PHYSICAL CAPITAL AND CAPITAL SERVICE COSTS IN U.S. COLLEGES AND UNIVERSITIES: 1993

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Physical capital creates a real problem for understanding the economics of higher education. It represents an important input to the production process — the essential services of buildings, equipment, and land — for which we have only highly inadequate measures. In conventional collegiate financial accounting, in fact, there has been *no* required recognition of capital services as the source of a cost of education even though it adds more than 30 percent to reported total costs.[1] The magnitudes are impressive: in total, U.S. higher education used physical capital with a replacement value of $387 billion in 1993 and the yearly cost of its capital services came to about $40 billion.

Much of the analysis of higher education, then, proceeds as if classes were held in wheat fields and vacant lots. We don't have an accurate sense of total educational costs or of cost differences among institutions — by public or private control or by type or wealth or region. We don't know how much of society's scarce resources are tied up in higher education. And, at the other end of the continuum, we neglect what is an individual institution's most visible symbol of what it provides for its students. Our data don't let us reflect the old truth that the most appealing college is one with beautiful buildings, attractive students, and slightly seedy professors.

But the neglect of physical capital in colleges and universities is probably most damaging in denying administrators the information on input costs that are essential to efficient management. So long as a scarce and important resource is seen to have an effectively zero price, misallocation is unavoidable [Winston, 1993b]. Unfortunately, while the method of capital cost estimation used in this study is appropriate for these managerial purposes, the data are not. So to the end of improving local institutional cost information, we can only hope that the present work will add both a methodology and a sense of urgency.

This paper has three objectives: to report estimates of the value of the capital stocks used by 3,148 colleges and universities in the United States in 1993 (virtually all of them), to give a sense of the distribution of physical capital and capital costs among different kinds of institutions within higher education, and to make these

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

Since T.W. Schultz' 1960 study of U.S. higher education [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 [1971] used a "perpetual inventory method" borrowed from the national accounts in which reported investment flows for each year were adjusted for inflation and depreciation and added up over a long period of time to estimate a resulting capital stock. Bowen and Douglass [1971] used experts' estimates of capital requirements for a hypothetical representative institution while Bowen, alone [1980], based estimates on "the rental value of comparable land, buildings, and equipment in the private market economy." Duc Le To [1987]used replacement values for buildings reported in HEGIS data from the U.S. Department of Education, a method similar to that used here though his objective was not to generate estimates for individual schools. 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, 163].

The capital stock estimates here are based on individual institutions' reports to the U.S. Department of Education (IPEDS — Integrated Postsecondary Educational Data System[3] — Financial Survey) for 1993. All of the 3,148 U.S. colleges and universities that reported both positive student enrollments and current fund expenditures for that year are included. The method of estimation is described in some detail in the Appendix; broadly, it uses reported capital stock figures to generate an estimate of the current replacement value of the buildings (B_r), equipment (E_r), and land (L_r) 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 the following two sections after which the capital service costs are described. We then compare the broad patterns of capital use in 1993 with those reported for 1967 in the pioneering work of O'Neill [1971].

The first section that follows looks at the distribution of the U.S. educational capital stock by institutional type and control, both in the aggregate and as it is divided among schools and among students[4] — which schools and which students have how much of the capital wealth. The next section looks at how that capital stock is distributed over the hierarchy of schools differentiated by wealth.[5]

THE DISTRIBUTION OF THE CAPITAL STOCK BY TYPE AND CONTROL

These 3,148 institutions have total capital stocks with a replacement value of $387 billion which gives the average school a capital stock of just over $123 million and equips the typical student (FTE) with $39,000 worth of buildings, equipment, and land.

When that aggregate capital stock is divided between public and private schools, roughly two-thirds is 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

Table Ia
Physical Capital Stocks In US Higher Education by Institutional Type, Control and Quality
Buildings, Equipment and Land, 1993

	Number of Institutions (1)	Average Enrollment (FTE's) (2)	Total Capital Stock (3)	Fraction of Total Capital Stock (4)	Average Capital Per School (5)	Average Capital Per Student (6)	Average Capital/ Output Ratio (7)	Average Capital/ Asset Ratio (8)
All Institutions	**3,148**	**3,163**	**$387,359,653,523**	**100.0%**	**$123,049,445**	**$38,908**	**2.22**	**90.4%**
Research	127	18,087	$163,027,678,025	42.1%	$1,283,682,504	$70,972	2.01	83.3%
Doctoral	110	8,984	$38,023,969,482	9.8%	$345,672,450	$38,476	2.20	89.8%
Comprehensive	514	4,616	$68,334,076,122	17.6%	$132,945,673	$28,803	2.34	90.8%
Liberal Arts	619	1,359	$37,548,934,183	9.7%	$60,660,637	$44,642	2.61	80.8%
Two-Year	1,132	2,692	$45,256,286,100	11.7%	$39,979,051	$14,849	1.95	98.1%
Specialized	646	634	$35,168,709,611	9.1%	$54,440,727	$85,927	2.26	87.4%
Research I	89	19,331	$135,517,510,402	35.0%	$1,522,668,656	$78,767	1.94	82.3%
Research II	38	15,173	$27,510,167,623	7.1%	$723,951,780	$47,712	2.18	85.7%
Doctoral I	52	9,946	$19,950,332,086	5.2%	$383,660,232	$38,576	2.25	89.5%
Doctoral II	58	8,122	$18,073,637,396	4.7%	$311,614,438	$38,365	2.16	90.1%
Comprehensive I	425	5,153	$62,679,959,410	16.2%	$147,482,257	$28,622	2.33	91.4%
Comprehensive II	89	2,051	$5,654,116,712	1.5%	$63,529,401	$30,980	2.39	87.7%
Liberal Arts I	165	1,518	$18,229,653,266	4.7%	$110,482,747	$72,762	2.79	63.6%
Liberal Arts II	454	1,301	$19,319,280,917	5.0%	$42,553,482	$32,713	2.55	87.1%
Two-Year	1132	2,692	$45,256,286,100	11.7%	$39,979,051	$14,849	1.95	98.1%
Specialized	646	634	$35,168,709,611	9.1%	$54,440,727	$85,927	2.26	87.4%

TABLE 1b
Physical Capital Stocks by Institutional Type, Control and Quality
Buildings, Equipment, and Land
1993

	Number of Institutions	Average Enrollment (FTE's)	Total Capital Stock	Fraction of Sector's Capital Stock	Average Capital Per School	Average Capital Per Student	Average Capital/ Output	Average Capital/ Asset Ratio Ratio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All Public	**1,406**	**5,349**	**$251,259,170,795**	**100.0%**	**$178,704,958**	**$33,407**	**2.15**	**98.6%**
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%	$51,384,783	$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%
All Private	**1,742**	**1,398**	**$136,100,482,728**	**100.0%**	**$78,128,865**	**$55,899**	**2.27**	**83.9%**
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	$6,044,751,367	4.4%	$262,815,277	$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%

much capital — at $179 million — as does the average private institution — with $78 million. The apparent superiority of public institutions is eliminated, though, when we look at physical capital per student : the average institution in the public sector has 5,300 students while the average in the private sector is 1,400. This means that the student in the private sector is equipped with almost 60 percent more capital than the typical student in a public institution.

The broad picture, then, is that the $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 associated with far less capital in the public than in the private sector.

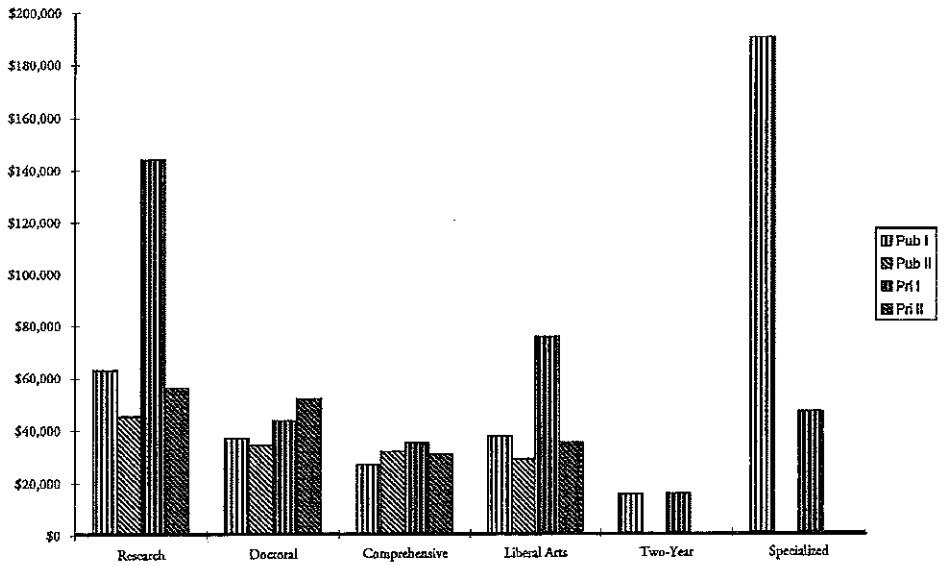
The next section of Table 1a puts public and private sectors together to describe the allocation of the U.S. capital stock by type of institution. The familiar Carnegie classifications are used that separate Research, Doctoral, and Comprehensive Universities, Liberal Arts and Two-year Colleges, and a catchall, Specialized Institutions. It's useful to concentrate at first on the six broad types of institution and ignore the further qualitative breakdown of these types into Carnegie quality levels I and II.

Research Universities have the lion's share of the U.S. educational capital, which is hardly surprising. The 127 such institutions have, in total, $163 billion or 42 percent of all the physical capital even though they represent only 4 percent of the schools. Further, the average Research University uses about $1.3 billion of physical capital and the typical student in the Research Universities is associated with $71,000 of capital stock. Once again, it is important to keep in mind that 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 affected by 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, giving different rankings depending on what comparisons are being made. Comprehensive Universities have the second largest amount of capital in the aggregate ($68 billion or 18 percent), 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. Two-Year Colleges are in a similar position with more than $45 billion or 12 percent 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 percent 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 again becomes relevant that we are reporting total institutional capital stock in each case so with their much greater concentration of activities on students, Liberal Arts Colleges most likely have the largest amount of student-oriented capital. Doctoral Universities are second to Research Universities in capital-

FIGURE 1
Physical Capital per Student by Control and Carnegie Type with Quality Levels



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 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: Research-II schools have only half as much capital per school and 60 percent as much per student as their more highly ranked peers. 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 percent less — at the same time that an institutions' capital is almost 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.

Finally, if we look at Carnegie type and public/private control dimensions, together, we see capital allocations by institutional type separately for public and private sectors. In addition to Table 1a, this is summarized in Figure 1.

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

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 percent 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 percent that of public Research-I institutions. In the private sector, Research-II schools do relatively worse with only 39 percent as much capital per student as Research-I institutions, though they still have 25 percent more than the public Research-II Universities.

In colleges, too, the gap between Liberal Arts-I and -II is large: students in the second-tier private Liberal Arts schools have only 46 percent as much capital as those in the first-tier schools. Note that it is not useful to make much of the figures for public Liberal Arts-I schools since there are only six of them in the population.[6] Figure 1 also reveals two anomalies that we can't explain without going much farther into Carnegie's classifications. Public Comprehensive Universities and private Doctoral Universities, Carnegie I institutions have, on average, less capital per student than Carnegie II institutions.

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 percent 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 religious schools (51 percent). Specialized schools are not quality-ranked in the Carnegie classification.

The last two columns of Table 1b 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.[7] 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 their students are. 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 the table describes the relative importance of physical capital in total assets[8] with the predictable result that private institutions, with their greater endowment wealth, have a smaller fraction of their total assets in the form of physical capital than do public institutions. It is notable, though, that among public institutions, even Research-I Universities have the vast majority (92.4 percent) of their assets in a physical form.[9] Overall, the average private institution has 83.9 percent of

its assets in physical form while the average public institution has 98.6 percent. Among private institutions, Research-I Universities have the smallest share of their assets tied up in physical capital, with 61.4 percent, followed closely by Liberal Arts-I schools, with 62.3 percent, and Research-II Universities, with 63.7 percent. Private Two-Year Colleges look a lot like the public institutions with 95.0 percent of their assets in the form of physical capital.

THE DISTRIBUTION OF THE CAPITAL STOCK BY SUBSIDY RANKING

This section looks at how the capital stock is distributed among wealthy and poor institutions as measured by the level of their student subsidies. Winston and Yen [1995] provided evidence that these subsidies and the ability to award them describe a hierarchy of colleges and universities with important ramifications for their price, quality, size, and aid policies.

The most central results from that analysis[10] are these:

- That in sharp contrast to an intuition based on ordinary businesses — or the microeconomic and I-O theory they support — colleges and universities charge their customers prices that are far below their costs of production in equilibrium. The price/cost ratio for the average U.S. school in 1991 was 1/3 and in the public sector, taken alone, it was 1/9. Customers paid 30 cents and 11 cents, respectively, on the dollar of cost.
- That the subsidy resources — broadly, "wealth" — that pay for the difference between price and cost (appropriations, gifts, and returns on assets) are *very* unevenly distributed.
- That this subsidy hierarchy is also a hierarchy of costs, prices, selectivity, student quality, and institutional prestige.

In Tables 2a and 2b, 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. Subsidies per student range from an average of $22,619 a year for those 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 $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 — the beautiful campuses that go with seedy professors.

TABLE 2a
Physical Capital Stocks by Institutional Wealth
Buildings, Equipment and Land, 1993

	Average Enrollment (FTE's) (1)	Average Subsidy Per Student (2)	Total Capital Stock (3)	Fraction of Capital Stock (4)	Average Capital Per School (5)	Average Capital Per Student (6)	Average Capital/ Output Ratio (7)	Average Capital/ Asset Ratio (8)
All Institutions	**3,543**	**$7,635**	**$371,772,644,972**	**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	$23,241	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%

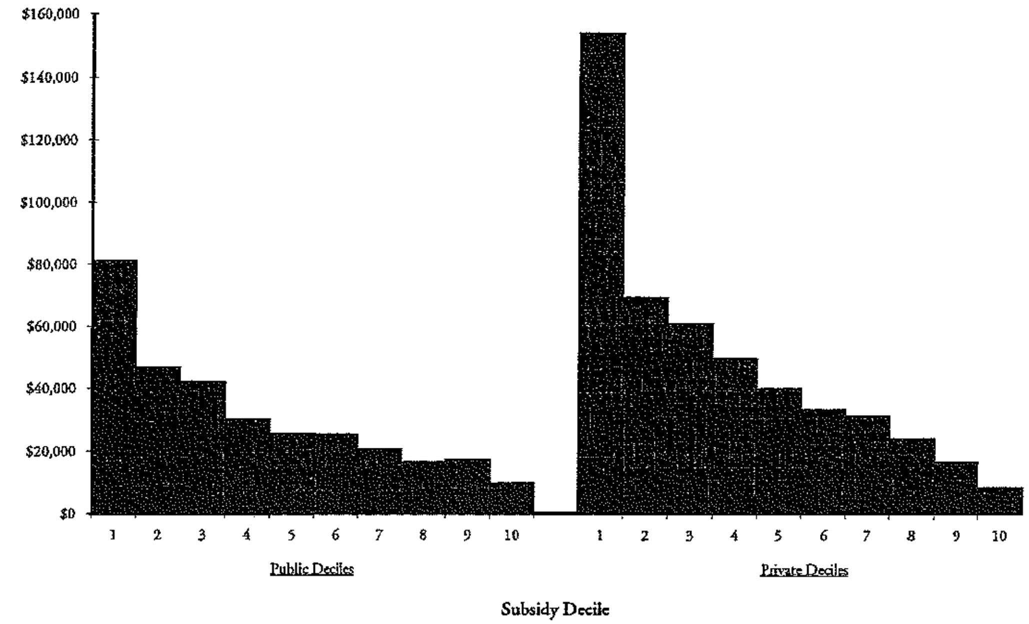
*The 2,773 US Institutions reporting in the Integrated Postsecondary Educational Data System in 1993 with undergraduate enrollment ≥ 20% and ≥100 FTE.
All Deciles have 278 or 277 institutions.

TABLE 2b
Physical Capital Stocks by Institutional Wealth
Buildings, Equipment and Land, 1993

	Average Enrollment (FTE's) (1)	Average Subsidy Per Student (2)	Total Capital Stock (3)	Fraction of Sector's Capital Stock (4)	Average Capital Per School (5)	Average Capital Per Student (6)	Average Capital/ Output Ratio (7)	Average Capital/ Asset Ratio (8)
All Public	**5,406**	**$8,088**	**$244,464,757,605**	**100.0%**	**$176,254,331**	**$32,606**	**2.15**	**98.6%**
Decile 1	5,553	$22,619	$62,628,341,837	25.6%	$450,563,610	$81,133	2.43	96.7%
Decile 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%
All Private	**1,680**	**$7,182**	**$127,307,887,367**	**100.0%**	**$91,852,733**	**$54,678**	**2.26**	**84.1%**
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%

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

FIGURE 2
Physical Capital per Student
by Institutional Wealth and Control



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 student in a private school pays 24.7 cents on the dollar while one in the least subsidized decile pays a full 91.6 cents.

Comparing the amount of capital used in public and private schools arranged by size of student subsidy — Table 2b and Figure 2 — 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 2a. Lower subsidies still go with use of less capital. But it is the skewness of the capital allocation in the private sector — and its moderation in the public sector — that comes through most clearly in Table 2b. Fully 43 percent of all private sector capital stock — almost half — is concentrated in the 10 percent of 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.

TABLE 3
Current Costs and the Distortions from Omitting Capital Services by Type, Control and Quality, 1993

	Number of Institutions (1)	Current Expenditure[a] (2)	Annual Cost of Capital Services (3)	Distortion for Average School (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	$2,081,779,255	30.9%
Doctoral I	29	$3,917,670,000	$1,423,695,967	35.3%
Doctoral II	36	$4,581,269,000	$1,253,313,645	31.3%
Comprehensive I	246	$14,640,281,000	$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	$21,757,296,000	$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	$311,606,654	31.2%
Liberal Arts I	159	$4,418,938,000	$1,819,266,719	41.4%
Liberal Arts II	378	$3,966,511,000	$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%

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

The last two columns of Tables 2 show a strong decline in capital-output ratios with falling subsidies in the aggregate data indicating 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.

THE COSTS OF CAPITAL SERVICES — AND DISTORTION WHEN THEY ARE IGNORED

Everything to this point has been in terms of capital *stocks* and their distribution. 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 remains. While, as noted in the introduction, these data can't provide an individual school's administration with information on its own capital costs, they can, usefully, indicate how important are the costs that they conventionally neglect. To that end, we turn first to the data of Tables 3 and 4 that report the percent by which total yearly costs[12] are increased when we recognize the costs of capital services. Table 3 disaggregates by public and private control and Carnegie type while Table 4 breaks the population down by subsidy decile.

The top three lines of Table 3 show annual current expenditures and capital service costs for all institutions together 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]
- 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 4 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.

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 4 suggests that 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

TABLE 4
Current Costs and the Distortions from Omitting Capital Services by Institutional Wealth and Control, 1993

	Average Subsidy Per Student (1)	Current Expenditures (2)	Annual Cost of Capital Services (3)	Distortion for Average School (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	$10,713,372,000	$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	$548,510,046	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%

TABLE 5
Physical Capital Stocks in US Higher Education: 1967 and 1993 (in 1993 Dollars)

	Number of Institutions (1)	Enrollment (FTEs) (2)	Fraction of Enrollments Stock (3)	Total Capital (4)	Fraction of Capital Stock School (5)	Average Capital Per Student (6)	Average Capital (7)
				1967 - O'Neill's Data			
All Institutions	**2,491**	**6,438,500**	**100.0%**	**$126,482,963,696**	**100.0%**	**$50,775,979**	**$19,645**
Public Institutions	(a)	4,381,100	68.0%	$75,542,792,079	59.7%		$17,243
Private Institutions	(a)	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

a. The number of public and private institutions is not reported. SOURCE: O'Neill, 1971.

TABLE 6
Capital Service Costs as a Fraction of Total Costs: 1967 and 1993 (in 1993 dollars)

	Number of Institutions (1)	Current Expenditures (2)	Annual Cost of Capital Services (3)	Total Cost (4)	Capital Cost/ Cost (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	(a)	$32,473,030,960	$5,994,102,153	$38,467,133,113	15.6%
Private Institutions	(a)	$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%

a. The number of public and private institutions is not reported. SOURCE:O'Neill, 1971.

dramatic when reported over all public (29.5 percent) and all private (33.6 percent) institutions aggregated in Table 3, they become clearer in Table 4 where schools of comparable wealth can be seen so that the concentration of that distortion in the wealthiest schools is more clearly revealed. Looking at the top decile of each sector, distortion due to omitted capital costs is 57 percent higher in private than in public schools (21.3 percentage points) while in the bottom decile, it is 12 percent lower in private schools (2.6 percentage points). And the transition between them is relatively smooth.

THE LONG TERM — A COMPARISON WITH O'NEILL'S 1967 CAPITAL ESTIMATES

This final section briefly compares our results for 1993 to the 1967 data on capital reported in O'Neill [1971]. Her estimates are reported in Tables 5 and 6, in 1993 dollars, along with our comparable estimates.

O'Neill's methods were different from ours, but if consistent, we would not expect those differences to affect the direction of changes observed in the *distribution* of capital between public and private sectors. So it appears from the table that while the stock of capital in the public sector has grown faster than that in the private sector over this 26-year period — from $76 billion in the public sector or 60 percent of the total capital in 1967 to $251 billion or 65 percent in 1993 — that growth has been overwhelmed by an even faster growth in public sector enrollments — from 4.4 million or 68 percent of the total in 1967 to 7.5 million or 76 percent 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 percent as much capital as the student in the private institutions but by 1993 he had only 60 percent as much. This is consistent with McPherson, Schapiro, and Winston's finding that plant additions per student grew more than twice as fast 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,[16] but with that caveat, it appears that the amount of capital used in higher education grew considerably over the period. In these data, 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 the use of other inputs to higher education though capital's share of total higher education expenditures in Table 6 increased from 15 percent in 1967 to 21 percent in 1993. This difference is explained in part by the interest rate increase between those dates — in O'Neill's period, 5 percent represented the opportunity cost of physical capital while 7.89 percent was appropriate in the later period.[17] Nonetheless, higher education appears to have become more capital-intensive over these two and a half decades.

CONCLUSIONS

The capital stock used in U.S. higher education is simply very large, very important, 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 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 U.S. 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 have answered those and similar questions.

And data like those presented here, built up from individual institutions, allow 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 other dimensions. To repeat an earlier caveat, however, it is not advisable to put much faith in these numbers *disaggregated* for any individual institution 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 off the mark in unbiased ways. So we make far more confident claims for the validity of the kinds of aggregate results reported here than we could for those for 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 neglecting to consider the costs of capital services.[18] On the one hand, they fly nearly blind in the broad portfolio decisions they make whenever they alter the allocation of their institutional 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 even a hint of the value of the capital services those assets contribute to the enterprise. On the other and even more significant hand, neglect of the costs of physical capital services guarantee internal misallocation of their scarce resources and makes the delegation of production decisions further down in the organization virtually impossible since those decisions cannot realistically reflect the important costs of capital services.

Some $387 billion of buildings, equipment, and land is inadequately accounted for in U.S. higher education, leading to a distortion in reported costs of nearly $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 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. In terms of educational costs, the distortion that results from omitting capital services range from roughly 25 percent for Research-I Universities, both public and private, to more than 40 percent 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 or administration that ignores them.

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

This appendix provides 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[19] as well as the book value of the land used.[20] The 1995 study of capital used numbers from the study of institutions' student subsidies [Winston-Yen, 1995], 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[21] 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.

CAPITAL SERVICE COSTS

From the replacement values of a school's buildings (B_r), equipment (E_r), 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 percent, near the middle of the range suggested by campus physical planners [Dunn, 1989; Probasco, 1991][22], and for opportunity cost, the five-year average of the long term Federal bond rate, which was 7.89 percent 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 $(d + r)(B_r + E_r) + rL_r$.

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_r) for buildings.
2. 541 schools reported the book value of buildings (B_b) but not their replacement value (B_r). To estimate the latter, we used the 2,145 reported values of both to generate the coefficient, $B_r \doteq 2.218B_b$ and fill in missing building replacement values.
3. 2,002 schools reported both book (E_b) and replacement values (E_r) 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_r) and equipment (E_r).
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, $E_r = 0.306B_r$.[23]
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.[24]
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 $L_b = 0.027(B_r + E_r)$.
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 current replacement values for buildings, equipment, and land for each of the 3,148 schools. These are discussed in the first two sections in the text. From these data, the yearly costs of total capital services for each school were estimated as, for the ith school, $.025(B_i + E_i) + .0789(B_i + E_i + L_i)$ since $d = .025$ and $r = .0789$. These capital cost data are reported in the section, "The Costs of Capital Services" 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 percent undergraduate enrollment were not included in the subsidy estimates. In the 1993 data of this paper, the first of these restrictions eliminated 364 schools and 105,950 FTE students (11.6 percent of schools or 1.1 percent of students) while the second eliminated 8 schools and 14,620 FTE students.[25]

Educational capital costs were allocated in proportion to the role of educational expenditures in total current expenditures, $Educational\ Expenditures_i/(E\&G_i + Auxiliary_i + Hospital_i + Independent\ Operations_i - Scholarships\ \&\ Fellowships_i - Mandatory\ and\ Non\text{-}mandatory\ Transfers_i)$, 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. Note that the first of these 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.[26] As noted in the text, Mandatory Transfers represented only 1.4 percent 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* all of its capital stock outright (whether or not it is used as collateral on indebtedness). Once Mandatory transfers are disposed 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 but *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 *will not* distort the measure of total capital costs. We doubt that double counting of costs in the presence of rented capital is of practical moment, but we can't be sure. [Winston, 1993b]

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 [Winston, 1992]. 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.[27]

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.

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 1,000,000 resulting, clearly, from misplaced decimal points. Others are values that embed 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 1991. When that comparison revealed an error as a simple multiple of 10 to 1,000,000, 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.

NOTES

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 [1995], though it uses a larger and more appropriate population and updates the results from 1991 to 1993.

1. For a discussion of the sometimes-arcane reasons for this and the prospects for change, see Winston [1993b].
2. Contact the authors at gwinston@Williams.edu or elewis@Williams.edu.
3. From CASPAR, ver. 4.4.
4. Though it is important that these are figures for *total* institutional capital and not just that portion allocated to educational purposes.
5. Bradburd and Mann [1993] usefully describe the wealth equivalent of e.g. appropriations flows. It is in that sense that non-tuition resources measure wealth.
6. 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.
7. 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. As noted above and developed extensively in Winston [1995; 1996], the fact that price-cost ratios in higher education are much less than one recommends measuring output as cost, not price times quantity. In a competitive for-profit firm, they would, of course, come to the same thing. And problems of multiple product output are no more nor less serious here than in any aggregate capital-output ratio.
8. 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, 1992]. 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.
9. 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, 1992]
10. See, too, Winston [1996].
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 in 1991 Cooper Union granted a $33,030 subsidy by giving a $33,030 education at a zero price while Williams gave a similar $33,244 subsidy by charging $13,182 for an education that costs $46,426 to produce. And, of course, the opportunity costs of capital accrue to its owner as income in kind matches imputed rent — as in the national accounts. So all of an institution's assets support its subsidies.
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 percent of total current expenditures, so it did not seem necessary to honor that distinction.

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.
15. As does Table 5 in showing declining capital-output ratios by subsidy decile.
16. 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.
17. Note, too, that the numbers in Table B-2 [O'Neill, 1971] 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.
18. Or their inaccurate measure as book values.
19. 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.
20. So IPEDS asked schools to report, for all of the capital used in their activities: book values of buildings (B_b), equipment (E_b), and land (L_b), along with replacement values for buildings (B_r) and equipment (E_r).
21. 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].
22. Alternative approaches to depreciation 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 percent and 5.0 percent 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 percent — reassuringly close to our 2.5 percent.
23. Note that this coefficient is substantially larger than Brinkman's reported in Duc-Le To [1987].
24. 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.
25. 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.
26. 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.
27. In a set of stable competitive markets with perfect information, net physical worth would describe the market price of the capital stock.

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