



Technical report

Data Mining and Predictive Modeling in Institutional Advancement: How Ten Schools Found Success

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Produced jointly with the Council for the Advancement and Support of Education (CASE) and SPSS Inc.



Table of contents

Executive summary.....	2
Introduction: Advancement and the promise of data mining.....	2
Creating and applying the predictive model: A case study of ten institutions	3
Using the model to identify patterns of giving.....	5
Benefits and implications	7
Conclusions.....	8
About the author.	9
About the internship.....	9
About SPSS Inc.	9
About CASE	9
Appendix: Aggregated study results	10

Executive Summary

This technical report, produced in partnership by the Council for Advancement and Support of Education (CASE) and SPSS Inc., explores the promise of data mining alumni records at educational institutions. Working with individual alumni records from The Johns Hopkins Zanvyl Krieger School of Arts and Sciences (A&S), a predictive regression model is developed based on commonly collected variables and a ten-step model-building and testing process. The resulting model's wider applicability is tested successfully on datasets from nine other educational institutions in the United States, Canada, and Europe. Analysis reveals four distinct patterns of giving by alumni. Fundraisers will benefit from this work by using the model to generate predictive scores identifying prospects in their own alumni databases, likely to make a major gift as well as appreciating their own institutions' pattern of giving when making strategic fundraising decisions.

Introduction: Advancement and the promise of data mining


As higher education moves into the 21st century, the advancement office has emerged as a powerful player with the capacity to consistently supplement traditional funding sources of colleges and universities through private philanthropy. These funds, collected from a built-in constituency of grateful alumni and other donors, have grown tremendously in the past 20 years, shifting from pleasant footnotes on university balance sheets to critical line items.

Institutions now rely on their advancement offices to subsidize rapid growth in diverse areas, including faculty positions, student aid packages, programs, buildings, renovations, and other capital projects. For context, consider that nearly 75 United States colleges and universities have initiated or closed campaigns totaling more than \$1 billion, and that the top ten fundraising institutions in the United States each reported more than \$350 million in total support for fiscal year 2007. As receipts increase and drive expectations ever higher, advancement offices must respond by adding staff and supplanting tired research procedures with new techniques that can expand their reach and raise standards for success without sacrificing efficiency.

One method for increasing productivity involves tapping into the expansive data warehouses that each institution systematically assembles from the earliest years of its relationship with alumni. Throughout the life cycle of its constituents, every school collects useful data on its future donors. This data is frequently updated and augmented as alumni establish their identities and embark upon careers, attain success and develop financial security, and begin to give back to the institution that contributed to their success.

It is unusual for institutions to have a long-term plan for utilizing the data they have so carefully collected. Until recently, very little has been done to convert raw data into usable information on a large scale. Many advancement researchers would be hard pressed to define a practical advancement application for such common database fields as marital status, race, and membership in affinity groups, yet the norm is to preserve this data rather than purging it from the database. In the for-profit world, this is exactly the type of data that has been collected and put to immediate use for decades by corporations seeking an edge over their competition. From seemingly trivial zip code inquiries from cashiers to intrusive advertisements based on the content of personal e-mails, corporations collect and analyze data in ways that non-profit institutions, with deep reserves of usable intelligence, have never considered.

The approach to data mining recommended in this paper will expand upon and standardize the prospect identification work already carried out by advancement offices in the United States and abroad. Advancement operations employ research to focus the efforts of gift officers, albeit on a small scale. An office might decide to focus on a single variable it believes to be correlated with giving, such as zip code, job title, age, or membership in a gift club, or perhaps even a combination of these variables. But until the relationships among the characteristics and behaviors of donors are understood in relation to one another, and until this analysis is conducted with a foundation in hard science, prospect identification will not rise from the ranks of the anecdotal; prospecting results are only as accurate as the assumptions upon which they are based.



This paper proposes a methodology for analyzing variables that may be linked to giving, considering variables proposed both by advancement offices and the relevant literature. The goal is to mine data systematically using multiple linear regression, a statistical method that assesses the unique relationship between multiple predictor variables (for example, “Marital Status” or “Consecutive Donor”) and an outcome variable (here, “Total Giving”). The resultant model will produce the ideal profile of a major donor by evaluating whether each predictor variable is positively, negatively, or uncorrelated with the outcome variable, and quantifying the relative size of each variable’s contribution. The ultimate outcome of this model is an institution-specific formula designed to predict the future giving of each individual based on how his or her profile corresponds to the ideal major donor profile.

Creating and applying the predictive model: A case study of ten institutions

The Johns Hopkins University (JHU), founded in 1876, is a private research institution offering undergraduate, graduate, and professional degrees and certificates. JHU is located in Baltimore, Maryland, with satellite campuses elsewhere in Maryland; in Washington, D.C.; in Bologna, Italy; and Nanjing, China, as well as a presence in India, Singapore, and the United Arab Emirates. The Johns Hopkins Zanvyl Krieger School of Arts and Sciences (A&S) features several departments that are among the top-ranked of their kind in the country. With approximately 3,000 current students and more than 40,000 total alumni, A&S is the largest non-medical division of JHU and the second-largest division overall.

Excellence at JHU is not confined to the classroom. The university consistently ranks among the top five fundraising institutions in the United States on the basis of annual cash receipts and will soon close a \$3.3 billion campaign. In 2008, A&S developed an aggressive new growth plan for the school’s advancement operation that aspires to nearly double fundraising returns within a period of five years.

Committed to developing a more sophisticated approach to prospect identification, A&S successfully nominated a member of its staff for the 2008 CASE Peter B. Wylie Data Mining Internship. Through the Wylie Internship, A&S worked under the direction of CASE and experts from the field of data mining, using cutting-edge data mining and statistical analysis software from SPSS Inc. to create a predictive model that could be put to immediate use by the A&S advancement office. Within months, this model—testable, replicable, and applicable to other divisions at JHU and institutions worldwide—became a critical piece of the A&S advancement office’s prospect identification procedures.

The A&S model was created using the following ten-step process:

1. Consider your possible predictors.

While one might naturally think that the perfect model would contain every potential indicator of major giving, in practice, only a few choice fields are needed to create a strong predictive model. The predictive model for A&S succeeded by using just twelve database fields: “Graduation Year,” “Gender,” “Marital Status,” “Race,” “Type of Program,” “Number of Children,” “Number of Children Affiliated with the University,” “City,” “State,” “Country,” “Business Address” (Y/N), “Consecutive Giving” (Y/N), and “Employment Specialty”. Other possible predictors, such as student life activities and academic awards, were omitted because of missing information.

2. Assemble the dataset.

Having decided on the variables to be included in this analysis, the next step was to compile a dataset with these variables. Using a basic spreadsheet program, each alumnus/a was entered on his or her own row, and a column was created for each of the twelve fields.

3. Clean up the data.

Because missing values have the potential to skew results, the blanks in each column were addressed. The closest attention was paid to continuous variables, such as “Graduation Year” and “Number of Children”; for these variables, missing values were either eliminated (all cases without a “Graduation Year” were removed) or transformed (all missing values for “Number of children” were replaced with 0). Missing values for nominal, or categorical, variables were replaced with *Unknown* and addressed in subsequent steps.

4. Review descriptive statistics.

Statistical software provides valuable information about large datasets by allowing users to view minimum, maximum, average, and median values for continuous variables, and counts and percentages for nominal variables. It was useful to learn that the median graduation year for alumni is 1987, and that 63 percent of alumni are male. Other figures, such as the percentage of alumni who have never made a gift or the top states by alumni population, should inform advancement decisions.

5. Test relationships.

In order to evaluate the relationship between potential predictor variables and lifetime giving, A&S employed a simple test: it identified the ranges of dollar amounts that divided alumni into four equal lifetime giving groups and recorded whether any particular values of a possible predictor yielded a larger percentage of alumni in either the top or the bottom giving group. For example, A&S evaluated all alumni in the database who were labeled *Married* on the basis of their lifetime giving. While 25 percent of all A&S alumni rank in the top lifetime giving quartile, more than 40 percent of married alumni were in that top group. This implied that *Married* was positively correlated with lifetime giving and should be included in the A&S model. A look at the *Male* value did not show a significant difference in the top giving group (25 percent vs. 29 percent), so A&S did not expect gender to play a large role in its model.

6. Prepare possible predictors.

After determining variables in its model, A&S prepared the possible predictors. For nominal variables, this meant converting each value into a new variable with two possible values: 1 for *Yes* and 0 for *No*. Some continuous variables, such as “Graduation Year” and “Lifetime Giving,” were transformed as well. For example, a new predictor variable called “Square of Graduation Year” was introduced to strengthen the model’s ability to differentiate between the youngest and oldest alumni, and lifetime giving totals were compressed using a logarithmic transformation that reduced the influence of the highest values.

7. Create the regression model.

In perhaps the easiest step, the predictor variables and outcome variable were identified using SPSS Inc.’s statistical software. The regression method selected was stepwise backward. The threshold to enter the regression equation was set at $p < .05$, and the threshold for removal at $p > .10$. In order to see the regression line, the outcome variable was plotted against the model’s predicted value output.

8. Evaluate the model¹.

In addition to statistical tests of a model's strength, one can consider its output. Each of the predictor variables was evaluated by the model and either included or omitted based on its relationship with lifetime giving. The variable "Gender," as we expected, was not included in the model because it had no discernable relationship with lifetime giving. Those variables included in the model were ranked according to the size of contribution to lifetime giving. Consider whether, for example, prospects in close proximity to where a gift officer is based should be ranked higher than prospects further away or fully outside of established territories, such as those with international addresses. Given the relative ease of domestic travel, compared to international travel, this is a reasonable assumption.

9. Rank prospective major donors.

In addition to outlining the positive and negative predictors for lifetime giving, our model assigned a score to each alumnus/a. Those alumni with the highest scores were the most likely to become major donors, whereas those with the lowest scores were the least likely. By dividing alumni into ten equal groups, or deciles, of ascending scores, A&S created a ranking system for prospective major donors called the Philanthropy Likelihood Index (PLI).

10. Evaluate predictions.

Before unveiling its predictive model, A&S confirmed that the model could make accurate predictions about the likelihood of alumni to become major donors. The school approached this from two angles: applying both an annual gift test and a major gift test. For the former, A&S expected that the top-ranked decile would consist of fewer non-donors than the school's average. This was in fact the case, as the tenth decile contained 84 percent fewer non-donors than the rest of the population and 90 percent fewer non-donors than the first decile. The major gift test assessed the model's ability to predict major donors by measuring how many known major donors fit into the school's ideal major donor profile. A worthless model would, in theory, distribute 10 percent of major donors to each decile. The A&S model captured 90 percent of known major donors, indicating that it had discovered a profile shared by the vast majority of the school's major donors.

Using the model to identify patterns of giving

After completing the analysis of the A&S alumni dataset, these steps were applied to nine other institutions in the United States, Canada, and Europe to gauge the universal applicability and utility of the model. A more detailed discussion of the results from all ten schools can be found in the following pages and in the Appendix. In summary, the model was successful in developing a profile for the ideal major donor at each institution, identifying qualified prospects for major gifts, and the variables most closely related with lifetime giving. Using between four and eleven database fields to create an average of 26 predictor variables, the model produced an average r^2 value of 34 percent for the nine schools, demonstrated a 70 percent decrease in non-donors in the tenth decile, and created a profile capturing an average of 90 percent of known major donors.

A review of the output from the ten institutions involved in this analysis reveals several noteworthy similarities and telling differences. Predictors that are among the most influential for one institution are completely insignificant for another, and certain institutions produce stronger predictions than others despite including fewer database fields. The latter observation, paired with an understanding of the mechanics of multiple linear regression, warrants a cluster analysis based on the distribution of total giving for each of the ten schools.

¹ There are a number of ways to assess the strength of the model, even before reviewing the prospects and making discovery calls. Statistically, the strength of the model is measured by the coefficient of determination (r^2), with 0 indicating no discernible linear relationship between predictors and the outcome variable and 1 indicating a perfectly linear relationship. Figures vary tremendously by field. While there is no definitive rule, an r^2 value greater than 25 percent is considered acceptable in the social sciences, and an r^2 value of 30 percent is typically acceptable in business applications such as market research. The r^2 value from the A&S model was 37 percent, indicating that the model explained 37 percent of the variance from the entire dataset of more than 40,000 alumni.

Including A&S, the ten schools that volunteered data comprise every aspect of higher education:

- Seven universities (including one land-grant), two colleges, and one community college
- Six public and four private institutions
- Eight institutions across the United States, one in Canada, and one in England
- Five self-identified research institutions and two specializing in the liberal arts
- Alumni participation rates ranging from 3 percent to 92 percent

Within this diverse pool of institutions, four distinct cluster types are formed based on the giving behavior of their alumni and the output of the A&S model. These clusters are listed below in order of increasing alumni participation. Each cluster is descriptive and diagnostic, taking into account the characteristics of its member schools and predicting not only what the A&S model will produce, but also how it could be more beneficial.

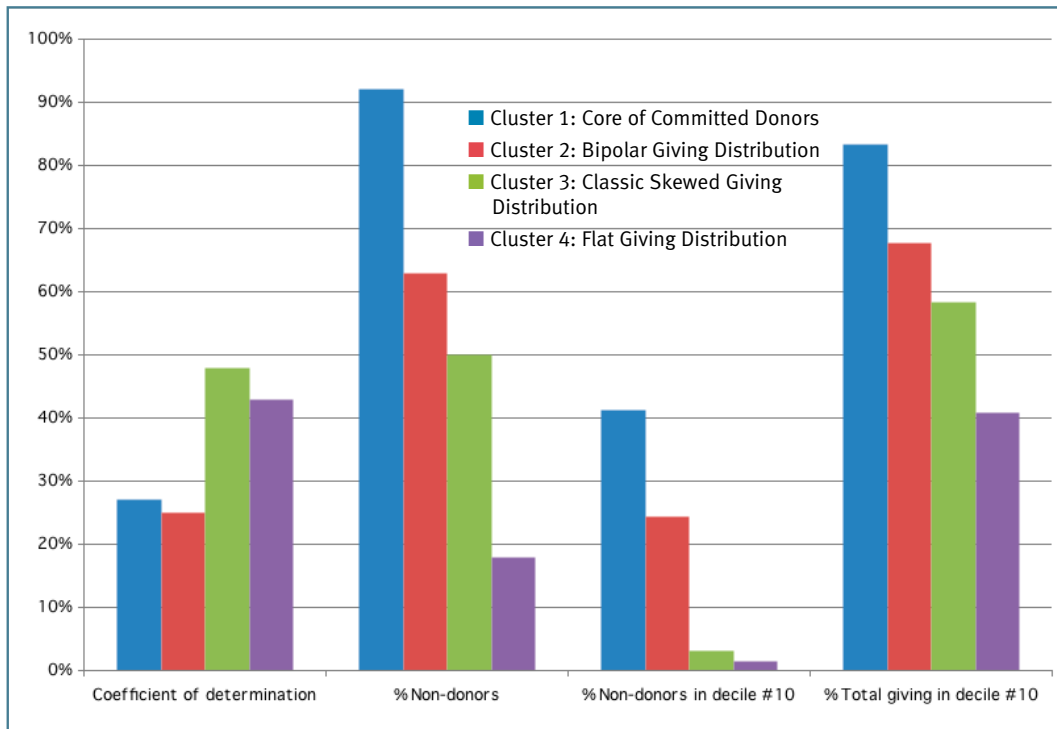


Figure 1: Cluster chart of alumni giving behavior and A&S model output

Cluster 1: The Core of Committed Donors²

This cluster is comprised of schools with relatively low lifetime participation rates (between 5 and 15 percent). Despite this fact, each institution in this cluster possesses a small subset of major donors who together provided most of the school’s total giving. While the high percentage of non-donors limits the ability of the A&S model to reduce non-donor representation in the top decile, the presence of few, committed major donors creates a strong ideal major donor profile that captures nearly 90 percent of known major donors for schools in this cluster. For these institutions (here, a community college in the United States and a university in England), data mining will be increasingly beneficial as the advancement office succeeds in raising the alumni percentage rate over time and gradually raises its standards for major giving.

² r^2 values were consistent within each cluster: low (avg. 11 percent) for the Core of Committed Donors, moderate (25 percent) for the Bipolar distribution, and high (47 and 43 percent) for the Classic Skewed and Flat distributions.

Cluster 2: The Bipolar Giving Distribution

Institutions in this cluster are characterized by considerable activity on both ends of the lifetime giving spectrum. A high lifetime non-donor percentage, between 55 and 75 percent, is contrasted with major donors who collectively contribute a large percentage of total giving. While the A&S model is still somewhat limited by the high percentage of non-donors characteristic of schools in this cluster, this is to a lesser extent than the Core of Committed Donors; here, the model produces both a strong top decile and a profile for ideal major donors that captures more than 90 percent of existing major donors. It is worth noting that five of the six total public institutions in this analysis, and both schools based outside of the United States, belong in the two clusters with the lowest rates of alumni participation. As with the previous cluster, institutions with this giving distribution (here, one Canadian university and two public universities in the United States) will continue to benefit from predictive modeling as alumni participation increases.

Cluster 3: The Classic Skewed Giving Distribution

This cluster features the giving distribution most commonly associated with advancement for higher education, whereby a majority of alumni—between 50 and 65 percent—make gifts in their lifetime but a very small percentage contributes the majority of funds. The A&S model was strongest for schools in this cluster, producing a significant decrease in non-donors in the top decile, an ideal major donor profile capturing an average of more than 90 percent of known major donors, and a median gift of more than \$1,000 in the top decile. The institutions in this cluster (here, one public and two private research universities) are in an ideal position to benefit from predictive modeling, because there is ample giving data from which to develop a comprehensive major donor profile; and they may have enough giving data to consider more specific applications of the A&S model.

Cluster 4: The Flat Giving Distribution

The final cluster is characterized by schools with exceptionally high lifetime participation rates exceeding 75 percent or even 90 percent. Unlike each of the previous clusters, giving totals for institutions with a Flat giving distribution are driven upward not just by major donors, but by alumni at all levels of giving. Alumni in any of the top three deciles are prospects for major gifts, as indicated by a lower non-donor percentage and a median gift amount of more than \$2,000. With such an abundance of giving data, schools in this cluster (two liberal arts colleges) and in the Classic Skewed Giving Distribution can entertain data mining projects that other schools likely cannot, focusing on specific constituencies or fundraising initiatives.

The following section highlights the potential of the A&S model to answer very specific advancement questions about fundraising projects, sub-constituencies, and giving vehicles.

Benefits and implications

The two primary goals of the A&S model were to predict the most likely prospects for major gifts and to identify predictors for major giving. On both counts, the model is an unqualified success for A&S:

- Of the 4,000 alumni in the model's top decile, more than 40 percent have never been identified by the advancement office as prospects for major gifts. Within this group, the nearly 450 alumni who have made gifts in excess of \$1,000 are considered Phase 1 prospects, and are assigned to gift officers for discovery.
- From twelve database fields, A&S created 129 possible predictors for major giving. Of these predictors, 80 are not correlated with major giving, 36 are positively correlated, and 13 predictors are negatively correlated. All of these predictors are shared with A&S gift officers to guide future discovery work, with particular emphasis on the six variables most closely linked to lifetime giving.
- More than 200 alumni in the model's lowest three deciles are currently listed as prospects for major gifts in the alumni database. This information is shared with A&S gift officers to ensure only the most worthwhile prospects are actively pursued.

The implementation of these results is greatly aided by SPSS Inc.'s comprehensive data mining workbench, which facilitates the development of predictive models. As seen in Figure 1 below, this software simplifies the complex logical operations upon which the A&S model bases its predictions, displaying the hierarchy of predictors and the corresponding influence of each predictor on lifetime giving.



Figure 2: An excerpt of the A&S decision tree model in text view in SPSS' Clementine®.

A&S continues to reap the benefits of its predictive modeling exercise, which has proven to be:

- **Easy to use.** Both SPSS Inc.'s statistical and data mining products are user-friendly applications for which ample support is available, including particularly useful online resources.
- **Quick.** Having completed this exercise, companion models can now be created and put to use within two to three weeks.
- **Testable.** The A&S model can be measured both quantitatively, as discussed in Section II, and qualitatively, as gift officers personally evaluate Phase 1 prospects.
- **Repeatable.** The analysis can be repeated as data is updated, identifying new prospects that previously occupied lower deciles and re-evaluating the relationships between each predictor and lifetime giving.

In sum, the greatest benefit of predictive modeling is that it can be used to answer very specific, very important advancement questions. When sufficient data is available, the model can be used to identify major prospects for a single fundraising initiative (e.g., undergraduate financial aid), for a category of related initiatives (e.g., capital projects), from an internal constituency (e.g., part-time alumni), or from a cohort (e.g., class of 1979). Similarly, the model can predict response to a particular annual fund solicitation (e.g., calendar year-end e-mail) or solicitation vehicle (e.g., direct mail.) By replacing lifetime giving with an outcome variable associated with any one of these more focused concerns, A&S is utilizing a proven model to create the ideal profile for that project. Even more valuable than a list of previously undiscovered major gift prospects or the predictors used to identify them is the ability to harness a proven model to guide strategic advancement decisions in real time that will maximize the potential of the A&S advancement office in the years to come.

Conclusions

With the advent of a new growth plan for advancement, the School of Arts and Sciences at the Johns Hopkins University developed a predictive model to increase the sophistication of its prospect identification efforts. The model was successful both in the short term, by identifying qualified prospects for major gifts, and in the long term by isolating the variables most closely related to major giving. These findings were confirmed through an analysis of nine institutions of higher education in the United States, Canada, and Europe.

A review of the predictions made by the Johns Hopkins model led to a cluster analysis that explained the model's output for each of the ten schools and identified the types of institutions for which predictive modeling would be most effective. As A&S implements the results of this data mining exercise, the most salient benefit is the inherent flexibility of its predictive model, which can be refocused in countless ways to guide strategic advancement decisions.

About the author

Dan Luperchio is the Campaign Administrator at the Johns Hopkins Zanvyl Krieger School of Arts and Sciences. Since 2006, his primary responsibility at A&S has been providing strategic support for the school's major gift operation. As the 2008 CASE Peter B. Wylie Intern, Dan developed and refined data mining and predictive modeling procedures that have been subsequently applied to a diverse pool of institutions of higher education in the United States, Canada, and Europe.

About the internship

The CASE Peter B. Wylie Data Mining Internship is a competitive, 8-week position offered annually for professionals interested in following a career path focused on data mining and predictive modeling in higher education and independent school advancement. CASE Research staff, Peter B. Wylie, and John Sammis advised on the data mining process and creation of the model. Additionally, CASE Research staff assisted with the preparation of this white paper and CASE member institutions contributed anonymous alumni data samples for analysis.

The internship is named after and supported by Peter B. Wylie, a national expert and leading author in the field of data mining. The internship is also supported by SPSS Inc. More information about the program, as well as application details, may be obtained by contacting Chris Thompson, Vice President of Research and Information for CASE, at thompson@case.org.

About SPSS Inc.

SPSS Inc. (NASDAQ: SPSS) is a leading global provider of predictive analytics software and solutions. The company's predictive analytics technology improves business processes by giving organizations consistent control over decisions made every day. By incorporating predictive analytics into their daily operations, organizations become Predictive Enterprises—able to direct and automate decisions to meet business goals and achieve measurable competitive advantage.

More than 250,000 public sector, academic, and commercial customers rely on SPSS Inc. technology to help them increase revenue, reduce costs, and detect and prevent fraud. Founded in 1968, SPSS Inc. is headquartered in Chicago, Illinois. For additional information, please visit www.spss.com.

About CASE

The Council for Advancement and Support of Education is one of the largest international associations of education institutions, serving more than 3,400 universities, colleges, and independent elementary and secondary schools in 60 countries. CASE is the leading resource for professional development, information and standards in the fields of educational fundraising, communications and marketing, alumni relations, and advancement services.

Appendix: Aggregated study results

Cluster	% Non-donors in decile #1	% Non-donors in decile #10	% Major donors in decile #1	% Major donors in decile #10	Median gift in decile #1	Median gift in decile #10	% total giving in decile #1	% total giving in decile #10
1: Core of Committed Donors	99.1%	41.4%	0.1%	86.8%	\$0	\$58	0.1%	83.4%
2: Bipolar Giving Distribution	91.8%	24.4%	0.0%	63.9%	\$0	\$199	0.1%	67.7%
3: Classic Skewed Giving Distribution	90.3%	3.0%	0.0%	64.4%	\$0	\$1,341	0.0%	58.4%
4: Flat Giving Distribution	59.4%	1.4%	0.1%	37.7%	\$18	\$3,453	0.2%	40.9%
Average	85.1%	17.5%	0.1%	63.2%	\$4	\$1,263	0.1%	62.6%

Cluster 1: Core Of Committed Donors

Type of institution	Country	% Non-donors in decile #1	% Non-donors in decile #10	% Major donors in decile #1	% Major donors in decile #10	Median gift in decile #1	Median gift in decile #10	% Total giving in decile #1	% Total giving in decile #10
Community college	U.S.A.	98.2%	0.5%	0.2%	98.1%	\$0	\$115	0.2%	97.6%
Public research university	England	99.9%	82.2%	0.0%	75.4%	\$0	\$0	0.0%	69.2%
Average	–	99.1%	41.4%	0.1%	86.8%	\$0	\$58	0.1%	83.4%

Cluster 2: Bipolar Giving Distribution

Type of institution	Country	% Non-donors in decile #1	% Non-donors in decile #10	% Major donors in decile #1	% Major donors in decile #10	Median gift in decile #1	Median gift in decile #10	% Total giving in decile #1	% Total giving in decile #10
Public research university	Canada	95.6%	12.8%	0.0%	74.0%	\$0	\$326	0.0%	80.2%
Public university	U.S.A.	86.1%	25.5%	0.0%	58.5%	\$0	\$190	0.2%	68.0%
Public research university	U.S.A.	93.8%	34.9%	0.0%	59.2%	\$0	\$80	0.2%	55.0%
Average	–	91.8%	24.4%	0.0%	63.9%	\$0	\$199	0.1%	67.7%

Cluster 3: Classic Skewed Giving Distribution

Type of institution	Country	% Non-donors in decile #1	% Non-donors in decile #10	% Major donors in decile #1	% Major donors in decile #10	Median gift in decile #1	Median gift in decile #10	% Total giving in decile #1	% Total giving in decile #10
Private research university	U.S.A.	88.3%	8.9%	0.0%	63.2%	\$0	\$1,200	0.0%	64.8%
Private research university	U.S.A.	85.7%	0.2%	0.0%	59.8%	\$0	\$1,250	0.1%	34.0%
Land-grant university	U.S.A.	97.0%	0.0%	0.0%	70.3%	\$0	\$1,574	0.0%	76.4%
Average	–	90.3%	3.0%	0.0%	64.4%	\$0	\$1,341	0.0%	58.4%

Cluster 4: Flat Giving Distribution

Type of institution	Country	% Non-donors in decile #1	% Non-donors in decile #10	% Major donors in decile #1	% Major donors in decile #10	Median gift in decile #1	Median gift in decile #10	% Total giving in decile #1	% Total giving in decile #10
Private liberal arts college	U.S.A.	89.4%	1.1%	0.0%	40.5%	\$0	\$2,718	0.0%	44.0%
Private liberal arts college	U.S.A.	29.3%	1.7%	0.2%	34.9%	\$35	\$4,188	0.4%	37.8%
Average	–	59.4%	1.4%	0.1%	37.7%	\$18	\$3,453	0.2%	40.9%



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