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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 because tuition revenue fails to cover the full cost of higher education and public subsidies provide a substantial source of funding for colleges and universities. At issue is how variation in resources per student for higher education changes collegiate attainment. Using data covering the last half of the twentieth century, we find strong evidence that large cohorts have relatively low undergraduate degree attainment. That large cohorts face lower public subsidies per student in higher education explains this result, indicating that public subsidies have large effects on degree production. Much of the explanation for this result rests on the supply-side of the higher education market. With relatively low resources per student for large cohorts, colleges and universities face a quantity-quality tradeoff, which leads to a net reduction in degree attainment. As a result, rising cohort size and lower state expenditures foreseeable in the next decade may have significant negative effects on the supply of college-educated workers in the labor market.

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Analysis of college enrollment and college completion rates typically focus on demand-side factors including the financial attractiveness of a college education and the availability of financial aid. Implicit in this line of research is the assumption that colleges and universities adjust supply fully with changes in demand. However, there is good reason to believe that supply is not close to perfectly elastic. The higher education market in the United States is dominated by public and non-profit production and colleges and universities receive considerable subsidies from state, federal and private sources. Indeed, Winston (1999) estimates that student fees cover only a little over 12% percent of total educational costs at public colleges and universities in the U.S. Parallel estimates of the average share of costs covered by student tuition and fees at private colleges and universities are substantially higher, but still less than 50%, and much lower at the most selective institutions. Because consumers pay only a fraction of the cost of production, changes in demand are unlikely to be accommodated fully by colleges and universities without commensurate increases in non-tuition revenue. For this reason, public investment in higher education plays a crucial role in determining degrees produced and the supply of college-educated workers to the labor market.

Because only part of any observed change in current expenditures is likely to be exogenous and expenditures translate to resources with long lags, direct assessment of the effect of resources per student on degree outcomes using measures of current expenditures or state appropriations is complicated in empirical analysis. The motivating hypothesis of this analysis focuses on the potential role of “crowding” brought about by relatively large cohorts vying for a limited number of spaces in the higher education

sector. 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 potential reductions in educational resources per student in aggregate. Thus, large cohorts are essentially “crowded out” of the higher education sector, as the increase in cohort size does not produce a proportionate increase in resources and, in turn, collegiate attainment. To this end, variation in cohort size leads to a test of how the availability of resources at the college and university level affects collegiate attainment.

Understanding how variation in resources per student affects collegiate attainment is important to understanding the overall returns to public subsidies for 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. By the 1990s, college completion began to rebound, with the share of college graduates rising in the cohorts born in the late 1960s and early 1970s.

The first section of this analysis sets forth the defining characteristics of the market for higher education in the context of a rudimentary but illustrative model. In short, the high degree of public subsidy, the mixed market of public and non-profit providers, and the differentiated nature of the product in higher education lead to adjustments along both quality and quantity dimensions in response to demand shocks, with the predicted change in undergraduate degree attainment ultimately less than proportionate to the change in cohort size. The second section turns to the measurement of variation within states over time in cohort size and the effect of this variable on collegiate attainment. The third section focuses more directly on the nature of adjustments in higher education by type of institution and the link between current revenues available to higher education and cohort size. In the fourth section, we assess the empirical strength of the alternative explanation that adjustments in enrollment demand (such as changes in precollegiate achievement or the demographic composition of a cohort), but find such alternatives too small 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.

I: The Market for Higher Education and Responses to Demand Shocks

Although there has been a substantial increase in the scale of the higher education industry since the World War II era, the salient features of the industry -- including a mix of public and non-profit provision, substantial public subsidies, and a market

differentiated by “quality” – have remained constant (Goldin and Katz, 1999; Winston, 1999). The substantial levels of private and public 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.

Public colleges and universities, in particular, expanded markedly in the immediate post-war years. 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%. Within the public sector, 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.

State colleges and universities provide the majority of enrollment opportunities in higher education to their residents at a steep discount in price, made possible through substantial public subsidies. Table 1 summarizes the role of state appropriations in the current revenue stream of colleges and universities. Notably, at the public community colleges, state and local support accounted for 57.5% of current revenues, while state support accounted for more than 36% of revenues at non-research four-year institutions. At public research universities, the share of state support (30%) is somewhat lower though the levels tend to be higher and these institutions also rely on a range of other non-tuition revenues including resources from private donations and research support

from the federal government. What is clear from this table is that tuition payments fall far short of covering total educational costs.¹

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. The final columns of Table 1 show the substantial nominal difference between in-state and out-of-state tuition prices.² It is these large differences in expected tuition prices – both between in-state and out-of-state schedules and between public and private charges – that lead to a concentration on public colleges and universities as the institutions determining the choice set within a state for students likely to be at the margin of college enrollment and completion.

Private institutions, particularly the selective colleges and research universities, also rely heavily on non-tuition sources of revenue, including private contributions and income from endowment. Nevertheless, the selective private institutions with substantial subsidies enroll a very small share of the undergraduate population. 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, the most competitive level of colleges and universities (e.g., Stanford University, Harvard University) define a highly integrated and national market and are unlikely to attract students at the margin of college enrollment (Hoxby, 2000).

¹ Estimates by Winston (1999) place the degree of subsidy even higher, because conventional statements of revenues and expenses for colleges and universities fail to account for capital costs (both depreciation and the opportunity cost of funds), which account for an average of 25% of educational costs.

² 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.

Understanding 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, requires consideration of how non-tuition revenue affects the tradeoffs faced by these institutions. The model developed below applies to both open access institutions and selective flagship institutions, speaking 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, 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)³ 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 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

³ What is important is that these revenues are, in turn, translated into resources such as faculty, computers, and libraries which enhance student learning.

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.⁴ We introduce the inverse demand function

$T\left(\frac{L}{n}, \frac{n}{pop}\right)$, which is positive in the first argument and negative in the enrollment rate

among college-age students $\left(\frac{n}{pop}\right)$.

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.⁵ Most

generally, the nondistribution constraint is: $nT\left(\frac{L}{n}, \frac{n}{pop}\right) - nc(q) + L = 0$ where $c(q)$

reflects per student costs as a function of quality (or resources), with $c'(q) > 0$ and total costs of $nc(q)$. 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 endogenous and reflects the tuition rate determined by inverse demand function for college enrollment. This specification is straightforward 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.⁶

⁴ 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.

⁵ This model builds on Hansmann's (1981) effort to illustrate the potential quality-quantity choice for a performing arts organization when private donations depend on the quality of the presentation.

⁶ 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

The nonlinear constraint provides much of the intuition for analyzing the institutional adjustment to a demand shock. The constraint, illustrated in Figure 1 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.⁷ 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 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)

generally the responsibility of governing boards or state higher education authorities, with these authorities often composed of political appointees (Kane, Orszag, and Gunter, 2002).

⁷ 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 $\frac{\partial c(q)}{\partial n} = \frac{-L}{n^2}T_1 + \frac{1}{pop}T_2 - \frac{L}{n^2}$.

and quality (q) components – $U(n,q)$. The public university problem in the case where tuition is exogenous is then to solve: $Max U(n, q)$ subject to the constraint

$nT - nc(q) + L = 0$. This produces the first order conditions:

$$\frac{\partial U}{\partial n} - \lambda(T - c(q)) = 0$$

$$\frac{\partial U}{\partial q} - \lambda nc'(q) = 0.$$

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 1 (top panel); 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. Note that, in addition to the decline in enrollment, this decline in quality or resources per student will have a negative

effect on collegiate attainment so long as resources are an input in the collegiate production process.

In another case, potentially more representative of the public research universities, institutions weigh the tradeoff between quantity and quality directly and choose to operate at the tangency between the institutional indifference curve and the nondistribution constraint (illustrated in the bottom panel of Figure 1). In such a situation enrollment 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. 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. 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.

While the magnitude of the response to an increase in cohort size in collegiate output—measured by degrees awarded—will vary with institutional circumstance, the

model predicts $\frac{\partial \ln BA}{\partial \ln Pop} < 1$ at the state level in the presence of non-tuition revenues that are invariant to cohort size. How large this effect is will depend on whether the institution begins on the steep portion of the budget constraint where there is a high “quantity / quality” tradeoff and how resources contribute to the transformation of enrollment to degree attainment. While the measurement of the differential adjustments of the various segments of the higher education market to demand shocks is of independent interest, the focus of this paper is on the net response of the higher education industry within a state to changes in cohort size.

II. Cohort Size and College Completion Within States

Our empirical approach begins with the measurement of the relationship between 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. The state is the unit of analysis and all specifications include state and year fixed effects.

Focusing on the within-state association between cohort size and college completion rates has a fundamental effect on our interpretation of this association. 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.⁸

We are interested in the within-state association between cohort size and college completion rates. Since state populations are not closed, cohort size can vary quite substantially by the time of measurement. Given our interest in how cohort size affects the resources available to those who might wish to attend college, it is natural to measure cohort size at a point in time when individuals would typically attend college (e.g. age 18). We would then like to be able to calculate the fraction of these cohorts that eventually receive a BA. Such data do not exist. The decennial Census allows researchers to calculate degree completion by state of birth, but does not identify state of residence at age 18. Alternatively, measures are available from colleges and universities enumerating the number of degrees conferred each year. 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

⁸ 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 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-

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.

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)).⁹ 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.¹⁰

Figure 2 plots cohort size and BA production per years for selected states. Similar figures for all states appear in as appendix figures. [NECESSARY?] It is important to note that while the regressions we reported in Table 2 took out year effects, much of the observed variation in these figures represents the growth and then the decline

specific college age population size has on college completion rates can not be working through labor market incentives.

⁹ 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. Like Card and Lemieux (2000), we have also estimated these effects separately for men and women and do not find a significant difference in the effect of cohort size by sex.

¹⁰ Following Fortin (2003), one might be concerned that the market adjustments in states with smaller private higher education sectors would be different from those in states with larger private higher education sectors. Interacting cohort size with an indicator for states with public higher education enrollment below the median does not yield a significant effect.

of the overall size of the college aged population. For each of the states shown, the 1950s and 1960s saw a very dramatic rise in both cohort size and in the number of individuals receiving BA degrees. However, around 1970 BA production levels off. Over the past 30 years the number of BAs being produced has remained approximately constant, despite continuing rises in cohort size through the 1980s and a drop in cohort size since then. The figures give the strong impression of capacity constraints. During the 1950s and 1960s many states were investing heavily in higher education and, as a result, capacity expanded. Starting in the 1970s, investments leveled off and capacity remained relatively fixed.

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.

The majority 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. Indeed 83 percent of the variation in our cohort size variable can be explained by a simple linear trend. 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).¹¹ Doing so further attenuates the link between cohort size and degrees awarded.

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.¹² 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 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-age 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 of our population measures, following Baker, Dwayne, and Stanger (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 ξ_k and γ_k are

estimated in a regression for each state, leading to the estimate of each of Fourier

¹¹ We also experimented with quadratic trends, which show results very similar to those presented.

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.

The contrast between results based on specifications with state-specific trends and those without state-specific trends is consistent with what would be expected were the effect of the association between cohort size and college completion rates driven by cohort crowding at the college level. In the specifications that exclude the state-specific trends, secular trends dominate the variation in the cohort size variable – essentially representing population shifts that have continued through the entire post World War II period and plausibly persisting indefinitely. Once the state-specific trends are added, the variation in cohort size is of somewhat higher frequency. It is easy to imagine that policy and institutional responses would 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. In addition, the strong association between within state changes in employment and cohort size suggest that states with secularly growing college-age populations are states experiencing significant economic growth – with expanding economies it will be relatively easy for such states to expand resources devoted to higher education. In contrast, once secular trends have been removed, the fact

¹²While 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

that there is relatively little association between changes in the size of the college-age population and employment suggests that responding to higher frequency changes in cohort size may be difficult for states.¹³

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. We estimate the elasticity of total enrollment at the state level with respect to population [0.61 (0.11)] and the elasticity of enrollment of state residents with respect to population [0.62 (0.08)]. If increased out-of-state enrollment were a substantial part of the response to cohort expansion, we would see larger elasticities

between family size and cohort size.

¹³ 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. While our cohort size measures at age 18 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. Because the Census population estimates are surely not iid white noise, it is not at all clear what effect these errors will have on our estimates. To try to gauge the effect of these errors on our estimates, we re-

(closer to 1) for enrollment of state residents than for total enrollment in the state. Yet, the elasticities for these two measures are virtually identical. 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 2.¹⁴

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.¹⁵ 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

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

¹⁴ Focusing on just the flagships schools we do find that out of state enrollment does tend to fall in the face of large cohorts, however this effect is small enough and the flagship schools represent a small enough share of total enrollment, that this pattern hardly shows up when we combine data on all colleges and universities.

¹⁵ 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.

cohort size.¹⁶ All in all, we doubt these inter-temporal substitution effects have much effect on our estimates.

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.¹⁷ These alternative data sources serve to underscore the reliability of our results while necessarily answering somewhat different questions. 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

¹⁶ 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 of BAs. As a result, we would underestimate $\partial \ln(\text{BA}) / \partial \ln(\text{Pop})$ 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 $\partial \ln(\text{BA}) / \partial \ln(\text{Pop})$. 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.

¹⁷ 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

the same footing. Focusing on those born between 1932 and 1975 (or those age 22 between 1954 and 1997) in the 2000 Census, regressions of the share of the population born in each state and year with a BA degree on 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 (1990) or -.24 (2000) vs. -0.33 (institutional)), but the two sources reveal the same broad finding of a negative relationship between cohort size and college completion. However, including state-specific trends in the specifications using institutional data tends to strengthen the evidence of “crowd out”, doing so significantly weakens the evidence in the specifications using Census data.

Possible explanations for the large difference between the results based on the institutional versus the Census data with the inclusion of state-specific trends involve both differences in the timing of the cohort size variable and difference in the nature of the measures used. One difference is in the timing of the cohort-based measure: cohort size at birth in the Census regressions while cohort size at age when individuals would typically enroll in college (age 18) is employed with institutional measures of collegiate attainment. Given our maintained hypothesis, the reason that the size of the birth cohort matters 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-age population 18-22 years later. Indeed, the correlation between year of birth measures of cohort size and measures of the same cohort at age 18 after having taken out state and

elasticity of completion with respect to population than related estimates with the dependent variable specified as a completion rate.

year effects is .84. Removing state-specific trends drops the simple correlation to .37. Thus, relatively short-run fluctuations in the size of cohorts measured in the year of birth are more weakly related to the size of the college-age population in a state 18 years later. The modest degree of cohort crowding shown in columns (2) and (4) 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.

III. 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. While price is a natural margin for adjustment to a demand shock, the unusual link between political actors at the state level and public colleges and universities undercuts this potential channel for adjustment to market forces.¹⁸ The link between cohort size and tuition charged by public institutions is not positive. Instead, the evidence from regressions of the tuition charged to in-state students by public colleges and universities on cohort size points clearly in the other direction at public institutions: 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. As in previous specifications, these regressions include state and year fixed effects. Since there were

¹⁸ 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.

secular increases in tuition at state schools over the period under study the right way to think about these results is that they suggest that tuitions rose less rapidly in states which experienced population growth over the period in question. It is only among the non-research private institutions that we see the expected positive link between tuition and cohort size. 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 at public universities. These results suggest that state universities raise tuition to cover expenses as a last resort in adverse budgetary environments.¹⁹

Beyond tuition levels, we consider the relationship between all sources of revenue and cohort size in the regressions presented in Table 5. 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 than 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

¹⁹ When either state employment or state and local appropriations are included in the regression the effect of cohort size on tuition approaches zero, with increases in either state employment or state appropriations having a substantial negative effect on tuition prices. These results would seem to confirm the notion that states tend to raise tuitions when state economies are in trouble.

state trends. Tuition revenues do not appreciably fill the revenue gap, with changes in cohort size associated with an elasticity of about 0.6.²⁰

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 6, we revisit the within-state regressions of collegiate attainment on cohort size with the addition of a measure of expenditures instrumented 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.

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.

²⁰ 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.

The regression results in Table 7 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.²¹ Plainly, institutions differ appreciably in resources per student and students

²¹ 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 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.

attending more resource-intensive institutions have somewhat higher collegiate attainment (and BA completion) than those attending lower-quality institutions.²²

IV. 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.

²² 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. 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 colleges and 10 percent higher than students attending other public four-year institutions (Authors’ tabulations from the National Longitudinal Study of the Class of 1972).

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 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. 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. 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

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. 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. Using data for the 1970 to 1995 period, we find that variation in elementary and secondary enrollment or average daily attendance are linked to lower levels of teachers per student, with coefficients $-.18$ (0.00) and $-.16$ (0.00) respectively.²³ Of substantive interest is how such changes in resources per student affect academic achievement and, more specifically, college completion.

What effect might these changes in resources available to students on college achievement? 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. 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. To estimate the cumulative effect of class size on college completion rates, following Card and Krueger, we use the average of the potential pupil-teacher ratio faced by the student in a state. We find significant and effects of the teacher-student ratio for all Census years examined.²⁴ using measures of collegiate attainment from the 1926-1975 birth cohorts from the 2000 Census, estimates

²³ Data are from Statistics of State School Systems (1998) for 1970-1995. 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.

²⁴ 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.

of the effect of the teacher-student ratio on college completion yield large effects -- 0.46 (.157), with both collegiate attainment and resources measured in logs.²⁵ Such evidence is indicative of reductions in college preparedness associated with resource declines in large cohorts.²⁶ 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 upper bound effect on college completion operating through resources is likely to be quite modest (.07 to 0.08). 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.

V. Conclusion

The empirical analysis in this paper demonstrates that college completion will fail to increase with growth in cohort size without sustained expansion in public resources for higher education. 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

²⁵ It is not clear our estimates represent the causal effect of class size on college completion rates. Loeb and Bound (1996) and Hanushek, Rivkin and Taylor (1996) argue that state level aggregation is likely to exacerbate omitted variable bias, leading to an overstatement of causal effects. As such, we think of the estimates reported in Table 8 as representing upper bounds on estimated effects.

²⁶ 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.

universities. What is more, our estimates suggest that neither the effects of declines in school quality in the elementary and secondary years nor the effects of changes in the composition of the pool of potential college students associated with large cohorts 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. To the extent that the distribution of enrollment shifts away from these resource-intensive institutions, the college completion rate will fall. 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. While it is plain that the well-known cyclical variation in state funding for higher education may have deleterious effects on public colleges and universities, it is the more sustained depletion in resources per student accompanying relatively large cohorts that has the significant impact on collegiate attainment and the supply of college-educated workers to the economy.

The substantial variation in public subsidies available for higher education over the last half century has significantly affected collegiate outcomes. Resources for higher education were 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.²⁷ One study sites an average annual growth rate of 8 percent in education and general expenditures per student during the decade of the 1960s, which some authors have characterized as the “Golden Years” of higher education (Cheit, 1971). The reach of public subsidies during this period extended to capital projects as well as current expenditures, with the number of colleges 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 dubbed by one analyst as the “New Depression in Higher Education” (Cheit, 1971). Resources from both state and federal sources for higher education failed to maintain the dramatic rate of growth of the 1960s and in some cases declined, leaving many institutions financially strained. Figure 3 records broad trends in real resources per student by source of support for the period from 1960 to 1995. Beyond the changes in current revenues in evidence over this period, public subsidies have also been integral in building the physical capital of colleges and universities. The period from 1950 to 1970 brought about an enormous expansion in the “capital stock” of the college and university system, and federal and state support were integral in this building process (bottom panel of Figure 3). For example, the contribution federal government sources in plant fund accumulation increased from \$12.3 million dollars in 1950 to \$333.7 million in 1966, while state funds increased from \$285.2 million dollars in 1950 to \$738.7 million in 1966.²⁸ To this end, the long-term variation in the capital stock of

²⁷ 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.

²⁸ These data are from Table 129 of the 1972 Digest of Education Statistics, with the Department of Education Surveys *Financial Statistics of Institutions of Higher Education* providing the original source. In addition to the direct grants from the federal government over this interval, the federal government also provided access to substantial (subsidized) loan funds through the Housing Act until 1969.

colleges and universities combined with changes in state appropriations for operating expenses have substantial effects on the availability of collegiate resources and, in turn, educational attainment.

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.²⁹ Adding to the demographic pressure on higher education resources created by increasing cohort size are persistently tight state budget circumstances with higher education competing with entitlement programs and the rising cost of healthcare (Kane, Orszag and Gunter, 2003).

The impending collision of large cohorts and limited public resources in higher education is not just a predicament for colleges and universities, but a potential crisis in economic growth for decades to come if the flow of college-educated workers to the labor force is further curtailed. Because tuition is a small enough part of the total revenues of higher education, it would take enormous increases in tuition to provide the necessary resources for colleges and universities to expand and maintain quality, with such a shift adversely affecting the level and distribution of enrollment. At issue is how colleges and universities, particularly in the public sector, can raise resources from non-tuition sources to expand the pool of collegiate opportunities, without diluting quality. While states have, historically, been central to the development of infrastructure and the provision of subsidy in higher education, the current fiscal crises and restrictions against deficit funding may limit the capacity of states to make investments in human capital

²⁹ 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).

through public colleges and universities. What is more, the costs of underinvestment in higher education for large college-age cohorts may be spread across the nation as interstate migration has weakened the link between state of education and state of employment.

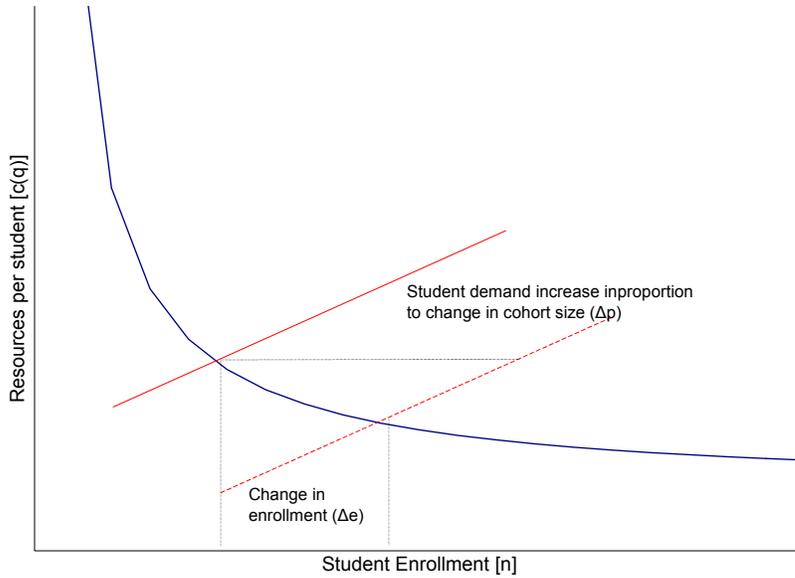
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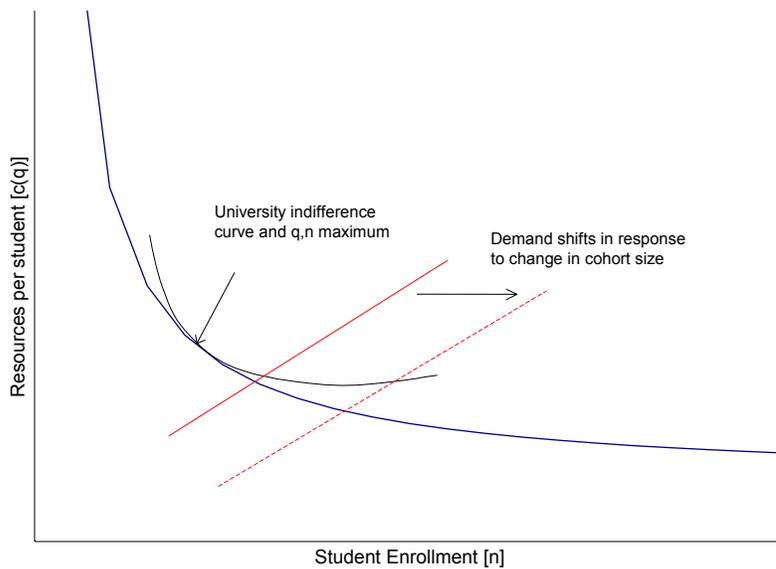
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Figure 1: Public university adjustment to changes in cohort size absent changes in subsidy

a. Enrollment maximization



b. Quality maximization



Notes: Changing the level of subsidy (L), holding tuition and costs constant, shifts the non-distribution constraint as illustrated above. Collegiate demand is drawn holding tuition constant, with the assumption of exogenous tuition setting.

Figure 2: State-specific trends in cohort size and BA degrees conferred
 Figure 3a: Selected State Trends in Cohort Size and BA Degrees

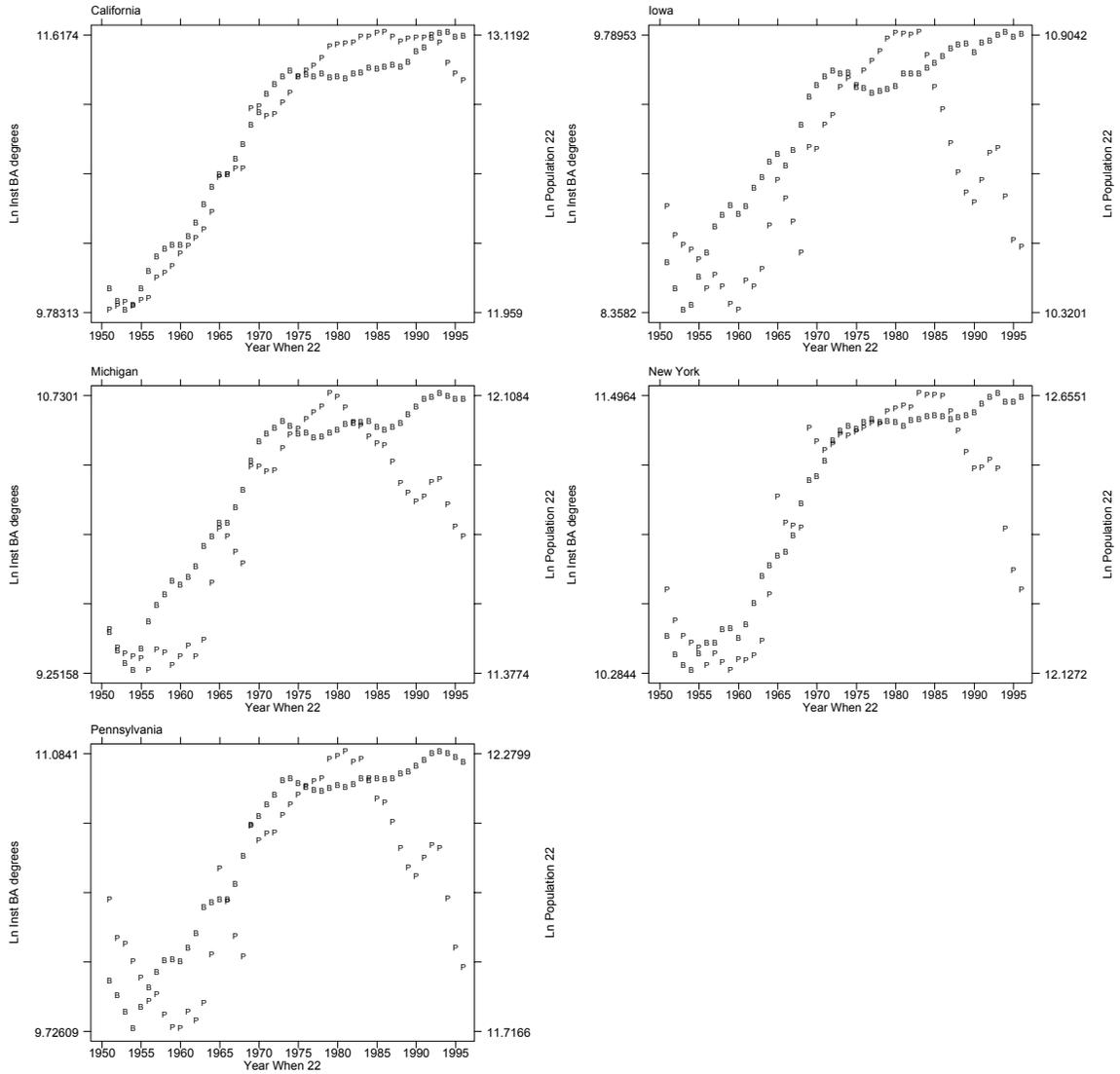
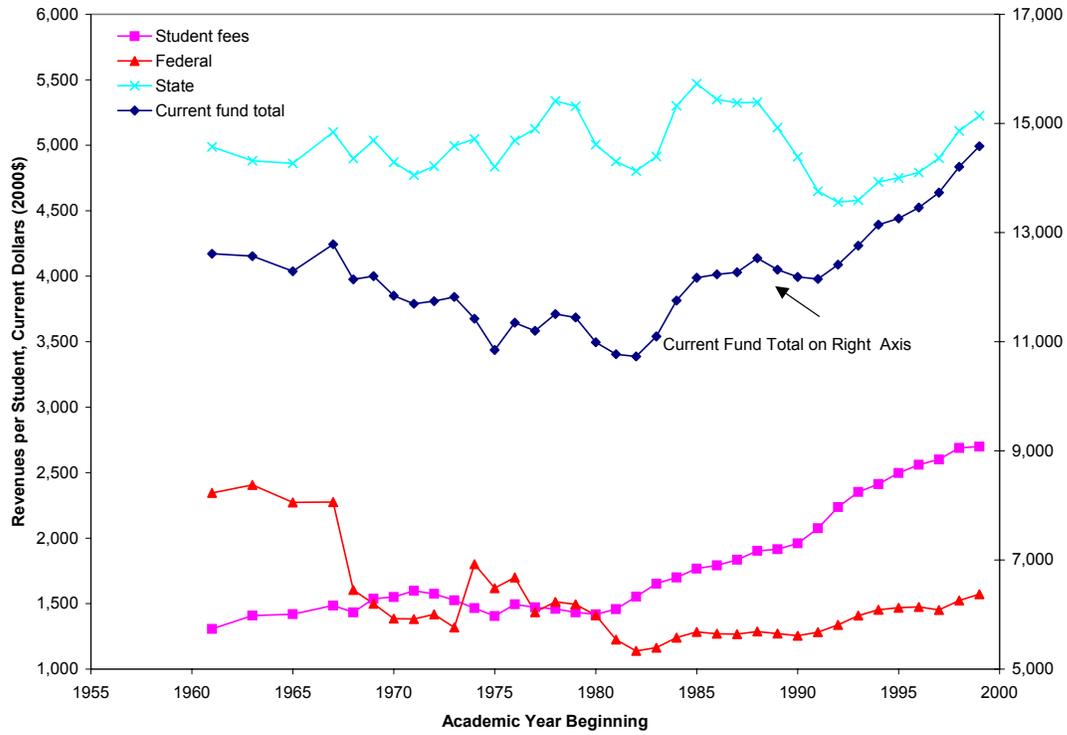


Figure 3: Current and capital resources for higher education

a. Current fund revenues by source, public institutions only



b. Capital funds, all institutions

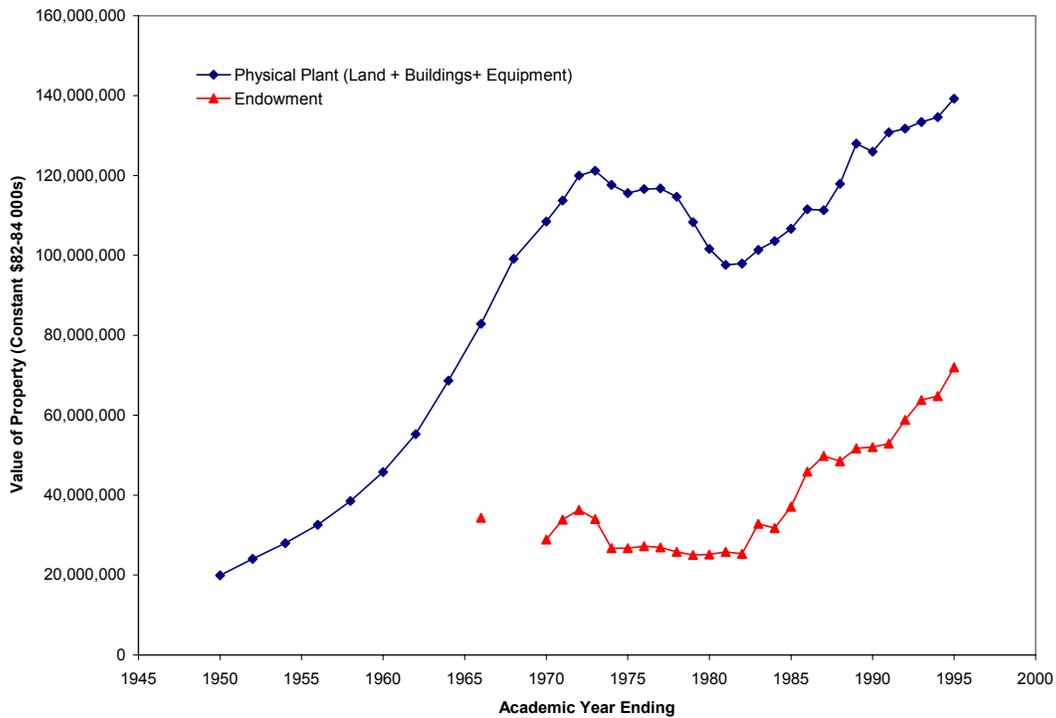


Table 1: Distribution of revenues and tuition by type of institution

	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)		Ln Tot BA on Ln Pop 18 Late Years (1967-1997)		Ln Public Inst BA on Ln Pop 18 Late Years (1967-1997)	
		(1)	(2)	(3)	(4)	(5)	(6)
<i>A. No Weights</i>	Ln Pop 18	0.71 (0.07)	0.20 (0.08)	0.62 (0.09)	0.15 (0.12)	0.59 (0.08)	0.21 (0.13)
<i>B. Avg Pop Wt</i>	Ln Pop 18	0.63 (0.09)	0.20 (0.07)	0.56 (0.08)	-0.03 (0.10)	0.54 (0.08)	0.06 (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)		Ln Tot Enr on Ln Pop 18 Late Years (1967-1997)		Ln Public Tot Enr on Ln Pop 18 Late Years (1967-1997)	
		(1)	(2)	(3)	(4)	(5)	(6)
<i>A. No Weights</i>	Ln Pop 18	0.89 (0.15)	0.21 (0.09)	0.79 (0.18)	-0.01 (0.09)	0.66 (0.16)	-0.02 (0.12)
<i>B. Avg Pop Wt</i>	Ln Pop 18	0.82 (0.11)	0.42 (0.18)	0.63 (0.18)	-0.18 (0.11)	0.49 (0.20)	-0.16 (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

Explanatory Variable	Ln Census BA Share on Ln Pop Yr of Birth			
	1990 Census		2000 Census	
	1954-87 Degree years	1954-97 Degree years	1954-97 Degree years	1954-97 Degree years
	1932-1965 Birth cohorts	1932-1965 Birth cohorts	1932-1975 Birth cohorts	1932-1975 Birth cohorts
	(1)	(2)	(3)	(4)
<i>OLS Regression of BA on Population Variable</i>				
Ln Pop Coefficient	-0.26 (0.05)	-0.11 (0.03)	-0.24 (0.03)	-0.13 (0.05)
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 observations by year and state of birth from the 1990 Census and Vital Statistics measures of birth cohort size; Columns (5)-(6) use measures of the population age 18 and institutional measures of BA degrees conferred.

Table 5: Regressions of revenue variables on population

	Coefficient on Ln Pop 18	
	(1)	(2)
<i>Weighted by Avg Pop</i>		
Ed & General Expenses	0.308 (0.182)	0.414 (0.187)
State Appropriations	0.477 (0.167)	0.262 (0.169)
Federal Revenue	-0.172 (0.560)	-0.174 (0.202)
Tuition and Fee Revenue	0.638 (0.050)	0.380 (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 6: Regressions of collegiate attainment on cohort size and resources

Regression	Explanatory Variable	Ln Total Enrollment on Ln Pop 18 Late Years (1954-1996)		Ln Inst BA on Ln Pop 18 All Years (1954-1996)	
		(1)	(2)	(3)	(4)
<i>First Stage</i>					
		0.35 (0.02)	0.26 (0.02)	0.34 (0.02)	0.24 (0.02)
<i>IV-State Appropriations Instrument</i>					
	Ln Education and & General Exp.	0.34 (0.10)	-0.12 (0.09)	0.21 (0.09)	-0.02 (0.10)
	Ln Population 18	0.76 (0.14)	0.16 (0.10)	0.60 (0.09)	0.23 (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 7: 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 (0.37)		0.21	0.37
Other Public	0.56 (0.13)	0.82 (0.22)	0.38	0.33
Flagship Public	0.20 (0.07)	0.28 (0.05)	0.13	0.09
All Private	0.99 (0.42)	1.20 (0.45)	0.28	0.21
Research I Private	-0.07 (0.36)	-0.19 (0.45)	0.03	0.02
Liberal Arts Colleges	0.26 (0.17)	0.71 (0.17)	0.04	0.02

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.

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.³⁰ 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.

³⁰ 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.

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