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A value-added estimate of higher education quality of US states

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States differ substantially in higher education policies. Little is known about the effects of state policies on the performance of public colleges and universities, largely because no clear measures of college quality exist. In this paper, I estimate the average quality of public colleges of US states based on the value-added to individuals' early career earnings. I explicitly deal with the problem of self-selection in both where to go to college and where to work. I find considerable variation in the quality of states' public college systems. Using this quality measure, I then explore how various aspects of state higher education policy are associated with college outcomes. I find that states with better faculty quality and with more diversity among public colleges tend to have higher value-added to student earnings.

Keywords: college quality; value-added; individual earnings; self-selection; state higher education policies

1. Introduction

State public colleges are the largest segment of the higher education market. A significant portion of state spending goes to higher education, and it accounts for the majority of the college students. In fiscal year 2000, state expenditure on higher education accounted for 11.4% of total state expenditure, the third largest category following primary–secondary education and Medicaid. In the same year, about 50% of high school graduates were enrolled in colleges; public colleges and universities enrolled 76.8% of all college students and about two-thirds of undergraduate students in four-year institutions (National Association of State Budget Officers 2001; NCES 2002). Knowledge of public college performance is of great interest to both the public and the policy-makers. In contrast to the abundance of studies on school education, both its finance and its performance (Hanushek 2002), most of the existing literature on higher education policies has been concerned with how different aspects of federal and state higher education policies affect access of and costs to different groups (for example, McPherson, Schapiro, and Winston 1993; Dynarski 2002; Kane 1994; Fortin 2003). Little is known about the performance of colleges and about what factors may affect college performance.

This paper is the first attempt to estimate a quality measure for public four-year colleges based on college graduates' labor-market outcomes. Ideally, one would like to examine the quality of each individual college and relate the quality to its input combination. In reality, no data-set contains a large enough sample for each college to allow meaningful statistical analysis. As a compromise of the data limitation, I focus on state four-year public college systems and examine the average performance of a state's public colleges. Focusing on the

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state average inevitably conceals the heterogeneity of public colleges within a state; nevertheless, relationships between the state average quality and state higher education policies provide important insights into the college production.

The quality of a state public college system is defined as its value-added to the earnings of its college graduates relative to the earnings of college graduates from a benchmark state – Alabama.[1] The goal is to distinguish the quality of a state college system from the quality of its students. I estimate the college quality controlling for students' characteristics. In particular, I create proxy variables to deal with students' self-selection based on unobserved qualities: selection of in which state to go to college and selection of in which state to work. The quality estimates range from −10% to 40% of a college graduate's annual earnings. Moreover, a traditional college quality measure based on the widely used Barron's selectivity category is shown to only moderately reflect college performance.[2]

Another contribution of this paper is to take the study of college quality a step further by exploring what aspects of state public college systems might be related to college quality. In a multiple regression framework, I find that better quality is associated with better faculty quality and more diversity among public colleges. However, since the analysis is based on one cross-section of quality estimate, and many unmeasured factors cannot be controlled by state fixed effect, these associations cannot be interpreted as causal.

This paper is most closely related to studies on the effect of college selectivity on future earnings in the United States. Brewer and Ehrenberg (1996) review 15 early studies on colleges' contribution to future earnings; none of them have attempted to control for college selection based on unobservable characteristics. Several recent studies have attempted different methods to correct this selection bias, but they have their own problems. In Behrman et al. (1996), Brewer and Ehrenberg (1996), and Brewer, Eide, and Ehrenberg (1999), colleges are grouped into a few categories based on either the median SAT score of the entering class or Barron's selectivity category. They find that attending more selective colleges leads to higher future earnings. There are two problems with these studies. First, grouping colleges into a few categories conceals large heterogeneities across colleges within each category. Second, selectivity category represents perhaps only one of many college characteristics – peer group quality – while other important college characteristics, such as college resources, are ignored. Dale and Krueger (2002) examine separately the roles of peer quality and expenditure per student; they find that expenditure per student appears to have a positive effect on future earnings, while peer quality does not. However, their sample of 30 highly selective colleges is far from representative.[3]

These studies also share two common problems. First, they estimate the return to college characteristics one at a time. Black and Smith (2004), assuming selection based on observed abilities, suggest that estimates based on single college characteristics underestimate college contributions to future earnings. Value-added estimates of the present paper, in contrast, represent the joint contributions of college characteristics. Second, none of the studies have controlled for influences of local labor markets; therefore, it is not clear how much of the college effect they obtain is attributable to variations in local labor market conditions. This paper explicitly separates out this factor and deals with the selective migration issue discussed in Heckman, Layne-Farrar, and Todd (1996) and Dahl (2002).

The paper is organized as follows. Section 2 estimates state college qualities. It first sets up the empirical model, then describes the data and discuss the regression results. Section 3 explores the relationship between college quality and state higher education policies. Section 4 concludes.

2. Estimating college quality

The empirical analysis employs a two-stage estimation approach. In the first stage, I estimate the average value-added by state public college systems from individual earnings data; in the second stage, I explore the relationship between college quality and state higher education policies.[4] This section focuses on the first stage analysis.

2.1. Empirical framework

Following the literature on estimating the value-added by schools (for example, Aitkin and Longford 1986; Hanushek 1979), to isolate the college contribution to earnings it is important to adequately control for individual differences in both the pre-college achievement and labor market experience. I model the relationship between earnings and individual characteristics and state college system as:

$$y_{ijk} = \beta_0 + X_{ijk} \cdot \beta_1 + S_{ij} \cdot \beta_2 + R_{ik} \cdot \beta_3 + \varepsilon_{ijk} \qquad (1)$$

where y_{ijk} is the natural logarithm of annual earnings of individual i, who went to college in state j and currently lived in region k; X_{ijk} is a vector of observed individual characteristics, including college admission test score (SAT), family background and school education experience; S_{ij} is a complete set of dummy variables for states of college; R_{ik} is a complete set of dummy variables for regions of current residence; and ε_{ijk} is a stochastic error term.

I seek to identify the estimates of β_2, the state-of-college specific value-added to earnings of college graduates. Assume that all variations in individual characteristics that are correlated with earnings are fully controlled for by X_{ijk}; then the ordinary least squares (OLS) estimates of β_2 are identified by otherwise identical individuals who have attended college in different states but are currently residing in the same region – the difference between the average earnings of these individuals represents the difference between the value-added by their states of college.

The OLS estimates of β_2 will not be a consistent measure of state college quality if either of the two following statements is true. First, conditional on covariates, state-of-college choice is endogenous. Second, conditional on covariates and conditional on state of college choice, migration decision to a local labor market is endogenous. Formally, the error term in Equation (1) is composed of two groups of unobserved abilities and a stochastic error term:

$$\varepsilon_{ijk} = Z_{ij} \cdot \alpha_1 + Z_{ik}(j) \cdot \alpha_2 + u_{ijk}$$

Z_{ij} represents unobserved individual abilities that affect both earnings and state of college choice; one often cited individual quality is ‘motivation’. These unobserved qualities are likely to help students get into more selective colleges, as well as succeed in their careers regardless of the college they have attended. Omitting Z_{ij} from the wage equation could lead to an overestimation (under-estimation) of the quality of the more (less) selective college systems.

Z_{ik} (j) represents unobserved individual abilities that affect both earnings and labor market migration decisions given that individual i has gone to college in state j. One story could be the following. Students going to college in a state with relatively unfavorable labor market may tend to move to other states; those with better qualities, observable by potential employers but not by economists, could have a better chance of employment in other states and would move away. Therefore, in a given local labor market, conditional on observed attributes, the average unobserved ability of college graduates from a state with a less favorable labor market would be higher than the ability of college graduates from a state with a more favorable labor market. Omitting Z_{ik} (j) from the wage equation would lead to overestimation (underestimation) of the college quality of states with a less (more) favorable labor market for college graduates.

To correct the potential omitted variable bias, I create proxy variables for unobserved individual abilities, and estimate the wage equation in an OLS framework.[5]

I use a dummy variable for whether an individual goes to college within her home state as a proxy for Z_{ij}. College admission officers consider many factors when selecting students, including their high school grades and test scores, and factors such as their essays, teacher recommendations, community services, and extracurricular activities. Many of these factors are also valued in labor market, but they are not observable to economists. Since out-of-state students are usually subject to a higher standard in the admission process, attending an out-of-state college could signal better unobserved qualities on average. States that take in more out-of-state students may have a student body with better underlying quality distributions; such states may appear to add more value to students' future earnings simply because part of the value-added can be attributed to better unmeasured student quality. Controlling for students' in-state status could mitigate the bias in college quality estimates.[6]

Two variables are created as proxies for Z_{ik} (j). The first variable is an individual's college grade point average (GPA) normalized within his or her state of college.[7] The GPA may be interpreted as a signal for both observable human capital and unobservable characteristics such as ability combined with willingness to work hard. Students with a high GPA are likely to have good job opportunities and to be more productive at work. By normalizing students' GPA within each college state, I place all students on the same ability distribution, and the normalized GPA is essentially a uniform end-of-college ability rank for all students. Thus, the normalized GPA allows me to control for differences in student ability within each regional labor market in an additional dimension.[8]

The second proxy for Z_{ik} (j) is a dummy variable for whether a college graduate moves to another state to work. One moves to a labor market where one has a comparative advantage; therefore, we expect movers to have higher earnings, conditional on other attributes. States with a large number of movers may appear to add higher values to students' future earnings because a portion of the value-added can be attributed to the realized comparative advantage in the labor market.

2.2. Data description

The primary data source is the Baccalaureate and Beyond 93/97 (B&B) Longitudinal Study of the Department of Education. The base year survey includes a national sample of students who received their bachelor's degree in academic year 1992/93; most of them started college in 1988 or 1989. The first follow-up was conducted in 1994, and the second in 1997. The base year survey reports information on students' demographic characteristics, college admission test scores, college GPA, and family background. The two follow-ups contain information on employment history and earnings after degree completion. The B&B data include reasonable number of college graduates from each state and allow meaningful statistical analysis; however, the number of observations is not sufficiently large to generate a highly precise estimate for every state. The B&B data are supplemented by state level information from the US Census and from NCES (1998).

Included in the regression are public college graduates who went to school, college, and worked in the 51 states of the United States – who, in 1997, were between the ages of 24

Table 1. Mean values of individual characteristics.

	All	In-state[a]	Out-of-state	Non-mover	Mover[b]
Number of students	4066	3434	632	2876	1190
1997 annual salary ($)	32,132	31,881	33,493	$31,633	33,336
SAT percentile	54	53	58	53	57
Normalized college GPA within state of college[c]	–0.111	–0.112	–0.105	–0.109	–0.116
1991 parental income (number of students)	$58,178 (2560)	$55,745 (2070)	$68,467 (490)	$55,300 (1711)	$63,983 (849)
Father's education (years) (number of students)	15 (3677)	13 (3086)	16 (591)	13 (2606)	16 (1071)
Mother's education (years) (number of students)	13 (3277)	13 (2754)	15 (523)	13 (2302)	13 (975)
Age in 1997 (years)	27.8	27.9	27.2	27.9	27.4
Male	0.45	0.45	0.47	0.45	0.48
Female	0.55	0.55	0.53	0.55	0.52
White	0.83	0.82	0.88	0.83	0.85
Black	0.05	0.05	0.06	0.05	0.06
Asian	0.04	0.04	0.02	0.04	0.03
Hispanic	0.04	0.04	0.01	0.04	0.03

Note: [a]In-state students are students going to college in their home state; out-of-state students are students going to college outside their home state. [b]Movers are students who move to a state other than their college states to work; non-movers are students working in their college state. [c]Students' GPAs are normalized within their college states to an $N(0,1)$ distribution and hence are comparable.
Source: B&B survey data 1993/1997.

and 35 years, were not full-time students, and had annual earnings greater than $5000. The sample used for the analysis includes about 4000 public college students.[9] Almost 80% of them went to college within their home state, and 30% of the students moved to a state other than their college state after graduation. Table 1 describes individual characteristics for all students in the sample, for students going to college within their home states (in-state) and outside their home states (out-of-state) separately, and for students who after graduation work in their college states (non-movers) and in other states (movers) separately. For the entire sample, four years after receiving a bachelor's degree, college graduates earned on average $32,132 annually; the standard deviation of annual earnings was about $16,500. There were more female graduates than male, but blacks were much under-represented among college graduates relative to the blacks of the same age group in the population. There were considerable differences between in-state and out-of-state students, and between movers and non-movers. Compared with in-state students, out-of-state students tended to have higher SAT score and higher GPA, to be from wealthier families, and to have more educated parents. All these factors are considered favorable in the labor market, and they appear to be associated with higher earnings. Differences in all aspects but college GPA are statistically significant. Similar differences are evident between movers and non-movers.[10]

2.3. Estimation results

The first column of Table 2 reports the basic OLS estimate of college quality from a wage equation. The specification controls for a rich set of individual, family, and high-school state

Table 2. Estimating college quality: wage equation.

	Column 1	Column 2	Column 3	Column 4	Column 5
Female	–0.153	–0.160	–0.16		
	[0.017]**	[0.017]**	[0.017]**		
Black	–0.014	–0.010	–0.012		
	[0.034]	[0.034]	[0.033]		
Hispanic	–0.049	–0.049	–0.049		
	[0.043]	[0.044]	[0.043]		
Asian	0.038	0.044	0.04		
	[0.043]	[0.044]	[0.044]		
Other	0.057	0.053	0.057		
	[0.041]	[0.040]	[0.041]		
SAT/ACT percentile	0.190	0.118	0.118		
	[0.077]*	[0.081]	[0.081]		
SAT score missing	0.072	0.028	0.028		
	[0.054]	[0.056]	[0.056]		
Age	0.004	0.006	0.006		
	[0.004]	[0.004]	[0.004]		
Experience	0.092	0.095	0.095		
	[0.014]**	[0.014]**	[0.014]**		
Experience^2	–0.006	–0.006	–0.006		
	[0.001]**	[0.001]**	[0.001]**		
HS state NAEP mathematics, eighth-grade 1990	–0.333 [0.260]	–0.307 [0.253]	–0.318 [0.253]		
Ln(HS state K–12 expenditure per pupil)	–0.076	–0.076	–0.077		
	[0.208]	[0.206]	[0.207]		
Ln(HS state K–12 average teacher salary)	0.386 [0.277]	0.274 [0.275]	0.202 [0.275]		
HS state K–12 pupil–teacher ratio	0.005	0.006	0.007		
	[0.018]	[0.018]	[0.018]		
State of college					
Alabama				10	16
Alaska	–0.612	–0.558	–0.473	1	3
	[0.121]**	[0.122]**	[0.126]**		
Arizona	0.146	0.158	0.16	32	37
	[0.095]	[0.096]$^+$	[0.096]$^+$		
California	0.098	0.150	0.14	28	42
	[0.087]	[0.087]$^+$	[0.087]		
Colorado	0.126	0.149	0.145	29	25
	[0.099]	[0.100]	[0.101]		
Connecticut	0.283	0.318	0.269	44	38
	[0.116]*	[0.116]**	[0.116]*		
Delaware	0.013	–0.002	–0.025	8	36
	[0.124]	[0.121]	[0.118]		
District of Columbia	0.380	0.336	0.18	36	6
	[0.089]**	[0.090]**	[0.128]		

Table 2. (*Continued*).

	Column 1	Column 2	Column 3	Column 4	Column 5
Florida	0.200	0.219	0.221	39	40
	[0.065]**	[0.066]**	[0.066]**		
Georgia	0.088	0.104	0.109	20	22
	[0.078]	[0.078]	[0.078]		
Hawaii	–0.083	–0.039	0.002	11	27
	[0.229]	[0.228]	[0.230]		
Idaho	–0.089	–0.085	–0.094	2	5
	[0.121]	[0.119]	[0.120]		
Illinois	0.214	0.241	0.246	41	34
	[0.069]**	[0.069]**	[0.069]**		
Indiana	0.175	0.171	0.164	33	29
	[0.073]*	[0.072]*	[0.072]*		
Iowa	0.178	0.167	0.159	31	44
	[0.082]*	[0.080]*	[0.080]*		
Kansas	0.166	0.163	0.166	34	2
	[0.093]$^+$	[0.092]$^+$	[0.091]$^+$		
Kentucky	–0.031	–0.052	–0.055	6	21
	[0.084]	[0.080]	[0.081]		
Louisiana	0.071	0.057	0.036	12	4
	[0.085]	[0.084]	[0.084]		
Maine	–0.115	–0.104	–0.033	7	23
	[0.279]	[0.275]	[0.269]		
Maryland	0.255	0.295	0.239	40	19
	[0.071]**	[0.070]**	[0.077]**		
Massachusetts	0.252	0.276	0.254	43	35
	[0.113]*	[0.111]*	[0.114]*		
Michigan	0.109	0.139	0.137	26	45
	[0.086]	[0.084]$^+$	[0.083]$^+$		
Minnesota	0.200	0.213	0.196	37	24
	[0.089]*	[0.089]*	[0.089]*		
Mississippi	–0.035	–0.056	–0.058	5	31
	[0.083]	[0.082]	[0.081]		
Missouri	0.196	0.197	0.211	38	14
	[0.084]*	[0.085]*	[0.085]*		
Montana	0.073	0.078	0.116	23	1
	[0.103]	[0.103]	[0.103]		
Nebraska	0.406	0.393	0.392	47	11
	[0.150]**	[0.149]**	[0.151]**		
Nevada	0.123	0.150	0.089	16	28
	[0.093]	[0.089]$^+$	[0.096]		
New Hampshire	0.272	0.266	0.278	45	41
	[0.142]$^+$	[0.141]$^+$	[0.144]$^+$		
New Jersey	0.145	0.189	0.101	18	46
	[0.107]	[0.109]$^+$	[0.121]		

Table 2. (*Continued*).

	Column 1	Column 2	Column 3	Column 4	Column 5
New Mexico	0.256	0.244	0.248	42	9
	[0.100]*	[0.100]*	[0.100]*		
New York	–0.004	0.041	0.059	13	39
	[0.083]	[0.082]	[0.081]		
North Carolina	0.040	0.055	0.061	14	30
	[0.060]	[0.060]	[0.060]		
Ohio	0.101	0.109	0.092	17	12
	[0.067]	[0.066]$^+$	[0.065]		
Oklahoma	0.115	0.111	0.115	22	13
	[0.076]	[0.075]	[0.076]		
Oregon	–0.139	–0.095	–0.067	4	26
	[0.100]	[0.102]	[0.103]		
Pennsylvania	0.020	0.045	0.065	15	32
	[0.079]	[0.078]	[0.078]		
South Carolina	0.146	0.147	0.149	30	18
	[0.075]$^+$	[0.075]$^+$	[0.075]*		
South Dakota	0.188	0.165	0.177	35	10
	[0.089]*	[0.090]$^+$	[0.090]*		
Tennessee	–0.067	–0.075	–0.076	3	20
	[0.071]	[0.071]	[0.070]		
Texas	0.093	0.115	0.111	21	15
	[0.071]	[0.070]$^+$	[0.070]		
Utah	0.131	0.145	0.103	19	8
	[0.158]	[0.155]	[0.157]		
Vermont	0.125	0.107	0.132	25	43
	[0.107]	[0.106]	[0.105]		
Virginia	0.304	0.321	0.302	46	47
	[0.077]**	[0.078]**	[0.079]**		
Washington	0.072	0.105	0.117	24	33
	[0.099]	[0.099]	[0.100]		
West Virginia	0.010	–0.009	–0.004	9	7
	[0.090]	[0.090]	[0.089]		
Wisconsin	0.137	0.137	0.138	27	17
	[0.083]$^+$	[0.082]$^+$	[0.082]$^+$		
Region of residence post–college					
Middle Atlantic	0.117	0.116	0.155		
	[0.076]	[0.075]	[0.077]*		
South Atlantic	–0.020	–0.028	0.071		
	[0.068]	[0.067]	[0.076]		
East South Central	0.078	0.092	0.211		
	[0.085]	[0.085]	[0.094]*		
West South Central	0.036	0.046	0.18		
	[0.082]	[0.082]	[0.094]$^+$		

Table 2. (*Continued*).

	Column 1	Column 2	Column 3	Column 4	Column 5
East North Central	–0.047	–0.029	0.051		
	[0.079]	[0.079]	[0.078]		
West North Central	–0.074	–0.065	0.056		
	[0.083]	[0.083]	[0.091]		
Mountain	–0.108	–0.107	–0.006		
	[0.078]	[0.077]	[0.086]		
Pacific	0.066	0.052	0.087		
	[0.076]	[0.075]	[0.076]		
Business and management major	0.284	0.289	0.289		
	[0.028]**	[0.028]**	[0.028]**		
Science and engineering major	0.323	0.329	0.329		
	[0.029]**	[0.029]**	[0.029]**		
Public affairs major	0.287	0.291	0.293		
	[0.029]**	[0.029]**	[0.029]**		
Social science major	0.178	0.186	0.187		
	[0.032]**	[0.032]**	[0.032]**		
Humanities and history major	0.112	0.118	0.118		
	[0.030]**	[0.030]**	[0.030]**		
Other major	0.164	0.168	0.171		
	[0.029]**	[0.029]**	[0.029]**		
Indicator for in-state students		–0.054	–0.054		
		[0.026]*	[0.026]*		
Normalized college GPA		0.025	0.025		
		[0.010]*	[0.010]*		
Indicator for 'movers'		0.035	0.029		
		[0.024]	[0.025]		
Residence state mean earnings			0.015		
			[0.006]*		
Residence state interquartile range of earnings			–0.003		
			[0.008]		
Constant	6.960	8.056	7.531		
	[1.464]**	[1.444]**	[1.451]**		
Father's education	Yes	Yes	Yes		
Observations	3894	3894	3894		
Adjusted R^2	0.17	0.18	0.18		

Note: HS= high school. Robust standard errors presented in square brackets. +Significant at 10%; *significant at 5%; **significant at 1%. Dependent variable is the logarithm of 1997 annual earnings; sample includes individuals with annual earnings greater than $5000. Column 1, basic OLS estimation; Column 2, OLS estimation with proxy variables; Column 3, OLS estimation with proxy variables, controlling for state-of-residence average earnings and interquartile range of earnings – earnings are median earnings of individuals greater than 16 years of age and with earnings in 1999 (Census 2000); Column 4, rank of state college quality, based on quality estimate of Column (3) – one is the lowest, and 47 is the highest; and Column 5, rank of state college selectivity, based on Barron's selectivity categories – one is the lowest, and 47 is the highest.
Note: Alabama is the omitted category for state of college; sample has no observations for Arkansas, North Dakota, Rhode Island, and Wyoming. New England is the omitted category for region of residence. Education major is the omitted category for the major dummy variables.

covariates in the wage equation, but not the three proxy variables for college selection and selective migration. These variables control for differences in students' observed qualities that are correlated with earnings and choices of college and labor market locations.

As expected, individuals scoring higher on SAT and having more work experience earn significantly more than otherwise identical individuals.[11] Earnings may be affected by individuals' occupation and industry types, which are closely related to individuals' college majors. Compared with the education majors (the omitted category), students in other fields all have significantly higher earnings. Female graduates earn significantly less. Black graduates are not disadvantaged compared with their white counterparts, reflecting in part the fact that black college graduates represent the more accomplished portion of the black population: blacks account for about 5% in the sample, compared with 15% in the population of the same age group. This finding is consistent with other studies in the literature (for example, Dale and Krueger 2002). Family background as measured by father's education does not appear to affect future earnings after other individual characteristics are controlled for. School Quality of a student's high school state is primarily measured by the state's National Assessment of Educational Progress (NAEP) mathematics score for eighth graders in 1990[12] – but it does not have a significant effect on earnings after individual ability is controlled. Other school characteristics such as pupil–teacher ratio, per-student expenditure, and average teacher salary are also insignificant.

Dummy variables indicating the census region in which an individual worked in 1997 are included to control for the influence on wage of local labor market conditions, such as cost of living and demand for educated workers; the omitted category is New England. Coefficients on the dummies are not precisely estimated; however, they are suggestive that college graduates have the lowest earnings in the Mountain region and the highest earnings in the Middle Atlantic region, consistent with both the cost-of-living and the demand-for-educated-worker stories.

The variable of primary interest is the indicator for the state of college from which an individual received a bachelor's degree. Dummy variables for 46 states of college are included in the wage equation: Alabama is the omitted category, and the sample does not contain individuals graduating from public colleges in Arkansas, North Dakota, Rhode Island, and Wyoming. Coefficients on state-of-college dummies are estimated with various degrees of precision, largely because both the numbers of observations and the value-added levels vary across states. The results suggest that, on average, relative to the baseline state Alabama, attending a public college in a majority of states increases a college graduate's earnings by a significant fraction. For example, attending a public college in Virginia increases one's early career annual earnings by 30% relative to Alabama. For all states but Alaska, the value-added ranges between –14% and 40%.[13] A Wald test of equality of value-added by different state public college systems is rejected at 1% significance level.

Column 2 of Table 2 reports the OLS estimate of college quality from the specification where the three proxy variables for college selection and selective migration – 'in-state' indicator, normalized GPA, and 'mover' indicator – are controlled. Before estimating the full equation, I first test whether adding these proxy variables to the wage equation will indeed mitigate the bias in quality estimates in the expected direction. We expect that the basic OLS estimates of college quality are more overestimated for states with more out-of-state students, for states ranked higher on the common GPA distribution curve, and for states with more students moving out of state to work. I estimate the wage equation augmented by one proxy variable at a time. The differences between the basic OLS estimate and the estimates from the three augmented wage equations provide a gauge of the extent of overestimation due to the omission of unobserved ability that can be captured by each proxy variable. The correlations between states' net intake of out-of-state student, states' average GPA rankings, and states' 'loss' of college graduates in the labor market to other states and the corresponding difference in quality estimates are 0.56, 0.76, and 0.60, respectively – all significantly different from zero. These test results lend more confidence to the proxy variables.

When all three proxy variables are included, the overall range of quality estimate remains similar to that in Column 1, between –10% and 39%. However, the change in quality estimate varies significantly across states, with some increasing by as much as five percentage points and others decreasing by as much as four percentage points. Coefficients on the three proxy variables all have the expected signs, and two of them are significant. For an average student, a one standard deviation increase in college GPA is associated with 2.5% increase in annual earnings; an instate student on average earns 5.4% less, but the partial effect of being a mover is insignificant.[14] Coefficient estimates of other control variables are barely changed.

One concern is that the region indicators in the above models are not sufficient to remove the heterogeneity of local labor markets. Labor market conditions for college graduates may vary both across states and across localities within a state. Because the B&B data do not provide more detailed geographical information beyond state of residence in 1997, this issue cannot be completely addressed. Nevertheless, in Column 3 of Table 2 I include two more variables as an attempt to further remove local labor market variations. These are the average earnings of individuals older than 16 years of age and with earnings in a state in 1999, and the interquartile range of the earnings of these individuals. I obtain county level earnings data from Census 2000 and aggregate them to the state level to create these two variables. The quality estimate again ranges between –9% and 39%, with various degrees of change for each state compared with Column 2. *Ceteris paribus*, college graduates living in states with higher overall earnings have significantly higher earnings as well, but their earnings do not appear to be affected by within-state earnings variation. With these controls, individuals living in the south central region appear to have the highest earnings, reflecting perhaps the relative scarcity of college-educated workers in the labor force in this region. Figure 1 illustrates the quality estimates from Column 3 in a US map. I divide states into

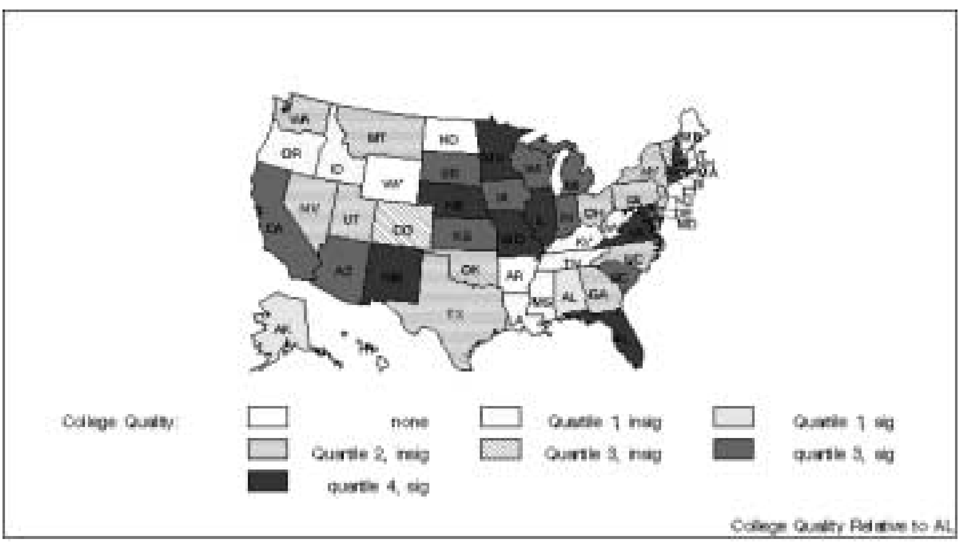

Figure 1. Average quality of state colleges.

Table 3. Correlations coefficients between quality measures.

	Quality 2	Quality 3	Full-time equivalent weighted state average selectivity index for public colleges
Quality 1	0.98	0.96	0.14
Quality 2		0.97	0.20
Quality 3			0.19
Average wage			0.45

Note: Quality 1, OLS estimates; Quality 2, OLS estimates with proxy variables; Quality 3, OLS estimates with proxy variables and controlling for state-of-residence average earnings and interquartile range of earnings – earnings are median earnings of individuals older than 16 years of age and with earnings in 1999 (Census 2000); average wage, average wage of individuals by college state; state selectivity index, full-time equivalent undergraduate students weighted average of the Barron's selectivity indices of all public four-year colleges within a state.

four quartiles based on their quality estimates and paint them in different shades of gray. States with an insignificant quality estimate are painted in the same color but shaded.

Quality estimates in the first three columns of Table 2 are all highly correlated with each other, as shown in the first two columns of Table 3. These high correlations suggest that, despite the imperfect nature of the data, the value-added estimates capture the fundamental pattern of the variation in the quality of state public college systems. This pattern is strikingly different from the traditional college quality measure based on Barron's selectivity categories – the correlations are at most 0.20, as shown in Column 3 of Table 3.[15] These low correlations are expected because the selectivity index is mainly based on students' characteristics and hence reflects student quality rather than college value-added. Indeed, the selectivity index has a much higher correlation (0.45) with the average wage of students graduating from colleges in the same state. Columns 4 and 5 of Table 2 report the state quality ranks based on the quality estimates in Column 3 and the state selectivity ranks based on Barron's selectivity index; there again is much discrepancy between the two rankings.

Several comments are in order. First, all the quality estimates are relative to the average value-added to college graduates by Alabama public colleges, which is normalized to zero. Practically, data limitation does not allow a comparison between the choice of working after high school and that of going to college in one of the states, and hence obtaining the college value-added relative to the return to a high school diploma. As a result, the estimates do not reflect the absolute value-added by any state public college system to average high school graduates, and whether these students are better off in absolute terms by going to any state public college system. Second, based on the quality estimate in Column 3 of Table 2, relative to the lowest-quality state, the value-added by the highest-quality states is about 40%. This is roughly comparable with available estimates in the literature. For example, Brewer, Eide, and Ehrenberg (1999) found that, controlling for college selection, the value-added by the top public colleges relative to the bottom public colleges is about 39% of annual earnings for 1972 high school cohort in 1986, and about 30% for 1982 high school cohort in 1992. Third, the value-added estimates combine two perceived college functions: producing human capital useful in the workplace, and providing screening of students' qualities for potential employers. These two functions cannot be separately identified in the current context. One plausible way to separate these two functions is to use panel data; the wage growth should be related more to the accumulated human capital observed by employers over time than to credentials (Altonji and Pierret 2001).

2.4. Tests of selective migration concern

We are concerned that selective migration in the labor market is not adequately accounted for by regressors in the wage equation; in that case, the value-added estimates will be contaminated by interactive terms between state of college and region of residence. I address this concern by testing whether individuals attending public colleges in the same state tend to have the same relative rank in wage distributions across all the regional labor markets. Absent interactions between state of college and region of residence mean that wage rankings by college state will be invariant across all regional labor markets. In the analysis, to control for observed individual heterogeneity, I use as wage measure the residual from a wage regression controlling for all the regressors in Column 3 of Table 2 except the state-of-college and region-of-residence indicators. Due to data limitation, I compare college state wage rankings in four big regional labor markets according to the US Census: Northeast, South, Midwest, and West.

Column 1 of Table 4 reports the Kendall Coefficient of Concordance statistic (W) and p value across the four census regions. It is used to test the stability in college state wage rankings across regional labor markets (Heckman, Layne-Farrar, and Todd 1996).[16] In the sample, 17 states 'send' at least two graduates to all four labor markets. W takes a value of 0.43; the null hypothesis that there is no agreement in ranking is rejected at 0.03 significance levels. For the eight states that 'send' at least three graduates to all four labor markets, $W = 0.52$ and $p = 0.04$. For the seen states that 'send' at least four graduates to all four labor markets, $W = 0.57$ and $p = 0.03$. The consistently low p values indicate the stability of college-state wage rankings across labor markets. In addition, as expected, with more observations from each college state in each labor market, the degree of stability in wage rankings gets higher – since more individual idiosyncrasies are removed as averaging is taken over larger numbers.

For robustness, I conduct the same test while changing the border or definition of the regional labor market. In Column 2, I 'move' Delaware, District of Columbia, Maryland, and Virginia from the South region to the Northeast – Baltimore and Washington, District of Columbia join Boston, New York City, and Philadelphia to form the famous Northeast Corridor, the largest urban area in the United States (Gottmann 1961). In Column 3, I 'move' Kentucky and West Virginia from the South to the Midwest (Garland 1955). In Column 4, the regional labor markets are defined as five of the nine census divisions that take in the largest number of college graduates from across the country: Pacific, South

Table 4. Kendall coefficient of concordance statistics of state college wage rankings across regional labor markets.

Minimum number of students from each college state in each region	Column 1	Column 2	Column 3	Column 4
2	0.43 (0.03) [17]	0.35 (0.12) [19]	0.43 (0.04) [17]	0.27 (0.22) [9]
3	0.52 (0.04) [8]	0.37 (0.13) [11]	0.41 0.11) [9]	0.36 (0.16) [3]
4	0.57 (0.03) [7]	0.39 (0.12) [9]	0.41 (0.11) [9]	NA

Note: Data in each cell are Kendall Coefficient of Concordance (p value) [number of states]. NA= not available. Statistics in Column 1 are calculated over four census regions: Northeast, South, Midwest, and West. In Column 2, Delaware, District of Columbia, Maryland, and Virginia are moved from South to Northeast. In Column 3, Kentucky and West Virginia are moved from South to Midwest. In Column 4, statistics are calculated over five of the nine Census Divisions that take in the largest number of college graduates: Pacific, South Atlantic, East North Central, West South Central, and Middle Atlantic.

Atlantic, East North Central, West South Central, and Middle Atlantic. The Kendall Coefficient of Concordance statistics become smaller, but we can still reject the null hypothesis of no agreement in ranking at reasonable significance level. Owing to the small sample size, the test does not allow a conclusive statement of the stability of college state wage rankings, but it is highly suggestive that the disturbance due to interactions between state of college and region of residence is small, and the estimates on state-of-college indicators capture primarily the value-added by state colleges.

3. College quality and state higher education policies

Given the large variation in the estimated state college quality, it is natural to ask whether college quality is systematically related to certain aspects of state higher education policies. Because we have only one cross-section of quality estimates, it is not possible to estimate how policies *causally* affect college quality. In this section, I investigate the association between state policies and college quality in a multiple regression; this exploratory study nevertheless highlights the importance of higher education policy variation among states.[17]

Assume state college quality is linearly related to various input factors,

$$\beta_{2_j} = \gamma_0 + Q_j \cdot \gamma_1 + \eta_j, \tag{2}$$

where Q_j is a vector of state j's measurable college inputs, such as peer quality, faculty quality, and other resources; η_j captures all the unmeasured factors related to college quality. Because we use an estimate of the college quality rather than the true value, there is an additional error in Equation (2) due to sampling error, $\hat{\beta}_{2_j} = \beta_{2j} + \mu_j$, and the regression becomes:

$$\hat{\beta}_{2_j} = \gamma_0 + Q_j \cdot \gamma_1 + \eta_j + \mu_j. \tag{3}$$

Because the sampling variance of the estimated quality differs across states, μ_j is heteroskedastic. I assume that the variance of μ_j is proportional to the first stage sampling variance of $\hat{\beta}_{2_j}$ and apply generalized least squares to Equation (3).

Input factors of public colleges are heavily dependent upon and influenced by higher education policies approved by the state government. Every state has a statewide board or commission that acts as an intermediary between institutions and state legislature or governor. This agency is assigned by the state the responsibility of proposing, evaluating, and, in some cases, implementing a variety of policies including long-term planning; mission definition; academic program review; budget development, funding formulas, and resource allocation; student financial assistance; and, in many states, faculty personnel policies.[18] Some policies can be directly measured, such as state appropriation to colleges; others cannot, such as rules related to personnel and course and major offering. All of these policies jointly determine the resources and learning environment of college students in a state, which may be directly related to the quality of state colleges.

Table 5 summarizes some measurable characteristics of state higher education systems for academic year 1988/89 – there exists substantial variation across states. Data sources are listed at the end of the table.

Variables in the top panel are measures of state polices. First, there is large variation in states in in-kind subsidy for their public higher education institutions, reflected by remarkable differences in state appropriations to and tuition charges for public colleges and openings available each year for college-aged population. Second, need-based grant aid relative to college-aged population, although small in absolute amount, displays even larger variation across states. Since grant aid is fungible, this difference reflects the divergent willingness of states to support students' college choice with tax revenue.[19] Finally, states differ considerably in the allocation of resources to different types of institutions, illustrated by the percentage of undergraduates in research I universities (Carnegie Classification of Higher Education Institutions) and the interquartile range of appropriation per student.[20]

Variables in the bottom panel of Table 5 – including total expenditure, expenditures on physical facilities and faculty separately, faculty quality, and quality of student body – enter more directly into the college learning process and are included in the regression analysis. These variables are determined by the above policy variables and other unmeasured state policies. For example, state appropriation and tuition, which account for more than 50% of public college revenue (NCES 2002), determine, to a large extent, how much public colleges can spend. Faculty salary and the percentage of faculty with a doctoral degree can be significantly influenced by state policies regarding class size and substitution

Table 5. Summary statistics of state higher education policies and characteristics.

	Mean	Standard deviation	Minimum	Maximum
State appropriation to public universities per FTE ($)	5584	1550	2625	10,093
FTE undergraduates weighted average tuition in public universities ($)	1679	556	905	3350
Percentage of freshmen in public universities as 17-year-old population	37.3	12.4	13.1	64.8
State need-based aid per 17-year-old population ($)	333	382	22	1598
Interquartile range in state appropriation per FTE[b] ($)	2565	1592	0	6410
Fraction in research I universities	0.47	0.20	0	0.89
Total expenditure per FTE[a] ($)	11,301	2567	7456	18,108
Capital service expenditure per FTE[a] ($)	2929	714	1857	5297
Total current expenditure per FTE[a] ($)	8372	2079	5093	13,840
Non-salary student-related expenditure per FTE ($)	1948	498	981	3122
Average faculty salary ($)	37,713	5112	28,328	51,342
Faculty student ratio	0.045	0.0056	0.036	0.061
Fraction of faculty with doctoral degree	0.69	0.084	0.46	0.84
State average SAT	926	35.4	863	1016
Interquartile range in expenditure per FTE[b]($)	2539	1599	0	7201

[a]From Winston (1995), calculated for academic year 1991. [b]Interquartile range of state appropriation (expenditure) per student is the difference in appropriation (expenditure) per student between students in the top 25th percentile and in the bottom 25th percentile.

Note: All but statistics from Winston (1995) are for the 1989 academic year. There are 45 observations, not including Alaska, Arkansas, District of Columbia, North Dakota, Rhode Island, and Wyoming. Included in the student-related expenditure are expenditures on instruction, academic support, and student services. Average faculty salary and faculty student ratio are based on the number of faculty on nine-month or 10-month contract and are from IPEDS 1989; percentage of faculty with doctoral degree is from Barron's (1988). When not specified, full-time equivalent (FTE) students include both undergraduate and graduate students in four-year public colleges.

Source: Author's calculation, based on data from Integrated Postsecondary Education Data System for academic year 1989 (URL http://nces.ed.gov/ipeds), National Association of State Student Grant and Aid Programs (1995), US Census, Carnegie Classification, Barron's (1988), and Winston (1995).

of full-time tenure-track faculty with part-time non-tenure track faculty. Finally, the scope of a state's public higher education system and policies regarding tuition, financial aid, and admission jointly determine both the quantity and quality of students in public colleges (Clotfelter et al. 1991). Student quality, measured by the average median SAT score of the entering class of state public colleges, enters the regression as a proxy for peer quality (for example, Zimmerman 2003).

Because all of the input variables are determined by the same set of state policies or underlying state characteristics, these variables tend to be correlated with each other. Correlations are in general not high, but they are pretty strong between average SAT score, faculty PhD percentage, and average faculty salary. High correlations between these variables confirm the common belief that colleges with good students tend to have other favorable factors, such as outstanding faculty. High correlations also suggest multicollinearity as a potential concern.

Table 6 presents coefficient estimate of Equation (3) by generalized least squares. The dependent variable is the quality estimate from Column 3 of Table 2. A series of model specifications are estimated. The first is the crudest one, including only average SAT score and total expenditure per student. Neither is significantly associated with college quality. Because much of the capital service expenditure may not be directly related to undergraduate learning, in the next column I examine separately the capital service expenditure and current expenditure. Again, neither the two types of expenditure nor the SAT score is significantly related to college quality.

In the rest of the specifications, I focus on the part of current expenditure that is most relevant for student learning: expenditures on instruction, academic support, and student services. I also examine faculty inputs and expenditure on physical facilities separately. The expenditure measure is thus the current non-salary expenditure per student. In Columns 3–5, I add the faculty input variable one at a time. *Ceteris paribus*, a $1000 increase in average salary is associated with a 0.7% increase in college quality, and a 10 percentage point increase in PhD is associated with a 5.4% increase in college quality, while a change in faculty student ratio does not appear to affect college quality, suggesting that class size may be less relevant than the quality of lecturers in the classrooms. In Column 6, all three variables are added simultaneously. The positive association between quality and PhD percentage is still significant, while that between quality and average salary becomes insignificant. The explanatory power of all the specifications is much stronger than the first two. In all but Column 3, higher SAT score is uncorrelated with better college quality.

In all four specifications, as well as in the remaining two, non-salary expenditure per student is significantly negatively associated with college quality. Although puzzling, it should not be taken at its face value or interpreted as causal. With one cross-section, it is impossible to disentangle the effect of this expenditure variable from the effects of other unmeasured factors. Further research is necessary to understand the role of non-salary expenditure.

States differ also in how they allocate resources to different types of colleges. In Column 7, I explore the potential association of college quality with two measures of college diversity. The first is the percentage of undergraduates in research universities. Undergraduate learning may be influenced by the presence of faculty research and doctoral students. On the one hand, there are diversion of resources and detraction of faculty effort from undergraduate teaching; on the other hand, there is more vigorous academic environment conducive to learning in general. The second is the inter-quartile range of per student spending of state public colleges. Larger variation in spending across colleges may indicate more efficient resource allocation that allows a broad spectrum of

Table 6. College quality and characteristics of state colleges: generalized least squares estimation.

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
State average SAT/100	0.06	0.059	0.095	0.039	0.04	0.018	0.026	0.029
	[0.045]	[0.046]	[0.045]*	[0.047]	[0.050]	[0.052]	[0.050]	[0.050]
Total expenditure per FTE/1000	0.001							
	[0.007]							
Capital service expenditure per FTE/1000		0.014						
		[0.029]						
Current expenditure per FTE/1000		–0.002						
		[0.010]						
Student related current expenditure per FTE/1000 (excluding faculty salary)			–0.091	–0.113	–0.091	–0.111	–0.157	–0.16
			[0.035]*	[0.031]**	[0.031]**	[0.034]**	[0.039]**	[0.039]**
Faculty student ratio			0.049			0.208	1.507	2.101
			[3.037]			[2.834]	[2.794]	[2.880]
Fraction of faculty with doctoral degree				0.543		0.442	0.417	0.386
				[0.205]*		[0.231]+	[0.226]+	[0.226]+
Average faculty salary/1000					0.007	0.004	0.002	0.001
					[0.003]*	[0.004]	[0.004]	[0.004]
Fraction of undergraduates in research I universities							0.159	0.166
							[0.089]+	[0.089]+
Interquartile range in current expenditure per FTE/1000							0.021	0.02
							[0.011]+	[0.011]+
Type of state higher education board (one for coordinating, zero for governing)								0.029
								[0.031]
Constant	–0.453	–0.45	–0.588	–0.399	–0.343	–0.299	–0.359	–0.386
	[0.413]	[0.418]	[0.428]	[0.386]	[0.399]	[0.425]	[0.408]	[0.412]
Observations	45	45	45	45	45	45	45	45
Adjusted R^2	0	–0.02	0.13	0.26	0.21	0.25	0.3	0.3

Note: Standard errors in square brackets. +Significant at 10%; *significant at 5%; **significant at 1%. Dependent variable is the state college quality estimated from the specification in Column 3 of Table 2. Other notes are the same as Table 5.

skills acquisition or less efficient allocation where resources are concentrated on a small number of students in the most prestigious universities. The implication for average quality is uncertain. When these two variables are included, 30% of the variation in state college quality is explained. *Ceteris paribus*, a \$1000 increase in the interquartile range of per student expenditure is associated with about 2.1% increase in college quality, and a 10 percentage point increase in the capacity of research universities is associated with 1.6% higher quality. More detailed study of the higher education funding process and student learning is necessary to understand the mechanisms for these associations.

In Column 8, I add an indicator for the type of state higher education board – one for coordinating board and zero for governing board. The information is obtained from the Education Commission of the States web site (URL http://www.ecs.org). Public colleges in a state with a governing board may have less autonomy and flexibility, but they may also be held more accountable for their performance. Twenty-four states in the United States have a governing board, and the rest have a coordinating board. The type of board, however, is not shown to be significantly associated with college quality.

Relationships estimated in Table 6 are robust to several sensitivity tests. First, to address the concern of multicollinearity, I estimate the models dropping one state at a time; the regression results are virtually identical. Second, using as dependent variables the other quality estimates from the first stage, I find similar relationships between the input variables and college quality. Third, one might be concerned that expenditure per student and faculty salary are both correlated with state average income, hence the estimated relationships being possibly spurious. Using the ratios between these variables and state median income as regressors, I again find virtually identical relationships.

4. Conclusion

Higher education is deemed the crown jewel of the US education system. College quality itself, however, has remained much elusive. This paper estimates public college qualities from individual earnings data. Data limitation prevents a quality estimate for each individual college; as a compromise, I estimate average quality of state public college systems. This approach still allows me to explore the relationships between aspects of state higher education policies and performance of public colleges.

Controlling for differences in observed individual characteristics, and correcting for self-selection of college and labor market locations based on unobserved individual characteristics, I find considerable variation across states in the average quality of state four-year public colleges as measured by the value-added to individual earnings. This finding is robust to different estimation specifications. This value-added estimate of college quality is noticeably different from the traditional measure of college quality based on Barron's selectivity index, which essentially measures the quality of college students rather than the quality of colleges *per se*.

In the second stage of the analysis, I find that better performance of state public colleges is associated with better faculty quality and more differentiation in public college provision. Owing to data limitation, this association does not reflect a causal relationship. Future work will supplement the current analysis with information on a new college graduate cohort; the panel will allow a better understanding of college performance and its determinants. One particularly interesting factor ignored in the present paper is competition. It is the general belief of educational researchers that the superiority of US universities comes in part from the intense competition in the US higher education market (for example, Hoxby 1997). Future work will examine directly how competition affects college qualities.

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Notes

1. Besides enhancing students' subsequent earnings, college education also helps students develop a sense of intellectual curiosity, social responsibility, and leadership. Higher education more generally produces ideas that affect both economic growth and human development. Labor market earnings is arguably the most easily measured dimension of college output.
2. Barron's (1988) rates all colleges as belonging to one of six categories: most competitive, highly competitive, very competitive, competitive, less competitive, and noncompetitive. A college's category is determined by the average SAT or ACT score and high school ranking of the entering class, and the acceptance rate of the applicants.
3. Recent research also found positive return to college quality in Japan, where college quality is measured as the average college entrance examination scores (Ono 2004), and in Italy, where college quality is measured by a comprehensive performance index (Di Pietro and Cutillo 2006). Lindahl and Regnér (2005), using a similar method as the present paper, found large variation in value-added across all Swedish universities, and older universities enjoy higher value-added. They use sibling data to control for college selection.
4. Same approach is employed by Card and Krueger (1992) to study school quality and by Waldfogel and Tracy (1997) to study the quality of business schools.
5. One can potentially correct the omitted variable bias by using instrumental variable estimation. In the present context, it is difficult to identify valid instrumental variables for both types of omitted variables. In one specification not reported, I use distances from home state to 51 potential college stages as instrumental variables for state-of-college indicators; the estimates are of implausibly large magnitude, and the problem of selective migration is still severe as measured by Kendall's coefficient of concordance.
6. To what extent this can mitigate estimation bias depends on the quality of the out-of-state students that a state takes in, which in turn depends on the number of college-qualified high-school graduates (demand) relative to the number of freshman slots in state universities (supply). States that have large demand relative to supply may indeed have more stringent criteria for admitting out-of-state students, while states that have large supply relative to demand may be willing to accept some out-of-state students with lower qualifications. I thank a referee for making this important distinction.
7. GPA distributions are different across states; on a four-point scale, the mean of state GPA ranges from 2.8 to 3.4, and the standard deviation ranges from 0.16 to 0.62.
8. The ability ranking variable thus created may be measured with error because grades from different colleges may not be comparable; for example, a grade from a flagship university may be considered worth more than the same grade from a lesser university. However, if the measurement error is similar across states, only the estimate of the constant term will be affected, and the estimates of the slope terms will not.
9. The B&B base year survey includes 11,192 students, of which 65.7% graduate from public colleges; 10,093 are surveyed again in the 1997 follow-up. The sample size is reduced to 8052 because of age and location restrictions. Finally, the enrollment and earnings restrictions reduce the sample to 6026 students, of which 4066 (67%) graduated from public colleges. The percentage reduction due to the last restrictions varies between 15% and 30% for most states, but appears to be random – it is not correlated with variables such as student SAT, average selectivity of state public colleges, state average income and unemployment rate. The estimate may be biased, however, if this sample selection is related to other unmeasured state college characteristics.
10. Comparisons between private and public college students do not reveal significant differences between the two groups; hence the choice between public and private colleges is not discussed below.
11. Work experience includes any experience both before and after college graduation. One concern is that postgraduation work experience is correlated with college choice; removing the experience variables from the wage equation, however, does not affect college quality estimates.

12. The NAEP is the only nationally representative assessment of students' achievement in various subject areas at Grades 4, 8, and 12. State-level NAEP scores have been reported since 1990. I use the scores for 1990 to approximate state K–12 education quality for the mid and late 1980s. Missing scores are projected with available scores for 1992, 1996, or 2000.
13. Alaska has only one observation in the sample. Both Alaska and District of Columbia (with three observations) are dropped from the second-stage analysis due to small sample.
14. Having high mobility in the labor market might be an outcome of having attended a high-quality college; thus, the value-added by high-quality colleges might be underestimated, and *vice versa*. However, since the coefficient estimate on 'mover' is insignificant, the bias is likely to be small.
15. The 'state average selectivity index' in Table 3 is calculated as the full-time equivalent undergraduate students weighted average of the Barron's selectivity indices of public colleges in a state. To calculate the state average selectivity index, I assign a numerical value to each Barron's category – with one denoting non-competitive and six denoting most competitive. One inevitable weakness in using the state average selectivity index, as well as the average quality estimate of state colleges, is that the heterogeneity of colleges within a state is not reflected. Data limitation, however, prevents further exploration of this heterogeneity.
16. The Kendall Coefficient of Concordance for measuring the relative agreement between m rankings of n objects is given by $W = [12S] / [m^2(n^3 - n)]$, where $S = \Sigma^n_{i=1}[R_i - m(n+1)/2]^2$ and R_i is the sum of the ranks for object i. For $n > 7$, $\chi^2 = m(n-1)W$ is approximately χ^2 with $n-1$ degree of freedom. When all ranking agree, $W = 1$. As W gets closer to zero, there is less agreement in the rankings. In this application, $m = 4$ for the four regional labor markets, and n equals the number of college states included. For each included state, I calculate separately the average (residual) earnings of college graduates from that state who work in each of the four regional labor markets. The college state average earnings are ranked within each regional market. Thus, each included college state has four ranks, and their sum is R_i.
17. The Department of Education is conducting the B&B survey on a new cohort: college students receiving a bachelor's degree in the academic year 1999/2000. With information on this cohort, we could estimate college quality for a different period. Comparing estimates for the two periods would provide insight into the causal relationships between college quality and state policies.
18. For a detailed discussion of state's governance role in higher education, see McGuinness (1999).
19. States with larger public higher education systems tend to provide more in-kind support and less grant aid to college education, suggesting that these measured policies might reflect some historical differences across states.
20. Interquartile range is the difference in spending per student between students in the top 25th percentile and students in the bottom 25th percentile.

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