Chapter 11
HBCUs:
Efficiencies of Creating a Scientific Workforce Outta Fifteen Cents

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ABSTRACT

Using data from the Integrated Postsecondary Educational Data System (IPEDS) and the NSF Awards Database, this study generates productivity per dollar invested (PDI) by the National Science Foundation (NSF) to support the creation of scientific research and undergraduate science and engineering scholars. The PDI is comprised of three components 1) faculty development; 2) undergraduate development; and 3) organizational development. The PDI is a metric for how efficient HBCUs and non-HBCUs are at using grant dollars to produce undergraduate science and engineering degrees. There is no statistical difference between the PDI for HBCUs and non-HBCUs. However given the difference in average grant funding, HBCUs produce more undergraduate scientists more efficiently.

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BACKGROUND

The disparate treatment of black colleges dates back to 1862 with the establishment of the Morrill Act, which authorized the creation of land grant colleges. The land grant system of education has essentially four major areas of operation: resident instruction, military training, extension service, and research and experimentation. The Second Morrill Act of 1980 provided access to a land grant education for blacks, but also sanctioned the "separate but equal" doctrine with respect to higher education. The Second Morrill Act states,

Provided, that no money shall be paid out under this act to any State or Territory for the support and maintenance of a college, where a distinction of race or color is made in the admission of students, but the establishment and maintenance of such colleges separately for white and colored students shall be held to be a compliance with the provisions of this act, if the funds received in the State or Territory be equitably divided as herein- after set forth (Brunner, 1966, p. 69)

The Secretary of the Interior suggested that states allocate funds based on the percentage of black and white students in each state's public school population.[1] This funding formula was also used in the allocation of the Nelson Amendment of 1907 for resident instruction in agriculture and mechanic arts. This funding formula suggests that the cost of equal educational opportunity is a function of the number of students and fails to account for the additional expenses associated with natural and physical sciences and engineering instruction.

By the late 1920s, blacks constituted 23% of the population; hence, black land grants received 23% of the 1.5 million of the Morrill-Nelson funds allocated to the 17 border and segregationist states (Kujovich, 1993-1994). Kujovich states,

Unequal resources and racial isolation dominated black public higher education from its beginnings in the 1870s to the Supreme Court's decision in Brown v. Board of Education…Between the enactment of the Second Morrill Act in 1890 and the NAACP's successful challenge to separate but equal in the 1940s, black public colleges suffered substantial, consistent, and nearly universal discrimination in funding. The gross disparity in the allocation of public funds is most clearly evident in the land grant colleges; the main stays of the black system. (p. 76)

The funding inequities were not limited to resident instruction, but were also present in the allocation of funding for research and cooperative extension. Cooperative extension research was funded by the Hatch Act (1887), Smith-Lever Act (1914) and Purnell Act (1925). The Smith-Lever Act stipulated that funds "be administered by such college or colleges as the legislation of such state may direct." Since all 17 border and segregationist states allocated all of their funding to the white land grants, black land grants were excluded from significant participation in the program that became the hallmark feature of the land grant's contribution to the economic, social and industrial progress of the nation. Consequently, by 1937, West Virginia State University was the only black land grant receiving federal research funding – "the paltry sum of $1,800" (Kujovich, 1993-1994).

The consequence of inequitable funding was most evident in the curriculum. Alabama and Georgia's public black colleges, which served nearly 70 percent of each state's black population, offered no instruction in physics, chemistry or biology (Kujovich, 1994). Again Kujovich (1994) provides a detailed description of the consequences of inequitable funding had on the curriculum. He finds:

1. Six of the black schools did not offer a degree in agriculture.
2. Home economics curriculum included courses in clothing, tailoring, home management, laundering, and household physics.
3. No programs in architecture, literature, journalism, psychology, geology, geography, anthropology or philosophy, accounting, marketing, advertising, banking and finance, manufacturing or management.
4. No engineering curriculum in 14 of 17 states.
5. Limited access to instruction in political science or government, or foreign language.

Sharpe (2005) finds that the advantages bestowed to white land grants extends beyond the student body to the faculty. Faculty at white land grant institutions in the 17 border and segregationists states for 2000 – 2001 were paid more at every rank; white land grants are classified as doctoral extensive and are ranked higher in prestige. The disparities in funding of public black education are not limited to land grant institutions. Sav (1997) reports the federal government has compensated when states have failed in "relative terms" to support historically black colleges and universities (HBCUs). Sav (2010) finds that the differential in state support for HBCUs can be explained by differences in institutional characteristics. The differences in institutional characteristics are an outgrowth of historical funding disparities. Yet despite these institutional character and funding differences, HBCUs produce a disproportionate share of African American bachelor's degrees and black engineers and scientists and are the top producers of undergraduates that go on to complete the doctorate.

However instead of the public discourse about HBCUs focusing on their contribution to the scientific workforce, *Fisher v. University of Texas, Ayers v. Fordice* and Gainful Employment regulation have fueled conversations about the need for efficacy and efficiency of HBCUs.

This study seeks to alter the conversation about HBCUs to focus on their contribution to the scientific workforce. This study will address the efficiency of HBCUs. Specifically, this paper provides a productivity per dollar invested (PDI) estimate for tax payers by analyzing the number bachelor level scientists and engineers produced by HBCUs relative to the funding received from the National Science Foundation (NSF). The PDI will be comprised of three components 1) productivity for grants for research – a proxy for faculty development; 2) productivity for student development grants – proxy for undergraduate development, recruitment and faculty-student interaction; and 3) productivity for curriculum development and infrastructure improvements – proxy for organizational development. The PDI will be used as metric for efficiency and will be computed for HBCUs and non-HBCUs.

Data and Methodology

The data for this study came from two sources: Integrated Postsecondary Educational Data System (IPEDS) and the NSF Awards Database. IPEDS data was limited to the years 2004-2013. IPEDS data was used to identify the number of bachelor's degrees in science and engineering awarded for each institution. Table 1. provides a list of science and engineering disciplines as defined by the NSF and used in this study. This list is appropriate for this study because these disciplines may receive funding from the NSF. IPEDS data produced 1,007,228 observations for 1964 unique FICE codes. The NSF grants data was limited to grants that began in 2004, which produced 31,960 observations. The IPEDS and NSF data sets were merged matching on institution name. Institutions not in both datasets were dropped from the sample. The final dataset had 335,823 observations and 709 institutions. Community Colleges were not included in sample.

The formula for calculating PDI is

$$PDI_T^i = \frac{F_T^i}{BS_T^i} + \frac{S_T^i}{BS_T^i} + \frac{O_T^i}{BS_T^i} + \frac{OT_T^i}{BS_T^i} \tag{1}$$

where $\mathrm{PDI}_\mathrm{T}^\mathrm{i}$ is productivity per dollar invested for institution, i, and takes values 1 if HBCU; 0 if non-HBCU for time T. $\mathrm{F}_\mathrm{T}^\mathrm{i}$, S_T^i, $\mathrm{O}_\mathrm{T}^\mathrm{i}$, and $\mathrm{OT}_\mathrm{T}^\mathrm{i}$ are the total awards

Table 1. Science and engineering disciplines

Agricultural Sciences	Economics
Biological Sciences	Political Science
Atmospheric Sciences	Sociology
Earth and Ocean Sciences	Other Social Sciences
Computer Sciences	Aerospace Aeronautical and Astronautical Engineering
Mathematics	Chemical Engineering
Astronomy	Civil Engineering
Chemistry	Industrial and Manufacturing Engineering
Physics	Material Science Engineering
Psychology	Other Engineering

Appendix B (National Science Foundation, 2015)[23]

for F=faculty development, S = student development, O = organizational development and OT = other development. Faculty development is defined as grants awarded to faculty for research, workshops or travel. Student development is defined as grants that support undergraduate scholarships. Organizational development is defined as grants for equipment or curriculum changes. Other development is defined as graduate student, dissertation support or support that does not fit into the other categories. All categories are mutually exclusive. BS^i_T is the number of science and engineering BS degrees awarded by institution, i, in time T.

While PDI is regularly used in efficiency studies, the estimates of PDI may overstate or understate productivity for at least three reasons. First, data do not allow for the allocation student's educational expenses that were covered by a grant. Even when students receive scholarships for tuition, other educational expenses may be covered in part by NSF grants support; hence, PDI may be overstated. Second, funding to support dissertation research is included. This funding is not likely to directly impact undergraduate education. Finally, although students may not be directly supported by grant funding, there are spillover effects from the human capital development of faculty, graduate students, and the improvement to facilities and instructions. Students who do not graduate with a science or engineering degree may reap benefits from grant funding; therefore, PDI may be understated.

For both HBCUs and non-HBCUs, faculty research was the largest share of grants awarded, 84 percent and 87 percent, respectively. Given that nine HBCU are considered research universities – high research activity or doctoral research universities, the number of research grants awarded to HBCUs suggests that HBCUs are engaged in research. [4] Additionally, HBCUs received at least 1% of the research grants awarded, which is proportional to or greater than their share of the total number of grants awarded. Therefore, this may be viewed as an equitable distribution based on the number of research grants funded. See Table 2 for grants awarded.

However, equitable distribution based on the number of grants does not mean an equitable distribution of grant funding. Table 3 provides the amount of grant funding awarded to HBCUs by year. Table 4 shows that the distribution of grant funding is not equitable. While HBCUs were 1 percent of all grants awarded, they were only .2 percent of the total faculty research and total grant dollars awarded. This means that the faculty at HBCUs receive a trivial amount of funding to generate new knowledge and advance science relative to Non-HBCU faculty. It also means that the opportunities for students at HBCUs to engage in research is limited, which could have negative consequences for student interest in and preparedness for completing graduate education.

HBCUs received a larger share of funding for student development and organizational development, 3.7 percent and 9.6 percent, respectively. The larger share of student development funding is likely due to the high proportion of promising students from low-income households and students who are first generation. The nearly 10 percent share of funding for organizational support may be to offset the lack of endowments available for investment in institutional improvements. Despite the larger share of grant funding for student and organizational development, the total grant funding receive by HBCUs is not proportional to their share of the number of grants awarded. Therefore, using proportionality as a metric, the distribution of grant dollars is not equitable.

Table 5 provides the summary statistics. There were 335,823 observations for non-HBCUs representing 664 institutions and 11,581 observations for non-HBCUs representing 45 institutions. On average, non-HBCUs produced 11,432 science and

Table 2. Grants awarded

	HBCU	Non-HBCU	Total	HBCU Share
Faculty Research	156	15,088	15244	1%
Undergraduate Scholarships	14	344	358	4%
Organizational Development	17	157	174	10%
Other Support	0	966	966	0
Total Grants	187	16,555	16742	1%

Table 3. Total grant funding by type and year

Non-HBCU	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Faculty Research	44,800	49,400	52,900	50,800	59,700	56,400	65,000	61,400	56,600	61,400	558,400
Student Scholarships	238	141	138	171	108	150	131	274	143	239	1,733
Organizational Development	33	42	19	31	40	22	42	42	42	17	331
Other Support	21	38	35	27	38	26	31	46	37	46	345
Total Grant Support	45,092	49,620	53,092	51,029	59,886	56,598	65,204	61,762	56,822	61,702	560,808
HBCU	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Faculty Research	173	72	52	20	74	186	19	108	79	86	869
Student Scholarships	0	11	0	5	0	5	11	15	12	7	66
Organizational Development	3	1	0	9	2	3	6	5	2	3	35
Other Support	0	0	0	0	0	0	0	0	0	0	0
Total Grant Support	176	84	53	34	76	194	36	128	92	96	970
All Institutions	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Faculty Research	44,973	49,472	52,952	50,820	59,774	56,586	65,019	61,508	56,679	61,486	559,269
Student Scholarships	238	152	138	176	108	155	142	289	155	246	1,799
Organizational Development	37	42	19	40	42	25	48	48	44	20	366
Other Support	21	38	35	27	38	26	31	46	37	46	345
Total Grant Support	45,269	49,705	53,145	51,063	59,962	56,792	65,240	61,891	56,914	61,798	561,778

Values are in 100,000 thousands.

Table 4. Percentage of grant funding by type and year

Non-HBCU	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Faculty Research	99.6	99.9	99.9	100.0	99.9	99.7	100.0	99.8	99.9	99.9	99.8
Student Scholarships	100.0	92.7	100.0	97.2	100.0	96.6	92.4	94.7	92.5	97.2	96.3
Organizational Development	90.4	98.2	97.4	77.2	96.0	88.2	87.7	89.0	94.8	85.0	90.4
Other Support	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Grant Support	99.6	99.8	99.9	99.9	99.9	99.7	99.9	99.8	99.8	99.8	99.8
HBCU	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Faculty Research	0.4	0.1	0.1	0.0	0.1	0.3	0.0	0.2	0.1	0.1	0.2
Student Scholarships	0.0	7.3	0.0	2.8	0.0	3.4	7.6	5.3	7.5	2.8	3.7
Organizational Development	9.6	1.8	2.6	22.8	4.0	11.8	12.3	11.0	5.2	15.0	9.6
Other Support	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Grant Support	0.4	0.2	0.1	0.1	0.1	0.3	0.1	0.2	0.2	0.2	0.2

engineering degrees compared to 3,881 science and engineering degrees produced by HBCUs. There is also a large gap between the average awards for faculty research $1.16 mil for non-HBCUs compared to $350,000 for HBCUs. However, HBCUs received more support on average for student development, $60,544 compared to $60,687, and for organizational development $3,700 compared to $6,995. HBCUs received no awards for other development. The average grant award for non-HBCUs was $1.196 mil compared to $417,908 for HBCUs.

The difference in average grant award to HBCUs and Non-HBCUs is $777,611. To put the differential into perspective, the funding differential could be used to support 2 more grants for faculty research, 10 more grants for student development or 100 grants for organizational development awarded to HBCUs. However, the focus of this paper is not on the funding differentials between HBCUs and non-HBCUs, but on how efficient each is at producing undergraduate scientist.

Solutions and Recommendations

Table 6 provides the productivity per dollars invested estimates along with the means and standard deviations. Given that PDI is a measure of efficiency, a lower

Table 5. Summary statistics

Non-HBCU	Observations	Mean	Std. Dev.	Min	Max
BS Degrees	335,823	11,432	11,185	3	50,087
Faculty Research	335,823	1,164,717	1,957,135	0	16,500,000
Student Scholarships	335,823	26,544	121,566	0	3,000,000
Organizational Development	335,823	3,700	27,334	0	3,190,230
Other Support	335,823	558	4,935	0	550,000
Total Grant Support	335,823	1,195,519	1,942,664	1	16,500,000
Faculty Research Percent	335,823	0.8905197	0.3122413	0	1
Student Scholarships Percent	335,823	0.0551421	0.2282578	0	1
Organizational Development Percent	335,823	0.0293488	0.1687825	0	1
Other Support Percent	335,823	0.0249894	0.1560928	0	1
HBCUs	**Observations**	**Mean**	**Std. Dev.**	**Min**	**Max**
BS Degrees	11,581	3,881	3,638	197	15,062
Faculty Research	11,581	350,226	388,354	0	2,897,371
Student Scholarships	11,581	60,687	176,790	0	1,163,001
Organizational Development	11,581	6,995	31,297	0	374,767
Other Support	11,581	0	0	0	0
Total Grant Support	11,581	417,908	367,141	10,000	2,897,371
Faculty Research Percent	11,581	1	0	0	1
Student Scholarships Percent	11,581	0	0	0	1
Organizational Development Percent	11,581	0	0	0	1
Other Support Percent	11,581	0	0	0	0
All	**Observations**	**Mean**	**Std. Dev.**	**Min**	**Max**
BS Degrees	347,404	11,181	11,100	3	50,087
Faculty Research	347,404	1,137,565	1,931,086	0	16,500,000
Student Scholarships	347,404	27,682	123,956	0	3,000,000
Organizational Development	347,404	3,810	27,482	0	3,190,230
Other Support	347,404	539	4,853	0	550,000
Total Grant Support	347,404	1,169,597	1,916,276	1	16,500,000
Faculty Research Percent	347,404	0.8889823	0.3141545	0	1
Student Scholarships Percent	347,404	0.0568704	0.2315951	0	1
Organizational Development Percent	347,404	0.029991	0.1705627	0	1
Other Support Percent	347,404	0.0241563	0.1535345	0	1

Table 6. Average productivity per NSF grant dollar

Non-HBCU	Observations	Mean	Std. Dev.
PDI- Faculty	15,088	239.22	4.20
PDI - Undergraduate	344	507.39	326.63
PDI-Institution	157	90.82	54.03
PDI-Other Support	966	2.15	7.76
HBCU	**Observations**	**Mean**	**Std. Dev.**
PDI- Faculty	156	169.11	16.56
PDI - Undergraduate	14	273.07	81.50
PDI-Institution	17	84.71	15.72
PDI-Other Support	0	0.00	0.00
All Institution Type	**Observations**	**Mean**	**Std. Dev.**
PDI- Faculty	15,244	238.50	4.17
PDI - Undergraduate	358	498.23	313.86
PDI-Institution	174	90.23	48.76
PDI-Other Support	966	2.15	7.76

PDI value suggests the institution type is more efficient at producing undergraduate scientists. The values in Table 6 are grant dollars per undergraduate scientist produced. For example, PDI-Faculty for non-HBCUs was $239 compared to $169 for HBCUs, which means non-HBCUs spent $239/undergraduate scientist produced compared to $169/undergraduate scientist produced spent by HBCUs. Using a similar comparison for the remaining values in Table 6, HBCUs spent less grant money per undergraduate scientist produced.

In order to make sound policy recommendations, the PDI values should be statistically different. Hypothesis testing is used to determine if the difference is statistically significant. For the difference to be statistically significant, the t-value must be greater than 1.96. Table 7 provides the results from the hypothesis test comparing the mean values of PDI. The difference between PDI-Undergraduate for non-HBCUs and HBCUs is $234.33, $507.40 less $273.07. This difference indicates that non-HBCUs spent $234 more per undergraduate scientist produced than did HBCUs; however, the t-value of .1445 is less than 1.96. Hence, the difference of $234 is not statistically different. Although, HBCUs have lower PDI values, the hypothesis tests show no statistical difference between the PDI values of HBCUs and non-HBCUs. Hence, HBCUs are as efficient as non-HBCUs with respect to utilizing grant dollars to produce undergraduate scientists.

Table 7. Hypothesis testing for PDI

Undergraduate	Observations	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
non-HBCU	344	507.39	326.63	6057.99	-135.05	1149.8
HBCU	14	273.07	81.50	304.96	96.99	449.15
combined	358	498.23	313.86	5938.48	-119.01	1115.5
diff		234.32	1621.32		-2954.25	3422.9
t = .1445	degrees of freedom = 356					
Faculty	**Observations**	**Mean**	**Std. Err.**	**Std. Dev.**	**[95% Conf. Interval]**	
non-HBCU	15,088	239.22	4.20	516.43	230.98	247.46
HBCU	156	169.11	16.56	206.84	136.40	201.83
combined	15,244	238.50	4.17	514.25	230.34	246.67
diff		70.11	41.38		-11.01	151.22
t = 1.6941	degrees of freedom = 15,242					
Institution	**Observations**	**Mean**	**Std. Err.**	**Std. Dev.**	**[95% Conf. Interval]**	
non-HBCU	157	90.82	54.03	676.96	-15.90	197.54
HBCU	17	84.71	15.72	64.80	51.40	118.03
combined	174	90.23	48.76	643.14	-6.01	186.46
diff		6.11	164.69		-318.97	331.18
t = .0371	degrees of freedom = 172					

While there is no difference in the PDI values, the disparity in average grant funding to HBCUs implies that HBCUs are doing more with less grant funding. NSF's "Report to Congress on Advancing Historically Black Colleges and Universities" recognizes the need to increase grant participation from HBCUs. A summary of the key recommendations for HBCUs and NSF are:

HBCUs should:

1. Work to identify internal impediments that hinder faculty from generating and submitting grant proposals, which include single investigator and Faculty Early Career Development Program Awards;
2. Increase support given to junior faculty and partner with local research centers to increase research participation of faculty and students;
3. All grant proposals to Education and Human Resources must include a 10-year plan to increase research activities and support.

NSF should:

1. Examine collaborations with HBCUs to identify ways to encourage single investigator awards;
2. Provide more support to HBCUs, especially junior scholars, to increase single investigator awards;
3. Identify other organizations and NSF programs to provide support to HBCUs to meet the NSF's goal of broadening participation. (National Science Foundation, 2015)

This study finds that the recommendations from the report make good fiscal sense given the efficiency of HBCUs and disparity in average grant funding.

FUTURE RESEARCH DIRECTIONS

The increasing costs of postsecondary education couple with public concern about the returns to a college education will require scholars to be more critical about the structure of the postsecondary system. Scholars who focus on HBCUs will need to create a body of research that is outcomes based using both qualitative and quantitative data. As resources become more constrained, HBCUs must partner with scholars to create narratives that contextualize their productivity given historical and current fiscal challenges. Additionally, scholars must work to shift the conversation about HBCUs from one that is deficient based, poorly trained students, to one that focuses on the productivity of HBCUs given the fiscal resources allocated.

NSF evaluates grants using two primary criteria: intellectual merit and broader impacts. Neither of these criteria explicitly take into consideration efficiency as examined in this study. NSF does take into consideration institutional resources available to achieve the goals of the grant proposal. I know of anecdotal evidence that suggests grant reviewers have questioned the ability of HBCUs to accomplish grant goals because the budget request was so low.

It is difficult to speculative about the consequences of using efficiency metrics to advocate for additional funding for HBCUs. For example, being more efficient could also be used as rationale for not increasing funding. On the other hand, the results from this study support the reasoning that HBCUs could do more if they had access to more funding. What will strengthen the results of this study, as evidence for additional funding for HBCUs, are narratives that speak to the value added to their students and the societal benefits of HBCUs.

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KEY TERMS AND DEFINITIONS

Faculty Development: Grant funding to support the research interest faculty.

HBCU: Is an acronym that refers to historically black colleges and universities.

Land Grant Institution: Is an institution of higher education created by fund provide by either Morrill Act, 1862 or 1890.

Organizational Development: Grant support for curriculum development and facilities improvement.

Productivity Per Dollars Invested: Provides a *productivity* ratio of grant dollars invested per science and engineering graduate.

Student Development: Grant support to support undergraduate scholarships.

ENDNOTES

[1] The population-based formula was also used to distribute funds under the Nelson Amendment of 1907.

[2] Other Social Sciences includes: Area/ethnic/cultural/gender studies; Criminal justice and corrections; Criminology; East Asian Studies; Demography/population studies; Geography; International relations/affairs; Linguistics; Public policy analysis; Gerontology; Statistics; Urban affairs/studies; Urban/city, community, and regional planning; Social sciences, general; History, science and technology, and society; American/U.S. studies; and Archaeology.

[3] Other Engineering includes: Agricultural engineering ; Bioengineering and biomedical engineering; Ceramic sciences; Structural engineering; Communications engineering; Computer engineering; Engineering mechanics ; Engineering physics; Engineering science; Environmental health engineering; Geotechnical and geoenvironmental engineering; Metallurgical engineering; Mining and mineral engineering; Nuclear engineering; Ocean engineering ; Operations research; Petroleum engineering; Polymer and plastics engineering; Systems engineering; Transportation and highway engineering; Engineering management and administration; Engineering, general; and Engineering, other.

[i] Two HBCUs are considered research universities – high research activity – Howard University and Jackson State University, and seven are considered doctoral research universities – Bowie State, Florida A&M University, Morgan State University, NC A&T University, South Carolina State University, Tennessee State University and Texas Southern University.