Team Control Number
54295

Problem Chosen
C

2016
MCM/ICM
Summary Sheet

Our goal is to make top tier institutions more available to prospective students that come from backgrounds of financial need and low education. We develop a model which rates public and private institutions as potential donation recipients based on the financial need of students in attendance and the success of alumni. We select the top ten rated public and top ten rated private schools and distribute funds proportional to the size of each institution. Since this is a charitable donation we estimate a Social Return on Investments (SROI). The SROI is calculated based on the goals of the students attending a given institution as well as the goals of the institution itself. This value estimates the extent to which our donation assist them in their endeavors.

A Small Grant of $100,000,000

Abstract

Our goal is to make top tier institutions more available to prospective students that come from backgrounds of financial need and low education. We develop a model which rates public and private institutions as potential donation recipients based on the financial need of students in attendance and the success of alumni. We select the top ten rated public and top ten rated private schools and distribute funds proportional to the size of each institution. Since this is a charitable donation we estimate a Social Return on Investments (SROI). The SROI is calculated based on the goals of the students attending a given institution as well as the goals of the institution itself. This value estimates the extent to which our donation assist them in their endeavors.

Introduction

We are interested in supplying aid to schools based on two major characteristics: a high need for financial assistance and demonstrated production of successful and well-equipped graduates. To determine which schools need financial assistance we look at each school's median student debt upon graduation and percentage of full price attendance that a low income student must pay on average. If a school's values are particularly high in both of those categories, we say the school is in need. Schools with high earnings when compared to the average and high completion rates show they are capable of consistently supplying students that are successful post graduation. This also makes them more desirable as candidates for donations.

Private schools do exceedingly well in our generalized rating system, however we also want to provide aid to public schools as they tend to be more accessible to low income and first generation students. Thus for the purposes of our investigation we choose to select, separately, the top ten public and the top ten private schools for donation. We calculate the amount to donate to each school based on the size of the school.

In order to predict the return on our investments, we must consider that we are a foundation with charitable goals. Thus we consider a Social Return on Investments model [3] which allows us to account for our effect on the institution and the students to which we are donating. This model will take into account the goals we have for the institution as well as for the students in our investment, and estimates how much of an impact we have on these two entities. The goal for the schools is to increase the population of students from diverse income backgrounds, and the goal for the students is to increase availability of this quality of school. It then estimates how much the Goodgrant Foundation assists them in achieving their goals.

Candidate Elimination

We determined that institutions meeting any of the following criteria should be immediately disqualified from our considerations.

- Schools that have been deemed financially irresponsible. We want to see our donation be used in a productive manner and the schools that fall under this category have shown that they cannot manage their money well.

- Schools that are not currently operational. A school may not be operational for a multitude of reasons but we are not interested in donating the amount of money necessary to reconstruct an entire educational system from the ground up.

- Schools that only offer graduate programs. We are interested in providing undergraduate students the necessary means to have access to a high quality education. A school solely offering graduate degrees does not reach our demographic, nor does it show a high need for student funding.

- Schools that are online only. These schools are generally not as expensive as in-person learning (no facilities, need to relocate, etc.), and we believe they generally do not offer the quality of education we are hoping to better equip our undergraduates with.

This leaves us with 2,988 candidate schools for donation.

Assumptions

- Schools that did not provide data for a particular category were given the minimum score for that category (based on other reported values).

- All funds will be used as we intended and will have a direct, positive impact on student/school performance.

Variables

Table 1 lists all of the variables used in our model and throughout this paper

Notation	Property
A	Lack of financial aid percentile of a given institution (compared to institutions of similar type)
C	Maximum cost of attendance for a given institution
D	Median debt upon graduation percentile of a given institution (compared to institutions of similar type)
G	Graduation rate percentile of a given institution (compared to institutions of similar type)
H	Total donation to a particular institution
M	Predicted gain of investing in a given institution
P	Earnings difference percentile of a given institution (compared to institutions of similar type)
R	Overall rating of a given institution
a	Percentage of full price attendance a low income student must pay on average at a given school
c_i	Average net price for a student in the ith family income bracket to attend a given institution
$\max\{c_i\}$	Maximum of the average net prices for students in the five family income brackets to attend a given institution
d	Median student debt upon graduation of a given institution
$\bar{e}_j$	Mean of the set of median earnings of students working and not enrolled 10 years after entry for schools of type j
$\widetilde{e}$	Median earnings of students working and not enrolled 10 years after entry to a given institution
g	Graduation rate of a given institution
j	Type of institution (Public $= 0$, Private $= 1$)
p	Earnings difference $(\widetilde{e} - \bar{e}_j)$ of a given institution
w_k	Weight on kth rating factor
q	Percentage of students receiving the Pell Grant at an institution.
$SROI_I$	Social Return of Investment for Institutions
$SROI_S$	Social Return of Investment for Students

Table 1: Nomenclature

Model Development

School Selection

In order to rank every school against the other, we devised a weighted rating system based on four criteria we identified as most important. The equation we used to rate a given school is

$$R = w_1 P + w_2 G + w_3 D + w_4 A \tag{1}$$

where P is the percent of institutions of the same type (public or private) whose earnings difference is lower than that of a given school, G is the percent of institutions of the same type whose graduation rate is lower than that of a given school, D is the percentage of institutions of the same type whose median debt upon graduation is lower than that of a given school, A is the percentage of institutions of the same type who offer more financial aid to their lower income ($0-$30,000 family income bracket) students than a given school, and w_1 through w_4 are the weights placed on each rating term. The larger a weight is for a given rating variable, the more influential the variable becomes to the school's overall rating.

The earnings difference percentile (P) is determined by comparing the earnings difference of students produced by a given school (p) to that of all other institutions of that type (public if the given school is public and private if the given school is private). We define earnings difference as the difference between the reported median salary of a school's students ten years after entry ($\tilde{e}$) and a mean median salary of all institutions of the same type ($\bar{e}$). The distribution of earnings differences was normalized and corresponding percentiles (see Appendix II) represent the variable P in our model.

The graduation rate percentile (G) is determined by comparing the graduation rate of a given school (g) to that of all other institutions of that type. The distribution of graduation rates was normalized and corresponding percentiles (see Appendix II) represent the variable G in our model.

The median debt upon graduation percentile (D) is determined by comparing the median debt upon graduation of a given school (d) to that of all other institutions of that type. The distribution of median debts was normalized and corresponding percentiles (see Appendix II) represent the variable D in our model.

The lack of financial aid percentile (A) is determined by comparing the percentage of full price attendance that a low income student must pay on average at a given school (a) to that of other institutions of that type. We estimate this percentage to be the average cost of full-time attendance for a student in the $0-$30,000 family income bracket to attend the institution (c_1) divided by the maximum average cost of full-time attendance for the five different family income brackets ($\max\{c_i\}$). The distribution of percentages was normalized and corresponding percentiles (see Appendix II) represent the variable A in our model.

Applying our model to each of the 2,988 candidate schools we find our top ten rated public and top ten rated private institutions as listed in Tables 3 and 4.

Distribution of Funds

In total we selected twenty schools to whom we would distribute grant money; ten public and ten private. We decided the amount of money invested in a single school should be proportional to the number of undergraduates enrolled at the given school. Exact amounts for donation can be found in Tables 5 and 6. Our aim is for a proportion of the money given to a school to be distributed among the currently attending low-income students in the form of tuition grants. We suggest that this proportion be equal to the estimated percentage of low-income students at the

school. As for the rest of the donation, it will be distributed as grants for in-need students whom would otherwise not have attended the given institution for financial reason.

Social Return on Investments

Using a Social Return on Investments (SROI) model, we aim to gauge the impact of our donations on each of the twenty selected institutions. We model the school and student impacts separately (as detailed in Table 2) and compute a cumulative year one SROI for each individual donation. Allocating the money in the same way each year, the total SROI for our 5 year investment plan will be five times the SROI for one year.

Stakeholder	Outcome	Indicator	Value	Deadweight	Attribution	SROI for 1 Year
Students	Improved quality of education and future	Increase career prospective	Median earning for school	Subtract the proportion of money that a student could have made at a similar institution.	The role that the Goodgrant Foundation played in assisting students get this degree: 15%	SROI value after one year for students
Institution	Investing in the future of students and increasing diversity in institutions as well as availability to students	Increased number of degrees obtained by students that are low income	The amount of debt decreased overall	Subtract the proportion of students that would have already attended that are eligible for the Pell grant	The role that the Goodgrant Foundation played in helping the institution achieve increasing this value outside of time alone: 15%	SROI value after one year for the institution

Table 2: SROI Model

Equations 2 and 3 utilize the process detailed in Table 2 to compute the projected one-year SROI values for a given donation.

$$\text{SROI}_I = 0.15(H - qH) \qquad (2)$$

where H is the total donation for a particular institution and q is the proportion of Pell grant recipients (our estimated proportion of low-income and first generation students) at the institution. For this model, we estimate the Goodgrant Foundation donation will be solely responsible for 15% of the increase in diversity within an institution.

$$\text{SROI}_S = 5(0.15)[\widetilde{e} - \overline{e}_j] \qquad (3)$$

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where $[\widetilde{e} - \overline{e}_j]$ is used to estimate how much the donation, by enabling a student to attend the institution, is contributing to the student's success post-graduation. For this model, we estimate the Goodgrant Foundation donation will be solely responsible for 15% of the increase in the education/future quality of the student.

Results

Selected Schools

Using our model's overall rating output, we recommend the following ten public and ten private schools to receive a share of the $100 million donation. As our model suggests, top rated schools do exceptionally well at producing educated and hard-working members of society (higher graduation rates and earning differences than most other candidates of the same type). However, as our model also suggests, top rated institutions also exhibit a strong need for financial assistance (larger median student debts upon graduation as well as smaller proportions of financial aid available to low income students than most other candidates of the same type).

Public Institutions

Table 3 lists the ten selected public institutions for donation and their corresponding statistics.

Institution	Rating	Earn.Diff.	Stud.Debt	Grad.Rate	Aid.Lack
Maine Maritime Academy	0.932	1.000	0.949	0.992	0.785
Colorado School of Mines	0.916	1.000	0.932	0.975	0.757
College of William and Mary	0.906	0.994	0.771	0.999	0.858
Montclair State Institution	0.890	0.953	0.882	0.953	0.773
Institution of Pittsburgh - Pittsburgh Campus	0.890	0.948	0.947	0.996	0.666
Rowan institution	0.887	0.954	0.786	0.983	0.824
Pennsylvania State Institution - Altoona	0.880	0.939	0.949	0.972	0.661
Temple Institution	0.874	0.925	0.928	0.967	0.675
Institution of Iowa	0.872	0.953	0.838	0.980	0.715
Pennsylvania State Institution - Main Campus	0.863	0.939	0.949	0.983	0.567

Table 3: Statistics for the Top 10 Public institutions

For example, our model ranks Maine Maritime Academy as our number one choice public institution with an overall rating of about 0.932. This particular institution shows great promise as it has a higher graduation rate than about 99.2% of public school candidates and a higher earning difference than about 100% of public school candidates. This school also exhibits a great need for financial assistance. Our data shows that Maine Maritime Academy has a larger median student debt upon graduation than about 94.9% of public school candidates and the amount of aid Widener's low income students receive is lower than about 78.5% of public school candidates.

Private Institutions

Table 4 lists the ten selected private institutions for donation and their corresponding statistics.

Institution	Rating	Earn.Diff.	Stud.Debt	Grad.Rate	Aid.Lack
Widener Institution (Delaware)	0.839	0.836	0.751	0.935	0.833
institution of the Sciences	0.820	0.999	0.703	0.820	0.758
Art Center College of Design	0.819	0.836	0.985	0.722	0.732
Rose-Hulman Institute of Technology	0.818	0.998	0.703	0.842	0.728
Bryant Institution	0.788	0.952	0.703	0.908	0.588
Catholic Institution of America	0.773	0.878	0.638	0.746	0.828
Albany College of Pharmacy & Health Sciences	0.768	1.000	0.569	0.795	0.709
MCPHS Institution	0.768	1.000	0.569	0.819	0.683
Coleman Institution	0.766	0.791	0.822	0.501	0.951
Xavier Institution	0.766	0.783	0.703	0.871	0.708

Table 4: Statistics for the Top 10 Private institutions

For example, our model ranks Widener institution - Delaware Campus as our number one choice private institution with an overall rating of 0.839. This particular institution shows great promise as it has a higher graduation rate than about 93.5% of private school candidates and a higher earning difference than about 83.6% of private school candidates. This school also exhibits a great need for financial assistance. Our data shows that Widener has a larger median student debt upon graduation than about 75.1% of private school candidates and the amount of aid Maritime's low income students receive is lower than about 83.3% of private school candidates.

Money Allocation and SROI

Listed below in Tables 5 and 6 are the suggested donation amounts as well as projected five-year SROIs for our top ranked public and private institutions.

Public Institution	Donation	SROI After Five Years
Maine Maritime Academy	$3,048,425	$1,627,859
Colorado School of Mines	$3,051,492	$1,887,195
College of William and Mary	$3,054,558	$2,021,736
Montclair State Institution	$3,057,625	$1,438,765
Institution of Pittsburgh-Pittsburgh Campus	$3,069,893	$1,909,626
Rowan Institution	$3,060,692	$1,605,256
Pennsylvania State Institution-Altoona	$3,066,826	$1,534,409
Temple Institution	$3,063,759	$1,527,590
Institution of Iowa	$3,072,959	$1,865,440
Pennsylvania State Institution-Main Campus	$3,103,628	$1,916,179

Table 5: Money Allocation and SROI for Public institutions

These results give us a total institution SROI value of $17,334,060 and a total student SROI value of $151,461.

Private Institution	Donation	SROI After Five Years
Widener Institution - Delaware Campus	$322,016	$186,544
institution of the Sciences	$5,612,291	$3,101,352
Art Center College of Design	$5,342,411	$2,529,498
Rose-Hulman Institute of Technology	$6,639,678	$4,063,981
Bryant Institution	$10,007,054	$6,247,403
Catholic Institution of America	$11,166,314	$7,342,968
Albany College of Pharmacy and Health Sciences	$3,296,838	$1,924,941
MCPHS Institution	$11,678,474	$6,123,315
Coleman Institution	$1,631,551	$627,372
Xavier Institution	$13,653,510	$8,369,260

Table 6: Money Allocation and SROI for Private institutions

These results give us a total institution SROI value of $40,516,637 and a total student SROI value of $224,441.

Across the board, our total investment strategy SROI value comes out to be $58,226,600, which is just over half of the value we donated to these schools. It is important to note that we are not necessarily looking for a return that results in profit for our organization. We are interested in having a positive impact on these institutions and their students. If we are able to make such high caliber institutions more available to students from low income families, then we are reaching the goals we have set for the Goodgrant Foundation donation.

Analysis

Strengths

- We prioritize candidate schools based on a number of relevant relevant factors.

- Top ranked schools are high performing and have actual need.

- Our school selection model is versatile as we are able to vary the weights to reflect different prioritization of school factors.

- It would be easy to add more variables of interest to our selection model.

Weaknesses

- We'd like to have a better method for estimating the expected median salary of a school than just taking the mean median salary of schools of the same type in our data set.

- Unreported values reduce the accuracy of our model results.

- Better method for determining number of in need students.

- We have little to no control over how the school will use the money (they may not contribute to our goals as desired).

- Weighted all variables the same. Probably should be different for public and private schools.

Future Research

- Parameter sensitivity analysis regarding the weighting of the factors in our model.

- More research into SROI parameters.

- Currently our model seems to favor smaller schools. We would like to investigate this to see if student population size has a significant impact on rating.

- Introduction of more variables into our school selection model.

- Investigation of other methods of dealing with missing/unreported data.

Conclusion

Our donation goal is to assist students in financial need attend top tier schools as rated by our system. We distribute our donation among the top ten public and top ten private schools according to the size of each school. We estimate an SROI based on the how much our donation is predicted to accomplish our goals for the institutions and their students. Our model predicts an SROI of about $58 million. This means that over half of our donation is going towards increasing the population of students at these schools that would otherwise not consider attending the particular school for financial reasons, thus improving the overall education and future of students.

References

[1] Collegescorecard.ed.gov. "College Scorecard". N.p., 2016. Web. 31 Jan. 2016.

[2] Nces.ed.gov. "The Integrated Postsecondary Education Data System". N.p., 2016. Web. 31 Jan. 2016.

[3] Princes-regeneration.org. "Social Return On Investment Analysis. Sustainable Heritage Toolkit". N.p., 2016. Web. 31 Jan. 2016.

Appendix I - Variables to Data

A majority of the given variables (see Table 1) were either taken directly or else derived from the data set [2][1] provided by the original problem. Here their correspondence is tabulated. Note: if data terms are in [ ] brackets, this means that the variable was either a function of all those data terms or took on the value of multiple of the terms enclosed. If there is an 'or' between terms, this means that there were two equivalent sets of data and the variable was taken to be whichever term in either set was not NULL.

Variable	Notation in "Most Recent Cohorts Data" file
a	NPT41_PUB or NPT41_PRIV
c_i	[NPT41_PUB ... NPT44_PUB] or [NPT41_PRIV ... NPT45_PRIV]
$\widetilde{e}$	md_earn_wne_p10
$\overline{e}_j$	md_earn_wne_p10
g	C150_4_POOLED_SUPP or C200_L4_POOLED_SUPP
q	PCTPELL

Table 7: Variables as they appear in the original data set [2]

Appendix II - Determining Z-Scores

Notation	Property
$\overline{a}_j$	Mean of the set of percentages of full price attendance that a low income student must pay on average for schools of type j
$s(a_j)$	Standard deviation of the set of percentages of full price attendance that a low income student must pay on average for schools of type j
$\overline{d}_j$	Mean of the set of median student debts upon graduation of schools of type j
$s(d_j)$	Standard deviation of the set of median student debts upon graduation of schools of type j
$\overline{g}_j$	Mean of the set of graduation rates for schools of type j
$s(g_j)$	Standard deviation of the set of graduation rates for schools of type j
$\overline{p}_j$	Mean of the set of earnings differences for schools of type j
$s(p_j)$	Standard deviation of the set of earnings differences of schools of type j

Table 8: Additional Nomenclature

The z-score of an earning difference is determined by $z = \frac{p - \overline{p}_j}{s(p_j)}$, where p is the earnings difference of the school in question, $\overline{p}_j$ is the mean of the set of earnings differences of schools of type j, and $s(p_j)$ is the standard deviation of the set of earnings differences of schools of type j. Since this process normalizes the distribution of earnings differences, the percentile P can then be found using a Normal distribution with mean 0 and standard deviation 1.

The z-score of an institution's graduation rate is determined by $z = \frac{g - \overline{g}_j}{s(g_j)}$, where g is the graduation rate of the school in question, $\overline{g}_j$ is the mean of the set of graduation rates of schools of type j, and $s(g_j)$ is the standard deviation of the set of graduation rates of schools of type j. Since this process normalizes the distribution of graduation rates, the percentile G can then be found using a Normal distribution with mean 0 and standard deviation 1.

The z-score of an institution's median debt is determined by $z = \frac{d - \overline{d}_j}{s(d_j)}$, where d is the median debt upon graduation for the school in question, $\overline{d}_j$ is the mean of the set of median debts of schools of type j, and $s(d_j)$ is the standard deviation of the set of median debts of schools of type j. Since this process normalizes the distribution of median debts, the percentile D can then be found using a Normal distribution with mean 0 and standard deviation 1.

The z-score of a this value is determined by $z = \frac{a - \overline{a}_j}{s(a_j)}$, where a is the percentage of full price attendance a low income student at the school must pay, $\overline{p}_j$ is the mean of the set of these percentages for schools of type j, and $s(a_j)$ is the standard deviation of the set of these percentages for schools of type j. Since this process normalizes the distribution of percentages, the percentile A can then be found using a Normal distribution with mean 0 and standard deviation 1.

Dear Mr. Chiang,

We have constructed a model to optimize our investment strategy and have determined the institutions which are most deserving of our support. We have utilized a metric (SROI) to estimate our social-return-on-investment and how effective our investments will be.

Our model captures two elements of each sampled school: how in need of funding it is and how desirable an investment target it is. Our model then assigns a decimal rating to each school. We determine a school to be in need of funding if:
- it provides little aid to its lowest-income students and
- its students have a high amount of debt at the time of their graduation.

We determine a school to be desirable as an investment target if:
- it has a high graduation rate and
- it produces students who make a high mean salary

All four of these categories carry equal weight in our model so no one factor is any more or less of a determining factor.

Based on our model, we have determined a list of the top ten public schools and the top ten private schools for our donations. We plan to invest in each school a fraction of the allotted $100,000,000 proportional its undergraduate population. Our model happened to favor smaller schools so the per-student donation will be notably high. This way we can have a significant impact on the best schools who are in the most need.

To gauge how effective our investments will be, we used a Social Return on Investments (SROI) model borrowed from the research of others. We believe this is a useful metric for our organization because it gives us a meaningful value that takes into account the fact that we are a charitable organization and will never make any money back directly.

The most deserving schools, their individual allotments, and the estimated SROI are as follows:

- **Maine Maritime Academy**, Investment: $3,048,425, SROI: $1,627,859
- **Colorado School of Mines**, Investment: $3,051,492, SROI: $1,887,195
- **College of William and Mary**, Investment: $3,054,558, SROI: $2,021,736
- **Montclair State University**, Investment: $3,057,625, SROI: $1,438,765
- **University of Pittsburgh - Pittsburgh Campus**, Investment: $3,069,893 SROI: $1,909,626
- **Rowan University**, Investment: $3,060,692, SROI: $1,605,256
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- **Temple University**, Investment: $3,063,759, SROI: $1,527,590
- **University of Iowa**, Investment: $3,072,959 SROI: $1,865,440
- **Pennsylvania State University-Main Campus**, Investment: $3,103,628, SROI: $1,916,179
- **Widener University-Delaware Campus**, Investment: $322,016, SROI: $186,544
- **University of the Sciences**, Investment: $5,612,291, SROI: $3,101,352
- **Art Center College of Design**, Investment: $5,342,411, SROI: $2,529,498
- **Rose-Hulman Institute of Technology**, Investment: $6,639,678, SROI: $4,063,981
- **Bryant University**, Investment: $10,007,054, SROI: $6,247,403
- **Catholic University of America**, Investment: $11,166,314, SROI: $7,342,968

- **Albany College of Pharmacy & Health Sciences**, Investment: $3,296,838, SROI: $1,924,941
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- **Coleman University**, Investment: $1,631,551, SROI: $627,372
- **Xavier University**, Investment: $13,653,510, SROI: $8,369,260

We hope you agree with our assessment and approve of these suggestions.

Sincerely,

Investment Team 54295

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