Discussion Paper No. 35

Williams Project on the Economics of Higher Education
Denison Gatehouse
Williams College
Williamstown, MA 0 1267

Physical Capital and Capital Costs in US Colleges and Universities: 1993

Gordon C. Winston
Williams College

Ethan G. Lewis
Williams College

DP-35
February 1996

 Funding for this paper was provided by the Andrew Mellon Foundation through the Williams Project on the Economics of Higher Education.

ABSTRACT

Physical Capital and Capital Costs in U.S. Colleges and Universities

by

Gordon C. Winston and Ethan G. Lewis

This paper reports on the distribution of capital stocks and the costs of capital services in 3,148 colleges and universities in 1993. The $387 billion in physical capital estimated for these institutions imply that $40 billion in yearly capital service costs are incurred in US higher education, adding roughly 3 1% to reported current costs. While private Research-I Universities, among major Carnegie types, have the most capital per student ($143,954) and public Two-Year Colleges have the least ($14,83 l), a greater disparity in capital stocks appears when schools are differentiated by wealth -- their average subsidies per student. The top decile of private schools average over $150,000 of physical capital per student and the bottom decile of public and private schools have less than $10,000. The distortion of educational costs that results from omitting capital services range from 25% for Research-I Universities, both public and private, to more than 40% for private Liberal Arts-I Colleges and public Comprehensive-II Universities. Clearly, capital service costs are large and unevenly distributed within higher education, creating serious distortions in any economic analysis that ignores them. The data are available as FoxPro files.

February, 1996

PHYSICAL CAPITAL AND CAPITAL SERVICE COSTS IN US COLLEGES AND UNIVERSITIES: 1993*

Gordon C. Winston
Williams College

Ethan G. Lewis
Williams College

Physical capital creates a problem for understanding the economics of higher education. It represents an important economic input to the production process -- the essential services of buildings, equipment, and land -- but one for which we have only highly inadequate measures. In conventional collegiate financial reporting, in fact, there is no required recognition of capital services as the source of a cost of education even though it adds more than 30% to reported costs.[1] In total, US higher education used $387 billion of physical capital in 1993 and the yearly costs of its capital services come to about $40 billion.

This paper has three objectives -- to report estimates of current values of the capital stocks used by 3,148 colleges and universities in the US in 1993, to give a broad sense of the distribution of physical capital and capital costs within higher education, and

* The authors want to acknowledge the generous support of the Andrew W. Mellon Foundation through its support, in turn, of the Williams Project on the Economics of Higher Education. Ivan C. Yen worked out many sticky problems in preparing the capital data for an earlier study of student subsidies [Winston & Yen, 1995]. This paper closely parallels Winston's DP-34, though it uses a larger and more appropriate population and updates the results from 1991 to 1993.

1For a discussion of the sometimes-arcane reasons for this and the prospects for change, see Winston, NACUBO.

to make these numbers available to other students of higher education in the form of FoxPro or Excel files.[2]

Since T.W. Schultz' 1960 study of US higher education [Schultz, 1960], economists have made efforts to fill in the missing information about physical capital. A number of approaches have been used. O'Neill's influential 1971 study for the Carnegie Commission [O'Neill 1971] used a "perpetual inventory method" borrowed from the national accounts in which reported investment flows for each year are adjusted for inflation and depreciation and added up over a long period of time to estimate a resulting capital stock. Bowen and Douglas used experts' estimates of capital requirements for a hypothetical representative institution [Bowen-Douglas, 197 1] while Bowen, alone [Bowen, 19801, based estimates on "the rental value of comparable land, buildings, and equipment in the private market economy." Duc Le To used replacement values for buildings reported in HEGIS data from the US Department of Education, a method similar to that used here though his objective was not to generate estimates for individual schools [To, 1987] But some authors have simply noted that capital costs "do not appear in the annual operating budget at all, and neither the totals nor their allocations among the various final products [of the institutions] are readily available" and consequently ignored them [James, 1978, p. 163]

The capital stock estimates used here are based on individual institutions' reports to the US Department of Education (IPEDS -- Integrated Postsecondary Educational Data

---

2 Which can be got by contacting the author at gwinston@Williams.edu or Ethan Lewis at Ethan.G.Lewis@Williams.edu.

System[3] -- Financial Survey) in 1993. The method of estimation is described in some detail in Appendix A, but, broadly, it used those reported capital stock figures to generate an estimate of the current replacement value of buildings (B,), equipment (E,), and land (L,) used by each school in the population and to estimate the consequent yearly flow of capital service costs. Capital stocks are reported and analyzed in Sections I and II below while capital service costs are described in Section III.

This paper updates an earlier report [Winston, 1995] that described the 1991 capital data generated for a study of student subsidies for that year [Winston-Yen, 1995] The conclusions drawn in that paper were qualified by the fact that only a subset of the population of US higher education institutions was examined -- those schools relevant to a study of student subsidies. This paper reports on all 3,148 of the US colleges and universities that reported both positive student enrollments and current fund expenditures for 1993.[4] Because that earlier study of capital borrowed data from the study of student subsidies, it was able to report on how the capital stock was distributed over the hierarchy of schools as defined by their wealth or ability to subsidize their students. In order to repeat this analysis with the current data, comparable subsidy figures were generated for 2,773 institutions using the 1993 data. In Appendix B, the broad patterns of capital use described here for 1993 are compared with those reported for 1967 in the pioneering work of June O'Neill.

---

3 From CASPAR, ver. 4.4.

4 Current fund expenditures were sometimes needed to fill in capital stock values for schools that did not report them (see Appendix A), as well as for the analysis in Section III. 108 schools with positive enrollment did not report current fund expenditures in 1993.

The first section that follows looks at the distribution of the US educational capital stock by institutional type and control, both in the aggregate and as it is divided among schools and among students.[5] The next section looks at how that capital stock is distributed over the hierarchy of schools differentiated by wealth.[6]

I. The Distribution of the Capital Stock by Type and Control

Table 1 shows that $387 billion in total physical capital assets at these 3,148 institutions give the average school a capital stock of just over $123 million and equip the typical student (FTE) with $39,000 of buildings, equipment, and land. Those, of course, are 1993 dollars.

The next two lines of Table 1 divide that aggregate capital stock between public and private schools showing that roughly two-thirds of all capital is to be found in the public sector. But since there are fewer public than private schools, the average public institution works with a bit more than twice as much capital -- at $179 million -- as does the average private institution -- with $78 million. The last column of the table, though, eliminates the apparent dominance of the public institutions by recognizing the very different size of the typical college or university in the two sectors -- an average of 5,300

---

5 Though it is important that these are figures for *total* institutional capital and not just that portion allocated to educational purposes.

6 Bradburd and Mann [19931 usefully describe the wealth equivalent of e.g. appropriations flows. It is in that sense that non-tuition resources measure wealth.

Table 1

Physical Capital In US Higher Education

	Number of Institutions	Average Enrollment (FTE's)	Total Capital Stock	Fraction of Total Capital Stock	Average Capital Per School	Average Capital Per Student
	(1)	(2)	(3)	(4)	(5)	(6)
AI1 Institutions	3,148	3,163	$387,359,653,523	100.0%	$123,049,445	$38,908
Public Institutions	1,406	5,349	$251,259,170,795	64.9%	$178,704,958	$33,407
Private Institutions	1,742	1,398	$136,100,482,728	35.1%	$78,128,865	$55,899

students in public institutions and only 1,400 in private ones -- so that the typical student in the private sector is equipped with almost 60% more capital than the typical student in a public institution.

The broad picture, then, is that a $387 billion capital stock has been allocated largely to public institutions but that their average size is so much greater than that of private colleges and universities that the typical student is left with far less capital in the public than in the private sector.

Table 2 puts public and private sectors together to describe the allocation of the US capital stock by type of institution, using Carnegie classifications. It's useful to concentrate at first on the six types of institution that Carnegie identifies -- Research, Doctoral, and Comprehensive Universities, Liberal Arts and Two-Year Colleges, and Specialized Institutions -- and initially ignore the further qualitative breakdown of these types into Carnegie quality levels I and II.

Research Universities have the lion's share of the US educational capital. Which is hardly surprising. The 127 such institutions included in Table 2 have, in total, $163 billion or 42% of all the physical capital in US higher education even though they represent only 4% of the schools. The average Research University, what's more, uses about $1.3 billion of physical capital and the typical student in the research universities is associated with $71,000 per student. Once again, it is important to keep in mind that

Table 2

Physical Capital By Institutional Type

	Number of Institutions	Average Enrollment (FTE's)	Total Capital Stock	Fraction of Total Capital Stock	Average Capital Per School	Average Capital Per Student
	(1)	(2)	(3)	(4)	(5)	(6)
All Institutions	3,148	3,163	$387,359,653,523	100.0%	$123,049,445	$38,908
Research	127	18,087	$163,027,678,025	42.1%	$1,283,682,504	$70,972
Doctoral	110	8,984	$38,023,969,482	9.8%	$345,672,450	$38,476
Comprehensive	514	4,616	$68,334,076,122	17.6%	$132,945,673	$28,803
Liberal Arts	619	1,359	$37,548,934,183	9.7%	$60,660,637	$44,642
Two-Year	1,132	2,692	$45,256,286,100	11.7%	$39,979,05 1	$14,849
Specialized	646	634	$35,168,709,611	9.1%	$54,440,727	$85,927

these are figures for total capital and not just that used in instruction or student residences or activities, so the average student in a Research University may be only remotely associated with much of that capital stock (or “What does the Linear Accelerator mean to a Stanford Sophomore majoring in Art History?").

For types of institutions other than Research Universities, the patterns of capital allocation are less consistent. Comprehensive Universities have the second largest allocation of capital in the aggregate ($68 billion or 18%), but there are so many of them that they have less capital per school than the Research or Doctoral Universities and they are so large that they have less capital per student than Research or Doctoral Universities, Liberal Arts Colleges, or Specialized Institutions. The Two-Year Colleges are in a similar position with more than $45 billion or 12% of all capital -- putting them third in aggregate terms -- but since they divide that capital among so many schools and among so many students, both the average Two-Year school and the average student in Two-Year Colleges are least well equipped with capital stock. The opposite kind of story is told for Liberal Arts Colleges and Specialized Institutions. Liberal Arts colleges have only $37.5 billion of the aggregate capital stock -- 10% of it -- yet they are few enough in number and small enough in enrollment that they rank third in capital per student with two-thirds as much as the Research universities. And it becomes relevant, to repeat it once again, that we are reporting total institutional capital stock in each case so with their much greater concentration of activities on students, Liberal Arts Colleges quite likely have the largest amount of student-oriented capital. Doctoral Universities are second to Research

Universities in capital-per-school, but again they are so large that they fall behind Research, Liberal Arts, and Specialized institutions in capital per student.

The Carnegie classifications further divide Research, Doctoral, Comprehensive, and Liberal Arts institutions into quality rankings, I and II, on the basis of the number and variety of degrees awarded, the magnitude of research funding, and admissions selectivity. Adding that detail in Table 3 (and Figure 1) modifies the picture of capital allocation somewhat. Research-I universities clearly have the largest capital stocks -- in the aggregate, per school, and per student -- but a quite sharp division appears among Research Universities as Research-II schools have about half as much capital per school and 60% as much per student. The other notable feature is that students at Liberal Arts-I Colleges are very nearly as well endowed with capital as are those at Research-I Universities -- only 8% less -- at the same time that an institutions' capital is certainly more directed toward student activities in the colleges than in the universities. Again, a sharp split is found between Liberal Arts I and II Colleges with the latter having roughly half as much capital stock per student as the former. All this is shown, too, in Figure 1.

Table 4 reports Carnegie type and public/private control dimensions, together, to show capital allocations by institutional type separately for public and private sectors.

The clear superiority of physical capital endowments at even the Research-I Universities looks rather different when we recognize this additional dimension of

Table 3

Physical Capital by Institutional Type and Quality

	Number of Institutions	Average Enrollment (FTE's)	Total Capital Stock	Fraction of Total Capital Stock	Average Capital Per School	Average Capital Per Student
	(1)	(2)	(3)	(4)	(5)	(6)
All Institutions	3,148	3,163	$387,359,653,523	100.0%	$123,049,445	$38,908
Research I	89	19,331	$135,517,510,402	35.0%	$1,522,668,656	$78,767
Research II	38	15,173	$27,510,167,623	7.1%	$723,95 1,780	$47,712
Doctoral I	52	9,946	$19,950,332,086	5.2%	$383,660,232	$38,576
Doctoral II	58	8,122	$18,073,637,396	4.7%	$311,614,438	$38,365
Comprehensive I	425	5,153	$62,679,959,410	16.2%	$147482,257	$28,622
Comprehensive II	89	2,05 1	$5,654,116,712	1.5%	$63,529,401	$30,980
Liberal Arts I	165	1,518	$18,229,653,266	4.7%	$110482,747	$72,762
Liberal Arts II	454	1,301	$19,319,280,917	5.0%	$42,553,482	$32,713
Two-Year	1132	2,692	$45,256,286,100	11.7%	$39,979,05 1	$14,849
Specialized	646	634	$35,168,709,611	9.1%	$54,440,727	$85,927

Figure 1

Physical Capital Per Student by Institutional Type and Quality

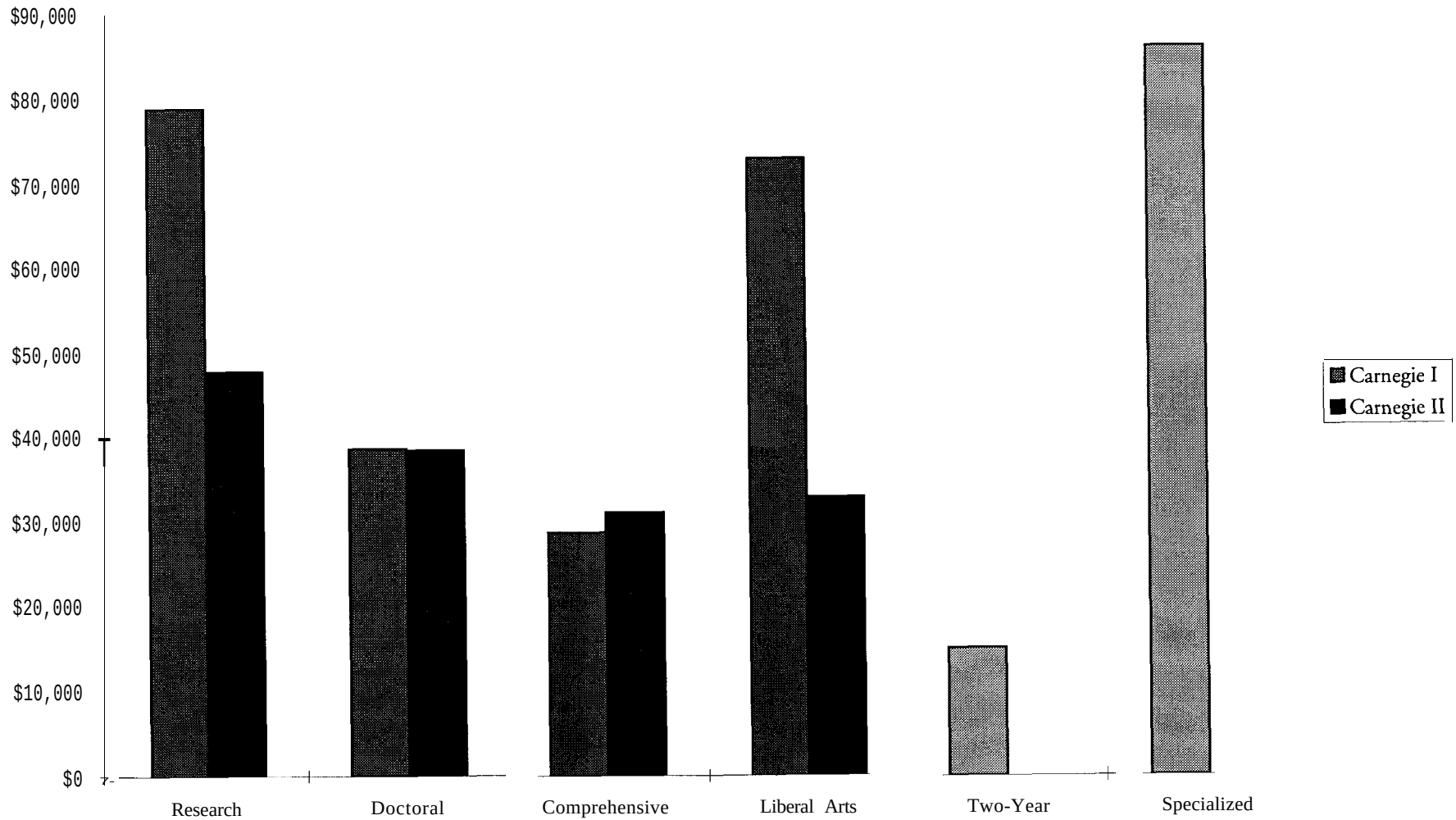

Table 4

Physical Capital by Institutional Type, Control and Quality

	Number of Institutions	Average Enrollment (FTE's)	Total Capital Stock	Fraction of Total Capital Stock'	Average Capital Per School	Average Capital Per Student	Average Capital/ output Ratio	Average Capital/ Asset Ratio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All Institutions	3,148	3,163	$387,359,653,523	100.0%	$123,049,445	$38,908	2.22	90.4%
Public Institutions	1,406	5,349	$25 1,259,170,795	64.9%	$178,704,958	$33,407	2.15	98.6%
Private Institutions	1,742	1,398	$136,100,482,728	35.1%	$78,128,865	$55,899	2.27	83.9%
			Public Institutions					
Research I	60	23,055	$86,978,429,819	34.6%	$1,449,640,497	$62,877	1.97	92.4%
Research II	27	16,616	$20,295,356,530	8.1%	$751,679,871	$45,239	2.28	94.7%
Doctoral I	29	13,032	$13,905,580,719	5.5%	$479,502,783	$36,795	2.51	96.5%
Doctoral II	36	9,972	$12,262,761,307	4.9%	$340,632,259	$34,160	2.27	98.5%
Comprehensive I	246	6,879	$45,357,905,957	18.1%	$184,381,732	$26,802	2.37	98.6%
Comprehensive II	23	3,592	$2,609,113,888	1.0%	$113,439,734	$31,583	2.74	98.0%
Liberal Arts I	6	2,433	$541,237,098	0.2%	$90,206,183	$37,080	2.71	97.4%
Liberal Arts II	76	2,464	$5,309,846,103	2.1%	$69,866,396	$28,350	2.58	98.9%
Two-Year	826	3,465	$42,443,830,729	16.9%	$5 1,384,783	$14,831	2.02	99.3%
Specialized	77	1,476	$21,555,108,645	8.6%	$279,936,476	$189,610	2.06	98.1%
			Private Institutions					
Research I	29	11,627	$48,539,080,583	35.7%	$1,673,761,399	$143,954	1.88	61.4%
Research II	11	11,634	$7,214,811,093	5.3%	$655,891,918	$56,378	1.94	63.7%
Doctoral I	23	6,054	$6,044,75 1,367	4.4%	$262,8 15,277	$43,410	1.92	80.6%
Doctoral II	22	5,096	$5,810,876,089	4.3%	$264,130,731	$51,832	1.97	76.4%
Comprehensive I	179	2,780	$17,322,053,453	12.7%	$96,771,248	$34,810	2.27	81.5%
Comprehensive II	66	1,514	$3,045,002,824	2.2%	$46,136,406	$30,481	2.27	84.1%
Liberal Arts I	159	1,484	$17,688,416,168	13.0%	$111,247,900	$74,969	2.79	62.3%
Liberal Arts II	378	1,067	$14,009,434,814	10.3%	$37,061,997	$34,739	2.54	84.8%
Two-Year	306	607	$2,812,455,371	2.1%	$9,191,031	$15,130	1.75	95.0%
Specialized	569	520	$13,613,600,966	10.0%	$23,925,485	$46,054	2.28	86.0%

'For public institutions, this column represents the fraction of the aggrcgatc capital stock of rhc public sector ; for private institutions, this column r epresents the fraction of the aggregate capital stock of the private scctor.

control: private Research-I Universities do work with a very large amount of physical capital -- and a very large amount per student -- but public Research-I Universities have far less. The figures for capital stock per student are $143,954 and $62,877, respectively so public Research-I schools have less than 45% of the capital per student found in private Research-I schools. Research-II Universities fare better in the public sector relative to their more highly-rated peers -- with a per-student capital allocation that is 72% that of public Research-I institutions. In the private sector, Research-II schools have only 39% as much capital per student as Research-I institutions, though they still have 25% more than the public Research-II Universities.

In private colleges, too, the gap between Liberal Arts-I and -11 is large: students in the second-tier private Liberal Arts schools have only 46% as much capital as those in the first-tier schools. It's not useful, note, to make much of the figures for public Liberal Arts-I schools since there are only six of them in the whole school population.[7]

Finally, the very different positions of public and private Specialized Institutions underlines the catch-all nature of that classification. The 67 public Specialized Institutions that give the average student a whopping $189,610 in capital are dominated by medical schools (41% of those that can be sub-classified) while the 569 private Specialized schools that give their students $46,054 of physical capital are dominated by religion (5 1%).

7 They are the Richard Stockton College of New Jersey, Shepherd College, St. Mary's College of Maryland, University of Minnesota - Morris, University of North Carolina at Asheville and the Virginia Military Institute.

The last two columns of Table 4, make two additional comparisons in which capital stocks are viewed, first, relative to institutional "output" and, second, relative to the institution's financial assets. The capital-output ratios reported there represent the value of an institution's capital stock relative to the value of its output as measured by total input costs over all activities.[8] Each entry describes the capital-output ratio of the average college or university of that type and control. The highest capital-output ratios are those of the private Liberal Arts-I Colleges, while Research-I Universities in both public and private sectors are among the lowest. Since we know that Research Universities have the largest amounts of capital per student in both sectors (ignoring public Specialized schools), these low capital-output ratios appear to reflect the greater significance of non-student oriented activities in these schools, leaving us with little sense, from these numbers, of how well equipped are their students. The high capital-output ratios of the Liberal Arts-I schools do, in contrast, reflect the use of capital in student-oriented activities.

The last column of Table 4 describes the relative importance of physical capital in total assets[9] with the predictable result that private institutions, with their greater reliance on endowment wealth, have a smaller fraction of their total assets in the form of physical

---

8 Net of financial aid costs but inclusive of capital costs. This conforms to the usual practice, in for-profit industries, of reporting capital-output ratios as the value of the capital stock per dollar of output which includes the value of capital services that are embedded in normal profits.

9 This is not the ratio of physical to financial wealth since neither asset figure is adjusted for liabilities -- in the form of accumulated deferred maintenance of physical assets or accumulated liabilities against financial assets [Winston, Planning]. Indeed, the financial assets here are only those reported as endowment and quasi-endowment in IPEDS so the (usually small) category of non-endowment financial assets is not included.

capital than do public institutions. It is notable, though, that among public institutions, even Research-I Universities have the vast majority (92.4%) of their assets in a physical form. [10] Overall, the average private institution has 83.9% of its assets in physical form while the average public institution has 98.6%. Among private institutions, Research-I Universities have the smallest share of their assets tied up in physical capital, with 61.4%, followed closely by Liberal Arts-I schools, with 62.3%, and Research-II Universities, with 63.7%. Private Two-Year Colleges look a lot like the public institutions with 95.0% of their assets in the form of physical capital.

II. The Distribution of the Capital Stock by Subsidy Ranking

This section looks at how the capital stock is distributed by institutional wealth as evident in the level of student subsidy. Winston and Yen [1995] provided evidence that these subsidies and the ability to award them -- which differ markedly among institutions -- describe an important hierarchy of colleges and universities with ramifications for their price, quality, size, and aid policies.

In Tables 5a and 5b, the value of physical capital is reported by the subsidy ranking of the 2,773 schools for which estimates of 1993 student subsidies comparable to Winston-Yen [1995] could be generated. Average subsidies per student range from an average of $22,619 a year for students in the top decile of public colleges down to negative $277 a year for those in the bottom decile of private institutions (a profit of

[10] Though some caution is advised in taking reported endowment figures too seriously for public institutions since the use of "foundations" to conceal endowment wealth in these schools is widespread. [Warren, 1991]

Table 5a

Physical Capital by Subsidy Decile

	Average Enrollment (FTE's)	Average Subsidy Per Student	Total Capital Stock	Fraction of Capital Stock	Average Capital Per School	Average Capital Per Student	Average Capital/ output Ratio	Average Capital/ Asset Ratio
		(2)			(5)	(6)		(8)
All Institutions	3,543	$7,635	$37 1,772,644,972	100.0%	$134,068,750	$37,836	2.21	91.3%
Decile 1	3,392	$22,676	$110,117,029,942	29.6%	$396,104,424	$116,760	2.77	78.8%
Decile 2	3,371	$10,510	$49,523,858,922	13.3%	$178,143,377	$52,848	2.64	86.8%
Decile 3	4,578	$8,674	$56,254,016,704	15.1%	$202,352,578	$44,202	2.49	91.1%
Decile 4	4,193	$7,568	$38,809,126,820	10.4%	$140,105,151	$33,413	2.41	92.9%
Decile 5	3,695	$6,744	$30,349,828,114	8.2%	$109,566,166	$29,650	2.28	93.4%
Decile 6	4,306	$5,953	$27,719,476,743	7.5%	$100,070,313	$23,24 1	2.20	94.6%
Decile 7	3,973	$5,263	$21,096,457,904	5.7%	$76,160,498	$19,167	2.02	95.2%
Decile 8	3,742	$4,522	$21,541,581,424	5.8%	$77,767,442	$20,783	1.96	92.5%
Decile 9	2,723	$3,470	$11,091,582,200	3.0%	$40,041,813	$14,705	1.73	93.5%
Decile 10	1,458	$903	$5,269,686,199	1.4%	$19,024,138	$13,050	1.54	94.8%

*The 2,773 US Institutions reporting in the Integrated Postsecondary Educational Data System in 1993 with undergraduate enrollment 2 20% and ≥100 FTE. All Deciles have 278 or 277 institutions.

Table 5b

Physical Capital by Public and Private Subsidy Deciles

	Average Enrollment (FTE's)	Average Subsidy Per Student	Total Capital Stock	Fraction of Capital Stock'	Average Capital Per School	Average Capital Per Student	Average Capital/ output Ratio	Average Capital/ Asset Ratio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All Institutions	3,543	$7,635	$371,772,644,972	100.0%	$134,068,750	$37,836	2.21	91.3%
Public Institutions†	5,406	$8,088	$244,464,757,605	65.8%	$176,254,331	$32,606	2.15	98.6%
Private Institutions†	1,680	$7,182	$127,307,887,367	34.2%	$91,852,733	$54,678	2.26	84.1%
				Public Institutions				
Decile 1	5,553	$22,619	$62,628,341,837	25.6%	$450,563,610	$81,133	2.43	96.7%
Deciles 2	5,865	$9,729	$38,131,499,608	15.6%	$274,327,335	$46,774	2.32	98.2%
Decile 3	6,694	$8,355	$39,199,568,329	16.0%	$282,011,283	$42,128	2.36	98.5%
Decile 4	5,382	$7,529	$22,560,421,145	9.2%	$162,305,188	$30,158	2.35	99.1%
Decile 5	4,629	$6,944	$16,416,768,767	6.7%	$118,106,250	$25,516	2.22	98.8%
Decile 6	5,360	$6,298	$18,867,767,657	7.7%	$135,739,336	$25,326	2.22	98.8%
Decile 7	5,743	$5,766	$16,523,136,743	6.8%	$118,871,487	$20,699	2.11	99.0%
Decile 8	4,889	$5,259	$11,140,544,505	4.6%	$80,728,583	$16,512	1.91	99.0%
Decile 9	5,289	$4,666	$12,740,242,109	5.2%	$92,320,595	$17,455	1.92	98.9%
Decile 10	4,642	$3,642	$6,256,466,905	2.6%	$45,336,717	$9,767	1.69	99.2%
				Private Institutions				
Decile 1	2,602	$22,243	$55,579,664,558	43.7%	$399,853,702	$153,686	3.09	68.6%
Decile 2	1,112	$11,538	$10,706,262,442	8.4%	$77,023,471	$69,291	2.73	75.5%
Decile 3	1,307	$9,202	$11,058,843,920	8.7%	$79,560,028	$60,853	2.76	79.5%
Decile 4	1,984	$7,613	$13,715,785,096	10.8%	$98,674,713	$49,744	2.58	80.9%
Decile 5	1,725	$6,370	$9,581,507,458	7.5%	$68,931,708	$39,960	2.38	84.2%
Decile 6	1,656	$5,258	$7,648,312,864	6.0%	$55,023,834	$33,225	2.18	86.8%
Decile 7	1,912	$4,328	$8,222,697,464	6.5%	$59,584,764	$31,163	1.95	85.9%
Decile 8	1,615	$3,271	$5,379,220,060	4.2%	$38,979,856	$24,139	1.78	90.1%
Decile 9	1,800	$2,134	$4,159,140,578	3.3%	$30,138,700	$16,745	1.59	91.3%
Decile 10	1,084	($277)	$1,256,452,927	1.0%	$9,104,731	$8,397	1.51	98.1%

'The sample contains the 2,773 US institutions reporting in IPEDS in 1993 with undergraduate enrollment ≥20% and ≥100 FTE.

"For public institutions, this column represents the fraction of the gross capital stock of all public institutions in the sample. For private institutions, this column represents the fraction of the gross capital stock of all private institutions in the sample.

†There are 1,387 public institutions and 1,386 private institutions in the sample. All deciles contain 138 or 139 institutions.

$277), with subsidies granted by public and private institutions falling between those extremes.

The dominant fact about the relationship between student subsidies and the schools' use of capital is the clear and relentless decline in capital endowment with declining subsidies. Large capital stocks go with high subsidies -- in the aggregate, in the average school, and for the average student -- and small capital stocks go with low subsidies. So more generous capital services are one of the very concrete ways that students are subsidized in high subsidy schools.[11] It is no accident that lavish physical plants are found at high subsidy colleges.

Winston and Yen [1995] showed that while average student subsidies are very similar in the public and private sectors ($7,839 and $7,244, respectively in 1991), they support very different price-cost-quality policies: public institutions on average charge a low price ($921) for a low-cost education ($8,760) while private institutions go the other way with both a higher price ($5,424) and a higher cost ($12,669). The *proportion* of his or her educational costs paid by the average student is always lower in public sector schools, over all the deciles. So in decile averages, the student in a highly subsidized public school pays 5.5 cents on the dollar of his educational costs while a student at the least subsidized public school pays 23.3 cents. But even the most highly subsidized

---

11 Note that this is not a tautology. While the cost of capital services is (an important) part of the per-student cost that determines a student's subsidy (the difference between cost and net price, S = C - P) a given subsidy can go with high price and cost or with low price and cost. So Cooper Union grants a $33,030 subsidy by giving a $33,030 education at a zero price while Williams gives a similar $33,244 subsidy by charging $13,182 for an education that costs $46,426 to produce.

student in a private school pays 24.7 cents on the dollar while in the least subsidized decile, he or she pays a full 91.6 cents.

Comparing the amount of capital used in public and private schools arranged by size of student subsidy -- Table 5b -- the same kind of decline of capital use with declining subsidy appears in both sectors separately, but with less regularity than in the aggregated data in Table 5a. Lower subsidies still go with less use of capital. But it is the skewedness of the capital allocation in the private sector -- and its moderation in the public sector -- that comes through most clearly in Table 5b. Fully 43% of all private sector capital stock -- almost half -- is concentrated in those 10% of the private schools that give the largest student subsidies. On average, those schools are equipped with nearly $400 million in capital stock and, because they are also relatively small, their students enjoy the services of $154,000 of capital each.

The last two columns of Tables 5 show a strong decline in capital-output ratios with falling subsidies in the aggregate data indicating, once again, that those schools offering the largest subsidies to their students use the largest amount of capital relative to other inputs. While that decline is not so regular within each sector considered alone, it is nearly so. In the last column, the relative importance of physical capital as an asset is shown to increase with decreasing subsidies -- poorer schools don't have or use much wealth other than physical capital stocks. That pattern, too, carries over from aggregates

to the sectors, taken separately, but again with greater variation among private than public schools.

III. The Costs of Capital Services -- and The Distortion When Ignored

Everything to this point has been in terms of capital stocks and their distribution. There remains the important question of how seriously the omission of yearly capital costs distorts our understanding of costs in higher education and how those distortions are, themselves, distributed among schools by type, control, and subsidy hierarchy. To that end, we turn first to the data of Table 6 that reports the percent by which total yearly costs[12] are increased when we recognize the costs of capital services.

The top three lines of Table 6 show annual current expenditures and capital service costs for all institutions and for public and private institutions separately. Two aspects of those data are remarkable:

- The distortion in measured educational costs due to the conventional omission of capital service costs is very large -- an accurate measure of the costs of higher education would, on average over all institutions, show them to be nearly one-third higher than they are reported to be.[13]

---

12 In Winston-Yen [1995], only educational (instructional) costs were at issue but the percentage distortions reported in this section apply, too, to them since we calculated the division of capital costs between instruction and non-instructional uses to be the same as the division of non-capital costs.

13 It should be noted that the measure of current expenditures used in Table 6 leaves out mandatory transfers because -- as explained in the Appendix -- they are sometimes the vehicle for recognizing actual capital service costs. Were such transfers of considerable moment, we could not reasonably describe the expenditures in Table 6, then, "as conventionally reported." But in fact, mandatory transfers are a mere 1.4% of total current expenditures, so it did not seem necessary to honor that distinction.

Table 6

Current Costs and the Distortions of Omitted Capital Service by Type, Control and Quality

	Number of Institutions	Current Expenditures[1]	Annual Cost of Capital Services	Distortion for Average School
	(1)	(2)	(3)	(4)
All Institutions	3,148	$148,573,294,000	$39,665,137,405	31.8%
Public Institutions	1,406	$95,442,872,000	$25,755,245,803	29.5%
Private Institutions	1,742	$53,130,422,000	$13,909,891,602	33.6%
Public Institutions				
Research I	60	$36,662,779,000	$8,939,939,218	25.9%
Research II	27	$6,687,894,000	$2,08 1,779,255	30.9%
Doctoral I	29	$3,917,670,000	$1,423,695,967	35.3%
Doctoral II	36	$4,58 1,269,OOO	$1,253,313,645	31.3%
Comprehensive I	246	$14,640,28 1,000	$4,649,736,885	33.4%
Comprehensive II	23	$711,719,000	$266,544,050	40.3%
Liberal Arts I	6	$149,068,000	$55,682,809	39.3%
Liberal Arts II	76	$1,371,998,000	$543,617,388	38.2%
Two-Year	826	$16,819,687,000	$4,319,331,060	27.0%
Specialized	77	$9,900,507,000	$2,221,605,526	30.7%
Private Institutions				
Research I	29	$2 1,757,296,000	$4,946,497,646	26.0%
Research II	11	$3,261,663,000	$740,745,725	25.7%
Doctoral I	23	$2,516,101,000	$617,279,060	25.2%
Doctoral II	22	$2,472,099,000	$593,526,732	26.1%
Comprehensive I	179	$5,827,943,000	$1,770,410,927	31.7%
Comprehensive II	66	$1,004,811,000	$3 11,606,654	31.2%
Liberal Arts I	159	$4,418,938,000	$1,819,266,719	41.4%
Liberal Arts II	378	$3,966,5 11,000	$1,434,694,989	37.9%
Two-Year	306	$1,289,252,000	$286,969,169	23.9%
Specialized	569	$6,615,808,000	$1,388,893,981	35.8%

1 Includes E&G, Hospital, Auxilliary Enterprises and Independant operations; excludes scholarships, fellowships and mandatory transfers. (See appendix.)

- Despite the sheer size of the cost distortion caused by the omission of capital costs, the distribution of that distortion by type and control does not appear to be very interesting. There are no significant differences either between public and private institutions or between quality levels, I and II, among Carnegie types. The only difference of note by type is the higher degree of cost distortion found in Liberal Arts Colleges, both public and private, and in public Comprehensive-II Universities.

Table 7 is another matter. In it, the distortion of costs due to omission of capital services is reported over the range of institutions ranked by student subsidy decile. Again, that hierarchy and its central role in higher education is developed in Winston and Yen.

Two facts stand out:

- There is, quite reasonably, far more distortion of reported costs in wealthy schools than in poorer ones -- those with the largest capital stocks will most seriously understate their true educational costs by ignoring them.[14] This does not follow trivially from the size of their capital stocks since what is reported here describes how much capital they use relative to their other ***spending. So*** Table 7 suggests that

14 Subsidy (as cost *minus* price) is clearly not independent of capital service costs but only if all else were held constant would this relationship reduce to tautology.

Table 7

Current Costs and the Distortions of Omitted Capital Service by Public, Private and All Institution Subsidy Deciles

	Average Subsidy Per Student	Current Expenditures	Annual Cost of Capital Services	Distortion for Average School
	(1)	(2)	(3)	**(4)**
		All Institutions		
Decile 1	$22,676	$44,885,914,000	$11,276,874,766	48.2%
Decile 2	$10,510	$16,972,008,000	$5,078,401,653	39.1%
Decile 3	$8,674	$19,870,309,000	$5,781,382,247	35.8%
Decile 4	$7,568	$12,963,671,000	$3,970,831,103	34.2%
Decile 5	$6,744	$ IO,71 3,372,OOO	$3,104,084,330	31.2%
Decile 6	$5,953	$9,736,083,000	$2,833,515,401	30.1%
Decile 7	$5,263	$8,270,045,000	$2,156,892,904	26.7%
Decile 8	$4,522	$8,825,423,000	$2,200,632,020	25.5%
Decile 9	$3,470	$4,963,191,000	$1,130,490,356	22.1%
Decile 10	$903	$2,867,501,000	$535,036,015	19.1%
		Public Institutions		
Decile 1	$22,619	$25,710,543,000	$6,430,002,245	37.2%
Decile 2	$9,729	$14,183,896,000	$3,912,939,711	32.3%
Decile 3	$8,355	$13,249,454,000	$4,031,212,513	33.0%
Decile 4	$7,529	$7,443,808,000	$2,304,266,845	32.9%
Decile 5	$6,944	$5,624,797,000	$1,679,601,022	30.5%
Decile 6	$6,298	$6,149,796,000	$1,928,378,359	30.2%
Decile 7	$5,766	$6,130,833,000	$1,688,751,628	28.5%
Decile 8	$5,259	$4,632,278,000	$1,141,972,245	24.9%
Decile 9	$4,666	$5,213,112,000	$1,304,261,588	24.8%
Decile 10	$3,642	$3,002,179,000	$634,857,725	21.3%
		Private Institutions		
Decile 1	$22,243	$21,722,017,000	$5,675,780,658	58.5%
Decile 2	$11,538	$3,855,318,000	$1,099,439,092	41.5%
Decile 3	$9,202	$3,002,754,000	$1,135,124,545	41.4%
Decile 4	$7,613	$5,499,197,000	$1,403,471,230	37.3%
Decile 5	$6,370	$3,453,448,000	$978,252,500	33.1%
Decile 6	$5,258	$2,650,458,000	$781,589,055	29.3%
Decile 7	$4,328	$3,372,775,000	$839,909,938	25.7%
Decile 8	$3,271	$2,256,559,000	$548,5 10,046	22.8%
Decile 9	$2,134	$2,084,228,000	$422,878,965	19.9%
Decile 10	($277)	$830,067,000	$126,940,885	18.7%

capital service inputs become *relatively* less important for poorer schools.[15] And the regularity of declining distortion over the ten deciles is notable.

- Private institutions show more distortion from the omission of capital costs than do public ones. While those differences in distortion were not very dramatic as reported over all public (29.5%) and all private (33.6%) institutions aggregated in Table 6, they become clearer in Table 7 when schools of comparable wealth can be seen so that the concentration of that distortion in the wealthiest schools is revealed. Looking at the top decile of each sector, distortion due to omitted capital costs is 57% higher in private than in public schools (2 1.3 percentage points) while in the bottom decile, it is 12% lower in private schools (2.6 percentage points). And the transition between them is relatively smooth.

IV. Conclusions

The capital stock used in US higher education is simply very large and very unevenly distributed among colleges and universities by public and private control, by Carnegie classification and, most markedly, by schools' wealth. By almost any measure, among the major Carnegie types the private Research Universities and Liberal Arts-I Colleges are best endowed with physical capital -- the average student at a public Two-Year College has access to 1/10th as much capital as the average student at a private

15 As does Table 5 in showing declining capital-output ratios by subsidy decile.

Research-I University. And from the poorest ten percent to the richest ten percent of private schools, capital per student increases 17 fold.

Without estimates of the value of the capital stocks and costs of the capital services used, we simply don't know how much it costs to produce US higher education each year. And these data suggest that absent such estimates, we're typically way off the mark. It's also important that even when we've known that the distortions were serious, we've had inadequate information on how those distortions are distributed within higher education -- for which kinds of schools does it matter very much and for which does it matter relatively little that we neglect capital costs? On the basis of these data, we can answer those and similar questions.

And data like those presented here, built up from individual institutions, allows us to aggregate over institutions in usefully different ways. Here, the aggregations have been by Carnegie type, by public and private control, and by wealth as reflected in student subsidies, but other purposes might be served by geographical aggregation or size or an other dimension. One caveat, however. It is not advisable to put much faith in the numbers for any individual institution, considered in isolation. Quite valid results can be reported for groups of schools even if individual observations are off the mark so long as they are inaccurate in unbiased ways. So we make far more confident claims for the validity of the kinds of aggregate figures reported here than we could for those from any single college or university.

Finally, these data should give college trustees and administrators a useful sense of how seriously their managerial and governance decisions may be distorted by the neglect the costs of capital services. On the one hand, they fly nearly blind in the broad portfolio decisions they make whenever they alter the allocation of their wealth between physical and financial assets -- whenever they build a building -- if they have neither an accurate measure of the value of their physical assets nor, importantly, even a hint of the value of the capital services those assets contribute to the enterprise. On the other hand, neglect of the costs of physical capital services must guarantee internal misallocation of their scarce resources and make the delegation of decisions to others further down in the organization virtually impossible since those decisions cannot realistically reflect the costs of capital services.

Some $387 billion of buildings, equipment, and land is inadequately accounted for in US higher education, leading to a distortion in reported costs of some $40 billion a year. While private Research-I Universities have the most capital per student ($143,557) and public Two-Year Colleges have the least ($14,540), an even greater disparity in capital stocks appears when schools are ranked by wealth -- by their average student subsidies. The top decile of private schools have over $153,000 of physical capital per student and the bottom decile of public and private schools have less than $10,000. The distortion of educational costs that results from omitting capital services range from roughly 25% for Research-I Universities, both public and private, to more than 40% for private Liberal Arts Colleges and public Comprehensive Universities. Capital service

costs are large and unevenly distributed within higher education, creating serious problems for any analysis that ignores them.

APPENDIX A -- The Estimation of Physical Capital Stocks and Capital Service Costs

This appendix will provide more detail on the way the capital stock figures used in this study were generated from the IPEDS data. With the exception of a small change in the interest rate used to estimate the annual opportunity cost of capital, it is the same as that used in Winston [1995].

In the IPEDS financial survey of 1993, each school was asked to report book and replacement values of the buildings and equipment used in their educational activities[16] as well as the book value of the land used.[17] Our earlier study on capital used numbers from the study of institutions' student subsidies, in which the objective was to estimate current replacement values of buildings, equipment, and land in order to estimate the costs of the yearly capital service flows used in instruction in each institution. To that end, it was necessary only to separate the sum of building and equipment values from the value of land[18] so the values of buildings and equipment were not estimated separately for all institutions.

The primary difficulty presented by these IPEDS physical capital data was, most simply, that not all schools reported all five of the measures of capital stock requested (book value of land and book and replacement values of buildings and equipment), nor even the three measures essential to these data (replacement values of land, buildings, and equipment). Indeed, had all schools reported to IPEDS as requested, no estimation -- but only aggregation -- would have been needed. A secondary difficulty was, of course, occasionally flaky numbers.

Capital Stock Estimates -- The Method

Broadly, for each school for which the replacement value of capital -- or any of its components -- was not reported, we filled in the missing value on the basis of the relationships revealed by those schools that did report. And while the CASPAR IPEDS data suffer from an ambiguity that makes it impossible to distinguish between a zero value (no capital) and a blank (no information), we took advantage of the fact that it's hard to imagine the production of higher education without the use of some physical capital, to justify the interpretation of all such zero-blank entries as blanks that needed to be filled in.

---

16 i.e., excluding those held for investment purposes but including those used by the institution but owned by another institution or agency -- a consideration that is of the frequent importance for public colleges and universities, as in the SUNY system where much physical capital is provided by another state agency without explicit charge.

17 So IPEDS asked schools to report, for all of the capital used in their activities: book values of buildings (B_b), equipment (Et,), and land (L_b), along with replacement values for buildings (B,) and equipment (E,).

18 Since, as noted below, we did not depreciate land or land improvements while land incurred an opportunity cost in full. Schultz does this, too [Schultz, 1960]

Capital Service Costs

From the replacement values of a school's buildings (B,), equipment (E,), and land (L_r), calculation of the yearly cost of capital services is straightforward: a defensible estimate of yearly real economic depreciation, d, is joined with a defensible estimate of the opportunity cost of capital, r, to generate a yearly rental rate, $(d+r)P_kK$, where P_k is the current replacement price of a capital stock of size K making P_kK the replacement value of that capital stock. For depreciation, we used 2.5%, near the middle of the range suggested by campus physical planners (see Dunn [1989] or Probasco [1991])[19], and for opportunity cost, the five-year average of the long term Federal bond rate, which was 7.89% in 1993. We assigned a zero value to the depreciation of land (so we ignored depreciation of land improvements) and expressed land in current replacement values. The rental rate we used, then, was $d(B_r+E_r) + r(B_r+E_r+L_r)$ or $(d+r)(B_r+E_r) + rL_r$.

Missing Data

The first broad step involved filling in the blanks -- getting replacement values for all components of the capital stock for each school -- while the second involved estimating the yearly cost of their capital service flows. The generation of a complete set of replacement values followed a sequence of steps:

1 - 2,145 schools reported both book (B_b) and replacement values (B,) for buildings.

2 - 541 schools reported the book value of buildings (B_b) but not their replacement value (B,). To estimate the latter, we used the 2,145 reported values to generate the coefficient, $B_r = 2.218B_b$ to fill in missing building replacement values.

3 - 2,002 schools reported both book (Et,) and replacement values (E,) for equipment.

4 - For the 820 schools that reported a book value of equipment but not its replacement value, we used the 2,002 reported values to fill in the blanks. The coefficient was $E_r = 1.411E_b$.

5 - There were then 2,673 schools with reported or estimated replacement value of buildings (B,) and equipment (E_r).

---

19 Alternative approaches to depreciation can come much the same thing. Attributing different depreciation rates to a variety of capital types [Probasco, 1991] might be desirable but would much exceed the limits of these data. O'Neill separated buildings from equipment, using depreciation rates of 2.0% and 5.0% respectively. Applying these rates to the 2,695 institutions for which we have separate building and equipment replacement values gives an aggregate annual depreciation rate of 2.66% -- reassuringly close to our 2.5%.

6 - For 22 schools that reported the value of buildings but not that of equipment, we used reported and estimated replacement values of buildings and equipment to establish the coefficient, $E_r = 0.306B_r$. [21]

7 - 303 schools did not report either book or replacement values for either buildings or equipment. To fill in these blanks, we estimated a capital-output ratio from the 2,695 schools for which we now had either reported or estimated capital values. We used as output, Q, Adjusted E&G plus Auxiliary and Hospital and Independent Operation expenditures (less all Scholarships and Fellowships and Transfers, Mandatory and Non-mandatory). The result was a capital estimate, $K_r = B_r + E_r = 2.086Q$.

8 - This coefficient was used, too, to estimate the replacement value of the capital stock for those 150 schools that reported the value of equipment but not buildings.[21]

9 - For the 571 schools that did not report a book value of land, we estimated it on the basis of the relationship between reported and estimated building and equipment replacement values and the book value of land so $L_b = 0.027(B_r + E,)$.

10 - IPEDS asked schools to report the book values of land so we estimated its replacement value as 2.218 of reported book value, using the coefficient that our data had produced between replacement and book value of buildings. This assumes that land has appreciated with inflation at the same rate, on average, as buildings.

Yearly Capital Service Costs

The result of these steps is a set of reported estimates of current replacement values for buildings, equipment, and land for each of the 3,148 schools. These are discussed in Sections I and II above. From these data, the yearly costs of total capital services for each school were estimated as, for the ith school, $.025(B_i + E_i) + .0789(B_i + E_i + L_i)$. These capital cost data are reported in Section III in the text.

Estimates of Student Subsidies

Student subsidies were estimated for 2,773 institutions following methods used in Winston-Yen [1995]. In that study, schools with fewer than 100 undergraduate FTEs and 20% undergraduate enrollment were not included in the subsidy estimates. In the 1993 data of this paper, the first of these restrictions eliminated 364 schools or 105,950 FTE

20 Note that this coefficient is substantially larger than Brinkman's reported in Due-Le To [1987].
21 The alternative of simply using the relationship in step 6 above was dismissed as amplifying, unacceptably, any noise in reported equipment values -- going in the other direction, from building to equipment values, such noise is damped.

students (11.6% of schools or 1.1% of students) while the second eliminated 8 schools or 14,620 FIE students[22].

Educational capital costs were allocated in proportion to the role of educational expenditures in total current expenditures, Educational $Expenditures_i/(E\&G_i + Auxiliary_i + Hospital_i$ + Independant Operationsi - Scholarships & Fellowshipsi - Mandatory and Non-Mandatory Transfers& then added to educational current costs. From this sum net tuition (gross tuition receipts minus student aid "expenditures" and Pell grants) was subtracted in order to get the subsidy.

Capital Ownership. Double Counting;, and Deferred Maintenance

Since IPEDS appropriately asks schools to report the value of all of the buildings, equipment, and land used in their activities, we were able to generate a measure of the total yearly cost of capital services for each institution. But there is the potential for overstating capital costs for two reasons. Our method will (a) double count to the extent that all or part of these capital service costs are already included in reported current costs and (b) overstate capital costs to the extent that replacement values overstate the current value of the capital stock by ignoring accumulated deferred maintenance, thereby overstating opportunity cost. The first of these, note, affects only the estimation of capital service costs while the second affects the estimation of the value of capital stocks.

One source of potential double counting was eliminated when we subtracted from E&G (and Auxiliary and Hospital and Independent Operations expenditures) the Mandatory Transfers that are sometimes a device for reflecting capital services in current costs. Our procedure, in effect, replaces a highly idiosyncratic, even quixotic, recognition of capital costs with a systematic one.[23] As noted in the text, Mandatory Transfers represented only 1.4% of current costs in these data so that correction was appropriate, but not large.

But variations in the ownership of the capital stock -- hence in the source of the capital service flows -- would also produce double counting under our procedures. Our method is wholly appropriate for a school that owns its capital stock outright (whether or not it is used as collateral on indebtedness). Once Mandatory transfers are got rid of, no other part of the current accounts will include the costs of owned capital. But to the extent that a school rents its capital services, those rental charges will show up in current spending not identified as rental payments so that we could avoid counting them twice. Finally, when capital services are provided, as such, by another agency, our method won't distort the measure of total capital costs. We doubt that double counting of costs in the

22 In addition, three schools (The Art Institute of Philadelphia, ICS-Center for Degree Studies and the Oklahoma Junior College of Business) were eliminated because they did not report the breakdown of current funds expenditures necessary to estimate the educational component of costs.

23 Whether these transfers will or won't acknowledge capital costs in excess of legally obligated debt service is entirely at the discretion of the institution, therefore the subject of considerable inconsistency.

presence of rented capital is of practical moment, but we can't be sure. [Winston, NACUBO]

The potential for overstating the true value of resources tied up in a capital stock -- hence the opportunity cost of that capital -- by using replacement values without an adjustment for accumulated deferred maintenance is best seen by analogy with the value of an institution's financial capital.[24] Conventionally, assets represent the gross value of financial holdings. Financial wealth, or "net worth," recognizes any offset to those financial assets in the form of financial liabilities. So net worth is assets less liabilities. A school (or firm or family) with $100 million in assets and $40 million in outstanding debt has a net worth of $60 million. To ignore debt and act as if all assets were unencumbered is clearly misleading. The same relationships hold with respect to physical capital, only here the value of 'assets' is the replacement value of the plant and equipment while the 'liabilities' are accumulated deferred maintenance. Their difference is 'net physical worth,' the measure of wealth held in the form of physical capital. So a school that owns land, buildings, and equipment with a replacement value of $100 million on which it has accumulated $40 million in deferred maintenance has a net physical worth of only $60 million.[25]

The opportunity cost of owning physical capital recognizes the yearly cost incurred because resources are tied up in a physical form that yields no explicit return rather than in the financial form that does. If a school has accumulated no deferred maintenance, the replacement value of its physical capital is the appropriate base for reckoning its opportunity cost. This is the opportunity cost we've used. But when a school defers maintenance spending, it effectively 'liquidates' or converts that portion of its physical wealth, releasing it for other uses including investment in financial assets. So it eliminates, to the extent of accumulated deferred maintenance, some of the opportunity cost of holding its physical capital. If the school above with its $100 million capital stock incurs $2.5 million of real depreciation each year and spends that much to offset it, deferred maintenance is zero and (ignoring inflation) the capital stock is worth $100 million at the end of the year as it was at the beginning. An opportunity cost is incurred by the full $100 million in resources -- all of them are tied up in physical capital at the end of the year just as they were at the beginning. But if, instead, nothing is spent on maintenance during the year and the full $2.5 million of maintenance is deferred, only an average of $98.75 million of resources (($100+$97.5)/2) will incur an opportunity cost -- the $2.5 million not spent on maintenance by the end of the year can be spent, inter alia, on financial assets that do earn a return. After, say, ten (inflation-free) years of deferring all maintenance, a quarter of the replacement value of the capital stock will have been thereby 'liquidated' so an opportunity cost will be incurred only by the remaining $75 million -- the 'net physical worth' -- even though replacement value remains unchanged at $100 million.

---

24 See Winston, ***Planning***

25 In a set of stable competitive markets with perfect information, net physical worth would describe the market price of the capital stock.

There is, of course, simply no way to estimate the accumulated deferred maintenance for the individual schools of this study -- indeed, it is a difficult and often controversial task to estimate it for a single institution. So it must remain a source of potential overstatement of the value of the capital stock and of capital costs.

Dirty Data

Aside from missing numbers (and zeros), the IPEDS capital data include some numbers that are, for one reason or another, simply unbelievable. Some of these are errors in magnitudes of 10 to l,000,000 resulting, clearly, from misplaced decimal points. Others are values that embedded economically implausible relationships. Chief among these are schools with reported current replacement value of buildings smaller than their reported book value -- an extremely unlikely relationship in a world of durable buildings in an environment of rising construction costs. (A stock of *equipment,* in contrast, might conceivably carry a lower replacement than book value if it were dominated by information processing equipment for which costs have fallen over time -- so this logic and its implied adjustment were not applied to equipment estimates.)

In these cases, outliers were identified by examining extreme values of, for instance, replacement/book value relationships. Using IPEDS in the CASPAR CD-ROM format has the considerable virtue of providing data for all the years of the survey which allowed the simple and often fruitful check of a flaky looking number against its value for the same institution in proximate years. So we were often able to correct a number for 1993 on the basis of its value reported for 1992 or 199 1. When that comparison revealed an error as a simple multiple of 10 to l,000,000, the corrections carried considerable conviction. In all of these, we focused on comparative *replacement* values -- the goal of our estimates -- and worried less about accurately reported book values, which served as on a route to the replacement values.

When the sources of error were less obvious, we simply treated the outlier as a blank and estimated its value as if none had been reported. These are included in the counts reported above.

APPENDIX B -- A Comparison with June O'Neill's 1967 Capital Estimates

This appendix briefly compares our results to the 1967 data on capital reported in O'Neill [197 1] Her estimates are presented in Appendix Table B- 1 in 1993 dollars along with our comparable estimates.

O'Neill's methods were different from ours, but if consistent, we would not expect these differences to effect the direction of changes observed in the distribution of capital between public and private sectors. It appears from the table that while the stock of capital in the public sector has grown faster than that in private schools over this 26-year period -- from $76 billion in the public sector or 60% of the total capital in 1967 to $251 billion or 65% in 1993 -- that growth has been overwhelmed by an even faster

Table **B-l**

Physical Capital in US Higher Education: 1993 and 1967

(in 1993 Dollars)

	Number of Institutions	Enrollment (FTE's)	Fraction of Enrollments	Total Capital Stock	Fraction of Capital Stock	Average Capital Per School	Average Capital Per Student
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				1967 -- O'Neill's Data			
All Institutions	2,491	**6,438,500**	**100.0%**	**$126,482,963,696**	**1oo.w**	**$50,775,979**	**$19,645**
Public Institutions	†	4,381,100	68.0%	$75,542,792,079	59.7%	--	$17,243
Private Institutions	†	2,057,400	32.0%	$50,940,171,617	40.3%	--	$24,759
				1993			
All Institutions	3,148	9,955,910	100.0%	$387,359,653,523	100.0%	$123,049,445	$38,908
Public Institutions	1,406	7,521,169	75.5%	$251,259,170,795	64.9%	$178,704,958	$33,407
Private Institutions	1,742	2,434,742	24.5%	$136,100,482,728	35.1%	$78,128,865	$55,899

'The number of public and private institutions is not reported.

SOURCE: O'Neill, 1971. 1967 Figures are inflated to 1993 dollars using GDP price deflator obtained from the ***Economic Report ofthe President.***

growth in public sector enrollments -- from 4.4 million or 68% of the total in 1967 to 7.5 million or 76% in 1993 -- so that the average student in the public sector is relatively less well equipped with capital in 1993 than at the beginning of the period. In 1967 he had nearly 70% as much capital as the student in the private institutions but by 1993 he had only 60% as much. This is consistent with McPherson and Schapiro's findings that plant additions per student grew more than twice as quickly in the private sector as in the public sector during the 1980s [McPherson-Schapiro-Winston, 1993].

Differences in even constant dollar values of capital between the two dates are almost certainly exaggerated by differences in methodology,[26] but with that caveat, it appears that the amount of capital used in higher education grew considerably over the period. The total value increased more than threefold, from $126 billion to $387 billion. Measured per school, capital more than doubled from $50 million to $123 million. And per student, it doubled from $19,600 to $38,900. It is less clear that the use of capital grew faster than other inputs to higher education. Capital's share of total higher education expenditures in Table B-2 increased from 15% in 1967 to 21% in 1993. This difference is explained in part by the interest rate increase between those dates -- in O'Neill's period, 5% represented the opportunity cost of physical capital while 7.89% was appropriate in the later period.[27] Nonetheless, higher education appears to have become more capital-intensive over these two and a half decades.

---

26 In particular, a major difference between O'Neill's study and ours is that her method implicitly assumes that colleges do not maintain buildings or equipment (allowing them to depreciate), where our method implicitly assumes that colleges fully maintain their stock of capital. She uses changes in the reported book value of capital from year to year to generate investment flows which she adjusts for inflation and depreciation over time to get the replacement value net of cumulated depreciation, where we use schools' reports of replacement value. To the extent that her method neglects expenditures on capital improvements not reflected in the cost series, the value of the capital stock will be understated. And to the extent that our method does not account for accumulated deferred maintenance, the value of the capital stock will be overstated.

27 Note, too, that the numbers in Table B-2 differ from the similar numbers reported in Table 6 as a capital cost/cost ratio because we used an average of calculated institutional capital cost to cost ratios over sectors and the aggregate while O'Neill calculated a capital cost/cost ratio for the aggregate.

Table B-2

Capital Costs as a Fraction of Total Costs, 1993 and 1967

(in 1993 dollars)

	Number of Institutions	Current Expenditures	Annual Cost of Capital Services	Total Cost	Capital Cost/ cost
	(1)	(2)	*(3)*	*(4)*	*(5)*
			1967 -- O'Neill's Data		
All Institutions	2,491	$54,859,706,681	$9,993,551,663	$64,853,258,344	15.4%
Public Institutions	†	$32,473,030,960	$5,994,102,153	$38,467,133,113	15.6%
Private Institutions	†	$22,428,187,569	$3,999,639,714	$26,427,827,283	15.1%
			1993		
All Institutions	3,148	$148,573,294,000	$39,665,137,405	$188,238,431,405	21.1%
Public Institutions	1,406	$95,442,872,000	$25,755,245,803	$121,198,117,803	21.3%
Private Institutions	1,742	$53,130,422,000	$13,909,891,602	$67,040,313,602	20.7%

†The number of public and private institutions is not reported.

SOURCE: O'Neill, 1971. 1967 Figures are inflated to1993 dollars using GDP price deflator obtained from the ***Economic Report ofthe President.***

CITATIONS

Bowen, Howard R., and Gordon K. Douglass. Efficiency in liberal education. New York: McGraw-Hill; 197 1.

Bowen, Howard R. The costs of higher education. San Francisco: Jossey-Bass; 1980.

Bradburd, Ralph M. and Duncan P. Mann, "Wealth in Higher Education Institutions," Journal of Higher Education, (July/August, 1993).

Dunn, John A., Jr. Financial planning guidelines for facilities renewal and adaptation. Ann Arbor: The Society for College and University Planning; 1989.

James, Estelle, "Product Mix and Cost Disaggregation: A Reinterpretation of the Economics of Higher Education," The Journal of Human Resources, Vol. XIII, No. 2, 1978.

McPherson, Michael S., Morton Owen Schapiro and Gordon C. Winston, Paying the Piper: Productivity, Incentives, and Financing in US Higher Education, Ann Arbor: The University of Michigan Press, 1993.

National Science Foundation. Computer Aided Science Policy Analysis & Research (CASPAR) Database System Ver. 4.4. Quantum Research Corporation (QRC), Bethesda, Maryland.

O'Neill, June A., Resource use in higher education: trends in output and inputs, 1930 to 1967. Berkeley: The Carnegie Commission on Higher Education; 197 1.

Probasco, Jack. "Crumbling campuses: What are the real costs?" The NACUBO Business Officer, vol. 25, no. 5 (November, 1991): 48-5 1.

Schulz, Theodore W. "Capital formation by education." Journal of Political Economy vol. 68, no. 6 (December, 1960): 571-583.

To, Due-Le. Estimating the cost of a bachelor's degree: An institutional cost analysis. Washington DC: Office of Educational Research and Improvement, U.S. Department of Education; 1987.

Warren, Thomas Hartwell. "Endowments at Public Universities and Related Foundations: A Growing Force?' Thesis (B.A.), Williams College, Department of Economics, 1992.

Winston, Gordon C., "Capital and Capital Service Costs in 2700 US Colleges and Universities," Discussion Paper No. 33, The Williams Project on the Economics of Higher Education, December, 1995.

Winston, Gordon C., and Ivan C. Yen, "Costs, Prices, Subsidies, and Aid in U.S. Higher Education," Discussion Paper No. 32, The Williams Project on the Economics of Higher Education, July, 1995.

Winston, Gordon C. "New dangers in old traditions: The reporting of economic performance in colleges and universities." Change, vol. 25, no. 1 (January/February, 1993): 18-23.

Winston, Gordon C. "The Capital Cost Conundrum," The NACUBO Business Officer, (June, 1993) pp. 22-27.

Winston, Gordon C., "The Necessary Revolution in Financial Accounting," Planning for Higher Education, Vol. 20, No. 4, (Summer, 1992), pp. 1-16.