenette, 2009).³ However, despite the increase in attendance, more-fractionalized structures are generally *not* associated with increased degree attainment (either in total or within the public system), calling into question the benefit of the attendance effect.

The variability in PSE structure observed in the data is generated by differential state policy – that the identifying variation is coming from just the 50 states is an important limitation of the empirical analysis. Because the data lack the variation necessary to employ more sophisticated empirical techniques, I estimate reduced-form regression models and rely on the quality of my data to limit estimation bias. Although such an approach will not convince the most steadfast skeptic, I perform a series of robustness tests to confirm that the findings are not driven by bias from any obvious source.

I also evaluate education costs at large and small universities. The cost analysis indicates that it is more expensive to educate students at smaller universities, which highlights a clear disadvantage of more-fractionalized PSE structures. Overall, my findings are consistent with the hypothesis that more-fractionalized PSE structures produce inferior outcomes at higher costs relative to their less-fractionalized counterparts. Put differently, there is virtually no evidence in the data to justify the additional state expenditures that are required to maintain more-fractionalized PSE structures.

II. The Across-State Variability and Within-State Persistence of PSE Structure

PSE structure varies considerably across states. Figures 1 and 2 illustrate the underlying across-state variability in PSE structure in 1990, the year for which states' structures are relevant for the empirical analysis that follows. First, Figure 1 plots the number of publicly funded state

³ Also, McMillen, Singell and Waddell (2007) show that distance is important by showing that universities compete for students based on proximity.

universities against statewide populations for each of the 50 states. Among the 13 states with populations in the 3-5 million range in 1990, for example, the number of publicly funded universities ranged from three to sixteen.

Figure 2 provides an alternative documentation of the across-state variability in PSE structure. It shows the statewide shares of public four-year university enrollments at universities with over 10,000 students, again using data from 1990. The 10,000-student threshold is just one of many possible thresholds that can be used to separate “large” and “small” universities. (I address the inherent subjectivity in defining “small” and “large” in more detail below). In some states, like Arizona and Iowa, all public universities had enrollments in excess of 10,000 students. But most states have some smaller colleges, and in more than half of the states, enrollment in “large” public universities accounted for less than 70 percent of total enrollment.

Although PSE structure varies widely *across* states, it is highly inertial *within* states over time. Even during the latter half of the 20th century, as the labor market underwent dramatic changes (see Katz and Murphy, 1992; Buchinsky, 1994), states’ PSE structures were highly persistent. Table 1 illustrates the within-state persistence of PSE structure over the second half of the 20th century by showing correlations between state-level university counts and measures of universities-per-capita. The table uses data on university counts and state-level populations from 1950, 1970, 1980 and 1990.⁴ The correlations are large and show that states’ PSE structures were virtually unchanged over this time period.

The empirical analysis that follows relies on the cross-sectional variability in PSE structure across states to evaluate the relationships between PSE structure and individuals’ educational and labor-market outcomes. The within-state persistence is an additional limitation in the data in the sense that there is little time-series variation that can be exploited to disentangle

⁴ The data for the public four-year university counts from 1970 on are from the National Science Foundation (NSF) population of universities in the Integrated Postsecondary Education Data System (IPEDS). The university counts from 1950 are from the 1950-52 Biennial Survey of Education produced by the U.S. Office of Education. I use the 1950-52 Biennial Survey of Education for the 1950 university counts because the NSF data are not available prior to 1967. Within each state, I count all public universities, liberal arts colleges, teachers’ colleges and technical colleges (non-community colleges) as designated by the Office of Education in 1950.

the effects of PSE structure from other differences across states, the consequences of which I consider in more detail in Section VII. However, the persistence of PSE structure within states also largely rules out one possible concern with the analysis because it implies that PSE structure does not respond endogenously to changing labor market conditions. Given the substantial changes to the labor market that occurred over the latter half of the 20th century, and the rapid rise in relevance of postsecondary education over this same time period, the persistence of states' PSE structures suggests that their initial determinants may be largely irrelevant to labor-market conditions in the immediate term.⁵

III. Data

I use two primary data sources to estimate the effects of PSE structure on individuals' educational and wage outcomes. Data for individuals are from the restricted-use version of the National Educational Longitudinal Survey, base-year 1988 (NELS:88), compiled by the National Center for Education Statistics (NCES). I also use the Integrated Postsecondary Education Data System (IPEDS), provided by the National Science Foundation (NSF), to construct the PSE fractionalization measures. These two primary data sources are supplemented with state-level data from the United States Census, the NCES and the Census of Agriculture.

The NELS:88 began with a nationally representative sample of eighth-grade students in 1988 and followed these individuals through high-school, college if applicable, and into the workforce. Follow-up surveys were administered in 1990, 1992, 1994 and 2000. I use the data file from the fourth follow-up survey in 2000.

Three features make the NELS:88 data particularly useful for investigating the effects of PSE structure. First, the survey's base year occurs when individuals are in the eighth grade, long before they make the higher-education decisions that are relevant to PSE structure. The base-

⁵ From 1980 to 2000 the share of the US population over the age of 25 who had completed at least a bachelor's degree increased by half - moving from 16.2 to 24.4 percent (US Census). Because the public sector plays such a large role in the provision of PSE (approximately three-fourths of all four-year university attendees attend public universities- see Snyder, Dillow and Hoffman, 2008), state expenditures on higher education have increased correspondingly. These expenditures rose over 160 percent during these same two decades (Snyder, Dillow and Hoffman, 2008).

year survey collected information on parental income, parental education, test score performance and grade point average, along with race, gender, number of siblings (which may affect the share of family resources that can be devoted to privately funding PSE), and whether English is the individual's first language. These variables are strong predictors of individuals' educational and wage outcomes and serve as important controls in the models. Second, the follow-up survey in 1992 indicates the state in which each individual attended the twelfth grade. I use these state indicators to link each individual to a state-level PSE structure. Finally, the fourth follow-up survey in 2000 provides information about educational and wage outcomes.⁶

As would be expected, attrition by the time of the fourth follow-up survey changed the composition of the sample from that of the original survey. Nonetheless, the NCES achieved a high response rate in the fourth follow-up, even among individuals in the lowest SES categories (see Appendix C in the Base-Year to Fourth Follow-up Data File User's Manual for NELS:88, available from the NCES). For my analysis of PSE structure, the sample attrition is unlikely to be a concern in terms of generating bias but is noteworthy because the estimates reported below are reduced-form estimates. Reduced-form estimates carry the interpretation of population-average effects, and the attrition in the survey affects the population being studied. Table 2 provides summary statistics for the final micro sample.

I construct the state-level PSE fractionalization measures using enrollment data from the NSF population of public, four-year universities in IPEDS. I use the enrollment data from 1990, two years before the micro-sample's high-school graduation year. The fractionalization measures are constructed as state-level enrollment shares at universities with enrollments below

⁶ I require individuals to have completed the base-year survey to be included in the analysis so that I can incorporate its information into the models. "Freshening" samples were also added to the NELS:88 dataset during the first two follow-ups. These samples were added to create comparable 10th and 12th-grade cohorts in NELS:88 to analogous cohorts in another NCES longitudinal dataset (High School & Beyond). My requirement that base-year survey information be available for all individuals necessarily omits the freshening samples, which make up just over 3 percent of the records in the fourth follow-up data file. I omit another 3 percent of the sample because a state identifier was not recorded in the twelfth grade, 2.2 percent because grade reports were not available in grade 8, and 1.5 percent because of ineligibility issues at the time of the base-year survey such that no data were collected (see NELS:88 user's manual for more details). I also drop seven individuals who attended grade 12 in the District of Columbia.

certain enrollment thresholds, which are used to distinguish “large” and “small” universities. I take this approach because there is a rough upper limit on university size across states. Therefore, although it might be assumed that something along the lines of a Herfindahl Index would be preferred; a Herfindahl Index would make it appear as though university systems in large states are more fractionalized than those in small states.

Because the definitions of “large” and “small” are inherently subjective, I use multiple enrollment thresholds in the empirical analysis – at 8,000, 10,000, 12,000 and 15,000 students. As just one example, if the threshold is set at 10,000 students, universities with enrollments below 10,000 would be designated as small, and those with enrollments above 10,000 as large. The fractionalization measures divide the number of students enrolled in “small” public universities by total statewide enrollment at public universities. The larger the value, the more fractionalized is the state’s structure. I base the fractionalization measures on total enrollments and do not distinguish by enrollment type (i.e., undergraduate, graduate, etc.). I exclude enrollments in military schools and include enrollments in medical schools in my calculations, but these enrollments make up such a small share of total enrollments that the results are entirely insensitive to these decisions.

Finally, in addition to the individual-level controls and the fractionalization measures, I also include state-level controls in the models. I discuss these controls in more detail in Section V, and again in Section VII.

IV. Private Universities

The purpose of this analysis is to identify the relationship between states’ PSE structures and individuals educational and wage outcomes. The primary focus is on publicly-funded four-year universities, for which the in-state structures are determined by public policy. However, the private sector in higher education also merits attention. One distinguishing feature between the public and private sectors is the availability of substantial in-state tuition subsidies at public universities for in-state residents (see, for example, Johnson, 1984, or Kane, 1995). These

tuition subsidies tie the residents in each state to the state's own PSE system.⁷ Put differently, the public-university market is highly localized to the state level such that very few individuals attend public four-year universities outside of their home states. Alternatively, the private market does not generally offer explicit cost savings for in-state attendance. Correspondingly, in the data, while over 85 percent of public-university graduates attended an in-state university (based on their state of residence in grade 12), only 52 percent of private-university graduates remained in-state.

Although the private-university market is clearly less-localized than the public-university market, even the 52-percent figure implies a home-state bias among college goers (a likely explanation is the distance mechanism). Therefore, in some models I also control for the degree of fractionalization of states' *private universities* in addition to their public universities (the fractionalization measures across the public and private sectors are weakly positively correlated within states – the correlation ranges from 0.10 to 0.20 depending on which fractionalization measure is used). In practice, private-university fractionalization has virtually no statistically distinguishable associations with any of the outcomes considered here, and its inclusion in the models does not meaningfully affect the results for public-university fractionalization. For brevity, in the analysis that follows I only report estimates from models that include private-university fractionalization using the 10,000-student fractionalization measure. Results from models where private fractionalization is defined using the alternative enrollment thresholds are generally very similar and available upon request.

⁷ I do not incorporate tuition-reciprocity or student-exchange agreements across states into the fractionalization measures. Although in principle these agreements merge participating states' PSE structures to some degree, there is no evidence in the data that they are of any practical importance. For example, Minnesota, North Dakota, South Dakota and Wisconsin had a tuition-reciprocity agreement in 1990. However, in the data, among state residents who obtain their degrees from four-year public universities, the share of degrees awarded at in-state institutions in these states was higher than in the general population (86 versus 85 percent). Similarly, the in-state share of degrees awarded was higher in Washington, Oregon and Idaho (89 percent) than in the general population despite a reciprocity agreement between these states. Student-exchange programs were equally unimportant in the data. It is not clear why the tuition-reciprocity and student-exchange programs had such a marginal impact in practice. It may be that the various rules and restrictions associated with these programs limited participation, or these programs may have been poorly publicized in the early 1990's. Regardless of the cause, there is no evidence in the data to suggest that these programs are relevant to the empirical analysis.

V. Educational Outcomes

I document the relationships between public PSE structure and four educational outcomes: (1) university attendance, (2) four-year degree attainment, (3) private-university degree attainment and (4) public-university degree attainment (by university size).⁸ I use a separate linear probability model (LPM) for each outcome because the estimates from LPMs are straightforward to interpret. However, note that these outcomes can also be jointly modeled (estimates from a multinomial probit analogous to those reported in the text are available upon request - they provide no additional insights beyond what is shown from the simple linear probability models). I estimate models of the following form:

$$y_{ij} = \beta_0 + X_i\beta_1 + S_j\beta_2 + F_j\lambda + \varepsilon_{ij} \quad (1)$$

In (1), y_{ij} is an educational outcome for individual i who resided in state j in the year that she graduated from high school, X_i is a vector of individual-level controls taken from the NELS:88 base-year survey as described in the previous section, S_j is a vector of the state-level controls, and F_j is a measure of the fractionalization of PSE structure. Because individuals are linked to the state in which they graduated from high school, the PSE-structure estimate comes from the structure to which each individual was initially exposed upon high-school graduation. This allows for the possibility that subsequent state moves are endogenous.

In each model, I construct the fractionalization measure first as the share of the statewide public-university population enrolled in a university with fewer than 8,000 students, then 10,000 students, and so on, and perform the analysis separately after defining fractionalization using each enrollment threshold described in Section III. A fractionalization measure of zero means that no public enrollment occurs at a “small” university in the state, and a measure of one means

⁸ I primarily consider degree-attainment outcomes, which are terminal educational outcomes in the context of this analysis. I focus on these terminal outcomes to avoid complications in accurately tracking student movement across different types of universities, where my data are imperfect. For example, private-university *attendance* might be of interest in addition to degree attainment. However, some individuals attend both public and private four-year universities over the course of their interactions with PSE institutions, and for individuals who attend more than two PSE institutions, including community colleges, the data are insufficient to fully track their movements. The terminal outcomes here are most tractable, and arguably most relevant for policy analysis. The exception is the general attendance outcome (Table 4), not distinguished by school type, which is easily measured in the data.

that all public enrollment occurs at “small” universities in the state. The summary statistics for the fractionalization measures across the 50 states are reported in Table 3.

I use discretion in selecting the state-level controls that are included in the models because the underlying variation used to identify the effects of PSE structure is coming from just the 50 states. My primary models include only four state-level controls, all tied to the state where students attended high school in the twelfth grade. First is the share of each state’s population that was white in 1990, included as a basic demographic control. Second, the models include per-capita state spending on higher education in 1990 to ensure that the fractionalization results are not confounded by states’ expenditures on, or, more generally, their commitments to higher education. The third and fourth state-level controls are median household income, also from 1990, and the share of the total land in each state that is involved in agricultural production, from the 1992 Census of Farms. These two controls capture the economic climate into which individuals graduate from high school, with the median-household-income control serving as a particularly important control in some models (see appendix). I evaluate the robustness of my results to specifications that include additional state-level controls in Section VII.

The tables report “effect sizes” that correspond to the fractionalization coefficients. The effect sizes are calculated by multiplying the fractionalization coefficients by the across-state standard deviation in the relevant measure of PSE fractionalization. That is, the effect size indicates “the effect of a one-standard deviation move in PSE fractionalization across states.” For brevity, the coefficients for the control variables in the models are suppressed, but they are important predictors of outcomes and strengthen inference from the models. I report selected estimates for the control-variable coefficients in the appendix.

Table 4 shows results for the first two outcomes together: *university attendance* and *completion*, both at any four-year university. I evaluate attendance and completion outcomes together because they are the relevant outcomes for individuals on the university-attendance margin. However, as shown in the table, attendance and completion are not synonymous, and the distinction is important. The table shows that more-fractionalized structures induce

university attendance, which again is consistent with a reduction in commuting costs. But the effect of PSE structure on degree-completion outcomes is generally not statistically distinguishable from zero (with the exception of the estimate in the final column of Table 4). Based on the fractionalization measure at the 10,000-student enrollment threshold, a one-standard deviation increase in the fractionalization of PSE structure corresponds to a 1.9 percentage point increase in university attendance.⁹ If the analogous point estimate in the degree-completion model is taken at face value, the corresponding completion effect is just 0.8 percentage points. For comparison, across the entire sample approximately 62 percent of four-year-university attendees ultimately obtain a degree by the time of the fourth follow-up survey. Not surprisingly, these estimates suggest that marginal attendees who are induced to attend by PSE structure are less likely to graduate.

The next educational outcomes that I consider are *degree attainment from a private university* and *degree attainment from an out-of-state public university*. I also present results where these outcomes are treated as synonymous, which may be most relevant because in both cases individuals exit their in-state public systems. Table 5 shows that individuals respond to more-fractionalized PSE structures by attending private and out-of-state public universities. The majority of the effect is driven by individuals moving to private universities. The results using the 10,000-student enrollment threshold indicate that a one-standard deviation increase in PSE fractionalization corresponds to a 2.0 percentage-point increase in degree attainment at universities outside of the in-state public system. One explanation for this finding is that individuals on the margin between public- and private-university attendance perceive public universities in more-fractionalized systems to be of lower quality, a perception that is supported

⁹ While Table 4 suggests an association between private-university fractionalization and attendance, it is unclear how to interpret this result. Unlike public universities, private universities can “shop” across states. Larger and more prestigious private universities may endogenously locate in states where more individuals are inclined to attend a private university – this would imply less private fractionalization in these states (by the definition used here), and these states may also have populations with stronger preferences for university attendance in general. Recall that private and public fractionalization are not highly correlated within states, suggesting that the two sectors are fairly unresponsive to each other along the dimension of structure.

by evidence in the next section showing that more-fractionalized systems are associated with lower worker productivity.¹⁰

Finally, I consider *degree attainment from small and large public universities*, and *total degree attainment at all public universities*, in Table 6. In addition to incorporating individuals on the attendance and public-private margins, the university-size outcomes also incorporate individuals who are bound to their in-state public systems by the substantial tuition subsidies, and thus mechanically affected by PSE structure. For these individuals, even when the quality of the public system declines, the costs associated with moving to the private sector remain prohibitively costly given the expected benefits, while the expected benefits of public-university attendance over non-attendance remain positive. The result is that these students shift within their in-state systems to fill the slots at public universities that are available.

As expected, a more-fractionalized PSE structure increases degree attainment at small public universities and decreases degree attainment at large public universities. Using the fractionalization measure based on the 10,000-student enrollment threshold, a one-standard deviation increase in fractionalization corresponds to a 3.2 percentage-point increase in degree attainment at small public universities, and a 3.7 percentage-point decrease in degree attainment at large public universities.

The magnitudes of the estimates in Table 6 suggest that individuals on the university-size margin drive much of the PSE-structure-induced movement. For example, even if all of the individuals who are induced into obtaining a four-year degree by a more-fractionalized system (shown in the bottom panel of Table 4) do so at a small public university, there is still much movement to be attributed to individuals on the university-size margin. Movement along the university-size margin is important because there are non-negligible differences in the human-capital production process across large and small schools. Significant differences across states in

¹⁰ Note that this result moves counter to what would be expected from the distance mechanism alone. The negligible importance of the distance mechanism is expected for these individuals if the benefits to university quality are sufficiently large such that the returns to a proper university match outweigh any cost savings associated with university distance.

their enrollment shares at large and small universities could have important implications for statewide human capital accumulations.

Table 6 also reports the relationship between fractionalization and total public-university degree attainment. These estimates combine movements into the system by marginal attendees (who graduate) and movements out of the system by those going to private and out-of-state universities. There are more of the latter, although the difference is only statistically significant when fractionalization is defined using the 15,000-student enrollment threshold.

In sum, Tables 4, 5 and 6 show that more-fractionalized PSE structures induce marginal attendees into higher education (although graduation outcomes for these individuals increase at a much lower rate), push individuals on the public-private margin toward the private sector, greatly increase the probability that individuals obtain degrees from small public universities and greatly decrease the probability that individuals obtain degrees from large public universities.

VI. Wages

This section examines the relationship between PSE structure and wages using a reduced-form model similar to Equation (1) where I replace the educational outcomes with wage outcomes (logs).¹¹ I focus the analysis on full-time workers who report working over 30 weeks in the prior year, and at least 35 hours in a typical week. I also add an additional criterion that excludes all individuals who report being in school. I add this criterion so that the results are relevant for full-time workers who are likely to be active in their careers, rather than students who may be working in a non-career job. The wage results are not qualitatively sensitive to reasonable adjustments to these criteria. For example, I consider various combinations of weeks- and hours-worked thresholds including 26/30, 30/30, 0/35, 35/35 and 40/35, and turn the

¹¹ The NELS:88 survey reports individuals' earnings either annually, monthly, bimonthly, weekly or hourly. I convert reported earnings to a comparable "annual rate" for all individuals. For earnings that are reported monthly/bimonthly/weekly I multiply them by 12/24/52. For reported hourly earnings, I multiply the hourly rate by the number of hours worked per week and then by 52. The results are virtually identical if I instead multiply monthly/bimonthly/weekly/hourly earnings by 12/26/52/[(hours worked)*52], or by 11.5/23/50/[(hours worked)*50]. The former conversion is performed because individuals who are paid bimonthly are grouped with individuals who are paid every two weeks in the survey.

schooling restriction on and off, and the results are always substantively similar. Importantly, the fractionalization measures do not predict selection into the wage-model sample.¹²

Table 7 reports wage results from the reduced-form model. The table reports separate results for both men and women, which are very similar with one exception – the coefficient on private-university fractionalization is large in magnitude and statistically significant for women (this occurs using the 8,000 and 10,000-student enrollment thresholds, although only the estimate using the 10,000-student threshold is reported). Interestingly, women are much more likely to attend private universities (16 versus 12 percent for women and men in the wage sample, respectively), and conditional on attending a private university are much more likely to do so in their home states (56 versus 49 percent). Otherwise, the general similarity in the estimates across genders is likely attributable to two factors. First, the analysis is restricted to full-time workers. Second, the wage data were collected when individuals were young - in their mid twenties. These two factors will significantly mitigate the across-gender selection issues that are problematic for pooled earnings analyses more generally.

The association between more-fractionalized PSE structures and wages is negative and economically meaningful. Using the fractionalization measure based on the 10,000-student enrollment threshold, a one-standard-deviation increase in fractionalization corresponds to a 1.8 percent decrease in wages (in the pooled regression). The estimates decrease in magnitude moving from left to right in Table 7, which indicates that high attendance rates at the smallest public universities are driving the wage results.¹³ This in no way marginalizes the problem – in 1990, the average enrollment share at public universities with less than 8,000 students across states was approximately 22 percent (Table 3), and in the entire micro sample, approximately

¹² This is generally the case across the different weeks/hours-worked thresholds, and is intuitive given the likely margins for PSE-structure effects. There is suggestive evidence that PSE structure affects whether individuals report being in school at the time of the fourth follow-up interview, but regardless of whether I add or remove the schooling restriction, PSE structure is not a significant predictor of inclusion in the wage-model sample.

¹³ I also estimate the reduced-form model with the fractionalization measures at all four university-size cutoffs included simultaneously. Only the measure based on the 8,000-student enrollment threshold is statistically significant, confirming that the fractionalization effect is driven by enrollments at the smallest public universities.

17.5 percent of graduates from public four-year universities graduated from a university with an enrollment below 8,000 students.

There are two direct-effect mechanisms associated with education quality that can explain the wage results. First, the value-added of the smallest public universities may be particularly low, negatively affecting the wages of individuals who attend these universities. The effect of fractionalization on enrollment shares at small public universities is large enough that this could influence the population-average wage results from the reduced-form model. Second, the funding of numerous small universities could adversely affect the budgets faced by *all* public universities within a fractionalized system. Such adverse funding consequences across an entire state, which are suggested by the cost analysis in Section VIII, would affect the quality of all public universities.¹⁴

In addition to its direct effects, PSE structure is also likely to influence the wages of individuals who are not directly involved with postsecondary education. Moretti (2004) shows that in cities where there are more college graduates the wages for non-graduates are higher, implying that there are spillover effects when the workforce is more educated. Moretti (2004) focuses on education-*quantity* spillovers – that is, he looks at the effects of the share of college graduates in the workforce. Education-*quality* spillovers are also likely, and will be incorporated in the estimates in Table 7. The within-state persistence of PSE structure over time is also relevant with respect to possible spillover effects because if there are differences in education quality across more and less-fractionalized structures, these differences will likely be reflected in states' labor markets across multiple cohorts of workers.¹⁵

¹⁴ At the individual level, endogenous student choices make it difficult to identify the causal effects of institution quality on earnings. It is perhaps not surprisingly that the micro-evidence on the effects of postsecondary institution quality on earnings is mixed. See, for example, Black and Smith (2004, 2006); Dale and Krueger (2002); Ehrenberg, Eide and Brewer (1998); Long (2008); Loury and Garman (1995).

¹⁵ Yet another possibility is that the positive attendance effects of PSE structure increase labor force participation among low-income individuals, raising their personal wages but lowering mean wages. However, this explanation seems unlikely as there is no evidence in the data to suggest that PSE fractionalization is correlated with employment outcomes per above.

VII. Robustness and Causal Inference

Although the reduced-form results in Sections V and VI are suggestive, the lack of a clear identification strategy limits inference. In this section, I consider some of the more likely sources of estimation bias in the above-reported findings.

First, one concern is that individuals (or their parents) might make state-of-residence decisions based on PSE structure, in which case the PSE structures to which they are exposed will be endogenous. I test for this possibility by dividing individuals into bins based on their conditional probabilities of college graduation, and then estimating the variance of PSE fractionalization within bins (using the 10,000-student enrollment threshold to measure fractionalization). I estimate individuals' probabilities of graduation using a probit where the dependent variable is four-year degree attainment and the independent variables include the individual-level controls from the base-year NELS:88 data. If the variance of PSE fractionalization is not roughly constant across the bins, this would suggest endogenous sorting. For example, if individuals with the highest graduation probabilities gravitate toward states with certain PSE structures, the variance of PSE structure should be smaller in the highest bin relative to the other bins. The sample is divided into five bins based on the fitted values from the probit. The variance of PSE structure by bin is documented in Table 8 – it is virtually constant, providing no evidence of endogenous sorting.

A second concern, returning to the discussion from Section II, involves the persistence of PSE structure within states. While the within-state persistence offers some benefits as discussed in Section II, it also complicates causal inference because it is difficult to separate the effects of PSE structure from other state-level determinants of outcomes. That is, because PSE structure does not change over time, the estimates in Sections V and VI may be confounded with other time-invariant state policies and/or economic conditions. One way to indirectly gauge the extent to which PSE structure is correlated with state-level unobservables is to evaluate its heterogeneity across *regions* of the United States. If state-level confounding variables are correlated with PSE structure, and these variables are themselves correlated within regions, we

might expect the between-region variance of PSE structure to be non-negligible in magnitude. As a specific example, if unobserved regional attributes of southern states correlate with a certain type of PSE structure, we would expect to find similar PSE structures in southern states that are different from the structures found outside of the south. This would imply that the between-region variance of fractionalization is non-negligible in magnitude. I use the four regions of the United States as defined by the US Census to decompose the across-state variance in PSE fractionalization into its within- and between-region components. The within-region variance of PSE structure accounts for almost 90 percent of the total across-state variance, providing little evidence that PSE structure is systematically determined by states' region-specific attributes (the lack of across-region variability in PSE structure is also visible in Figure 2).

Although the regional variance decomposition is suggestive, perhaps the most straightforward way to evaluate the extent to which confounding state-level variables are biasing the results is to perform a series of robustness checks that incorporate some of the most likely sources of bias. Although it is not feasible to exhaustively evaluate every possible source of bias, approaching the problem from multiple directions using the available data will provide some indication as to whether significant bias is likely. Table 9 reports robustness results for the wage model from the previous section. The educational-outcome results are similarly robust to the alternative models – these results are omitted for brevity and available upon request.

The first two horizontal panels of Table 9 report estimates from models that include additional state-level information about economic climate.¹⁶ In the first panel I add controls for population densities, median house prices, and occupation shares. The population-density and median-house-price data are from the US Census. The occupation-share data are from the Bureau of Labor Statistics (BLS). Using the BLS data, I grouped each state's workforce into five possible occupation categories: professional, skilled healthcare, community/social work, blue

¹⁶ Note that in the primary models the median-household-income control is a powerful predictor of outcomes (see appendix), and may even lead to an understatement of PSE-structure effects because it will capture some of the long-term effects of PSE structure. If I exclude the median-household-income control the estimated effects of fractionalization become significantly more negative. However, in such a model there are essentially no controls for differences in economic climate across states.

collar and unskilled.¹⁷ In the second horizontal panel, I return to the baseline model and add an additional three decades of data on median household income for each state. That is, in addition to the 1990-median-household-income control, I also include state-level median household income from 1980, 1970 and 1960, provided by the US Census. When wages are the outcome of interest, this history should push the model in the direction of a state-fixed-effects specification without the cost of altering the sample from which the PSE-structure effects are identified.¹⁸ In both of these more-detailed models, the primary finding that higher enrollment rates at smaller universities are associated with diminished productivity is upheld. There is no evidence that the fractionalization effects are driven by differences in economic climate across states.

The next panel of the table examines the extent to which K-12 education policy might confound the results. Specifically, I include a control for state-level per-pupil spending on K-12 education, obtained from the NCES. There is no evidence that the omission of this control in the primary model introduces any bias.

In the fourth panel of Table 9, I add a control for state-level research and development (R&D) expenditures at public universities, also obtained from the NCES. Perhaps not surprisingly, R&D expenditures are negatively correlated with fractionalization, but Table 9 indicates that they are not driving the results. This implies that the negative relationship between fractionalization and earnings is more likely to be an education-quality issue and is not the result of other university activities that might affect worker productivity at the state level (although it may still be the case that R&D expenditures have more-localized effects).

Finally, in the bottom two panels of Table 9 I consider the extent to which the estimates in Table 7 are attributable to regional differences across the United States (despite the limited

¹⁷ The five occupation categories are aggregated up from 22 more-detailed categories initially provided by the BLS. The aggregations are necessary because there are only 50 states contributing the identifying variation, and are available upon request. The BLS began collecting state-level occupational share data in the late 1990's. Therefore, I use year-2000 occupation shares across states to proxy for the 1990 shares, which would be more appropriate for the model if they were available.

¹⁸ Although a state-fixed-effects specification will by definition remove any state-level confounding factors in the model, if it were implemented in practice, identification would be entirely driven by movers (the state fixed effects would be assigned by state of residence when the wage data were collected). The sample-selection issues with such a tradeoff would likely introduce more bias than any state-level unobservables.

across-region variability). In the fifth panel of the table I omit northeasterners from the dataset.¹⁹ The northeast region of the United States is different from the other regions of the country with respect to higher education because private-university enrollments are high in relative terms in this region. Therefore, the degree of fractionalization of public PSE structures in the northeast may be less important than in the rest of the country.²⁰ The fifth panel of Table 9 is at least suggestive of this - the fractionalization estimates are nominally larger outside of the northeast.²¹

In the last panel of the table I return to the full sample and add regional indicator variables to the model based on the four regions of the United States as defined by the US Census. The inclusion of these indicator variables means that the limited across-region variation in PSE fractionalization is no longer used to identify the fractionalization effects. The negative association between earnings and fractionalization persists within regions.

Overall, none of the expansions of the model in Table 9 overturn the negative relationship between wage outcomes and exposure to more-fractionalized PSE structures. The negative productivity estimates consistently correspond to higher enrollments at the smallest public universities (i.e., universities with less than 8,000 students).

VIII. Costs

PSE structure may also affect education costs. Measuring education costs at the postsecondary level is complicated because universities produce types of degrees in different proportions (by discipline and level), and produce degrees of varying quality. Differences along these dimensions are generally related to university size, which makes it even more difficult to evaluate relative production costs at large and small schools. For example, a state's flagship university may offer programs in medicine, law and engineering, while its smaller counterparts

¹⁹ Northeasterners are individuals who were in the twelfth grade in a state in the northeast region of the United States as defined by the US Census. The northeast region includes ME, NH, VT, MA, RI, CT, NJ, NY and PA.

²⁰ Goldin and Katz (1999) show that during the first half of the 20th century, when states were beginning to invest heavily in higher education, states with higher private-university enrollments invested less in public universities.

²¹ In an omitted analysis I also confirm that the results are robust to separately dropping each of the four regions of the United States.

in the statewide system may not. Because it is more costly to produce pre-med students than, say, social-science students, evaluating differences in per-student costs is problematic.

Likely because of the difficulty in making apples-to-apples comparisons, I am not aware of any rigorous studies that evaluate quality-constant differences in production costs across universities.²² In the absence of any literature to draw on, I use two *ad-hoc* approaches to examine whether it is more expensive to produce human capital at large or small schools. Although it is unlikely that either of these approaches will fully resolve the non-comparability problem across different-sized universities, they will reduce its impact.

First, I start with two subpopulations of the NSF universe of public universities across the United States - the subpopulation of public universities where the highest degree offered is a master's degree, and the subpopulation where the highest-degree offered is a doctoral degree. (I ignore public universities where the highest degree offered is a bachelor's degree because these universities are rare and not well-represented across states). For each group I randomly select 100 universities and calculate the correlation between enrollment and the ratio of state appropriations to enrollment. State appropriations data are obtained from the Grapevine Project at Illinois State University, and are available for the 2006-07 fiscal year.²³ I match the appropriations data with 2005 enrollment data, which are the most-recently available from IPEDS. These correlations, although coarse, indicate the relationship between university size and appropriations per student. The extent to which they are purged of the non-comparability problem depends on the extent to which university size is correlated with the composition of programs offered across universities within each group. For the master's granting institutions, although larger schools tend to offer more master's degree programs, the non-comparability problem is not as severe as in the case of the doctoral-granting institutions. For these latter institutions, although it is important to separate them from the master's granting institutions

²² The Texas Public University Cost Study (2009) produced by the Texas Higher Education Coordinating Board would provide a starting point for someone interested in learning more about measuring education costs. More information on this study is available at <http://www.thecb.state.tx.us/Reports>.

²³ Institution-level appropriations data are reported for most but not all states. I order the universities within group by random number and take the first 100 universities with institution-level appropriations data.

because of the very large differences in services offered, the approach here is of less value because even within this group there is a non-negligible correlation between university size and the expenses of services offered. As just one example, the University of Louisiana at Monroe, with an enrollment of approximately 10,000 students in 2005, offers doctoral degrees in only a handful of disciplines. Within the doctoral-granting group, it is compared to the 35,000-student-plus University of California, Los Angeles, which offers doctoral degrees in many disciplines and operates a medical school.

The estimated correlation between base enrollments and appropriations per student among the randomly selected master's granting schools is approximately -0.13, which suggests that states provide more per-student funding to produce degrees at smaller universities. Any positive correlation between the expenses of services offered at these schools and their sizes, which would occur if larger master's granting institutions had larger shares of graduate students, would put positive pressure on this correlation.²⁴ For the doctoral-granting schools, the correlation estimate is essentially zero (≈ 0.003). Given the upward bias in this estimate that is implied by the non-comparability-in-services problem among the doctoral-granting schools, the true correlation is likely to be negative.

As an alternative investigation of the cost issue, I also obtained data on discipline-specific direct instructional costs at universities of different sizes from the National Study of Instructional Costs and Productivity (NSICP), an ongoing project maintained at the University of Delaware and directed by Dr. Michael Middaugh. The NSICP is designed to allow participating institutions to compare their direct instructional costs to peer universities. For example, a flagship university in the Midwest can use the data to identify how its direct instructional costs in any particular discipline compare to these same costs among other flagship universities in the Midwest that also participate. I use the data from the project to compare two groups of different-sized universities that are similarly classified by the NSICP as "large-program" master's granting

²⁴ The limited evidence on education costs suggests that master's-degree credit hours are roughly three to four times as expensive to produce as bachelor's-degree credit hours (see, for example, Texas Public University Cost Study, 2009).

schools.²⁵ Institutions that participate in the NSICP are unlikely to be representative of the universe of schools in the United States because participation is voluntary. However, among the institutions that are willing to participate, differences in direct instructional costs per full-time-equivalent student are straightforward to calculate.²⁶

The first comparison group from the NSICP consists of the ten schools with the highest enrollments among the 28 public universities in the “large program” group of master’s-granting universities as designated by the study. The average enrollment in these universities in 2005 was approximately 18,500 students. The second group consists of the ten schools with the lowest enrollments from this same group of 28 universities, where the average enrollment was approximately 8,050 students.

The NSICP allows for comparisons of average direct instructional costs in specific disciplines across the two groups. I consider five disciplines that are common across most universities and may differ in terms of direct instructional costs: chemistry, economics, English, math and political science. Table 10 shows comparisons of the direct instructional costs in these five disciplines and reports p-values from simple difference-in-means tests. The table corroborates the evidence from the correlations above. Across all five disciplines the average cost per full-time-equivalent student is higher at the smaller schools. Although the sample sizes are small, in two of the five disciplines the differences are statistically significant.²⁷

Despite the difficulty in making comparisons of education costs across different-sized universities, the evidence here strongly suggests that it is more expensive to produce bachelor’s degrees at smaller universities.

²⁵ The NSICP does not identify costs at the institution-level - only by group. This is to protect the privacy of participating institutions.

²⁶ At least in principle. Although calculating direct instructional costs is far from an exact science, institutions report direct expenditures for instruction separately from direct expenditures for research and service. Visit the NSICP website for more details: <http://www.udel.edu/IR/cost>.

²⁷ Not all of the twenty schools reported discipline-specific cost information in each subject. Only five schools in each group reported data for economics. In each of the other subjects, at least 9 universities in each group provided instructional-cost information. In unreported results I also compared these schools in biology, communications, philosophy, psychology and sociology. The smaller schools have higher direct instructional costs per full-time-equivalent student in each of these disciplines as well. However, only for sociology is the difference statistically significant ($p \approx 0.05$). I show results for just the five disciplines in Table 10 for brevity.

IX. Conclusion

This paper evaluates the relationships between PSE structure and individuals' educational and labor-market outcomes. More-fractionalized PSE structures induce university attendance (but have, at best, a very small effect on graduation outcomes), push some individuals from public universities to private universities, greatly increase the fraction of individuals who obtain degrees from small public universities and greatly decrease the fraction of individuals who obtain degrees from large public universities. Overall, individuals who are exposed to more-fractionalized PSE structures have lower earnings. Although the empirical analysis is somewhat limited because the identifying variation is coming from just the 50 states, the results offer little justification for the additional expenditures associated with operating a more-fractionalized PSE structure.

The evidence from this study may also be of interest to developing nations in the early stages of constructing their PSE structures. However, a caveat is that the analysis depends on the observed variation across the United States in PSE structure. For example, there are relatively few public universities in the United States with enrollments above 40,000 students. These findings may or may not carry over to cases where universities are considerably larger than what is observed in the U.S. data.

References

- Black, Dan A. and Jeffrey A. Smith. 2004. How robust is the evidence on the effects of college quality? Evidence from matching. *Journal of Econometrics* 121(1-2) pp. 99-124.
- 2006. Estimating the Returns to College Quality with Multiple Proxies for Quality. *Journal of Labor Economics* 24(3) pp. 701-728.
- Brewer, Dominic J., Eric R. Eide and Ronald G. Ehrenberg. 1999. Does it pay to attend an elite private college? Evidence on the effects of college type on earnings. *Journal of Human Resources* 34(1) pp. 104-123.
- Buchinsky, Moshe. 1994. Changes in the U.S. wage structure 1963 – 1987: application of quantile regression. *Econometrica* 62(2) pp. 405-458.

Card, David E. 1995. Using geographic variation in college proximity to estimate the returns to schooling. *Aspects of labour market behaviour: essays in honor of John Vanderkamp*. Eds. L.N. Christofides et al. Toronto: University of Toronto Press pp. 201-221.

-- 1999. The causal effect of education on earnings. *Handbook of Labor Economics, Volume 3A*. Eds. O.C. Ashenfelter and D.E. Card. Amsterdam: North-Holland pp. 1801-1863.

Dale, Stacy and Alan B. Krueger. 2002. Estimating the payoff to attending a more selective college: an application of selection on observables and unobservables. *Quarterly Journal of Economics* 117(4) pp. 1491-1527.

Frenette, Marc (2009). Do universities benefit local youth? Evidence from the creation of new universities. *Economics of Education Review* 28(3) pp. 318-328.

Goldin, Claudia and Lawrence F. Katz. 1999. The shaping of higher education: the formative years in the United States, 1890-1940. *Journal of Economic Perspectives* 13 pp. 37-62.

Johnson, George E. 1984. Subsidies for higher education. *Journal of Labor Economics* 2(3) pp. 303 – 318.

Kane, Thomas J. 1995. Rising public college tuition and college entry: how well do public subsidies promote access to college? NBER Working Paper #5164.

Katz, Lawrence and K. Murphy. 1992. Changes in relative wages, 1963-1987: supply and demand factors. *Quarterly Journal of Economics* 107(1) pp. 35-78.

Long, Mark C. 2008. College quality and early adult outcomes. *Economics of Education Review* 27(5) pp. 588-602.

Loury, Linda Datcher and David Garman. 1995. College selectivity and earnings. *Journal of Labor Economics* 13(2) pp. 289-308.

McMillen, Daniel P., Larry D. Singell, Jr., and Glen R. Waddell. 2007. Spatial competition and the price of college. *Economic Inquiry* 45(4) pp. 817-833.

Moretti, Enrico. 2004. Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data. *Journal of Econometrics* 121(1-2) pp. 175-212.

Snyder, Tom D., Sally A. Dillow and Charlene M. Hoffman. 2008. *Digest of Education Statistics 2007* (NCES 2008-022). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Texas Higher Education Coordinating Board - Division of Finance, Campus Planning, and Research. 2009. Texas Public University Cost Study FY 2006 – FY 2008. Available at: <http://www.theccb.state.tx.us/Reports>.

Figure 1. University counts plotted against statewide populations (in millions), 1990.

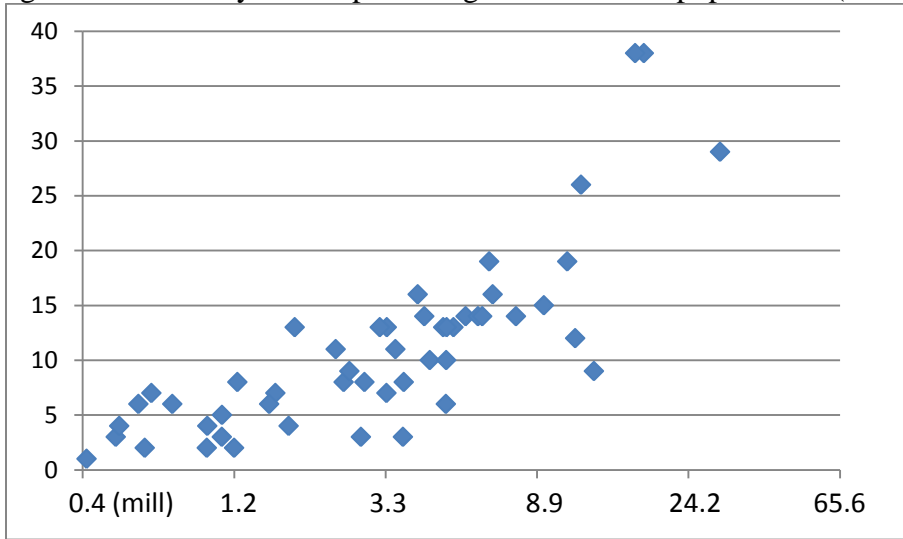


Figure 2. Shares of statewide public-university attendees enrolled at universities with 10,000 or more students, based on enrollment data from 1990. States ordered by total population in 1990.

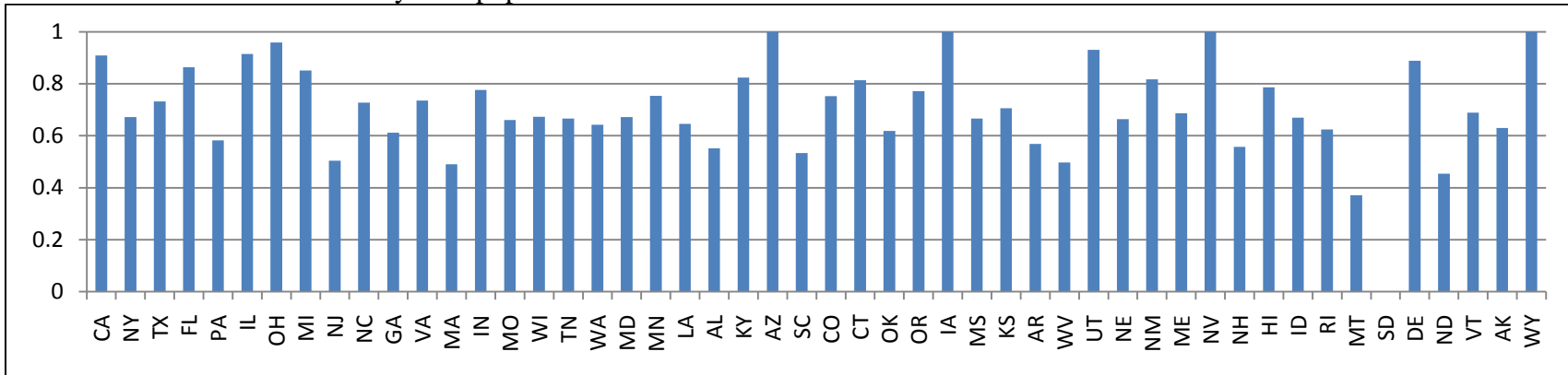


Table 1. Correlations of PSE structures within states over time

University Counts				
	1950	1970	1980	1990
1950	1.0			
1970	0.87	1.0		
1980	0.88	0.98	1.0	
1990	0.88	0.98	1.0	1.0

Universities Per Capita				
	1950	1970	1980	1990
1950	1.0			
1970	0.80	1.0		
1980	0.71	0.95	1.0	
1990	0.66	0.87	0.96	1.0

Table 2. Summary Statistics for Baseline Data Sample

<u>Basic Demographics</u>	Sample Mean (standard deviation)
Asian	0.07 (0.25)
Black	0.09 (0.29)
Hispanic	0.13 (0.33)
White	0.70 (0.46)
Female	0.53 (0.50)
<u>Family Income (base-year survey)</u>	
< 10,000	0.09 (0.29)
10,001 – 20,000	0.14 (0.35)
20,001 – 35,000	0.27 (0.44)
35,001 – 50,000	0.20 (0.40)
50,001 – 75,000	0.13 (0.34)
75,001 – 100,000	0.04 (0.19)
100,001 – 200,000	0.04 (0.18)
> 200,000	0.01 (0.12)
Unknown	0.09 (0.29)
<u>Four-Year University Outcomes</u>	
Attendance	0.57 (0.50)
Bachelor's attained	0.35 (0.48)
Bachelor's from private	0.14 (0.34)
Bachelor's from public out-of-state	0.03 (0.18)
Bachelor's from public in-state	0.18 (0.39)
Bachelor's from small public in-state (<10,000)	0.04 (0.20)
Bachelor's from large public in-state (>10,000)	0.14 (0.35)
N	10920
<u>Wages (wage sample only)</u>	
Log Annual Earnings	10.3 (0.49)
N	6043

Table 3. Descriptive statistics across states for the fractionalization measures, by enrollment threshold and public/private.

	<u>Public</u>				<u>Private</u>
	Share 8,000 or less	Share 10,000 or less	Share 12,000 or less	Share 15,000 or less	Share 10,000 or less
Mean	0.22	0.30	0.39	0.51	0.89
Standard Deviation	0.14	0.18	0.24	0.29	0.18
Min	0	0	0	0	0.07
Max	0.50	1	1	1	1
N	50	50	50	50	50

Table 4. Dependent Variables: Four-Year University Attendance (top); Any Bachelor’s Degree Attainment (bottom)

	<i>Fractionalization Measures</i>				Include private fractionalization:
	Shares of statewide four-year public university enrollment at universities with enrollments below:				
	8,000	10,000	12,000	15,000	10,000
<u>Four-Year University Attendance</u>					
Fractionalization (public)	0.081 (0.042) [†]	0.108 (0.039)**	0.105 (0.036)**	0.086 (0.026)**	0.109 (0.037)**
Fractionalization (private)					-0.103 (0.062)
P-value	0.06	<0.01	<0.01	<0.01	
Implied Effect size	0.011	0.019	0.025	0.025	
<u>Any Bachelor’s Degree Attainment</u>					
Fractionalization (public)	0.018 (0.037)	0.046 (0.030)	0.037 (0.027)	0.038 (0.018)*	0.046 (0.030)
Fractionalization (private)					-0.010 (0.058)
P-value	0.62	0.13	0.18	0.05	
Implied effect size	0.002	0.008	0.009	0.011	
N	10920	10920	10920	10920	10920

** Denotes statistical significance at the 1 percent level or better

* Denotes Statistical significance at the 5 percent level

[†] Denotes Statistical significance at the 10 percent level

Notes: Standard errors are clustered at the state level. Recall from the text that the “implied effect size” multiplies the fractionalization point estimate by the standard deviation of the fractionalization measure across states.

Table 5. Dependent Variable: Private-University Degree Attainment

	<i>Fractionalization Measures</i>				Include private fractionalization:
	Shares of statewide four-year public university enrollment at universities with enrollments below:				
	8,000	10,000	12,000	15,000	10,000
<u>Private-University Degree Attainment</u>					
Fractionalization (public)	0.053 (0.040)	0.077 (0.037)*	0.055 (0.035)	0.067 (0.023)**	0.077 (0.037)*
Fractionalization (private)					0.020 (0.054)
P-value	0.19	0.04	0.12	<0.01	
Implied effect size	0.007	0.014	0.013	0.019	
<u>Out-of-State Public Degree Attainment</u>					
Fractionalization (public)	0.031 (0.033)	0.033 (0.030)	0.026 (0.022)	0.043 (0.018)*	0.033 (0.030)
Fractionalization (private)					0.010 (0.019)
P-value	0.35	0.28	0.24	0.02	
Implied effect size	0.004	0.006	0.006	0.012	
<u>Combined Exits from In-State System</u>					
Fractionalization (public)	0.084 (0.059)	0.110 (0.052)*	0.081 (0.043) [†]	0.110 (0.028)**	0.110 (0.052)*
Fractionalization (private)					-0.009 (0.061)
P-value	0.16	0.04	0.07	<0.01	
Implied effect size	0.012	0.020	0.019	0.032	
N	10920	10920	10920	10920	10920

** Denotes statistical significance at the 1 percent level or better

* Denotes Statistical significance at the 5 percent level

[†] Denotes Statistical significance at the 10 percent level

Notes: Standard errors are clustered at the state level. Recall from the text that the “implied effect size” multiplies the fractionalization point estimate by the standard deviation of the fractionalization measure across states. In the third horizontal panel, private-university degree attainment and out-of-state public university degree attainment outcomes are treated to be the same (i.e., exits from the in-state public system).

Table 6. Dependent Variables: Small-Public-University Degree Attainment (top); Large-Public-University Degree Attainment (bottom)

	<i>Fractionalization Measures</i>				Include private fractionalization:
	Shares of statewide four-year public university enrollment at universities with enrollments below:				
	8,000	10,000	12,000	15,000	
<u>Small-Public-University Degree Attainment</u>					
Fractionalization (public)	0.171 (0.019)**	0.159 (0.022)**	0.176 (0.027)**	0.126 (0.022)**	0.159 (0.022)**
Fractionalization (private)					0.011 (0.022)
P-value	<0.01	<0.01	<0.01	<0.01	
Implied effect size	0.024	0.029	0.042	0.037	
<u>Large-Public-University Degree Attainment</u>					
Fractionalization (public)	-0.235 (0.050)**	-0.223 (0.041)**	-0.220 (0.032)**	-0.199 (0.024)**	-0.223 (0.043)**
Fractionalization (private)					-0.012 (0.055)
P-value	<0.01	<0.01	<0.01	<0.01	
Implied effect size	-0.033	-0.040	-0.053	-0.058	
N	10920	10920	10920	10920	
<u>Total In-State Public University Degree Attainment</u>					
Fractionalization (public)	-0.065 (0.055)	-0.064 (0.043)	-0.044 (0.040)	-0.072 (0.027)**	-0.064 (0.042)
Fractionalization (private)					-0.001 (0.056)
P-value	0.24	0.14	0.27	<0.01	
Implied effect size	-0.009	-0.012	-0.011	-0.020	
N	10920	10920	10920	10920	10920

** Denotes statistical significance at the 1 percent level or better

* Denotes Statistical significance at the 5 percent level

† Denotes Statistical significance at the 10 percent level

Notes: The “small-university” and “large-university” definitions for the dependent variables in each model correspond to the fractionalization enrollment thresholds. That is, in column (1), a degree is designated as from a “small university” if it is from a university with an enrollment below 8,000 students in 1990, and similarly for column (2) with the 10,000 cutoff, and so on. These definitional alignments generate the most predictive power, but the results are not sensitive to reasonable adjustments. All standard errors are clustered at the state level. Recall from the text that the “implied effect size” multiplies the fractionalization point estimate by the standard deviation of the fractionalization measure across states.

Table 7. Reduced-form estimates of the effect of PSE structure on wages

	<i>Fractionalization Measures</i>				Include private fractionalization: 10,000
	Shares of statewide four-year public university enrollment at universities with enrollments below:				
	8,000	10,000	12,000	15,000	
<u>Entire Sample</u>					
Fractionalization (public)	-0.155 (0.055)**	-0.101 (0.047)*	-0.067 (0.032)*	-0.032 (0.024)	-0.101 (0.049)*
Fractionalization (private)					-0.066 (0.045)
P-value	<0.01	0.04	0.04	0.19	
Implied effect size	-0.022	-0.018	-0.016	-0.009	
N	6043	6043	6043	6043	6043
<u>Men Only</u>					
Fractionalization (public)	-0.168 (0.073)*	-0.101 (0.068)	-0.058 (0.051)	-0.018 (0.038)	-0.101 (0.069)
Fractionalization (private)					-0.033 (0.055)
P-value	0.03	0.14	0.27	0.64	
Implied effect size	-0.024	-0.018	-0.014	-0.005	
N	3187	3187	3187	3187	3187
<u>Women Only</u>					
Fractionalization (public)	-0.166 (0.066)*	-0.116 (0.050)*	-0.082 (0.039)*	-0.050 (0.028) [†]	-0.112 (0.052)*
Fractionalization (private)					-0.122 (0.060)*
P-value	0.02	0.03	0.04	0.08	
Implied effect size	-0.023	-0.021	-0.020	-0.015	
N	2856	2856	2856	2856	2856

** Denotes statistical significance at the 1 percent level or better

* Denotes Statistical significance at the 5 percent level

[†] Denotes Statistical significance at the 10 percent level

Notes: Standard errors are clustered at the state level. Recall from the text that the “implied effect size” multiplies the fractionalization point estimate by the standard deviation of the fractionalization measure across states.

Table 8. Variance of PSE fractionalization by graduation-probability quintile (fractionalization defined at 10,000-student enrollment threshold)

Quintile	Population Share	Variance of PSE Fractionalization
1 (least likely to graduate)	0.2	0.022
2	0.2	0.021
3	0.2	0.020
4	0.2	0.021
5	0.2	0.020

Note: The variance of fractionalization here is not directly comparable to what is reported in Table 3 – the analysis in Table 3 is performed at the state level, this analysis is performed at the individual level.

Table 9. Robustness checks for the reduced-form wage model (pooled sample)

	<i>Fractionalization Measures</i>			
	Shares of statewide four-year public university enrollment at universities with enrollments below:			
	8,000	10,000	12,000	15,000
<u>Add Density, House Prices and Occupation Shares</u>				
Fractionalization	-0.170 (0.047)**	-0.116 (0.037)**	-0.073 (0.028)*	-0.034 (0.025)
P-value	<0.01	<0.01	0.01	0.17
N	6043	6043	6043	6043
<u>Add History of Median Household Income (1960-1990)</u>				
Fractionalization	-0.139 (0.059)*	-0.075 (0.054)	-0.050 (0.036)	-0.009 (0.030)
P-value	0.02	0.16	0.18	0.78
N	6043	6043	6043	6043
<u>Add Per-Pupil Spending on K-12 Education</u>				
Fractionalization	-0.158 (0.058)**	-0.101 (0.049)*	-0.065 (0.033) [†]	-0.030 (0.026)
P-value	<0.01	0.04	0.06	0.25
N	6043	6043	6043	6043
<u>Add (Public) Academic R&D Expenditures</u>				
Fractionalization	-0.147 (0.056)*	-0.101 (0.048)*	-0.072 (0.033)*	-0.040 (0.025)
P-value	0.01	0.04	0.04	0.12
N	6043	6043	6043	6043
<u>Omit Northeast Region (Primary Model)</u>				
Fractionalization	-0.162 (0.066)*	-0.130 (0.058)*	-0.086 (0.040)*	-0.045 (0.034)
P-value	0.02	0.03	0.04	0.19
N	4921	4921	4921	4921
<u>Include Region Indicators (Primary Model)</u>				
Fractionalization	-0.139 (0.058)*	-0.071 (0.052)	-0.051 (0.037)	-0.006 (0.029)
P-value	0.02	0.18	0.17	0.83
N	6043	6043	6043	6043

** Denotes statistical significance at the 1 percent level or better

* Denotes Statistical significance at the 5 percent level

[†] Denotes Statistical significance at the 10 percent level

Notes: All standard errors are clustered at the state level. The northeast region is defined by the US Census and includes ME, NH, VT, MA, RI, CT, NY, PA and NJ.

Table 10. Average direct instructional costs per FTE student, by university group and discipline

	Average Enrollment	Chemistry	Economics	English	Math	Political Science
Group 1	18,500	\$4765 (870)	3753 (796)	4112 (817)	3530 (606)	3438 (550)
Group 2	8,050	6428 (2450)	4465 (863)	4533 (1062)	4157 (1180)	4269 (795)
P-value		0.07	0.21	0.33	0.16	0.02

Notes: Standard deviations in parenthesis. P-values are reported for simple difference-in-means tests. Tests that allow for unequal variances across the two groups of universities produce similar results.

Appendix

This appendix reports coefficient estimates for the control variables used in the models described in the text. Estimates are reported from models for each educational outcome and wages using the fractionalization measure based on the 10,000-student enrollment threshold. The control-variable coefficient estimates are very similar across the models that use the different fractionalization measures.

Table A.1. Coefficient estimates for the control variables in each model (using fractionalization measure based on the 10,000-student enrollment threshold).

	Any Attendance	Any Bachelor's	Private- University/Out- of-State Public Bachelor's	Small-Public- University Bachelor's	Large-Public- University Bachelor's	Wages (logs, pooled sample)
Share of public enrollment at universities with 10,000 students or less	0.108 (0.039)**	0.046 (0.030)	0.110 (0.052)*	0.159 (0.022)**	-0.223 (0.043)**	-0.101 (0.047)*
<u>State Controls</u>						
Percent white	0.045 (0.097)	-0.006 (0.062)	0.031 (0.084)	0.062 (0.033) [†]	-0.099 (0.073)	-0.048 (0.080)
PSE spending per capita (log)	-0.066 (0.030)*	-0.075 (0.023)**	-0.117 (0.037)**	-0.001 (0.012)	0.043 (0.026)	-0.048 (0.030)
Median household income (log)	-0.036 (0.062)	0.084 (0.036)*	0.247 (0.045)**	-0.014 (0.027)	-0.149 (0.050)**	0.332 (0.059)**
Ratio of Land in Agricultural Production to Total Land (log)	-0.007 (0.003)*	-0.000 (0.005)	-0.006 (0.006)	0.002 (0.002)	0.004 (0.004)	0.004 (0.004)
<u>Individual Controls</u>						
English as second language	0.063 (0.014)**	0.042 (0.014)**	0.028 (0.012)*	0.005 (0.007)	0.009 (0.014)	0.101 (0.024)**
One sibling	-0.024 (0.015)	-0.018 (0.015)	-0.011 (0.015)	0.004 (0.009)	-0.012 (0.019)	0.025 (0.022)
Two siblings	-0.040 (0.018)*	-0.034 (0.017)*	-0.008 (0.017)	0.002 (0.008)	-0.028 (0.020)	0.017 (0.026)
Three or more siblings	-0.065 (0.016)**	-0.064 (0.018)**	-0.029 (0.017) [†]	0.001 (0.010)	-0.036 (0.020) [†]	0.006 (0.024)
Siblings unknown	-0.114 (0.06) [†]	-0.079 (0.044) [†]	-0.044 (0.027)	-0.009 (0.014)	-0.026 (0.050)	0.015 (0.070)
Father educ: high school	0.043 (0.017)*	0.004 (0.012)	-0.004 (0.010)	0.009 (0.004)*	-0.001 (0.009)	0.039 (0.019)*
Father's educ: some college	0.120 (0.019)**	0.071 (0.017)**	0.022 (0.013)	0.020 (0.008)*	0.029 (0.011)**	0.064 (0.021)**
Father's educ: college	0.181 (0.017)**	0.135 (0.019)**	0.069 (0.016)**	0.016 (0.007)*	0.050 (0.015)**	0.064 (0.025)*
Father's educ: grad school	0.181 (0.018)**	0.180 (0.023)**	0.121 (0.016)**	0.001 (0.008)	0.058 (0.019)**	0.112 (0.031)**
Father's educ: unknown	0.073 (0.018)**	0.009 (0.015)	-0.015 (0.017)	0.023 (0.008)**	0.001 (0.011)	0.012 (0.023)
Father's educ: empty	0.004 (0.047)	-0.047 (0.029)	-0.013 (0.027)	-0.027 (0.007)**	-0.006 (0.017)	-0.078 (0.056)
Mother's educ: high school	0.076 (0.015)**	0.035 (0.011)**	-0.002 (0.009)	0.011 (0.006) [†]	0.026 (0.007)**	0.027 (0.016) [†]
Mother's educ: some college	0.125 (0.018)**	0.067 (0.011)**	0.020 (0.012) [†]	0.017 (0.007)*	0.030 (0.009)**	0.054 (0.020)*

Mother's educ: college	0.140 (0.014)**	0.111 (0.014)**	0.090 (0.017)**	0.010 (0.008)	0.011 (0.013)	0.064 (0.022)**
Mother's educ: grad school	0.143 (0.015)**	0.111 (0.015)**	0.075 (0.016)**	0.014 (0.010)	0.022 (0.021)	0.056 (0.027)*
Mother's educ: unknown	0.086 (0.019)**	0.089 (0.013)**	0.039 (0.014)*	-0.007 (0.007)	0.057 (0.012)**	0.032 (0.026)
Mother's educ: empty	0.070 (0.067)	0.123 (0.052)*	0.070 (0.045)	0.031 (0.019)	0.022 (0.039)	0.009 (0.102)
Family Income: < 10K	-0.216 (0.024)**	-0.222 (0.022)**	-0.210 (0.026)**	0.033 (0.010)**	-0.045 (0.029)	-0.272 (0.047)**
Family Income: 10K – 20K	-0.192 (0.021)**	-0.215 (0.022)**	-0.218 (0.024)**	0.040 (0.012)**	-0.037 (0.029)	-0.253 (0.045)**
Family Income: 20K – 35K	-0.160 (0.018)**	-0.204 (0.023)**	-0.211 (0.025)**	0.040 (0.011)**	-0.033 (0.029)	-0.183 (0.048)**
Family Income: 35K – 50K	-0.118 (0.017)**	-0.151 (0.026)**	-0.202 (0.027)**	0.048 (0.013)**	0.003 (0.030)	-0.140 (0.042)**
Family Income: 50K – 75K	-0.056 (0.019)**	-0.080 (0.024)**	-0.150 (0.029)**	0.038 (0.010)**	0.033 (0.028)	-0.110 (0.045)*
Family Income: 75K – 100K	-0.027 (0.014) [†]	-0.023 (0.033)	-0.074 (0.045)	0.018 (0.011)	0.033 (0.036)	-0.034 (0.054)
Family Income: > 200K	0.006 (0.024)	0.076 (0.035)*	0.028 (0.035)	0.024 (0.017)	0.023 (0.032)	-0.025 (0.063)
Family Income: Unknown	-0.121 (0.027)**	-0.150 (0.028)**	-0.165 (0.024)**	0.050 (0.013)**	-0.036 (0.028)	-0.173 (0.057)**
Composite standardized test score	0.011 (0.000)**	0.010 (0.001)**	0.006 (0.001)**	0.001 (0.000)*	0.003 (0.001)**	0.004 (0.001)**
GPA	0.167 (0.007)**	0.154 (0.008)**	0.058 (0.007)**	0.021 (0.004)**	0.074 (0.005)**	0.088 (0.011)**
Indicator for missing test score	-0.589 (0.035)**	-0.481 (0.039)**	-0.306 (0.040)**	-0.037 (0.016)*	-0.138 (0.031)**	-0.235 (0.068)**
Asian	0.046 (0.025) [†]	0.038 (0.019) [†]	-0.035 (0.026)	-0.002 (0.009)	0.076 (0.024)**	0.042 (0.026)
Hispanic	0.015 (0.023)	-0.040 (0.011)**	-0.023 (0.009)**	-0.005 (0.008)	-0.012 (0.012)	-0.041 (0.022) [†]
black	0.096 (0.020)**	0.030 (0.012)*	0.029 (0.012)*	-0.003 (0.007)	0.005 (0.011)	-0.051 (0.019)**
American Indian	-0.007 (0.041)	-0.081 (0.025)**	-0.014 (0.020)	-0.004 (0.019)	-0.062 (0.021)**	-0.124 (0.074) [†]
Race unknown	-0.017 (0.058)	-0.089 (0.033)**	-0.042 (0.034)	-0.036 (0.006)**	-0.011 (0.038)	0.017 (0.063)
Female	-0.004 (0.008)	0.034 (0.009)**	0.016 (0.006)**	0.007 (0.004) [†]	0.011 (0.007)	-0.276 (0.012)**
Constant	-0.217 (0.670)	-1.557 (0.387)**	-2.979 (0.482)**	0.094 (0.285)	1.329 (0.529)*	6.281 (0.621)**
R-squared	0.36	0.35	0.23	0.03	0.11	0.21
Observations	10920	10920	10920	10920	10920	6043

** Denotes statistical significance at the 1 percent level or better

* Denotes Statistical significance at the 5 percent level

[†] Denotes Statistical significance at the 10 percent level

Notes: Standard errors are clustered at the state level. Omitted controls are: English is first language, Mother and Father education < HS, Family Income between 100K and 200K, race is white, gender is male, individual is an only child.