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# Cohort Crowding:

# How resources affect collegiate attainment

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**ABSTRACT**

Colleges and universities in the United States receive significant subsidies from state, federal and private sources. Changes in the number of potential college students within a state over time generate one source of variation in the per capita resources for higher education as tuition revenue fails to cover the full cost of higher education. At issue is how variation in resources per student for higher education changes the outputs of the higher education sector, including undergraduate degree production. Using data covering the last half of the twentieth century we find strong evidence of cohort crowding. A clear implication of this finding is that that the public expenditures on higher education have large effects on degree production.

## Cohort Crowding: How resources affect collegiate attainment

The question motivating this analysis is how resources matter in degree production in higher education. The higher education market in the United States is dominated by public and non-profit production and these institutions receive considerable subsidies from state, federal and private sources. The availability of public resources at these institutions may well have significant effects on the production of degrees, as student charges in the form of tuition often cover only part of the cost of education. As a point of reference, tuition and fee payments account for about 28% of the total revenue of colleges and universities in academic year 1995-96, with this share representing an increase from the share of about 20% persisting in the 1960s and 1970s (Table 334, *Digest of Education Statistics*, 2001).

The identification of the direct effect of changes in resources per student on degree outcomes is complicated because only part of any observed change in expenditures or state appropriations is likely to be exogenous. What is more, expenditures translate into resources with long lags. To get around these issues, we focus on changes in resources per student arising from changes in cohort size. With tuition price reflecting appreciably less than the full-cost of producing a college education, demographic variation -- changes in the size of the traditional college age population – affects resources available per student at the college and university level.

The motivating hypothesis of this analysis focuses on the potential role of "crowding" in the higher education sector. The supply side of the higher education market is an unusual mixed market, populated largely by a heterogeneous group of non-profit and public providers. Increases in the college age population shift out the higher

education demand function. Yet, in the absence of complete per capita adjustment in subsidies from public and private sources, increasing enrollment comes at the cost of reductions in educational resources per student. Thus, large cohorts are essentially "crowded out" of higher education sector as the increase in cohort size does not produce a proportionate increase in collegiate attainment.

Understanding how variation in resources per student affects collegiate attainment is important to understanding the overall returns to public subsidies to higher education. At different stages in history, public interventions in primary, secondary, and tertiary education have contributed to decisive increases in aggregate educational attainment and, in turn, economic growth. The dramatic increase in educational attainment, particularly the rise in high school graduation, is one of the major developments contributing to economic growth and the narrowing of income inequality over the first half of the twentieth century (Goldin, 1999). While the first half of the century was defined by the high school movement, the middle part of the century was defined by increases in collegiate attainment. Among those born in 1925 (and likely to have completed college before 1950), only about 15% had graduated from college. A quarter century later, 29% of those born in 1950 had completed college, an increase of about 75%. Yet, shortly after this point, college completion began to decline to a plateau through the birth cohorts of the early 1960s. The slowdown in degree completion beginning with graduates in the late 1970s has had significant effects on the structure of wages, as well as lasting effects on the prospects for long-term growth. In the coming decade, many states are facing

large increases in the college-age population, with serious questions about the capacity of state colleges to meet enrollment demand for these cohorts.[1]

To set the context of this analysis, it is important to fix the basic relationship among public support for higher education, changes in the size of the college-age population, and collegiate attainment. The first section of the paper outlines the dramatic growth in the post-World War II era in state and federal support for higher education and the subsequent arrest of growth in the 1970s, which coincided with rapid expansion in the college age-population. An idea central to this paper is that when public (or private) subsidies for higher education fall or do not expand with changes in cohort size, the resulting quality-quantity tradeoff in the production of higher education yields reductions in the share of the population completing college. The second section presents the idea of the link between subsidies, college enrollment demand, and the quantity-quality offering of colleges and universities in the context of a rudimentary but illustrative model. The third section turns to the empirical analysis of variation within states over time in cohort size and collegiate attainment. We pay particular attention to how measurement choices and alternative behavioral adjustments such as increased time to degree may affect the interpretation of the clear negative relationship between cohort size and college completion. Resources from public sources do not adjust completely to changes in cohort size and enrollment adjustment is most attenuated at flagship public institutions and selective private institutions. Other potential determinants of changes in enrollment demand such as changes in precollegiate achievement are considered, but found too small

[1] For example one report estimated that the number of students seeking to enroll at California's public colleges would rise by 36% between 2000 and 2010. Former University of California President Clark Kerr has dubbed this increase in demand "Tidal Wave II" as nearly three-quarters of the projected growth is strictly attributable to population growth (Schmidt, 1999).

to account for the reduction in college completion among relatively large cohorts. The basic result is that the incomplete adjustment of resources in response to population changes leads to a substantial reduction in collegiate attainment rates. The conclusion is clear: resources matter in the production of higher education.

*Section 1: Resources, cohort size, and collegiate attainment*

The substantial public and private subsidies in the market for higher education have fundamental effects on the "quantity" of collegiate attainment and the "quality" (or resource intensity) of this product.[2] The likely result is that subsidies lead to increases in quantity and quality of collegiate education. While the descriptive overview that follows focuses on the broad national trends, it is by no means the case that variation, trends and initial conditions in higher education are identical across states.

An important starting point is recognizing that the state is the appropriate unit of market definition at the extensive margin of changes in college completion.[3] States are the natural unit of analysis because public institutions of higher education are largely under the control of state governments, which provide both substantial funding and exercise regulatory power.[4] State colleges and universities provide the majority of

[2] Winston (1999) argues that it is this sustained "excess of production cost over price – the continuing ability of a college to subsidize all of its customers, not just cross-subsidize some at the expense of others or briefly let price fall below cost – is a defining characteristics of higher education both public and private."

[3] While the state-level is the appropriate unit of analysis for the consideration of the collegiate attainment of students likely to be at the margin of degree attainment, it is important to acknowledge the considerable variation and stratification in the higher education market. At the most competitive level (Stanford, Harvard), the market for higher education is highly integrated at the national level (Hoxby, 2000).

[4] The political economy developments of the late 19th and early 20th centuries fundamentally changed the position of the states in the provision of higher education. The federal Morrill Acts of 1862 and 1891 endowed each state (regardless of population or geography) with the resources for the founding of a state university. Second, states (to varying degrees) led the way in the early 20th century in transforming the college into the modern American research university – large in scale and with a full

enrollment opportunities in higher education to their residents at a steep discount in price. The share of undergraduate degrees awarded by public institutions has moved upward from about 50% in 1947 to nearly 66% in the most recent academic year, while the share of total college enrollment (including enrollment at sub-baccalaureate institutions) is even higher at nearly 80%.[5]

Nearly all states have differentiated systems of public higher education, including a mix of community colleges open to all students, comprehensive four-year institutions with modest admissions standards, and 'flagship' public research universities. Table 1 summarizes the role of state appropriations in the revenue stream of colleges and universities, particularly in the public sector. Because there are many public options – including community colleges – that are either open enrollment or require only modest admission credentials, it is these public options that are particularly relevant to students at the margin of enrollment or degree completion. Notably, at the public community colleges, state and local support accounted for 57.5% of revenues, while state support accounted for more than 36% of revenues at non-research four-year institutions.

Moreover, because in-state tuition levels are dramatically lower than out-of-state tuition, it is the conditions within-state higher education markets that are likely to affect the behavior of students at the margin of college completion. With extensive state subsidies at public institutions comes the price discount for in-state residents at public

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compliment of graduate and professional programs (Goldin and Katz, 1999). Heavily subsidized state institutions largely forced from the market the numerous small and educationally suspect trade schools of the early 20th century, including the private medical schools described in the 1910 Flexner report.

[5] Among those enrolled at four-year institutions, students at public institutions still comprise 67% of all undergraduates, though undergraduates at public two-year colleges are plainly a substantial share of all enrollment. (http://nces.ed.gov//pubs2002/digest2001/tables/dt177.asp )

colleges. The final columns of Table 1 show the substantial nominal difference between in-state and out-of-state tuition prices.[6]

In the last half century, subsidies for higher education have varied widely, from a euphoric state in the post-war years to a period of significant retrenchment in the 1970s. With resources for higher education especially plentiful in the two decades following World War II, a number of writers have referred to the period from the late 1950s through the 1960s as the "Golden Years" of higher education.[7] One study sites an average annual growth rate of 8 percent in education and general expenditures per student during the decade of the 1960s (Cheit, 1971). Much of this expansion was financed through public subsidies and, by 1970, nearly 50% of higher education revenue came from public sources with state and local entities providing 31% of revenues and federal sources providing 19% of revenues. The reach of public subsidies during this period extended to capital projects as well as current expenditures. New colleges and universities opened to meet demand, rising from 1,886 institutions in 1955 to 2,573 in 1970, a rate of almost 1 new institution per week (Finn, 1978).

Fortunes for colleges reversed dramatically at the end of the 1960s and through the 1970s, leading to the era described by one analyst as the "New Depression in Higher Education" (Cheit, 1971). Resources at both the state and federal levels dissipated, leaving many institutions financially strained. Figure 1 records these broad trends, showing expenditures per student in higher education and a series for the pupil-teacher

[6] The average ratio of in-state tuition to out-of-state tuition was .35 in 1996-97, amounting to an average tuition price difference of $6,145; examples of large differences include Colorado and Vermont where the difference between in-state and out-of-state undergraduate charges at the state university exceeded $11,500 in 1996-97. Rizzo and Ehrenberg (2003) examine tuition reciprocity agreements, which tend to be limited to a few geographic areas and specialized fields.

ratio in elementary and secondary education over the period from 1945 to 1995. What is notable is that resources per student in higher education fell during the 1970s while resources available in elementary-secondary education continued to rise over this period. Higher education funding lost ground at both the federal and state levels during these years.

At the state level, appropriations for higher education tend to vary with local economic conditions as well as public and political enthusiasm for the potential outcomes of higher education. During the 1960s, funding was often generous as states increased appropriations per student to public institutions, while also adding programs and campuses. The rise and contraction of state support for higher education in the post-war era is in some respects symbolized by the case of California, where the Master Plan for Higher Education (1960) focused statewide attention and resources on higher education in the state.[8] Funding and political support for higher education in the state of California shifted abruptly in the late 1960s. Then, Governor Ronald Reagan was displeased by the level of student demonstration at Berkeley and other UC campuses and dismissed Clark Kerr, President of the University of California and an architect of the Master Plan, while also cutting state funding for the university during the initial years of his term. More recently, Kane, Orzag and Gunter (2002) present evidence showing the languishing of state appropriations to higher education relative to personal income and state spending during the 1990s. Examining changes within states, they show the sensitivity of state

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[7] This reference is attributed to the manuscript by Hans Jenny and G. Richard Wynn titled *The Golden Years*, with the reference to the "golden years" appearing in Finn (1978), Cheit (1971), and other manuscripts tracing the history of state and federal support for higher education.

[8] The plan included the specification of distinct mission and goals for the three primary sectors of public higher education in California – the UC system, the Cal-State Colleges, and the community colleges. The plan called for the state to raise its commitment to fund community colleges to 45 percent of operating

appropriations to the business cycle (captured in the unemployment rate) and the susceptibility of state funding to crowd out from other obligations like Medicaid funding.

In the post-World War II era, federal aid to higher education expanded dramatically on two fronts: research and student aid.[9] The World War II G.I. Bill and, to a lesser extent the subsequent Montgomery G.I. Bill, increased the resources available to universities per student in addition to affecting enrollment of returning serviceman.[10] Beyond the direct aid to returning veterans, the experience of the war elevated the idea of universal access to higher education to the national policy discussion. The 1947 Truman Commission on Higher Education reported evidence based on the intelligence tests of those in the military that nearly twice as many young men had the "aptitude" for college as pursued college.[11] Somewhat later, the federal government opened up other forms of direct aid to students through the National Defense Education Act. In 1963, Congress passed the Higher Education Facilities Act which provided an extensive program of grants and loans for building dormitories, classrooms, and libraries. Symbolic of the distributive change occurring in the 1960s, the number of institutions receiving federal support of some form increased from 840 to 2,174 in the three years between 1963 and 1966 (Graham and Diamond, 1997, p. 43). Finally, the Higher Education Act of 1965 initiated programs for broad-based grant and loan aid to undergraduate students,

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budgets, while also calling for the creation of new institutions including 22 community colleges, 4 state colleges and 3 universities (San Diego, Irvine and Santa Cruz).

[9] Education – and higher education specifically – is broadly designated as a state function. Prior to World War II, federal funding led to the establishment of the land grant universities (through 1862 and 1891 Morrill Acts) and research funding was largely limited to agricultural topics.

[10] The World War II G.I. Bill provided institutions with $500 (about $5000 in current dollars) per student to cover tuition, fees and supplies. In 1947-48, total income of institutions of higher education reached $1.56 billion of which the federal share was 33.7 percent. The funds from the federal government include $364.7 million in federal payments for tuition and fees of veterans. (Biennial Survey, 1946-8, p. 35).

including the Guaranteed Student Loan program which was explicitly intended to address borrowing constraints in higher education.

Beyond increasing access and enrollment capacity in higher education, post-War federal leadership endorsed the notion that technological progress and economic growth would result from investments in research and development (Rivlin, 1961). A significant step in the permanent federal commitment to scientific research was the creation of the National Science Foundation with the endorsement of Vannevar Bush, director of the Office of Scientific Research and Development during the war. In this regard, total federal funding for research at colleges and universities increased by more than a factor of 5 between 1955 and 1970, rising from less than 2 billion dollars to more than 10 billion dollars (2000 dollars). Research funding increases were not limited to the engineering or military sciences, as federal investments extended to medicine and the social sciences. Growth in federal research funds to universities slowed dramatically after 1968, with some research areas experiencing decreases in resources, and it was not until the mid-1980s that significant growth for research returned, only to plateau again in the early 1990s with the end of the Cold War.

While the increased federal commitment to research in the two decades after World War II was extraordinary, it was by no means evenly distributed among colleges and universities.[12] Yet, with federal research funding quite concentrated among a few universities, particularly through the early 1960s, it is difficult to make a direct link

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[11] President's Commission on Higher Education [Truman Commission] *Higher Education for American Democracy*, Vol. I: Establishing the Goals (NY: Harper Brothers, 1947) pp. 1-49.

[12] With a heavy emphasis on competition and peer review, the allocation of federal research dollars went disproportionately to a small number of research universities. By one estimate, 20 universities received 79 percent of research funds in 1963, with this group dubbed the "federal grant universities" by Clark Kerr (Graham and Diamond, 1997, p. 42).

between these resources and degree production at the undergraduate level. By reducing the "price" of investments in higher education, federal research expenditures may fuel state investments in infrastructure.

The overall level of public support for higher education, including public support from the state and federal governments and private contributions is not necessarily tied to variation in the size of the potential college-age population. Even if current expenditures varied directly with cohort size, a substantial portion of the private and public subsidy for higher education comes in terms of capital support. For this reason, cohort size and public subsidies may interact in the production of collegiate attainment.

With the "baby boom" cohorts reaching college age, there have been marked adjustments in the size of the potential college cohorts over the last half century. Birth cohorts began to expand after the end of the depression in the early 1930s, and then spiked abruptly upward with the end of World War II in 1945 (Figure 2, right axis). The "baby boom" continued through the 1950s before birth cohort size began to contract dramatically in the 1960s. The overall size of the birth cohort in the continental states rose from about 2.2 million in 1937 to 4.25 million in 1957 and then shrank to about 3.1 million in 1973. Beginning with children born in the late 1950s, birth cohorts contracted in size and continued along a plateau into the mid-1970s. From the 1935 birth cohort to the 1950 birth cohort (or degree years 1957 to 1972, assuming completion at the modal age of 22) both cohort size and college completion increased at a sharp rate, indicating an even more dramatic increase in the number of college graduates. While cohort size continued to increase for nearly a decade, college completion rates reversed abruptly after the 1950 birth cohort, leading to the question of whether higher education institutions had

the capacity to provide college opportunities to this cohort. Thus, the aggregate empirical link between cohort size and collegiate attainment is ambiguous, as illustrated in Figure 2. Cohort size and collegiate attainment move virtually hand in hand from the 1920 birth cohort to the 1950 birth cohort, after which point college completion rates fall while cohort size continues to rise. Not only did the baby boom and the subsequent contraction vary by state (owing in part to changes in the age structure of the population), but migration also has a significant role in producing within-state variation in the size of the cohort attending college.[13]

Education is fundamentally a derived demand with the investments varying with expected returns. To this end, it is certainly plausible that larger cohorts may experience somewhat lower returns to education if the substitution between younger and older workers among the college educated is less than complete, thus reducing incentives to complete college in aggregate. A long research literature, much of which dates to the late 1970s (e.g., Stapleton and Young, 1988; Welch, 1979), focuses on the question of how adjustments of the labor market to relatively large cohorts affects incentives to invest in education for relatively large cohorts. While aggregate adjustments in cohort size may affect the return to college and, in turn, collegiate attainment, within-state variation in cohort size should not lead to variation in collegiate attainment in the presence of integrated labor markets.[14]

[13] One might consider the extent to which states anticipate changes in cohort size in planning the capacity of higher education at the state level. As David Card has suggested, the optimal response in capital investment to increases in demand for college may be to "overbuild" as cohort size increases while not building to the peak of the expansion.

[14] While we believe that, to first approximation, it makes sense to treat the labor market in the U.S. as integrated, there is good reason to believe that this approximation is not perfect. There are two distinct ways in which associations between the size of the state-specific college age population and state labor markets might affect the incentive individuals face for obtaining a college education. First, one could imagine that state specific college/high school wage differentials would vary by cohort size. We found no

If the labor market is integrated, within-state changes in cohort size will not affect relative wages and, in turn, college enrollment or college completion. If relative wages in a state respond to within-state changes in cohort size, the observed relationship between educational attainment and cohort size may represent the endogenous response of state labor markets to relatively large or small cohorts. We have employed Census data to test this proposition and find uniform evidence that cohort size at college age is unrelated to variation in the college-high school wage premium.[15] Thus, we can distinguish the question of the direct effect of cohort size on the production of education from the important, but conceptually distinct, question of how aggregate changes in relative wages associated with variation in cohort size affect incentives to invest in education.

*Section 2: A Conceptual Framework*

The objective in this section is to put forth a general model of how colleges and universities respond to changes in demand for higher education, particularly those brought about by variation in the size of cohorts entering college. The model developed below applies to both open access institutions and selective flagship institutions and

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evidence of this in census data. Additionally, the size of the college age population in a state is positively associated with employment growth in the state, and there is a well-known positive association between unemployment and college enrollment rates. Indeed in our data, we found statistically and quantitatively important negative associations between state-specific unemployment rates and the size of the college age population. However, we also found that link between the unemployment rate and college completion rates to be quantitatively small and statistically insignificant. These estimates suggest that the effect that state-specific college age population size has on college completion rates can not be working through labor market incentives.

[15] Estimates of these effects begin with regression-adjusted measures of the return to education for each single year age [25-44] at the state level for each Census year. These measures of relative wages are then the dependent variable in a regression that includes age fixed effects, census year effects, state effects, and the age 22 population for each state and age cohort. Thus, the estimates of the effect of cohort size on relative wages are based on within-state variation over time. We have investigated a number of

speaks as well to the choices made by private institutions. Yet, because these institutions frequently differ in mission and objectives, somewhat different behavioral results are predicted by type of institution.

On the supply side of the market, we focus on a representative university (or "firm"). Public universities are characterized by two unique features that define behavior: they receive substantial subsidies from the state and they may have limited capacity to set price or tuition. To the latter point, it is a third agent – state governments – that generally influence tuition setting and largely determine the level of public subsidy. Private universities are similar to public institutions in that a substantial share of revenue comes from sources other than tuition revenue, though their non-tuition revenues tend to be endowment income and private contributions. More generally, most colleges and universities are not "profit maximizers" and fall into the general category of non-profit institutions that serve broad objectives in the public interest that, presumably, would not be satisfied fully by a straight pursuit of market interests.

Colleges and universities combine their own resources with the energies of their students to produce collegiate attainment. Thus, both university revenues (which is the sum of tuition, fees, and public and private subsidies) and enrollment are inputs to the process. The essential choices made by the colleges and universities are how many students to admit and enroll and the level of resources to invest per student, subject to the university's own budget constraint and the level of student demand, which is a function of the quality (or resource intensity) of the education offered. Generating more money either through tuition revenues or subsidies implies having more resources to spend on

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specifications (men only, different age groups) and uniformly the point estimates are indistinguishable from zero.

instruction. [In this discussion, we focus only on the choices surrounding undergraduate education, though one might rightly consider other educational outputs such as research, graduate education and so forth.] Since the "donative" or non-tuition share of revenues does not vary with the number of students, enrolling more students necessarily implies spreading these resources more thinly.

Student demand varies, as usual, with price – the higher the price, *ceteris paribus*, the lower the share of the population attending college. Demand also varies with the subsidy per student (L/n, where L is the total non-tuition revenue and n is enrollment), as students would clearly prefer to pay a given price to attend an institution with more resources devoted to their education.[16] We introduce the inverse demand function $T(\frac{L}{n}, \frac{n}{pop})$, which is positive in the first argument and negative in the second and $\frac{n}{pop}$ is the enrollment rate among college-age students.

Much about the behavior of colleges and universities can be inferred from the non-distribution constraint, which applies to both public and private non-profit institutions of higher education and requires that there be no residual shareholders.[17] Most generally, the nondistribution constraint is: $nT(\frac{L}{n}, \frac{n}{pop}) - nc(q) + L = 0$ where c(q) reflects per student costs as a function of quality (or resources), with c'(q)>0 and total costs of n c(q). It follows that the per student cost of the quality of education provided is simply equal to tuition and per student subsidy (L/n). In this constraint, tuition revenue is

[16] Comparison of tuition levels among private institutions makes this point clear. In 2002-2003, Tufts University had a tuition price of $28,155 while Harvard University posted a tuition price of $27,748. With an endowment of $17.169 billion dollars at Harvard relative to the Tufts endowment of $651 million, it should be no surprise that demand revealed by application behavior is greater at Harvard than at Tufts.

[17] The model that follows builds on the effort by Hansmann (1981) to model the quality-quantity choice for a performing arts organization when private donations depend on the quality of the presentation.

endogenous and reflects the tuition rate determined by inverse demand function for college enrollment. This specification is straight forward for private institutions, but it is less clear that the treatment of tuition as endogenous applies fully to public colleges and universities, as state legislators and governors may have considerable sway in the determination of tuition.[18]

This formulation echoes the quantity-quality tradeoff in children common in the economics of the family (Willis, 1973). Much of the intuition underlying this way of analyzing the problem follows from the nonlinear constraint. The constraint, illustrated in Figure 3 for the case in which tuition is determined exogenously, is nonlinear and asymptotes at the level of quality equal to tuition, as the number of students enrolled goes to infinity.[19] At low levels of enrollment the price of expansion is high as the relative change in resources per student is substantial. At higher levels of enrollment (and lower levels of quality), the quantity-quality tradeoff is less pronounced as per student subsidy becomes a tiny piece of the cost of education for any individual student. Adding a form of subsidy that varied with enrollment would simply raise the constraint (and the asymptote). The constraint shifts with changes in subsidy. As the subsidy level decreases, there is an "income" effect and a "price effect". The first effect implies a

[18] A survey of State Higher Education Executive Officers finds that in 10 states legislatures explicitly set tuition in practice or in statute (Christal, 1997). In other states, tuition determination is generally the responsibility of governing boards or state higher education authorities, with these authorities often composed of political appointees (Kane, Orszag, and Gunter, 2002).

As an empirical point, we have examined the link between tuition and within-state variation in cohort size and find that over the 1970-1997 interval this link is *negative* at public flagship institutions and other public colleges. This result is consistent with the interpretation that neither institutions nor market forces have full power over the determination of public tuition levels. One further interpretation is that public tuition levels are an important symbolic variable for politicians.

[19] The basic "shape" of the constraint would be the same with the endogenous treatment of tuition though the slope would be steeper and the function would "flatten" at a greater rate. With tuition fixed, the slope of the constraint is $-L/n^2$, while endogenous tuition yields $\frac{\partial c(q)}{\partial n} = \frac{-L}{n^2}T_1 + \frac{1}{pop}T_2 - \frac{L}{n^2}$.

reduction in enrollment and quality, while the second increases the level of enrollment that must be foregone to obtain a given increase in quality of offerings.

As illustrated by the constraint, universities face a choice in the production of college education, implicitly weighing a tradeoff between the quantity variable (that might be thought of as the output of the enrollment decision) and resources per student. How colleges and universities weigh this tradeoff depends on their specific "mission" (the University of Michigan has been given different objectives by the state than Central Michigan University) and initial levels of endowment or fixed subsidy. Most generally, we assert that institutions maximize an objective function that includes both quantity (n) and quality (q) components – U(n,q).[20] The public university problem in the case where tuition is exogenous is then to solve: $MaxU(n,q)$ subject to the constraint $nT - nc(q) + L = 0$. This produces the first order conditions:

$$\frac{\partial U}{\partial n} - \lambda(T - c(q)) = 0$$
$$\frac{\partial U}{\partial q} - \lambda nc'(q) = 0$$

and it follows that a university will choose the point where the rate of marginal substitution between quantity and quality is equal to the ratio of the respective prices or:

[20] "Quality" may be one dimension of higher education that appeals to students, particularly if those attending institutions with more resources per student earn higher wages. "Quality" may also resonate to the institution as a complement to other activities such as research or simply providing "prestige" which is valued by faculty and administrators. It is fundamental to think of "quality" or resources per student as generating educational outputs. Explicitly, think of degree production $BA = nf(\frac{L}{n} + T, X)$ where X is an individual attribute affecting completion; thus, collegiate resources transform initial enrollment to completion.

$$\frac{\frac{\partial U}{\partial n}}{\frac{\partial U}{\partial q}} = \frac{T - c(q)}{nc'(q)}.$$

There is no reason to believe that the functional form of the objective function is the same across all universities nor do all universities and colleges have access to generous non-tuition revenues. Some institutional leaders may have ambitions to upgrade quality while others may find rewards in maximizing enrollment. How quality and enrollment adjust to changes in demand, driven by population variation, or by changes in subsidy, brought about by state fiscal shocks, will depend on the objective function governing the behavior of the university and the level of subsidy available to the university. At one extreme, institutions may simply maximize enrollment. In this case, the level of enrollment (and the quality of the collegiate experience) is determined at the intersection of the demand function and the constraint in quality-enrollment space. Without compensating increases in subsidy (L), which would shift out the constraint, the shift in demand occurs along a function where we have declining resources per student, leading to a less than proportionate increase in enrollment demand. This is illustrated in Figure 4; along the downward sloping part of the constraint, the change in enrollment will be less than the shift in demand. What is more, "quality" or resources per student decline as enrollment increases along the constraint.

In another case, potentially more representative of the public research universities, universities weigh the tradeoff between quantity and quality directly and choose to operate at the tangency between the institutional indifference curve and the nondistribution constraint. Such a situation may be independent of student demand (with the demand function crossing the constraint at or to the right of the tangency). Shifts in

demand do not change the optimal enrollment-quality choice of the institution, but rather lead to or exacerbate the condition of excess demand.[21] For private institutions, tuition is clearly endogenous, rising with increases in demand, and there is every reason to believe that demand shocks will be met by tuition increases and adjustments in enrollment and resources.[22] The institutions that adjust the most in enrollment will be those with relatively low levels of subsidy.

The implication of the model is clear: unless resources increase to match changes in demand, increases in cohort size are likely to lead to lower proportional levels of college enrollment and completion. Increases in cohort size will lead to reductions in the share of the cohort receiving BA degrees because colleges and universities must trade resources per student, which include substantial subsidies, against enrollment. Because cohort size (pop) and total subsidy (L) enter the model symmetrically we can use the effects of changes in cohort size on enrollment and attainment (d ln BA/d ln Pop) to make inferences about the effect of changes in subsidies on enrollment and attainment (d ln BA/d ln L). The extent to which institutions make adjustments in resources per student, tuition price, and enrollment will depend significantly on the mission and control of the college and university. In this section, we highlight the circumstances of public institutions because they enroll a large share of students and are central to the market; yet, for reasons given, the basic insights apply more broadly to all non-profit colleges and universities.

[21] Selective higher education is one of the few markets in which excess demand is evident to the casual observer. Public universities like the University of Michigan and the University of Virginia regularly receive more qualified applicants than they admit. Not only do these institutions maintain long wait lists, but they also reject a large fraction of applicants.

[22] When tuition is endogenous, an increase in demand brought by an increase in population will lead to an outward shift in the constraint.

*Section 3: Empirical Determinants of Collegiate Attainment*

Our empirical approach begins with the measurement of the relationship between cohort size and college completion within states. The basic empirical result that reductions in the fraction of a cohort with a college degree follow increases in cohort size is well established in the research literature (Card and Lemieux, 2000). The significant addition of this analysis is in understanding how changes in the college-age cohort size produce variation in resources per student in higher education, particularly from non-tuition sources, which in turn affect collegiate attainment.

We begin with estimates of the effect of variation in cohort size on collegiate enrollment and attainment, employing data from Census micro data and institutional measures of degrees awarded and probing how measurement choices affect the interpretation of our baseline results. The next step is investigating the role of adjustments in revenues and variation across types of institutions in understanding the cause of the attenuation of college completion with cohort size. Finally, beyond adjustments in the higher education sector, we consider the empirical importance of potential effects of cohort size on the demand for higher education or college preparedness. Thus, the task in this section is to provide empirical evidence to weigh the contribution of each of these factors in the explanation of why cohort size affects collegiate attainment so markedly.

### A. Cohort Size and College Completion Within States

The empirical analysis in this section focuses on the measurement of the elasticity of college completion, defined as the log of BA degrees awarded, with respect to cohort

size.[23] The state is the unit of analysis and all specifications include state and year fixed effects. A coefficient less than one implies that the correspondence between collegiate attainment and cohort size is less than one-to-one. Unambiguously, our estimates place this parameter at a value less than one, indicating incomplete adjustment in degrees awarded to changes in cohort size. In estimating these effects, a number of measurement issues are introduced in the consideration of college completion and cohort size. Broadly, there are two sources of data with the observation of degree completion over time: individual microdata measures like the Census and measures from colleges and universities enumerating the number of degrees conferred each year. Census data measures of degree completion are organized by state of birth and the corresponding measure of cohort size is the birth cohort size (which is compiled from the Vital Statistics tables). When degrees awarded in a year by colleges and universities in a state ("institutional measures") are used as the outcome variable, the population age 18 in the state is used as the measure of cohort size.[24] In all of the specifications presented, the population and attainment measures are specified in logs and we include state and year

[23] We estimate: $\ln BA_{jt} = \alpha + \delta \ln P_{jt} + \gamma_j + \lambda_t + \varepsilon_{jt}$ where $P_{jt}$ is the measure of cohort size, and the parameters $\gamma_j$ and $\lambda_t$ represent state and year fixed effects, respectively. Estimating a model with the implied share of the cohort with a college degree as the dependent variable $\ln r_{jt} = \ln \frac{BA_{jt}}{P_{jt}} = \alpha + \beta \ln P_{jt} + \gamma_j + \lambda_t + \varepsilon_{it}$ yields an estimated coefficient on $\beta$ equal to 1-$\delta$. For each individual represented in the data, we must assign a single cohort size and state. Implicitly, this assignment represents something of a deviation from the observed process through which cohort size affects educational attainment. While an individual may be born in a relatively large cohort in a given state, interstate mobility would imply that some individuals born in relatively large cohorts actually experience life in more modest size cohorts as they move to other states.

[24] The choice of the population age 18 reflects the observation that this is the age group most relevant at the beginning of a student's likely entry into college. We have also used the cohort size in the state at age 22 representing the modal age of college graduation; this alternative yields results that are substantively very similar.

fixed effects thus identifying the effect of cohort size on attainment using within state variation.

To this end, estimates of the magnitude of the elasticity between college completion and cohort size vary with the measures selected, reflecting conceptual differences in the framing of the question. Census-based measures capture degrees awarded to residents of a state (by state of birth); institutional measures record degrees awarded by the colleges and universities in a state. A conceptual difference between the Census measure and the institutional measure is that the former counts degrees awarded to residents of a state while the latter counts degrees awarded by institutions in a state to residents of any state. A second difference is that the Census data measures the stock of educational attainment to a given birth cohort, allowing for variation in the age at which degrees are received within a birth cohort, while the institutional data measures degrees awarded in a given year, with potential variation in the birth cohorts of degree recipients. Moreover, the choice of specification and nature of variation in cohort size also affects our estimates. In this regard, we consider both the inclusions of state-specific trends and the decomposition of the variance in our measures of cohort size. Tables 2-4 present the basic results and report the effects of cohort size on degree completion using institutional data, institutional measures of college enrollment, and Census measures of degree completion. A further implication of our theoretical model is that public institutions (or attainment and enrollment at these institutions) should be central in the adjustment process, as these institutions receive the largest subsidies from state sources, while also enrolling the largest share of students; where possible we delineate outcomes for public institutions.

Table 2 begins the empirical analysis with the estimation of the elasticity of the college completion, defined as the log of BA degrees awarded, with respect to cohort size, defined as the size of the population age 18 within the state. The elasticity of the college completion with respect to cohort size is significantly less than one, varying from .71 to .62 depending on the period of observation (columns (1) and (3)).[25] In addition, estimates in column (5) show that the effect of cohort size at age 18 on the number of degrees awarded by public institutions is broadly similar to the overall effect (.62 vs. .59) over the period for which this distinction is possible.[26]

Related directly to degrees awarded is the question of enrollment in higher education. Enrollment represents an "input" to educational attainment while degrees awarded are an outcome. Table 3 replicates the specifications in Table 2, focusing on total enrollment rather than the baccalaureate degree outcome. First, particularly for the longer series from 1954-1997, the elasticity of enrollment with respect to cohort size is larger than the corresponding measure for BA degrees, though it is still significantly less than one in all of the specifications.

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[25] To be sure, the general result that within-state growth in cohort size is negatively related to collegiate attainment is well established in the literature. Card and Lemieux (2000) have pursued this type of estimation strategy with both Census and CPS data. Estimating models with fixed state and year effects, Card and Lemieux find that cohort size has a consistently negative effect on college enrollment. Using the enrollment rate of students in the 19-21 age range calculated from the 1968-1996 CPS files, Card and Lemieux find that for both men and women a 10 percent increase in cohort size is associated with more than a 1.2 percentage point decrease in college enrollment. Looking at completed education and over a much wider range of cohorts afforded by the Census, yields parallel results as a 10 percent increase in cohort size is associated with a decline in college completion of about 0.8 percentage points for men and about 0.6 percentage points for women. Using Census data, Card and Lemieux report similar negative effects of cohort size on years of educational attainment, high school graduation, and college participation.

[26] Alternatively, one can see the relationship between cohort size and college completion rates graphically. Appendix Figure 1 presents time series plots of the number of cohort size and the number of BAs produced (both on a log scale) for each of the 48 continental states. To take one example, the pattern for New York in one that is typical of many states. Here we see a dramatic growth in both cohort size the number of individuals obtaining a BA in New York between the mid 1950s and the early 1970s. After that, the number receiving a BA flattens out, while cohort size first rises and then falls. By the mid-1980s, cohort size starts to decline while the number of BA degrees conferred trends upward.

A significant portion of the variation in the cohort size variables employed in these specifications is related to broad shifts in the population, with regions in the South and West growing much more rapidly than the North East and North Central regions in the post-World War II period. To eliminate these secular trends from the data, we have estimated specifications that include state-specific linear trends (see even numbered columns of Tables 2 and 3).[27] Doing so further attenuates the link between cohort size and degrees awarded. Policy and institutional responses may well vary with the duration of the change in cohort size, as the returns to capital expansion to absorb relatively large cohorts may be greater if cohort size is expected to persist. To the extent that there are capacity constraints at colleges, such limits are more likely to bind in the short run than the long run. In the long run, states can expand capacity, but in the short run they cannot. Quite plainly, state-specific trends represent slow moving variation and are related to the changes in cohort size; thus, the variation in cohort size identifying the effect on BA degree after time trends have been removed is relatively high frequency. Thus, one would expect to find stronger crowd out effects at the collegiate level when one uses regression strategies that focus on higher frequency variation in the data.

For the purpose of interpreting our results, it is important to understand the source and nature of that variation in our cohort size variables. Within state and year, the variation in the size of the college age population is being driven by cross-state and cross-country migration flows.[28] Presumably secular trends in the size of the college age population are being driven by secular trends in the locus of economic activity in the

[27] We also experimented with quadratic trends. Specifications with quadratic trends show results very similar to those presented.

country. Indeed, the within state and year correlation between the size of the 18 year old population and employment (both measured in logs) is 0.7. After secular trends have been removed this correlation drops quite dramatically to between 0.1 and 0.3 depending on the time period used. We suspect that even here changes in the size of the college aged population are being largely driven by changes in the location of economic activity, but that the timing is off – young adults migrate in response to economic opportunities, but have college age children one or two decades later.

To get a perspective on the time series properties or our population measures, following Baker, Dwayne, and Stanger's (1999), we decomposed our measured into orthogonal time series components using Fourier series techniques. With 44 years of data (1954-1997), we employ the Fourier decomposition to divide the measure of cohort size into 22 orthogonal components at varying frequencies (from 0 to Π) according to: $LnPop = \sum_{k=0}^{22} (\xi_k \cos(2\pi \frac{k(t-1)}{44}) + \gamma_k \sin(2\pi \frac{k(t-1)}{44}))$. The parameters $\xi_k$ and $\gamma_k$ are estimated in a regression for each state, leading to the estimate of each of Fourier components for each state and year. Computing the variance in the Fourier terms places the vast majority of the total variation in the data in the low frequency range, representing relatively long periods of variation. Within state and year, over 70% of the variance occurs at the lowest two frequencies identified in the data (frequencies corresponding to periods of 44 and 22 years), while once state specific trends have been removed over 50% does. Clearly state specific shifts in the size of the college age population tend to be slow and steady and are, presumably, quite predictable.

[28]While at the national level changes in cohort size during the second half of the twentieth century were driven by changes in cohort fertility rates, within state and year, there is essentially no association

An alternative way to measure the effect of cohort size on degree completion employs Census micro data as the outcome variable, with BA completion rates organized by state of birth and population by birth cohort as the relevant demographic variable.[29] These alternative data sources serve to underscore the reliability of our results while necessarily answering somewhat different questions.[30] Table 4 presents estimates of the effects of cohort size (measured in terms of year and state of birth) on degree completion using Census data, with estimates for the corresponding years using the institutional measures of degrees conferred presented in the adjacent columns as a point of reference. Note that since the dependent variable for the Census-based estimates is the cohort share (fraction with a BA) while for the institutional base results it is the number of BAs, subtract one from the results based on the institutional data to put these two estimates on the same footing. Focusing on those born between 1932 and 1965 (or those age 22

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between family size and cohort size.

[29] Note that when we use Census micro data organized by state and year of birth to measure the college completion rate, the regression estimates with the dependent variable specified as a completion rate (BA/N) are not equal to the specification in levels minus one. The reason is that that the denominator in the measure of the completion rate, a measure of cohort size calculated from the micro data, is not identical to the population measure from Vital Statistics sources. What we observe in the data is a negative correlation between the error (the difference in the measures) and the measure of population from the Vital Statistics source. While the simple correlation between the population measure from the Vital Statistics and the population measure from the Census micro data is 0.996, a regression of the Census measure on the Vital Statistics measure (both measured in logs), produces a coefficient of .952 (.0127). The result is that regression estimates using the Census micro data in levels will produce estimates suggesting a lower elasticity of completion with respect to population than related estimates with the dependent variable specified as a completion rate.

[30] In framing this algebraically, suppose that ln $r_{jt}$ depends on a weighted sum of population sizes from age 0 to 22 ( $\ln P_{jt}^{wt} = \sum_a w_a \ln P_{jt}^{a}$ where $\sum_a w_a = 1$ ) and we wish to estimate $\ln r_{jt} = \alpha + \beta \ln P_{jt}^{wt} + \gamma_j + \lambda_t + \varepsilon_{jt}$. However, what we do in practice is to regress ln $r_{jt}$ on $\ln P_{jt}^{Birth}$ or $\ln r_{jt} = a + b \ln P_{jt}^{Birth} + \gamma_j + \lambda_t + \varepsilon_{jt}$. Suppose we observe (or estimate) the relationship between our preferred population measure and the single-year measure we employ,

between 1954 and 1987), the Census measures of the change in the share of the population with a BA degree in response to changes in the respective cohort size (this time measured with cohort size at the year of birth) show a substantial decline in college completion shares with changes in cohort size. The magnitude of the estimated decline when using the Census data is somewhat smaller than the magnitude of the decline when using the institutional data (-0.26 vs. –0.33), but the two estimates reveal the same broad finding of a negative relationship between cohort size and college completion**.**

Including state-specific trends in the specifications with Census and institutional data has dramatically different effects on the estimates of the impact of cohort size on college completion rates. While taking out state-specific trends tends to strengthen the evidence of "crowd out" using the institutional measures, doing so significantly weakens the evidence when we use the Census measures.

**B. Interpreting the Difference Between Results Based on the Institutional and Census Data.**

Possible explanations for the large difference between the results based on the institutional versus the Census data involve both differences in the timing of the cohort size variable and difference in the nature of the measures used. One explanation for the difference between the results based on the Census and those based on the institutional data is the fact that in the Census regressions cohort size is measured at birth, while the other uses cohort size at the age when individuals would typically complete college (age 18). Given our maintained hypothesis, the reason that the size of the birth cohort matters

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$\ln P_{jt}^{wt} = a + g \ln P_{jt}^{Birth} + s_j + c_t + v_{jt}$. Thus estimating

$\ln r_{jt} = a + b \ln P_{jt}^{Birth} + \gamma_j + \lambda_t + \varepsilon_{jt}$ produces an estimate of b which is equal to βg.

in the regressions measuring collegiate attainment by state of birth using the Census is that the size of a birth cohort in a state is correlated with the size of the college aged population 18-22 years later. Indeed, the correlation between the population variables used in columns (1) and (3) in Table 4 after having taken out state and year effects is 0.8. The difference between the 0.26 and the 0.33 is what one would expect if the cohort size at birth represented an error ridden measure of cohort size at age 18.[31] On the other hand, short run fluctuations in the size of birth cohorts do not have much relationship to the short run fluctuation in the size of the college aged population in a state 18 years later. Indeed, the correlation between the population variables used in columns (1) and (3) after taking out state effects, year effects and state specific trends is only 0.16. The modest degree of cohort crowding shown in column (2) of Table 4 is consistent with that notion that, once state specific trends are included in the specification, cohort size at birth is a very poor proxy for cohort size at college attendance age.

Another interpretation of the difference between the results based on the specifications that do and do not include state-specific trends is that the introduction of the state specific trends seriously exacerbates the impact of measurement error in our cohort size measures on outcomes (the introduction of state trends eliminates 83% of the variation in our cohort size measure). While our cohort size measures at age 22 are based on Census data, this does not mean they are error free. The intercensal estimates are based on imputations that, importantly, involve Census estimates of migration flows. While there is good reason to believe that the census population estimates contain errors, these errors are surely not iid white noise. As a result, it is not at all clear what effect

[31] A regression of the log of cohort size in a state when the cohort was 18 on the log of cohort size in the state 18 years earlier at birth yields a coefficient of 0.62, where 0.26 is 0.78 of 0.33.

these errors will have on our estimates. To try to gauge the effect of these errors on our estimates, we re-estimated our models using the institutional data restriction attention to census years. Results from the analysis produced results that are completely consistent with results based on all years of data.[32]

There are a number of reasons why the institutional measure of BA production might tend to exaggerate the measurement of cohort crowding. It would not be too surprising to find that being born into a large (state specific) cohort would tend to increase the odds that a person went out of state to attend college or temporarily postponed going to college. In either case our estimates would overstate the magnitude of "crowding" or the effect of cohort size on college completion. Colleges outside a state may provide one avenue of response to increases in demand within a state. Such an interstate adjustment mechanism assumes that, for students at the margin, relative transportation costs of attending college out of state are modest and that there is a close substitute for the in-state product in the out-of-state market. The Residence and Migration survey, which has been conducted periodically by the Department of Education since the 1940s, provides some information on enrollment by state of residence and college. In Table 5, we estimate the elasticity of total enrollment at the state level with respect to population and the elasticity of enrollment of state residents with respect to population. If increased out-of-state enrollment were a substantial part of the response to cohort expansion, we would see larger elasticities (closer to 1) for enrollment of state residents than for total enrollment in the state. Yet, the elasticities for

[32] With state and year effects included in the specification the coefficient on Ln Population 18 was 0.733 (0.129). Once state trends are added this coefficient drops to -0.085 (0.167).

these two measures are virtually identical as shown Table 5.[33] The available empirical evidence does not support the notion that relatively large cohorts of college students are "absorbed" by neighboring states. In fact, it appears that the enrollment behavior of state residents is closely tied to college opportunities in-state, with elasticities of about 0.6, which is close to the estimates using the full panel of BA degree data in Table 2.

In addition, it seems plausible that time to degree may tend to rise with cohort size. If large cohorts faced fewer resources, this might make college less attractive and marginal college goers might delay going to college for a while.[34] What is more, fewer resources might translate into slower progress while in school. Empirically, calculations using the Current Population Survey suggest that increasing cohort size does increase the age at degree receipt, though the magnitude of this effect is by no means large enough to explain the overall effect on completion rates. One concern is that in the institutional measures of degree attainment increases in time to degree will tend to bias estimates of the effect of changes in cohort size on changes in the number of BAs produced per cohort; yet, such errors should be offsetting as time to degree expands and contracts with cohort size.[35] All in all, we doubt these inter-temporal substitution effects have much effect on our estimates.

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[33] Another approach to this question is to consider the enrollment state and the state of residence 5 years past for those ages 18-25 in the Census. For each Census comparison, we find that the elasticity of the college enrollment rate changes little with changes in population.

[34] If shifts in population size occurred at fairly high frequency, individuals who are part of particularly large cohorts might find it optimal to postpone college for several years. However, this kind of substitution is unlikely to be plausible in large scale as most of the movements in cohort size observed occur at relatively low frequency. Moreover, such intertemporal adjustment would likely reduce the number of years over which an individual would get the benefits of a college education, thus reducing the return to the degree.

[35] An example will illustrate. To make things simple, suppose that the fraction of a cohort ultimately receiving a BA remains constant, but cohort size grows at a rate of 1% per year. Also suppose that, as a result on the increase in cohort size, over a 10 year period of time the age at which individuals typically receive their BA rises from 22 to 23 years old. Over this period of time we would observe an approximately 10% increase in the size of the population, but only a 9% increase in the size of the number

### C. Higher education resources and cohort size

In considering the supply-side adjustment of colleges and universities to the reductions and expansions in cohort size, colleges and universities face the potential margins of adjustment of price (tuition), quantity (enrollment) and resources per student. As discussed above, how institutions balance quantity and quality will likely depend on the particulars of institutional mission. For the public colleges and universities, the extent to which tuition levels are determined by market forces or are set by arbitrary or political forces remains an open question.[36]

Examining the link between cohort size and tuition charged by public institutions does not yield a positive link between cohort size and tuition. Regressions of the tuition charged to in-state students by public colleges and universities on cohort size, the evidence points clearly in the other direction at public institutions, as a 10 percent increase in cohort size is associated with a 2.7 percent decrease in tuition at the state comprehensive schools and 4.2 percent decrease at flagship institutions.[37] [As in previous specifications, these regressions include state and year fixed effects.] This negative relationship between price and cohort size does suggest that local political economy, as

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of BAs. As a result, we would underestimate $\partial \ln(BA) / \partial \ln(Pop)$ by about 10% -- in the example, we estimate crowd out when none exists. This example might make it seem as if the data we are using will lead us to over estimate crowd out effects. However, if one runs this though experiment in reverse, one sees that during periods of declining cohort size (and decreased time to degree), we will tend to over estimate $\partial \ln(BA) / \partial \ln(Pop)$. Since the variables we use in our regressions are all deviations from year and state means, some states will be experience increases in cohort size (relative to the mean), while others are experiencing decreases in cohort size and the bias introduced by the fact that we are using period rather than cohort measures will tend to cancel out.

[36] For example, in 1999, the Virginia legislature instituted a 20-percent reduction in tuition at public colleges as part of the fulfillment of campaign promises of then Governor James Gilmore. With recent reductions in state tax revenues, states have turned to cutting appropriations and allowing public institutions to increase tuition.

[37] It is only among the non-research private institutions that we see the expected positive link between tuition and cohort size. Estimates of the effect of tuition on enrollment and degree completion, again following the estimation strategy employing state and year fixed effects, two-year enrollment is much

well as adjustments on other margins must play a substantial role in the adjustment of higher education to changes in cohort size.[38]

Beyond tuition levels, we consider the relationship between all sources of revenue and cohort size in the regressions presented in Table 6. For total education expenditures, state appropriations and tuition and fee revenue, regressions on the college-age population produce a remarkably similar story with these resources measures failing to adjust proportionately with changes in cohort size. Since the overall adjustment in education and general expenditures is less that the change in enrollment with changes in cohort size, the inference is that the resources per student decline with increases in cohort size. State appropriations fail to keep pace, as well, indicating that subsidy per student does decline. Not surprisingly, there is the least adjustment in federal resources and the coefficient on the population measure is indistinguishable from zero with and without state trends. Tuition revenues do not appreciably fill the revenue gap, with changes in cohort size associated with an elasticity of about 0.6.[39]

A central proposition of this analysis is that total educational resources lead to increases in both enrollment and attainment. Including educational resources as an explanatory variable is problematic to the extent that increases in total expenditures come from additional tuition revenue; yet, state appropriations provide a plausibly exogenous source of variation. In Table 7, we revisit the within-state regressions of collegiate attainment on cohort size with the addition of a measure of expenditures instrumented

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more responsive to tuition levels than either four-year enrollment or degree completion. What we see is well known in the literature [see, for example, Kane (1999)].

[38] When state and local appropriations are included in the regression the effect of cohort size on tuition approaches zero, with increases in state appropriations having a substantial negative effect on tuition prices. As such, tuition and state appropriations may be tightly coupled state political variables.

[39] Note that this tuition revenue measure is implicitly a weighted average of public and private tuition as it represents total tuition revenue for all institutions in a state.

with appropriations. In the models without state-specific trends, we find that the coefficients on expenditures are 0.34 (0.10) for the total enrollment outcome and 0.21 (0.09) for the BA outcome. The coefficients on the population variable are of the same magnitude as in the initial regressions. What we take from this is that the effect of population is operating largely through producing variation in expenditures per student. It is, nonetheless, not surprising that the effect of measured resources goes to zero when state trends are included as it is unlikely that year-to-year fiscal fluctuations have much effect on institutional capacity given the relatively long cycle required to hire faculty and so forth.

Variation in relative adjustments in resources and enrollment across institution types is to be expected from the differences in the objective functions of colleges and universities. Community colleges and four-year institutions with modest admission requirements tend to place "access" at the center of their mission, attempting to provide enrollment opportunities for all students who apply and meet minimum qualifications. At the other extreme, research universities and liberal arts colleges are likely to emphasize the role of student quality and resources per student as they make choices at the margin between quality and quantity. Thus, what the model predicts is substantial accommodation among two-year institutions to changes in cohort size and little accommodation (and, perhaps, a ratcheting up of selectivity) among universities.

The regression results in Table 8 show the elasticity of enrollment and BA completion with respect to cohort size (measured at age 18) by type of institution. In the public sector, we distinguish community colleges, flagship institutions (the highest ranked public university in the state) and other four year institutions. In addition to

presenting the total for all private institutions, we distinguish the unique and highly subsidized set of research universities and liberal arts colleges. At one extreme, cohort size has a coefficient that is close to 1 at the two-year colleges, indicating that at these institutions enrollment levels fluctuate markedly with changes in cohort size. Among public institutions awarding at least a BA degree, the flagship institutions are much less responsive in degrees awarded and enrollment to changes in cohort size than the other four-year institutions. At the other extreme, the elasticity of enrollment with respect to cohort size is close to zero at the private liberal arts colleges and universities. [Alternatively, one might place these institutions in a national, rather than regional market, and as such, these institutions do not face demand shocks at the state level; e.g., if there is a 10 percent population shock in New Jersey, the change in applications to Princeton is appreciably less than the change in applications to Rutgers.]

Because the likelihood of completing college differs markedly with the institution where an individual starts in the higher education pipeline, changes in overall college completion may be attributable to changes in the distribution of students among institutions. Plainly, institutions differ appreciably in resources per student and students attending more resource-intensive institutions have somewhat higher collegiate attainment (and BA completion) than those attending lower-quality institutions. Of course, there are complications in the interpretation of variation across institutions in completion rates: A high institutional completion rate may be indicative of high student quality rather than resource differences affecting student persistence.[40]

[40] Among high school seniors taking the mathematics assessment as part of the National Longitudinal Survey of the Class of 1972, those attending private research universities, private liberal arts colleges and public flagship universities scored about 20 percent higher than those attending community

Computing the change in enrollment shares associated with changes in cohort size points to marked shifts away from public four-year institutions toward community colleges in the years of substantial growth in cohort size. The change in the distribution of students among institutions with increases in cohort size is likely to lead to a decline in aggregate college completion through two channels. First, the proportion of students attending "high resource" institutions such as flagship universities drops as these institutions are accommodate few students in response to an increase in cohort size. For the elite institutions – primarily the private research universities – increased demand provides an opportunity to choose students ever more selectively. For these institutions with persistent excess demand, an empirical demonstration of the effects of "crowding" would be increases in the scores and achievements of entering students with increases in cohort size.[41] For selective institutions within the public sector, a margin of adjustment to increases in demand from within-state applicants may be seen through increases in the proportion of in-state students granted admission. Using data from the Residence and Migration survey for the years since 1972 with institution-level reporting, we find that the elasticity of the in-state share at the flagship public universities with respect to cohort size is .24(0.04). To the extent that resources are an important input to collegiate attainment, this between institution shift in the distribution of students will negatively impact attainment.[42] In addition, within institutions increases in enrollment may yield to dilution in resources which in turn affects college completion.

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colleges and 10 percent higher than students attending other public four-year institutions (Authors' tabulations from the NLS 72).

[41] Hoxby (1998) refers to this as "benchmark crowding" and notes that it is potentially observable at the level of individual colleges but, if supply increases, will not be evident in aggregate.

[42] Perhaps the most visible margin of differences in completion rates is the two-year four-year margin. Kane and Rouse (1995) calculate the likelihood of BA completion for students starting post-secondary education at two-year schools and four-year school. For men, starting at community colleges

### D. Changes in college preparedness and compositional changes

Within states, large cohorts are less likely to complete college than relatively small cohorts. Adjustments on the supply side of the market discussed above provide one explanation for this result. An alternative explanation is that changes in that the demand for college may be reduced among relatively large cohorts if college preparation is also linked to cohort size. At issue is whether results we attribute to adjustments on the supply-side of the higher market are instead related to demand-side explanations. Two related concerns surface. First, relatively large cohorts may be distinguished by adverse demographic or economic shocks that have direct effects on collegiate attainment. For example, if big cohorts are distinguished by low parental education or large family size, such compositional effects might provide the explanation for reduced college completion rather than "crowding" on the supply-side of the market. Secondly, membership in a relatively large birth cohort may also imply that educational resources are diluted at the elementary and secondary levels which would also reduce college preparedness. Both types of effects imply that the change in college demand may be far less than a change in cohort size.[43]

To understand the likely impact of "compositional" factors such as race, parental education, and family size on cohort size, we examined 16 year olds and their parental

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leads to a likelihood of completing college of 0.19 (unadjusted for differences in achievement and background); among those starting at four-year schools, 0.54 receive BA degrees.

[43] One starting point is the examination of the extent to which high school degree receipt is affected by cohort size. The elasticity of the high school completion rate with respect to the population age 18 is about -.09 in the 1990 Census. Similar results follow from estimates using institutional measures of high school completion. Such results provide one indication that, while there is some evidence of cohort size effects in at the pre-collegiate level, these effects are unlikely to be large enough to explain the observe link between cohort size and college completion. While we focus on explaining variations in formal educational attainment associated with variation in cohort size, Jacobson (2001) finds that increases in cohort size lead to increases in youth drug use. Presumably, drug use may be an intermediate outcome that also affects educational attainment.

characteristics by state for the 1970-1990 decennial Census enumerations. Regressions of a particular parental demographic characteristic (e.g. share black or number of children) on the size of the 16 year population in a state and Census year, with year and state fixed effects, provides an indication of how changes in cohort size are tied to observed demographic characteristics. More children in a family imply fewer resources per child and educational attainment—both formal and informal—is likely to be positively affected by the time and financial resources available to each child within the family (Becker, 1981; Willis, 1973). Similarly, other family characteristics such as maternal education, family structure, and race may affect the educational resources available outside of schools.

For the most part, we find effects that are not statistically significant and economically small. This applies to measures of family size, parental education, and ethnicity.[44] When we weight by state size, the only effect that is significant is the effect of cohort size on share Hispanic, with a coefficient of .27 indicating that a 2.7% increase in the share of college-age students of Hispanic origin would follow a 10% increase in the size of the 16 year old population.[45] Even with the upper end estimates of the effect of Hispanic origin on college completion, these compositional effects could not explain a sizable share of the reduction of college completion with increases in cohort size.

Individuals in relatively large cohorts may also face diminished resources in elementary and secondary schools, with these resource effects reducing college preparedness and completion. Examination of the link between resources per student at

[44] The family size effects are notable in that the effect of states like Utah, where the link between changes in family size and population is pronounced, is visible in the unweighted regressions [.624 (.366)] and the effects dissipate in the regressions weighted by state size [.133 (.335)].

the primary-secondary level and cohort size helps to place this question in perspective. First, resources per student are negatively affected by increases in cohort size at the elementary and secondary levels. Table 9 shows these regression results using data for the 1970 to 1995 period, with current expenditures per student and teachers per student as the key explanatory variables. Because it is not possible to distinguish expenditures or enrollments accurately at the grade level, year and state aggregates over all elementary and secondary enrollment form the variables of interest. Plainly, we observe a negative and significant elasticity of resources with regard to enrolled students, measured by either average daily attendance or fall headcount. For expenditures per student, the elasticity is about -.25 while the elasticity of teachers per student is about -0.18. Of substantive interest is how such changes in resources per student affect academic achievement and, more specifically, college completion.

One set of hypotheses explaining the reduction in resources per student is that budget rigidities – largely political – limit a locality's ability to raise additional nominal resources (Poterba, 1997). This would be particularly compelling if changes in cohort size were not age neutral. Also at issue is the observation that increased local demand for inputs to the education process like teachers would put upward pressure on the market price, subsequently reducing the education services that could be purchased for any fixed expenditure. Beyond the effects of the measured reductions in expenditures, increasing cohort size might have further deleterious effects on student achievement if marginal costs are not constant, but increasing with the number of students. For example, when

[45] This effect is much smaller .156 (.056) in the unweighted regressions, presumably owing to the incidence of migration in large states like Texas and California.

cohorts expand to the point where additional facilities are necessary, districts would face the added cost of new construction.

Under the traditional theory of the firm formulation, increases in inputs like the faculty- student ratio should lead to improved student performance. Yet, it has also been observed that schools may function at below productive efficiency (Hanushek, 1986). State-level variation over time does point to significant effects of school resources on earnings outcomes (Card and Krueger, 1992).[46] Empirically, we measure the link between within-state variation over time in the pupil-teacher ratio and educational attainment of students by year of birth. Following Card and Krueger, we use the average of the potential pupil-teacher ratio faced by the student. Educational resources in the state of birth are an imperfect proxy for the resources experienced during the educational pipeline as a youth may move to a different state, thereby leading to mismeasurement of educational experiences. The bottom panel of Table 9 presents the estimates of school resources on educational attainment. We find significant and negative effects for all four Census years examined, with the maximum number of observations afforded by the 1970 and 1980 data. Declines in resources produce large effects on college completion, with a 10 percent decrease in the faculty-student ratio leading to a decrease in college completion rates between 3 and 7.4 percent. Such evidence is indicative of reductions in

[46] While there are an increasing number of research papers that find a significant effect of class size on student achievement (see, for example, Krueger, 1999), most of these estimates measure the effect of lower class size in a single year on achievement. Thus, it is not surprising that relatively small changes in class size for short periods (i.e., both students and teachers may experience the reduction in class size for modest periods) may not produce significant changes in student achievement. Because we are interested in the cumulative effects of class size on educational attainment, existing estimates of the effect of class size on test scores do not provide an appropriate basis for inference. In this regard, the estimates in Table 9 measure the cumulative effect of large class sizes throughout the elementary and secondary years on collegiate attainment. There is nevertheless some reason to believe that that state-level aggregation may exacerbate omitted variables bias, leading to an overstatement of causal effects (Loeb and Bound, 1996; Hanushek, Rivkin and Taylor, 1996).

college preparedness associated with resource declines in large cohorts.[47] Still, combining the effects of enrollment on resources and resources on degree attainment ($\frac{\partial \ln BA}{\partial \ln Teachers/Student} \times \frac{\partial \ln Teachers/Student}{\partial \ln Pop}$, broadly), suggests that the effect on college completion operating through resources is likely to be quite modest (.05 to 0.09). While demand-side effects are plainly not zero and the impact of cohort size on precollegiate academic achievement is an interesting question in its own right, these effects are plainly too small to explain the entire effect of cohort size or resources on collegiate attainment.

*Section 4: Conclusion*

The empirical analysis in this paper demonstrates that much of the failure of college completion to increase with growth in cohort size can be attributed to the failure of public subsidies to keep pace. Because public higher education relies to a large degree on state government subsidies which provide a significant share of resources per student, market adjustment is not proportional. Neither out-of-state enrollment nor private enrollment is sufficient to "absorb" the effects of cohort size on enrollment and attainment at public colleges and universities. Our estimates suggest that neither the effects of declines in school quality in the elementary and secondary years nor the effects

[47] An alternative way to measure the effects of cohort size on college preparedness is to measure the effect of cohort size on test scores directly. Unfortunately, NAEP scores provide only a limited number of state-specific observations over time. SAT scores at the state level may suffer from changes in the selection of the test-taking population over time. Using data on SAT scores at the state level from 1971 to 2000, regressions of test scores on cohort size with state and year fixed effects, as well as a correction for selection, indicate an elasticity of verbal and math scores with respect to cohort size of -.06 (0.002). These effects are modest in magnitude, though indicative of some reduction in college-preparedness with cohort size. More surprising is the link between the share of eligible seniors taking the exam and cohort size, which is positive and significant. One explanation is that colleges increase requirements for standardized tests with relatively large cohorts.

of changes in the composition of the pool of potential college students are large enough to produce the observed negative relationship between cohort size and college completion.

On the supply side of the market, the reduction in college completion with cohort size occurs on two margins. Between institutions, those institutions with the greatest non-tuition resources per student such as flagship universities are the least likely to increase enrollment in order to accommodate relatively large cohorts; still, these universities have the highest levels of college completion. Within public institutions, those that expand to meet population-related shifts in demand may face reductions in resources per student, further reducing attainment of enrolled students.

Taking estimates of the effect of cohort size on college degree attainment at face value, the decline in college attainment associated with the baby boom cohorts would have been expected to have been much more prolonged, essentially commencing with the cohort born in 1935 rather than the cohort born in 1950. It is surely difficult to ponder fully the thought experiment of the counterfactual of no sustained increase in per capita state, federal, and private support for higher education in the years between World War II and the Vietnam conflict.[48] Yet, this is precisely what is in order to understand how public policy essentially overwhelmed underlying demographic trends, which moved against an increase in collegiate attainment.

Public support for higher education and the political determination of variables like tuition in the higher education market play a decided role in determining the level of

[48] Perhaps the most difficult dimension of this counterfactual to model is the extent to which the private market, including forprofit providers of higher education, would have entered the market in the face of increased demand for college spaces. Without question, the creation of new open access institutions – at both the two-year and four-year levels – led to a crowding out of some of these potential entrants.

output of colleges and universities, effectively shifting supply curves at the state level. While variation in cohort size did affect collegiate attainment through the 1960s as well as the 1970s, the secular increase in funding for higher education during the 1960s swamped much of the effect of rising cohort sizes. Yet, abrupt shifts in state and federal policies during the 1970s led to reductions in appropriations for higher education and, combined with the inability to respond to market forces with increases in tuition prices (owing to the political determination of these variables), led to the deterioration in available resources for each potential college student. The result was an aggregate decline in collegiate attainment among those cohorts born in the 1950s and likely to attend college in the 1970s.

The impact of this reduction in collegiate attainment is not limited to the market for higher education. Rather, this turn of events has been reflected in the structure of wages for a generation, with the college-high school wage premium rising appreciably among those cohorts for which college resources were most constrained. While much of the reduction in collegiate attainment was caused by changes in cohort size and changes in funding for higher education at the state level, the integration of the labor market produces implications for productivity and inequality that are national in scope.

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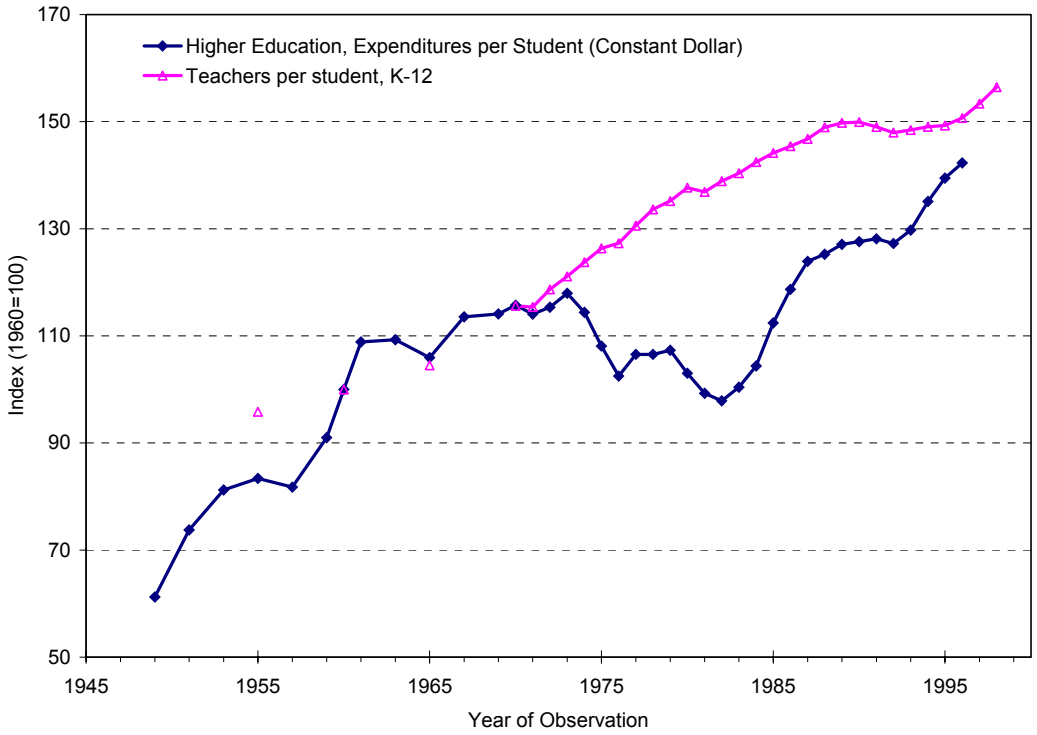
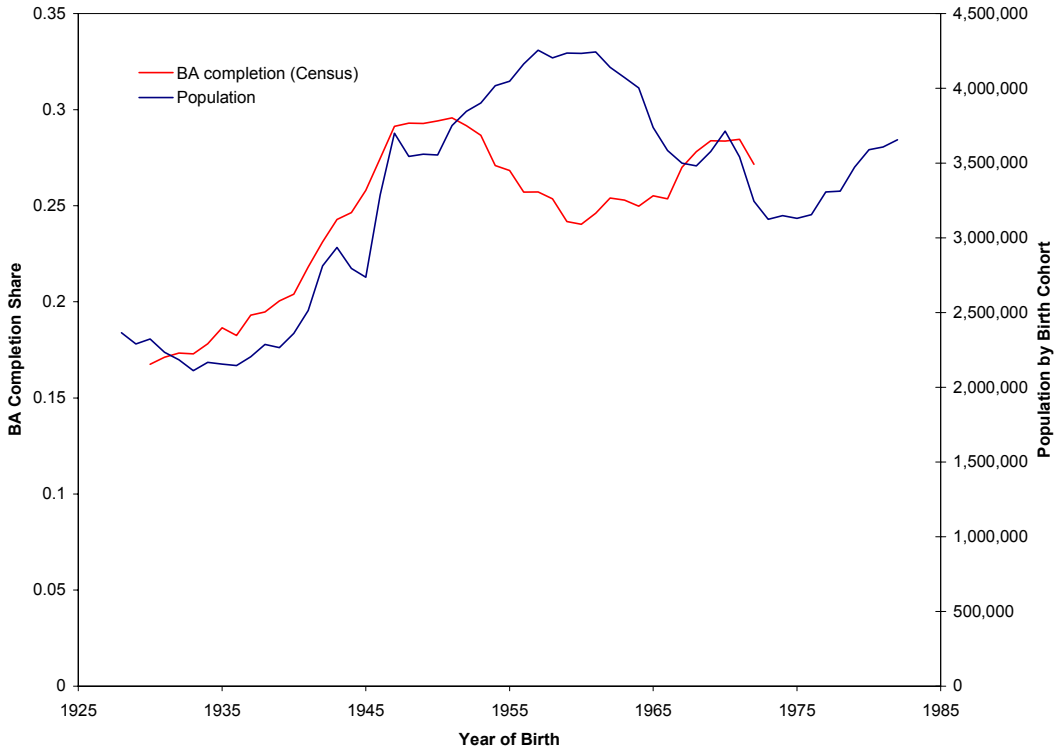
Figure 1: Resources per student in education, K-12 and postsecondary



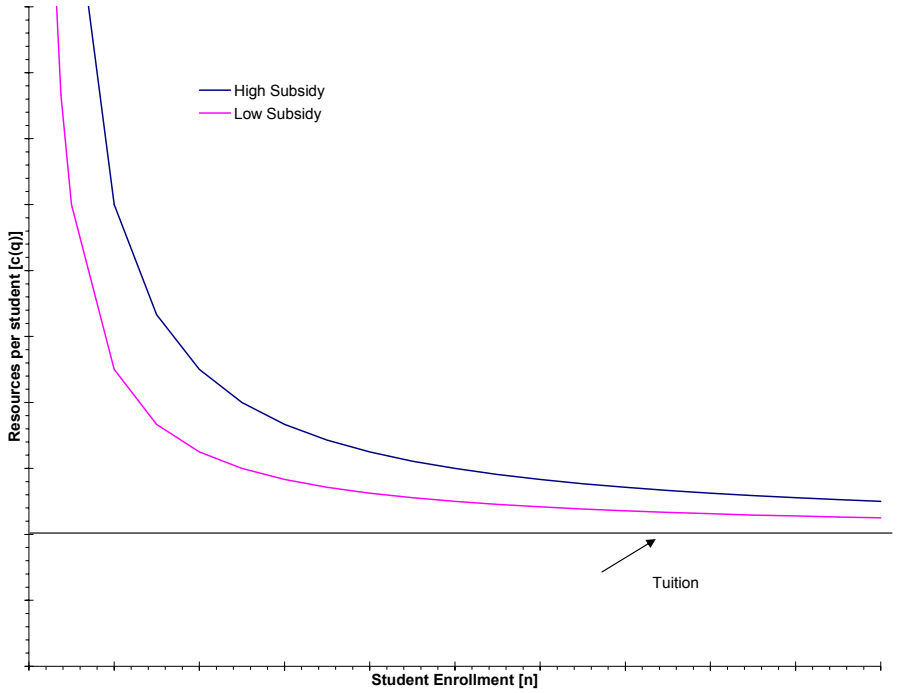

*Notes:* Total expenditures per student in higher education are from Table 339, Digest of Education Statistics (2001).

Figure 2: National trends in cohort size and BA degrees conferred




*Notes*: BA completion rate, illustrated on the left axis, is calculated by birth cohort using the 2000 Decennial Census (1% Sample). Population by birth cohort is from the Vital Statistics tables. Because individuals in their mid-20s are still at risk of degree completion, Census enumerations may underestimate degree completion among those born in the most recent birth cohorts and the series is truncated at age 28 at the time of enumeration.

Figure 3: Nondistribution constraint and the quality-enrollment tradeoff, adjusting parameters




Changing the level of subsidy (L), holding tuition and costs constant, shifts the non-distribution constraint as illustrated above.

Figure 4: Public university adjustment to changes in cohort size absent changes in subsidy

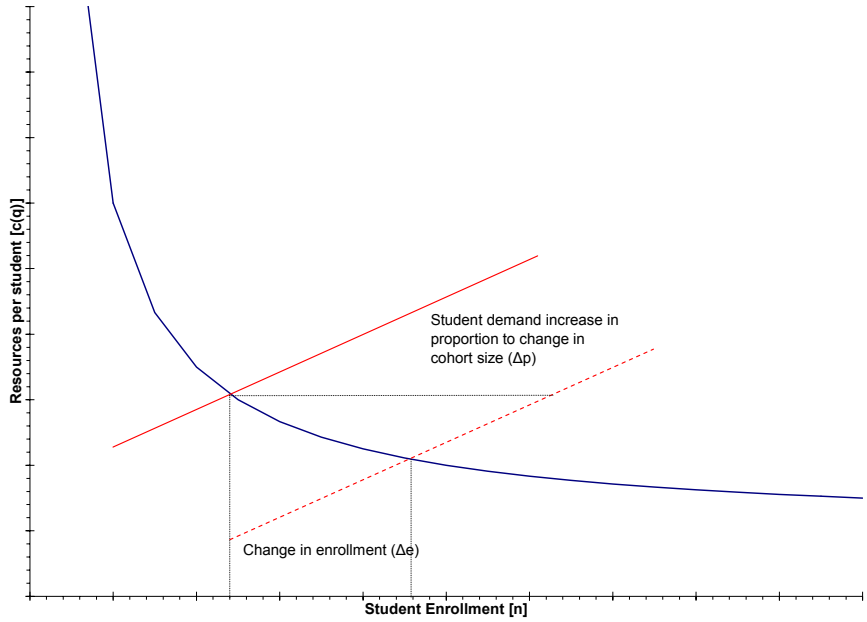


Table 1: Distribution of revenues and tuition by type of institution

| | Current Fund Revenues (1996) | | | | | | Undergraduate Tuition | |
|---|---|---|---|---|---|---|---|---|
| | State & Local | Federal | Private | Endow. | Tuition | Aux. & Other | In-state | Out-of-State |
| Community Colleges | 57.5% | 11.7% | 1.0% | 0.1% | 20.2% | 9.5% | 1,814 | 4,362 |
| Other Public | 36.3% | 10.7% | 4.0% | 0.4% | 18.3% | 30.2% | 2,725 | 6,981 |
| Flagship Public | 29.0% | 14.8% | 6.4% | 1.3% | 17.2% | 31.4% | 3,493 | 9,998 |
| All Private | 2.8% | 10.3% | 9.1% | 5.1% | 41.9% | 30.8% | | |
| Research I Private | 2.3% | 16.1% | 9.5% | 5.7% | 22.9% | 43.5% | | 19,814 |
| Liberal Arts Colleges | 1.4% | 3.0% | 9.1% | 10.5% | 55.5% | 20.5% | | 17,648 |

*Notes:* Revenue data are from 1996 IPEDS; tuition data are from 1997 IPEDS.

Table 2: Regression of BA degrees conferred on measures of cohort size

| Regression | Explanatory Variable | Ln Tot BA on Ln Pop 18 All Years (1954-1997) (1) | (2) | Ln Tot BA on Ln Pop 18 Late Years (1967-1997) (3) | (4) | Ln Public Inst BA on Ln Pop 18 Late Years (1967-1997) (5) | (6) |
|---|---|---|---|---|---|---|---|
| *A. No Weights* | Ln Pop 18 | 0.71 | 0.20 | 0.62 | 0.15 | 0.59 | 0.21 |
| | | (0.07) | (0.08) | (0.09) | (0.12) | (0.08) | (0.13) |
| *B. Avg Pop Wt* | Ln Pop 18 | 0.63 | 0.20 | 0.56 | -0.03 | 0.54 | 0.06 |
| | | (0.09) | (0.07) | (0.08) | (0.10) | (0.08) | (0.17) |
| | State Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| | Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| | State Trends | No | Yes | No | Yes | No | Yes |

*Notes:* Degree attainment measures are from institutional measures of degrees conferred. Population data are from single year of age tabulations of the Department of Census. See Data Appendix for details.

Table 3: Regression of total enrollment on measures of cohort size

| Regression | Explanatory Variable | Ln Tot Enr on Ln Pop 18 All Years (1954-1997) (1) | (2) | Ln Tot Enr on Ln Pop 18 Late Years (1967-1997) (3) | (4) | Ln Public Tot Enr on Ln Pop 18 Late Years (1967-1997) (5) | (6) |
|---|---|---|---|---|---|---|---|
| *A. No Weights* | Ln Pop 18 | 0.89 | 0.21 | 0.79 | -0.01 | 0.66 | -0.02 |
| | | (0.15) | (0.09) | (0.18) | (0.09) | (0.16) | (0.12) |
| *B. Avg Pop Wt* | Ln Pop 18 | 0.82 | 0.42 | 0.63 | -0.18 | 0.49 | -0.16 |
| | | (0.11) | (0.18) | (0.18) | (0.11) | (0.20) | (0.14) |
| | State Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| | Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| | State Trends | No | Yes | No | Yes | No | Yes |

*Notes:* Total enrollment measures are from institutional surveys. Population data are from single year of age tabulations of the Department of Census. See Data Appendix for details.

Table 4: Regression of BA degree attainment on cohort size, Census and Institutional data comparison

| | 1954-87 Degree years; 1932-1965 Birth cohorts | | | |
|---|---|---|---|---|
| | Ln Census BA Share on Ln Pop Yr Birth Census Years | | Ln Institutional BA on Ln Pop 18 Census Years | |
| Explanatory Variable | (1) | (2) | (3) | (4) |
| *OLS Regression of BA on Population Variable* | | | | |
| Ln Pop Coefficient | -0.26 | -0.11 | 0.66 | 0.03 |
| | (0.05) | (0.03) | (0.09) | (0.09) |
| State Effects | Yes | Yes | Yes | Yes |
| Year Effects | Yes | Yes | Yes | Yes |
| State Trends | No | Yes | No | Yes |

*Notes:* Columns (1)-(2) use observations by year and state of birth from the 1990 Census and Vital Statistics measures of birth cohort size; Columns (3)-(4) use measures of the population age 18 and institutional measures of BA degrees conferred.

Table 5: Estimates of effect of cohort size on enrollment by state, Residence and Migration data

| Population Covariate and Sample Restriction | (1) Enr of St Residents Coef (s.e.) | (2) Tot Enr in State Coef (s.e.) |
|---|---|---|
| *Pop 18, 1958-1996 (no 72)* | | |
| | 0.62 | 0.61 |
| | (0.08) | (0.11) |

*Notes*: Each table entry (and associated standard error) represents the effect of cohort size (measured in logs) on the indicated enrollment variable, with state and year fixed effects also included in the regressions. The dependent variables, measured in ln levels, are the enrollment of residents from state j in any state (Column 1) and the enrollment of residents from any state in state j (Column 2). Residence and Migration surveys were conducted periodically by the Office of Education, later the Department of Education. Specifically, data for the following years are available: 1949, 1958, 1963, 1968, 1972 (no enrollment of state residents measure), 1975, 1979, 1981, 1984, 1986, 1988, 1992, 1994, 1996. Each regression above includes year-specific fixed effects.

Table 6: Regressions of revenue variables on population

| | Coefficient on Ln Pop 18 | |
|---|---|---|
| | (1) | (2) |
| *Not Weighted* | | |
| Ed & General Expenses | 0.496 | 0.251 |
| | (0.085) | (0.099) |
| State Appropriations | 0.576 | 0.429 |
| | (0.110) | (0.134) |
| Federal Revenue | 0.270 | 0.039 |
| | (0.193) | (0.217) |
| Tuition and Fee Revenue | 0.606 | 0.257 |
| | (0.077) | (0.118) |
| *Weighted by Avg Pop* | | |
| Ed & General Expenses | 0.308 | 0.414 |
| | (0.182) | (0.187) |
| State Appropriations | 0.477 | 0.262 |
| | (0.167) | (0.169) |
| Federal Revenue | -0.172 | -0.174 |
| | (0.560) | (0.202) |
| Tuition and Fee Revenue | 0.638 | 0.380 |
| | (0.050) | (0.113) |
| State Fixed Effects | Y | Y |
| Year Fixed Effect | Y | Y |
| State Trends | N | Y |

*Notes*: Data extend from 1950-1996 (even years pre 1966). See Data Appendix for source notes.

Table 7: Regressions of collegiate attainment on cohort size and resources

| | | Ln Total Enrollment on Ln Pop 18 Late Years (1954-1996) | | Ln Inst BA on Ln Pop 18 All Years (1954-1996) | |
|---|---|---|---|---|---|
| Regression | Explanatory Variable | (1) | (2) | (3) | (4) |
| *First Stage* | | | | | |
| | | 0.35 | 0.26 | 0.34 | 0.24 |
| | | (0.02) | (0.02) | (0.02) | (0.02) |
| *IV-State Appropriations Instrument* | | | | | |
| | Ln Education and | 0.34 | -0.12 | 0.21 | -0.02 |
| | & General Exp. | (0.10) | (0.09) | (0.09) | (0.10) |
| | Ln Population 18 | 0.76 | 0.16 | 0.60 | 0.23 |
| | | (0.14) | (0.10) | (0.09) | (0.08) |
| | State Fixed Effects | Yes | Yes | Yes | Yes |
| | Year Fixed Effects | Yes | Yes | Yes | Yes |
| | State Trends | No | Yes | No | Yes |

*Notes:* Total enrollment measures and BA degrees conferred are from institutional surveys of colleges and universities. In the second panel, state appropriations are used as an instrument for education & general expenditures. Population data are from single year of age tabulations of the Department of Census. See Data Appendix for details.

Table 8: Effects of cohort size on BA completion and enrollment, 1968-1996

| | Dependent Variable | | | |
|---|---|---|---|---|
| | Ln Undergraduate FTE Enr on Ln Pop 18 Coef (s.e.) | Ln BA on Ln Pop 18 Coef (s.e.) | Undergraduate Enrollment Share 1967 | 1996 |
| Community Colleges | 0.82 | | 0.21 | 0.37 |
| | (0.37) | | | |
| Other Public | 0.56 | 0.82 | 0.38 | 0.33 |
| | (0.13) | (0.22) | | |
| Flagship Public | 0.20 | 0.28 | 0.13 | 0.09 |
| | (0.07) | (0.05) | | |
| All Private | 0.99 | 1.20 | 0.28 | 0.21 |
| | (0.42) | (0.45) | | |
| Research I Private | -0.07 | -0.19 | 0.03 | 0.02 |
| | (0.36) | (0.45) | | |
| Liberal Arts Colleges | 0.26 | 0.71 | 0.04 | 0.02 |
| | (0.17) | (0.17) | | |

*Notes:* Data on degrees conferred and enrollment by type of institution are tabulated from institution-level data from the HEGIS/IPEDs. Enrollment data are aligned with the population age 18 in the state in the concurrent year; BA data are aligned with the population age 18 years old in the state 4 years prior, in accordance with the expectation of a four-year modal time to degree. See Data Appendix for further details. Each entry and associated standard error is the coefficient on the log of population measure in a regression also including state and year fixed effects.

Table 9: Effect of cohort size on resources available and attainment in the K-12 grades

A. Effect of enrollment on resources per student

| | Dependent Variable | |
|---|---|---|
| | Ln Exp per Student | Ln Teacher per Student |
| Ln El & Sec Enr | -0.25 | -0.18 |
| | (0.03) | (0.00) |
| Ln Avg D Attend | -0.21 | -0.16 |
| | (0.02) | (0.00) |

*Notes:* Data are from *Statistics of State School Systems* (1998) for 1970-1995. Current expenditures are from Table 38, Average Daily Attendance is from Table 13, Fall elementary and secondary enrollment is from Table 10, and teachers per student is derived from the Pupil-Teacher Ratio reported in Table 24. Each table entry represents a single regression, with state and year fixed effects also included as covariates; standard errors are heteroskedasticity-corrected.

B. Effect of teachers per student (ln) on collegiate attainment

| Census Year | Coefficient on Ln (Teacher / Student) |
|---|---|
| 1970 | 0.733 |
| | (0.159) |
| 1980 | 0.502 |
| | (0.154) |
| 1990 | 0.332 |
| | (0.191) |

*Notes:* The dependent variable is the share of college graduates in each state and birth cohort, measured in logarithmic form. Pupil-teacher measures were provided by Alan Krueger and reflect the potential resources available to students in the K-12 years. All regressions include state and year fixed effects. Birth cohorts included are: 1916-1945 for the 1970 Census, 1916-1945 for the 1980 Census and 1926-1945 for the 1990 Census.

## Data Appendix

The primary sources of data for this analysis are: institutional surveys of colleges and universities, the decennial Census files, the decennial Census publications, population estimates by the Census Bureau, and standard measures of labor markets characteristics.

## Population data

Population measures by state and age are primary to our analysis. There are two sources for our population measures: age-specific estimates from the Census bureau and measures of birth cohort size from the Vital Statistics tabulations.

Measures of birth cohort size for each state from 1928 – 1975 were entered from vital statistics data distributed by the National Center for Health Statistics. The original data came from birth registrations. (These are the cohorts that would have been 22 between 1950 and 1997).

For the most recent three decades, data on population by state and single year of age are available through the Bureau of the Census website. For the years between Census enumerations, these numbers are estimates which take into account mortality and migration. See: http://eire.census.gov/popest/topics/methodology/stage98.txt for a discussion of this methodology. For the years before 1970, we combine data on the state and single year of age enumerations published in the U.S. Census Bureau State Volumes for 1950 (Table 51), 1960 (Table 94) and 1970 (Table 19) and the total population in each state and year for single years from 1950-1970. Because the population measures between census enumerations are estimates, measurement error is a logical concern with these data. We discuss in the text why we do not believe this to be a significant problem.

## College enrollment and BA degree outcomes

The primary measures of collegiate attainment are collected from federal surveys of colleges and universities. The degree data are based on the annual "Earned Degrees Conferred" survey conducted by the National Center for Education Statistics (NCES), which records degrees awarded in the 12-month academic year from July to June.[49] The enrollment data are from the "Fall Enrollment" surveys which record the number of students enrolled in classes in the fall. Through 1986, these surveys were part of the larger NCES Higher Education General Information Survey (HEGIS), which was subsequently redesigned as the Integrated Postsecondary Education Data System (IPEDS) collection.

The complete "Earned Degrees Conferred" survey records degrees and certificates completed by field and level, though this analysis makes use of only the total

[49] In 1960-61, the survey began to separately delineate first professional and baccalaureate degrees. Prior to this point, the two were combined, reflecting the fact that in the early part of the century first professional programs were concurrently undergraduate degree programs at some institutions.

baccalaureate degree series. Similarly, the "Opening (Fall) Enrollment" survey records enrollment by level (undergraduate/graduate) and full-time/part-time status. We work primarily with the total enrollment variable as this is available from 1950 forward.

Historical data (primarily in the years prior to 1966) are keypunched from published tabulations in the government document publications under the titles "Earned Degrees Conferred" and "Opening Fall Enrollment." Machine-readable data are employed after 1966 (1967 for enrollment), which allows for the distinction of institutions by control (public/private) and Carnegie Classification.

A final source of data from institutional collections is the Residence and Migration Survey conducted periodically by the by the Office of Education and later the Department of Education. Data for the following years are available: 1949, 1958, 1963, 1968, 1972, 1975, 1979, 1981, 1984, 1986, 1988, 1992, 1994, and 1996. This survey records first-time freshman enrollment by state of residence and state of attendance.

In addition to the data which record degrees awarded and enrollment in each year and state by colleges and universities, the decennial Census enumerations record college attainment to individuals by state of birth and age (or, implicitly, year of birth). As discussed in the text, the Census data are conceptually different from the institutional data in that they do not record the year or state of degree receipt. As is well known, the form of the Census question on educational attainment changed to a degree-based question from an item that recorded years of attainment with the 1990 Census. When we employ data from the 1970 and 1980 enumerations, we treat completing 16 years as equivalent to BA degree receipt.

**Higher education finance variables**

Each year as part of the institutional reporting to the federal government, colleges and universities complete a survey of institutional finances in which they report basic income and expense items including the sources of revenues and expenses. We are particularly interested in distinguishing sources of public support from tuition and fee revenue, while also measuring the total level of educational expenditures. For this purpose, we focus on the collection of four variables:

Revenues-Tuition and fees: Includes all tuition and fees assessed (net of refunds) against student for current operating purposes (except receipts from the Veterans' Administration and Federal grants or contractual payments for research which are included in Federal Appropriations). Tuition and fees remissions or exemptions are assessed and reported as revenue even though there is no intention of collecting from the student. An amount equal to such remissions or exemptions is reflected as expenditures and classified in the category Scholarships and Fellowships or Staff Benefits (i.e. if for faculty, staff or their offspring's tuition). Schools are instructed to include tuition and fees collected by the institution, sent to the state and returned to the institution in the form of appropriations.

Revenues-State appropriations: Those monies received from or made available to an institution through acts of the state legislative body, except institutional fees and other income reappropriated by the legislatures to the institution (i.e. tuition and fees collected by the institution and returned to the institution in the form of appropriations are subtracted as they already appear as tuition and fees). This line item also includes Federal aid received through State channels and regional compacts.

Revenues-Federal (Appropriations and Grants & Contracts): All other monies received from or made available to an institution by the Federal Government, excluding any income from Federal land grants which is included in endowment earnings. Grants and contracts are revenues from governmental agencies which are received or made available for specific projects or programs. Examples are research projects or training programs.

Expenditures-Education and General: Include the following categories of current expenditures:1) Executive and administrative offices, 2) Instructional departments , colleges and schools including office, equipment, laboratory expenses; and salaries of department heads, professors, and other instructional staff (including student assistants) technicians, secretaries, clerks, etc., 3) Extension and public services (e.g. non-degree courses, public lectures, or radio broadcasts), 4) Libraries (salaries, wages, operating expenses, books, periodicals, binding, etc.), 5) Operation and maintenance of the physical plant and 6) Organized research.

In years prior to 1977, all state level financial data are from published tabulations, as we have found the machine readable data for early years (through Webcaspar) to be unreliable, presumably due to problems with imputations. For years 1950-58, the *Biennial Survey of Education* includes tables reporting these items at the state level. Beginning with 1959 the annual Office of Education/Department of Education publication "Financial statistics of institutions of higher education" contains the tables with these data.

We note that we have compared the measures of state appropriations with data reported from state governments on appropriations and found these measures to be highly correlated. Data from state governments are compiled annually since 1960 by the Center for the Study of Education Policy at Illinois State in the *Grapevine* series. These data differ slightly from measures reported by institutions in that they also include state funds to non-collegiate higher education institutions such as the administrative boards coordinating higher education.

Data on tuition and fees, measured as a price, are available from 1970 to the current year. There are two sources for these data, which provide measures that are highly correlated. First, the Department of Education collects data on tuition and fees at the institution level as part of the Institutional Characteristics section of the annual HEGIS/IPEDS surveys. In addition, the Washington Higher Education Coordinating Board conducts an annual survey of tuition and fees at public institutions, which includes data from 1972-73 to the present.

**Labor market variables**

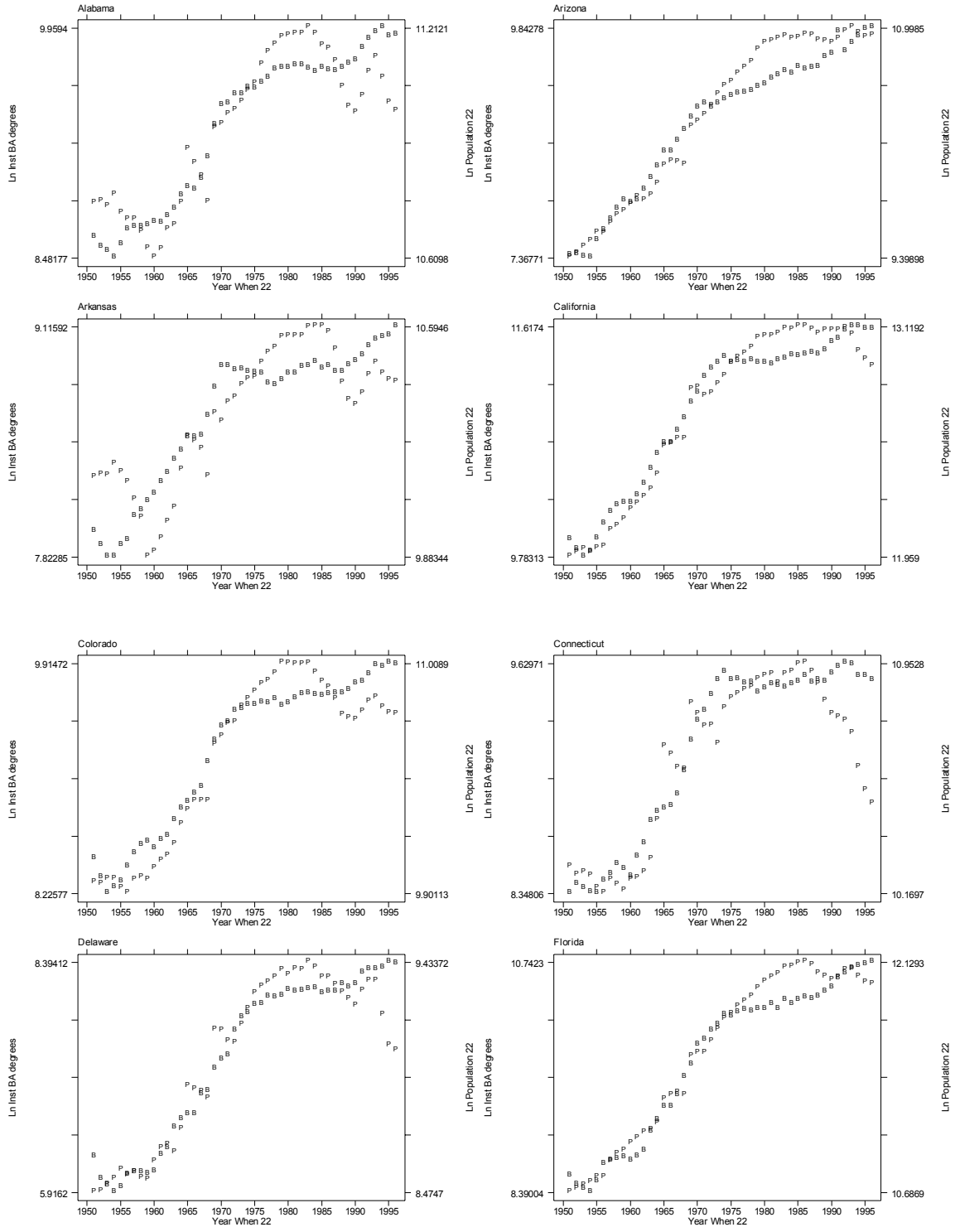
Labor market variables used in the analysis include the state specific unemployment rate, personal income and manufacturing wage bill. State-specific unemployment rates are available from 1970 through the Bureau of Labor Statistics [http://www.bls.gov/lau/staadoc.htm]. The personal income and manufacturing wage measures are from the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Accounts Data and are available from 1958 to 2001 [http://www.bea.doc.gov/bea/regional/spi/default.cfm#s2, the manufacturing wage bill is the s07 series, industry code 400].

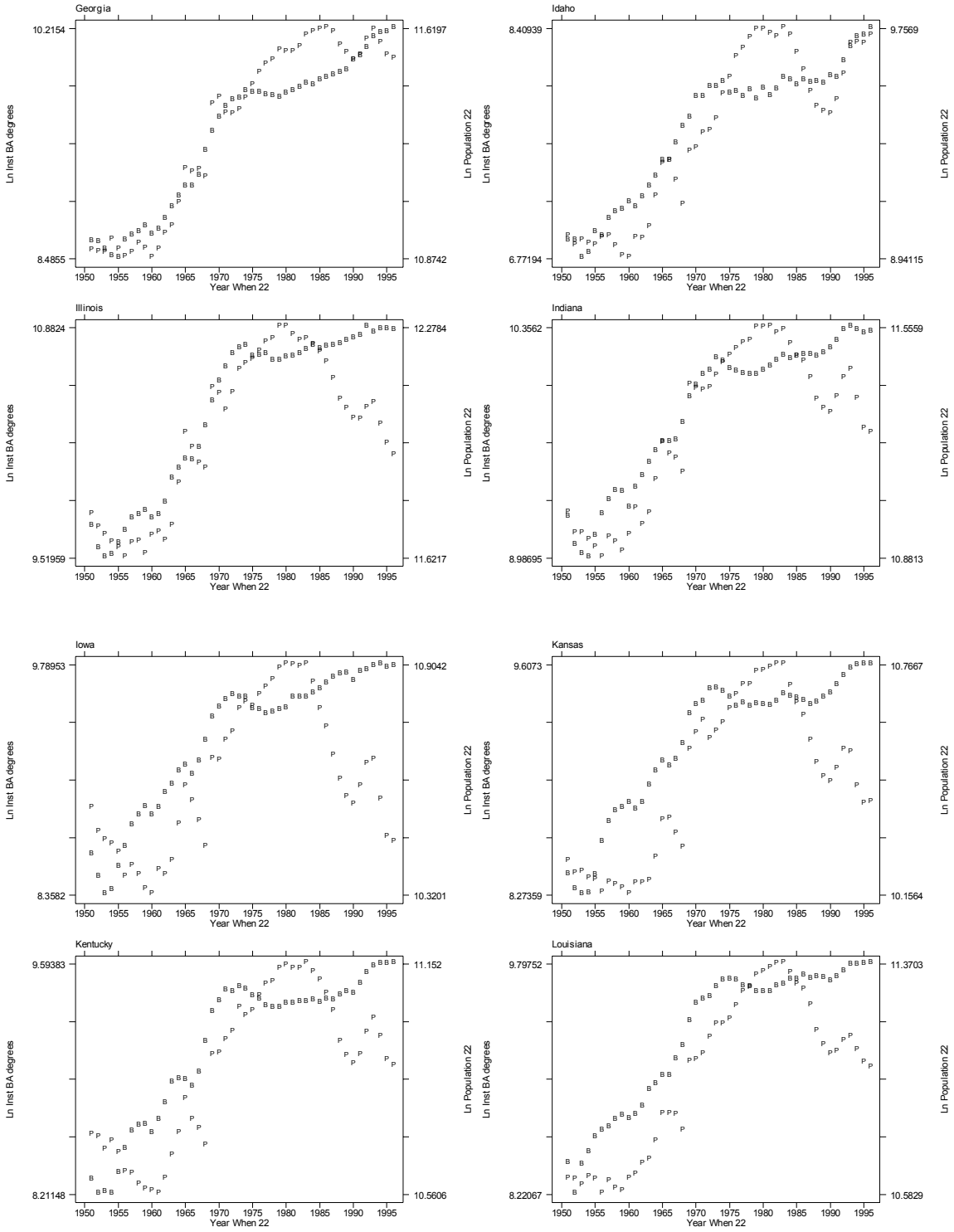
In addition, we compute the state- and age-specific measures of the college wage premium in the 1970, 1980, and 1990 Census enumerations. The adjusted average relative wage measures are computed as the return to exactly a BA Degree (or 16 years of completed education) from state-specific hourly wage regressions with a full set of controls for demographic and labor force characteristics including, race, sex, part-time status.

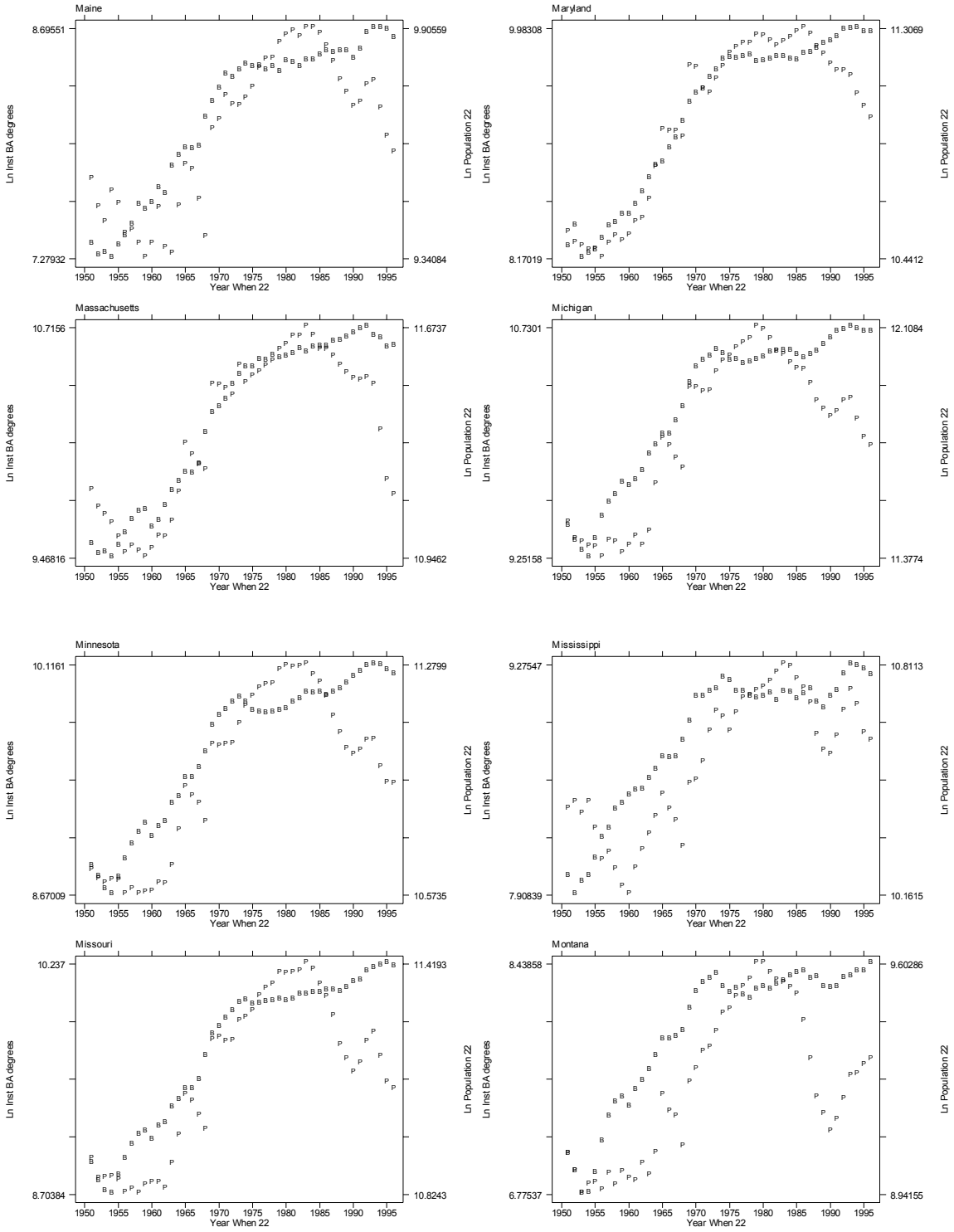
**Primary-secondary school quality measures**

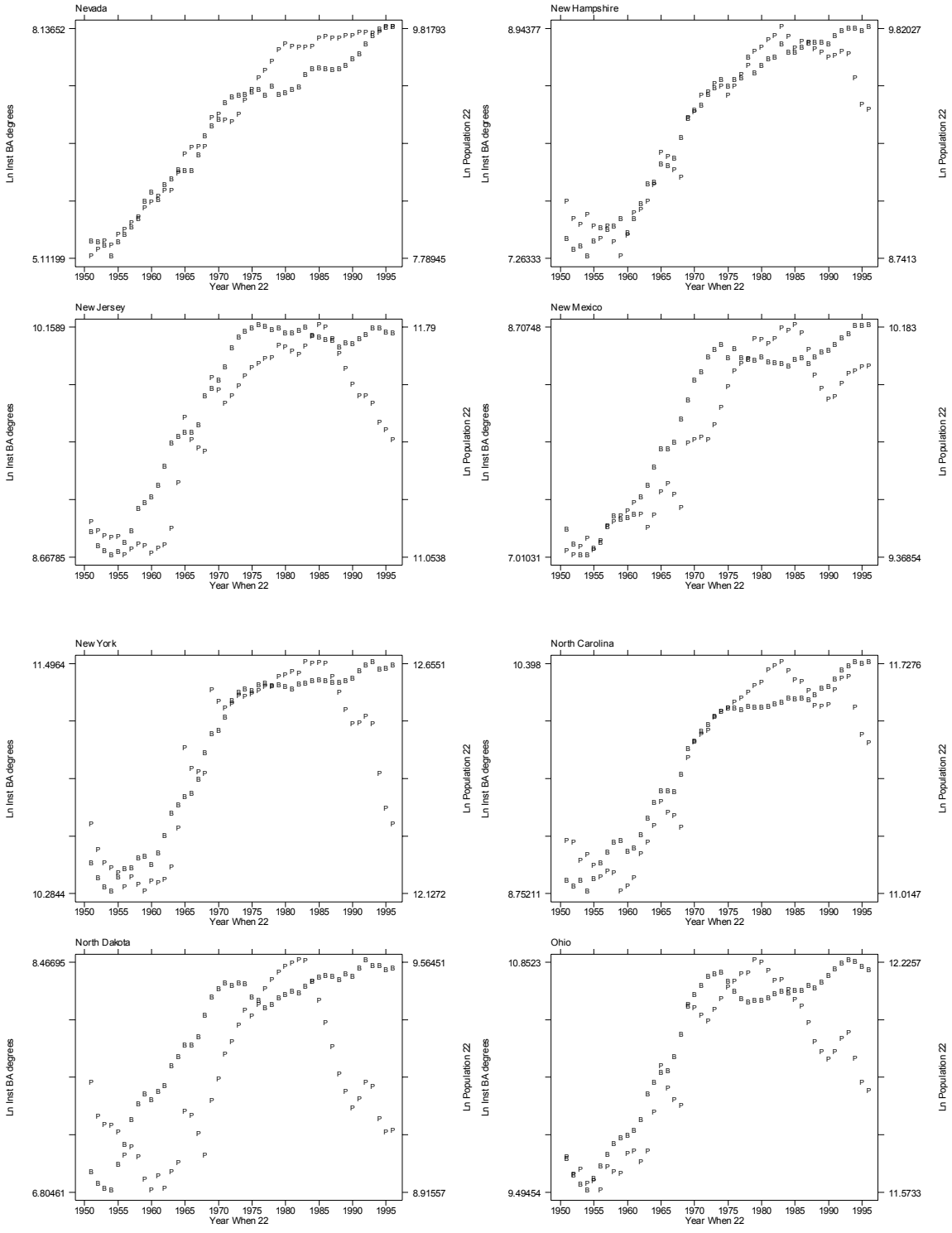
Measures of school quality experienced for students of different states and ages are from the data assembled by Card and Krueger (1992; see Appendix A of this paper) for the analysis of the effects of school quality on earnings. The original source for these data is the *Biennial Survey of Education in the United States* and related materials. The specific measures employed in this analysis the pupil-teacher ratio, average term length, and average teacher salary from academic year 1919-20 to academic year 1965-66 (coded by C-K as 1920-1960 for even years). To provide a single measure of school quality for each single year birth cohort, we averaged the potential school quality experienced from ages 6 to 17 within a state. In examining the contemporary relationship between school resources and enrollments, we use data from *Statistics of State School Systems* (1998) for 1970-1995, which records data on enrollments and resources (both expenditures and class size).

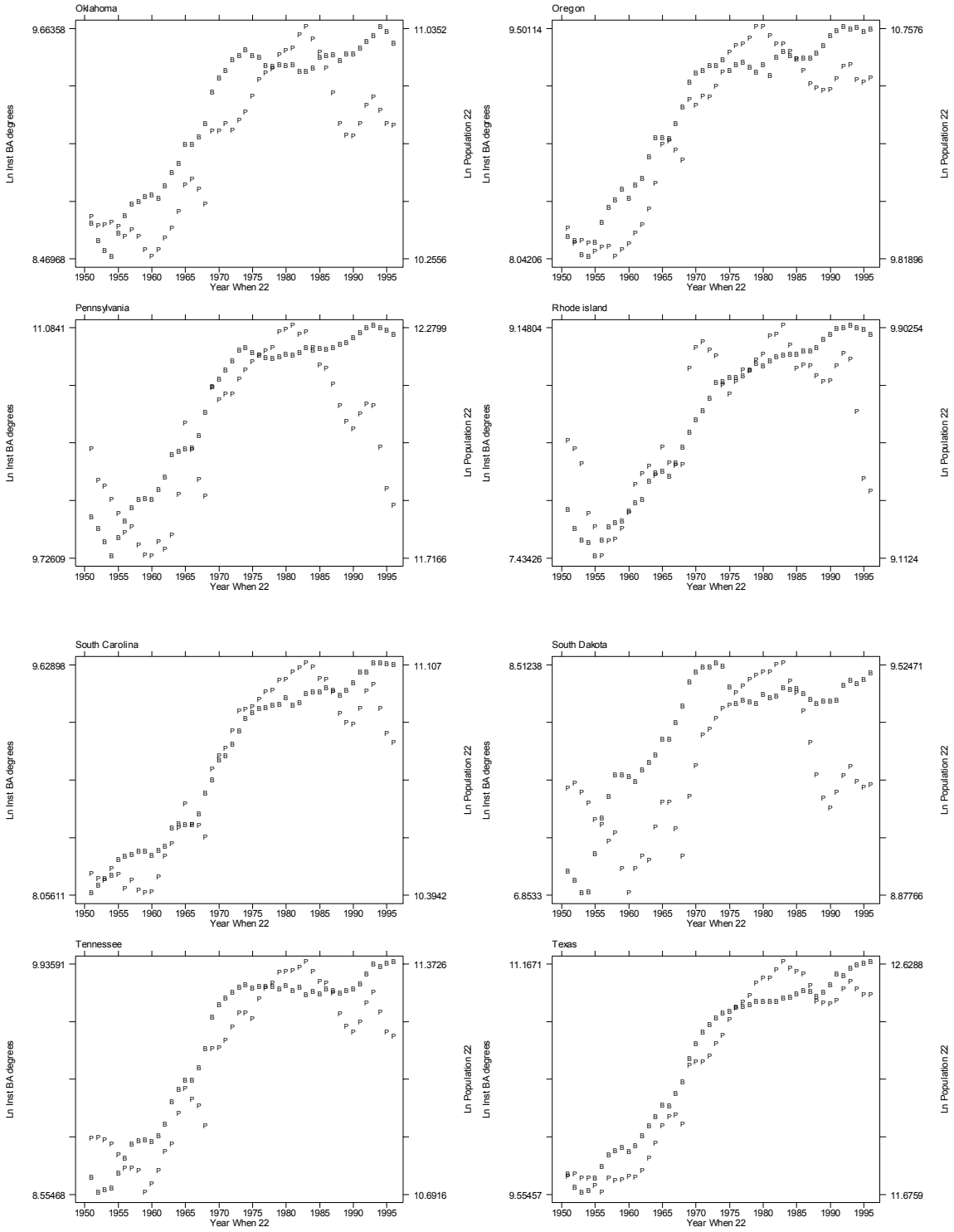
Appendix Figure 1: State-specific graphs of cohort size and BA degrees conferred

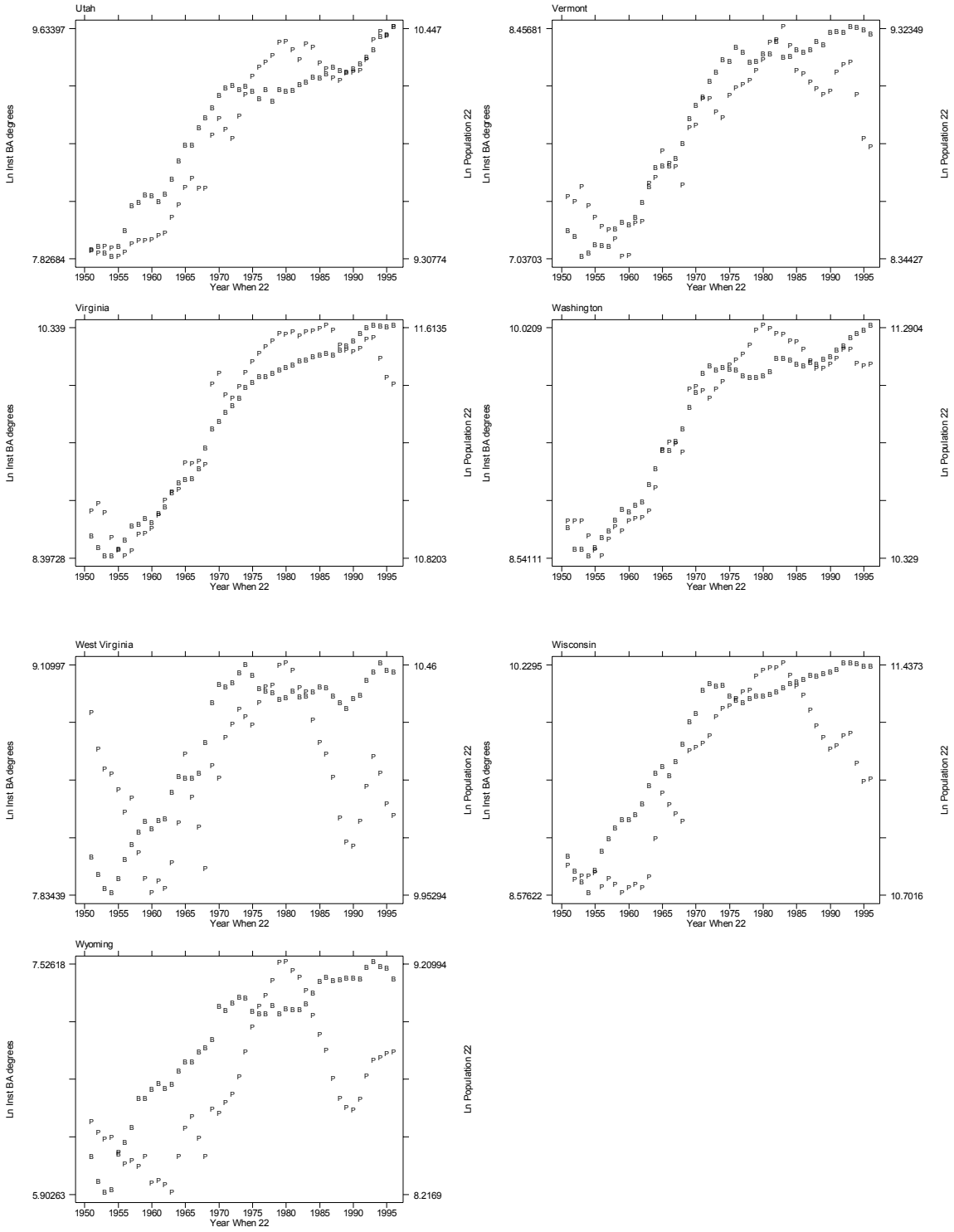



Georgia
Idaho
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Ln Inst BA degrees
Ln Population 22
Year When 22
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995


Maine
Ln Inst BA degrees
Ln Population 22
8.69551
7.27932
9.90559
9.34084
Maryland
9.98308
8.17019
11.3069
10.4412
Massachusetts
10.7156
9.46816
11.6737
10.9462
Michigan
10.7301
9.25158
12.1084
11.3774
Minnesota
10.1161
8.67009
11.2799
10.5735
Mississippi
9.27547
7.90839
10.8113
10.1615
Missouri
10.237
8.70384
11.4193
10.8243
Montana
8.43858
6.77537
9.60286
8.94155
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995
Year When 22


Nevada
8.13652
5.11199
9.81793
7.78945
New Hampshire
8.94377
7.26333
9.82027
8.7413
New Jersey
10.1589
8.66785
11.79
11.0538
New Mexico
8.70748
7.01031
10.183
9.36854
New York
11.4964
10.2844
12.6551
12.1272
North Carolina
10.398
8.75211
11.7276
11.0147
North Dakota
8.46695
6.80461
9.56451
8.91557
Ohio
10.8523
9.49454
12.2257
11.5733
Ln Inst BA degrees
Ln Population 22
Year When 22
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995


Oklahoma
9.66358
11.0352
8.46968
10.2556
Ln Inst BA degrees
Ln Population 22
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995
Year When 22
Oregon
9.50114
10.7576
8.04206
9.81896
Pennsylvania
11.0841
12.2799
9.72609
11.7166
Rhode island
9.14804
9.90254
7.43426
9.1124
South Carolina
9.62898
11.107
8.05611
10.3942
South Dakota
8.51238
9.52471
6.8533
8.87766
Tennessee
9.93591
11.3726
8.55468
10.6916
Texas
11.1671
12.6288
9.55457
11.6759


Utah
9.63397
7.82684
10.447
9.30774
Ln Inst BA degrees
Ln Population 22
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995
Year When 22
Vermont
8.45681
7.03703
9.32349
8.34427
Virginia
10.339
8.39728
11.6135
10.8203
Washington
10.0209
8.54111
11.2904
10.329
West Virginia
9.10997
7.83439
10.46
9.95294
Wisconsin
10.2295
8.57622
11.4373
10.7016
Wyoming
7.52618
5.90263
9.20994
8.2169