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Abstract

We introduce a quantitative model that can be used for decision support for planning and optimizing the composition of portfolios of market-driven academic programs within the context of higher education. This model is intended to enable leaders in colleges and universities to maximize financial performance of the selection of market-driven academic programs while also achieving qualitative targets for dimensions of the portfolio (e.g., mission alignment, student demographics, and faculty characteristics). This model is then applied to a case from a school of continuing education at a prestigious private university in the US. The results of the case highlight the potential positive impact of utilizing a model such as this for planning purposes.

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1. Introduction

Academic education is an important enabler for economic growth and expansion (Schultz, 1973; Seers, 2007; Denneen, 2012; Teixeira, 2016). Colleges and universities offer a variety of academic program types including traditional academic-focused bachelors, masters, and doctoral degree programs, market-driven degree programs, and other non-degree program offerings. To develop and maintain these programs, funding from the operating budget of a college or university is required. The operating budget is made up of many components. Some of these components are net negative financially for the overall budget (e.g., funds used exceed funds created by research in many cases, overhead expenses, PhD programs, traditional undergraduate programs, centers and institutes) while other components are net positive financially (e.g., funds created exceed funds used by non-traditional undergraduate programs, executive education, and market-driven masters degree programs). To ensure that the overall operating budget is balanced and provides funding for the core activities of the organization, strategic planning at the college and university level is employed and critical.

Over time, expenses in operating budgets have increased at a faster rate than sources of funding have grown and many colleges and universities are finding themselves in a difficult financial situation (Selingo, 2013; Denneen, 2012; Lyken-Segosebe, 2013; Drucker, 1997). As a response to these financial issues, colleges and universities are in-part, investing significantly in market-driven academic programs (Seers, 2007; Altbach, 2007; Hemsley-Brown, 2010; McDonald, 2007). These programs leverage academic research in a variety of disciplines as well as leading practices from industry to prepare students to address opportunities and challenges that exist in these areas of focus. Market-driven academic programs that address market gaps and needs for employee development of specialized skills, knowledge, and capabilities have the potential to not only impact society in a positive way, they can also play a key role in addressing the financial challenges of the colleges and universities who effectively address these market needs. That said, a balanced focus on financial performance, academic quality, reputation, and mission realization is desired and more likely to have a long term positive impact (Weisbrod, 2008; Chetkovich & Frumkin, 2002; Herman & Renz, 1998).

Colleges and universities can work to balance this dual objective of financial growth and quality by proactively managing sets of market-driven academic programs as a portfolio of programs. Portfolios of market-driven academic programs include multiple programs each with their own design, focus, and outcomes. These designs, foci, and outcomes result in programs that exhibit differing levels of alignment with desired portfolio dimensions. For example, one program could be very much in line with financial objectives for the portfolio, but be very far away from the mission desired for the portfolio. Another program could be the opposite. In this simplistic example, at a portfolio level, the financial and mission dimension objectives could both be achieved even though neither fully achieved by each and every program. Management of the portfolio is thus important to achieve the objectives of each dimension. This can be accomplished by adding new programs into the portfolio, redesigning elements of programs that exist within the portfolio, or removing programs from the portfolio. By viewing sets of market-driven programs as a portfolio of programs, all boats rise as these market-driven academic programs become a provider of much needed financial support for other areas of the college or university as well as contribute in new and different ways in the form of interdisciplinary and academically robust programs.

Significant complexity exists for many colleges and universities in planning for and managing the portfolio of market-driven academic programs and capabilities are still emerging (Friga, 2003). Traditionally, the maintenance and development of a portfolio of market-driven academic programs has evolved somewhat organically. In some cases, programs are launched or maintained as a result of an individual faculty member who is involved. Perceived market need, emulating competition in the market, or a personal interest of leadership are other drivers. Based on the observations of the researchers, some qualitative analysis is performed by colleges and universities to assess each program in the context of the overall portfolio for dimensions considered important for each college or university. Financial modeling is virtually always performed, however, as described above, this is only one dimension of the objective of leading colleges and universities operating in this space (Weisbrod, 2008). For both individual programs and the portfolio of all programs, objectives associated with financial performance are key drivers for decision making in the management of the portfolio. Additionally, qualitative objectives tied to academic quality, mission alignment, student demographics, and many other dimensions of the individual programs and the portfolio exist as well and must be taken into account. Balancing these dimensions to achieve the desired impact of the set of programs is critical and as the number of these programs increases within colleges and universities, proactive strategic planning and management are required.

While strategic planning in colleges and universities has been researched significantly (e.g., Keller, 1983; Fathi, 2009; Machado, 2010) and its importance clear, limited research on decision models to support portfolio planning exists especially as it relates to market-driven academic programs. Additionally, while program dimensions are analyzed retroactively, limited research exists tying these variables to proactive planning efforts to maximize the value of any qualitative dimension of a program or portfolio. Given the number of programs that can exist in a portfolio of market-driven academic programs, the financial and qualitative dimensions that are important to measure and monitor (Bilder, 1996; Sawhill, 2001), and the growing importance of these programs to colleges and universities, more sophisticated strategic planning models are required.

Strategic planning research for colleges and universities to this point has been focused primarily on implementing processes for strategic planning (Keller, 1983; Fathi, 2009; Machado, 2010) with limited research related to developing models for program planning specifically. Wells and Wells (2011) for instance have developed a qualitative model to assist leaders in strategic planning for managing a program portfolio. Using a model adapted from the General Electric McKinsey Product Portfolio Model, two dimensions, attractiveness of the academic program's marketplace and capabilities of the program and institution, are utilized to balance the market risk of a portfolio. Francis (2011) also provides significant detail on considerations at the program level for new program development processes for individual professional (e.g., market-driven) science masters programs. The models presented in the existing research are primarily qualitative with the exception of notable recent work by Labib (2014) where operations research techniques are used as a decision support model for high-level strategic planning for colleges or universities. Labib focuses on providing senior leadership in a college or university a model for their high-level entity strategic development “to model the changing scenarios in order to refine their strategic plans in response to external and internal drivers” (Labib, 2014: 887). However, their approach does not cover models for use in planning and optimization of market-driven portfolios of academic programs to inform complex decisions and environments.

In this paper we introduce a quantitative model that can be used as a decision support model for optimizing the composition of portfolios of market-driven academic programs. This model seeks to maximize financial performance of a portfolio of market-driven academic programs during a desired planning time period while also achieving targets for other non-financial dimensions of the portfolio (e.g., mission alignment, student demographics, and faculty characteristics) by deciding which programs to add, redesign, and/or remove for each year of the planning period. The output of the model is a program management schedule and development plan for the desired planning time period. We use an integer linear program (i.e., mathematical optimization) to describe the portfolio optimization problem. Integer linear programs are widely used for optimizing portfolios of financial and non-financial products and services in non-educational settings (e.g., Markowitz, 1952; Dantzig, 1963). The impact of (integer) linear programming on practice and theory has been significant. Some examples can be found in Troutt (1983), Mansini et al. (2014), Abbassi et al. (2014), and Schrijver (1999). An elementary overview on possible application of linear programming in practice can be found in Kanu et al. (2014). In order to use an integer linear program for our model, we must incorporate qualitative data into our quantitative model. To do so, we first discuss two methods of quantifying qualitative information related to market-driven program dimensions in the following section.

This paper adds to current theory and practice by applying operations research techniques to the problem of portfolio optimization in the context of market-driven academic programs in a college and university. To our knowledge no research on quantitative models exists for strategic planning in higher education especially as they relate to portfolio optimization. Given the importance of academic education to economic growth and expansion, more effective decision models are important to not only address market needs, but also to address the financial challenges within colleges and universities. This paper contributes significantly by providing a model for optimizing both financial and non-financial dimensions of portfolios of market-driven academic programs. Further, this model is applied to a case from a school of continuing education at a prestigious private university in the US. The results of the case highlight the potential positive impact of utilizing a model such as this for planning purposes. Financially, the model results in almost double the financial surplus than without the model while also achieving higher scores for all non-financial dimensions measured for the portfolio analyzed.

The remainder of this paper proceeds as follows. Section 2 discusses methods of quantifying qualitative market-driven program attributes. Section 3 introduces the integer linear programming model that provides an optimal program portfolio management and development plan for a desired planning time period. Section 4 applies the model to a case a school of continuing education at a prestigious private university in the US and illustrates how it can be utilized by a college or university and shows its potential impact. Section 5 concludes.

2. Quantifying qualitative market-driven academic program elements

Market-driven academic programs and portfolios of such programs have multiple dimensions of financial (e.g., revenue) and non-financial (e.g., faculty characteristics) measurement that are unique to each college or university. Each of these dimensions consists of one or more elements that are combined to determine the dimension score. Since some of these elements have a qualitative nature, we first need to assign quantitative scores to these qualitative elements. We describe two approaches of quantifying qualitative program elements in this section and then illustrate how they can be utilized to calculate the dimension score for an individual program and a portfolio of market-driven academic programs.

The first approach to assign a quantitative score for a qualitative element is to select a score based on a rubric established by an organization and assign that score to the element. Such a rubric transforms a measurable qualitative score into a score between 0 and 5, the so called *rubric score* for a given element *E*, i.e.,

$$(1) \qquad Rubric\ Score\ (E)\ =\ a\ number\ between\ 0\ and\ 5\ obtained\ from\ one\ or\ more\ rubrics$$

For example, a typical element for assessing the faculty characteristic dimension is the number of publications in specific types of journals. A rubric for the number of publications could be created by the college or university to transform this element into a score between 0 and 5. The rubric may prescribe that three publications in top journals in one year will lead to a score of 5 whereas three publications in non-peer reviewed journals will score a 2. This score would be recorded for the individual faculty member and leveraged as part of an overall calculation of the faculty characteristic dimension for a program. Rubrics for element scoring can be established by leadership teams and committees within the college or university and given that rubrics reflects the unique objectives and data available to each college or university, it is possible that different scores at different institutions will be established.

The second approach for quantifying qualitative program elements considers that an organization could be interested in the determining the degree of achievement of a certain target or optimal mix within the element. For instance, for the faculty characteristic dimension, a college or university could also be interested in achieving a certain target percentage of faculty have doctoral degrees. As colleges and universities seek to create balance in the amount of academic and practitioner expertise, faculty members with doctoral degrees not only bring the desired academic experience and rigor desired, they also have the potential to add substantively to the academic quality of the program. For this example, let's assume that a college or university seeks an optimal mix where 75% of their faculty members have a doctoral degree. When this target is achieved, a score of 5 on a scale from 0 to 5 for this element is determined. Calculating the so called *target score* for an element *E* first requires determining the absolute distance from the target and then converting it into a score between 0 and 5. The latter is performed in order to combine the rubric and target scores as desired in determining the overall score of dimension. Henceforth, the target score of an element *E* is defined as follows.

$$(2) \qquad Target\ Score\ (E) \ = \ 5 * \left(1 - \frac{|Target\ Value - Actual\ Value|}{Target\ Value}\right)$$

Using the introduced rubric and target score for a data element *E*, we can now calculate the dimension score of a portfolio of programs. Before this can be established we will define the score for an individual program made up of one or more elements. In the following, we will denote both the rubric score and target score of an element *E* by *score(E)*, since it will be evident from the nature of the element whether we are dealing with a rubric or target score.

Consider a set[1] of programs, portfolio *PP,* that consists of *n* programs $P_1, P_2, ..., P_n$. Next consider a specific dimension, *D*, and assume that the dimension *D* is specified by *m* data elements, $E_1, E_2, ..., E_m$. For each program P_i, where $i = 1, ..., n$, we determine the dimension score *D*. To do so, we introduce a set of non-negative weights $W_1, W_2, ..., W_m$ with the properties $\sum_{k=1}^{m} W_k = 1$ and $W_k \geq 0$ for each element. Each weight reflects the importance of its corresponding element in the dimension score, i.e. weight W_1 corresponds to E_1, et cetera. Then the dimension score *D* for program P_i is defined as the sum of the weighted scores of the elements, i.e.,

$$(3) \quad DimensionScore_D(P_i) = \sum_{k=1}^{m} W_k \, score(E_k) \; for \; each \; i \; \in PP$$

Observe that the individual program dimension score is a number between 0 and 5 by the definition of the rubric and element score and the definition of the weights. The following example illustrates the calculation of the individual program dimension score for the faculty characteristic dimension that is measured using two elements.

Example: In this example we assume that the faculty characteristic dimension, i.e., *D = 1*, score uses the two elements previous determined, research productivity (E_1) and percentage of faculty with a doctorate degree

[1]A set is a collection members (e.g., programs, years). For a given set A that includes members {a,b,c}, the symbol ∈ is used to denote that a is a member of A, i.e. a ∈ A.

(E_2). A college or university would only need to establish the desired weight for each of these elements to calculate the dimension score. Assume that the college or university values these elements equally and sets the weight for each to 50% of the total dimension score (i.e., $W_1 = W_2 = 0.5$). Using the previously described two methods of quantifying qualitative program elements, the faculty characteristic dimensions score for each program can be calculated. The left-hand side of **Figure 1** illustrates the calculation of the score of the faculty characteristics for each program $P_i, i = 1,2, \ldots, 9$. For example, utilizing a rubric to establish the score for research productivity, for Program 3, i.e. P_3, in the portfolio of nine market-driven academic programs has a research productivity element score of 4, i.e. score(E_1) = 4. Also, given that the percentage of faculty with a doctorate degree in Program 3 is 30% and the target percentage is 75%, using formula (2) to calculate the target score for the percentage of faculty with a doctorate degree element score (E_2), a score of 2 is determined, i.e. score$(E_2) = 5 * \left(1 - \frac{|75\% - 30\%|}{75\%}\right) = 2$. Hence, the score of the faculty characteristic dimension is, using formula (3) is $DimensionScore_D(P_3) = 0.5 * 4 + 0.5 * 2 = 3.0$. ■

In the final part of this section we will determine the dimension score of the portfolio PP. Assume that in the market portfolio PP, each program P_i has H_i students and the total number of students in a portfolio is T, i.e. $T = \sum_{i=1}^{n} H_i$. In order to demonstrate the relative importance of each program in the portfolio, the percentage of students in a specific program is compared to the total number students in the portfolio. Using the proportion of each program's enrollment to the total enrollment for the portfolio enables the dimension score for the portfolio to be reflective of the variation of program size and the impact to the overall portfolio. The *portfolio score* for the dimension *D* is calculated by summing the product of the dimension score (*D*) for each program (P_i) and the proportion of the total headcount of the program (H_i) as related to the total headcount of the portfolio (*T*), i.e.,

$$(4) \quad DimensionScore_D(PP) = \sum_{i=1}^{n} DimensionScore_D\,(P_i) * (H_i\,/\,T))$$

The following example illustrates the calculation of the portfolio score for a specific dimension.

Example: As illustrated in the right-hand side of **Figure 1,** for this portfolio, the faculty characteristic dimension weighted portfolio score is calculated for each program by multiplying the proportion of the total headcount of the program as related to the total headcount of the portfolio by each program's faculty characteristic dimension score. For example, Program 3, i.e. P_3, in the portfolio of nine market-driven academic programs has a faculty characteristic score of 3.0, i.e. $DimensionScore_D(P_3) = 3.0$. Multiplying the $DimensionScore_D(P_3)$ by the proportion of students in Program 3, i.e. $H_3 = 50$, relative to the total student headcount in the program portfolio PP, i.e. $T = 380$, yields the Program 3 individual program weighted score, i.e. $DimensionScore_D(P_3) * (H_3/T) = 3.0 * (50/380) = 0.39$. Using formula (4), all individual program weighted scores are then summed to determine the faculty characteristic dimension score for the portfolio, i.e. $DimensionScore_D(PP) = 2.29$. ■

Individual Program (i) Faculty Characteristic Dimension Score Calculation

Calculation of Weighted Portfolio Score

PROGRAM PORTFOLIO	Research Productivity E_1 (W_1=50%)	% of Faculty w/ Doctorate E_2 (W_2=50%)	Faculty Characteristic Score ($DimensionScore_D(P_i)$)	Program Headcount (T=380) **(H_i / T)**	Weighted Score ($DimensionScore_D(P_i)$ x (H_i / T))
Program 1	1	5	**3.0**	0 / 380	0.00
Program 2	2	1	**1.5**	10 / 380	0.04
Program 3	4	2	**3.0**	50 / 380	0.39
Program 4	2	1	**1.5**	100 / 380	0.39
Program 5	1	1	**1.0**	0 / 380	0.00
Program 6	1	4	**2.5**	30 / 380	0.20
Program 7	1	3	**2.0**	40 / 380	0.21
Program 8	1	1	**1.0**	50 / 380	0.13
Program 9	5	2	**3.5**	100 / 380	0.92

Weighted Portfolio Faculty Characteristic Score ($DimensionScore_D(PP)$) = 2.29

Figure 1: Example calculation of weighted-average faculty characteristic dimension score for a portfolio

As described above and illustrated through the faculty characteristics dimension score calculation example, it is possible to leverage this general method of quantifying qualitative program data detailed in this section to assign quantitative scores to qualitative data. By selecting the elements that are important in describing each qualitative dimension, determining the selected approach to quantify each element (e.g., assigning a score using a rubric or assessing the degree of achievement of a target), and then establishing each element's relative weight in the calculation of the qualitative score, a quantitative score can be established for each qualitative dimension for an individual program. Once the dimension scores are established for each program, the overall portfolio score is determined using the relative size of each program in the overall portfolio. These steps can be followed by colleges and universities to quantify many types of qualitative dimensions of academic programs.

3. General Portfolio Planning Model

We introduce a quantitative model that provides support in selecting the composition of portfolios of market-driven academic programs for a desired planning time period in order to achieve the desired financial and non-financial objectives of a college or university. As discussed previously, portfolios of market-driven academic programs have evolved somewhat organically in the past in part as a result of the complexity of measuring qualitative objectives (e.g., faculty characteristics) and the limited ability to balance these objectives with financial objectives. The former challenge is addressed using the methods presented in the previous section to quantify qualitative market-driven academic program elements and as a result of quantifying this information, an integer linear program can be utilized to address the latter challenge.

Optimization utilizing linear programming is well established as a technique for analyzing many complex decision or allocation problems (Kanu et al., 2014; Newman, 2013). As Luenberger states, "it offers a certain degree of philosophical elegance that is hard to dispute, and it often offers an indispensable degree of operational simplicity. Using this optimization philosophy, one approaches a complex decision problem, involving the selection of values for a number of interrelated variables, by focusing attention on a single objective designed to quantify performance and measure the quality of the decision. This one objective [function] is maximized (or minimized, depending on the formulation) subject to the constraints that may limit the selection of decision variable values." (Luenberger, 2008: 1)

The specific complex design problem we seek to inform is in establishing the annual composition of a portfolio of market-driven academic programs in a way to achieve the financial and non-financial objectives of the college or university. The output of the model is a program management schedule to achieve the desired results (e.g., programs to add, continue, and/or modify). **Figure 2** illustrates the potential output of the model for a 5-year planning time period. At the start of the planning period, the portfolio consists of 6 programs and over the course of the five years, the portfolio grows to 8 programs with only 2 programs remaining the same as in Year 0 (program 3 and 6). Two programs are modified during this planning horizon (program 2 and 4), and 4 new programs are added (program 7-10). Additionally, 2 programs are no longer matriculating new students (program 1 and 5).

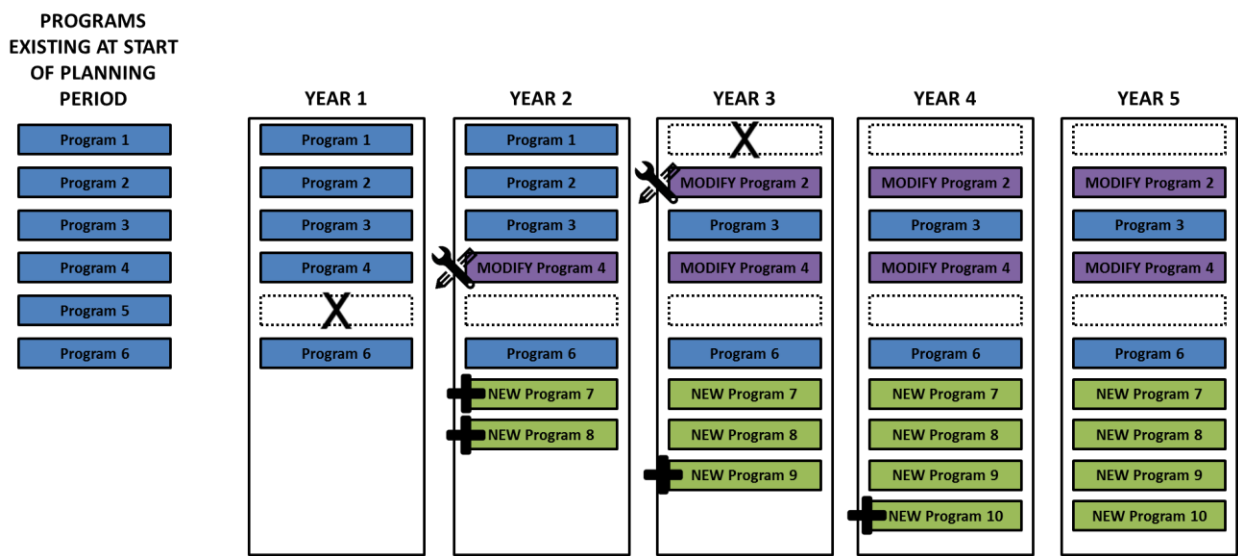


Figure 2: Illustrative Model Output

In the remaining part of this section we will provide the formal description of the integer linear program problem that is used in this paper.

Decision variables and parameters. In the general form of the model, decision variables for our integer linear program are the number of programs to add, continue, and modify for each year in the planning period are required. These decision variables will be solved to achieve the desired objective function subject to the constraints identified. If we denote *N* as the set of new program types, *E* as the set of existing program types,

M as the set of modified program types, and Y as the number of years of planning including the starting year indicated by year 0, the following decision variables can be established.

N_{ij} number of new program type i launched in year j, where $i \in N;\ j \in Y$

E_{ij} number of existing program type i running in year j, where $i \in E;\ j \in Y$

M_{ij} number of modified program type i launched in year j, where $i \in M;\ j \in Y$

Given programs cannot be partially in any of these states, the decision variables associated with adding, continuing, and/or modifying programs can only take a non-negative integer value (i.e., 0, 1, 2, etc.). This restriction makes our problem an integer linear programming problem.

A key input, described by several parameters in the general model, is detailed information for each 'program type' either existing currently in the portfolio or available to be developed by the college or university. Program types are defined by the college or university and financial and non-financial element scores are defined for each type for each year of the program's life (e.g., first year of running, ramp-up, and steady state). Many options exist for colleges and universities when developing new programs. The model assumes one or more program types are available to launch for new programs to be developed. For modified program types, it is assumed that existing programs are converted to one of the new program types available. Given pre-existing students, faculty, courses, and other elements are in place for the existing program, the financial objective measure and all required non-financial dimensions selected by the college or university for each program type are adjusted and are available to the model.

The variable amount of investment capital the model allocates each year is also an important decision variable in the general model. Program development and/or modification in the initial years can have a negative surplus (e.g., revenue – expense) while the program is ramping to desired returns. For colleges and universities, it is typical to have capital available that can be utilized to fund these investments. Investment in the model is assumed to be allowed in any year of the planning, however, there is a total maximum amount of investment capital available for the planning horizon. Each year of the planning horizon, the model determines how much investment capital to allocate to the portfolio.

I_j amount of investment capital provided in year j, $where\ j \in Y$

Objective function. For the case of optimizing a portfolio of market-driven academic programs, a college or university's objective function could be financial (i.e., revenue, profitability, cost) or qualitative (i.e., mission alignment) as the objective function seeks to optimize one dimension. A college or university could seek to maximize revenue, minimize cost, and/or maximize the mission alignment score of the portfolio. The objective of this general model is to maximize financial performance of the portfolio during the planning time period (*Y*) where S_{ij}^N (S_{ij}^E, S_{ij}^M) is the surplus estimated for each new (respectively existing, or modified) program type $i \in$ N ($i \in$ E, $i \in$ M, respectively) and $j \in$ Y.

The result of the objective function (formula 4) is the cumulative surplus for all years in the planning period (*Y*). The inner summation calculates the total surplus for all program types in a given year j. The outer summation then sums each year's total together to establish a total for the overall planning period.

$$(5) \qquad \text{maximize} \sum_{j \in Y} \left(\sum_{i \in N} N_{ij} S_{ij}^N + \sum_{i \in E} E_{ij} S_{ij}^E + \sum_{i \in M} M_{ij} S_{ij}^M \right)$$

Constraints. Constraints may limit the selection of decision variable values and ultimately potentially limit the achievement of the objective function (Luenberger, 2008). Constraints for colleges and universities with portfolios of market-driven academic programs can be financial or non-financial and are highly dependent on the college or university. Several constraints typically important to colleges and universities are included in the general model. Colleges and universities have limited resources and capacity to develop new programs. Programs take considerable time and resources to envision, design, approve, develop, launch, and ramp to steady state (e.g., grow program enrollment, offerings, and desired outcomes to full scale). Program modification goes through many of the same stages and requires significant resources and capacity as well. Let PDC_j (PMC_j, respectively), with $j \in Y$, denote the maximum capacity to develop new program (modify, respectively). A natural upper bound on the number of programs that can be newly developed or modified are ensured through the constraints, i.e.,

$$(6) \qquad \sum_{i \in N} N_{ij} \leq PDC_j \;\; for\ each\ j \in Y$$

$$(7) \qquad \sum_{i \in M} M_{ij} \leq PMC_j \;\; for\ each\ j \in Y$$

Colleges and universities in most all cases also have financial growth objectives for portfolios of market-driven academic programs and limited financial investment funds available. A portfolio growth requirement constraint has also been included in the general model. Let G_j, with $0 < G_j \leq 1$, be the portfolio growth rate requirement in year j, *IC* be the total investment capital available for the portfolio over the planning period, and I_j, with $0 < I_j \leq IC$, represent the current year's investment allocation. Therefore, the portfolio growth requirement constraint ensures the current year's total surplus and investment exceed the previous year's total surplus multiplied by the targeted growth rate, i.e. 1 + G_j. Formally, for all $j = 0,1, \ldots, |Y|-1$, we get,

$$(8) \qquad \sum_{i \in N} N_{ij+1} S^N_{ij+1} + \sum_{i \in E} E_{ij+1} S^E_{ij+1} + \sum_{i \in M} M_{ij+1} S^M_{ij+1} + I_j \geq$$

$$(1 + G_j) * (\sum_{i \in N} N_{ij}S_{ij}^N + \sum_{i \in E} E_{ij}S_{ij}^E + \sum_{i \in M} M_{ij}S_{ij}^M)$$

The final constraint ensures that total investment funds *IC* for the portfolio are not exceeded for the planning period by yearly investments I_j, $j \in Y$, i.e.,

$$(9) \qquad \sum_{j \in Y} I_j \leq IC \ for\ each\ j \in Y$$

Additionally, as colleges and universities seek to balance financial performance with the achievement of non-financial dimensions, the general model leverages the methods described in the previous section to include constraints on the financial performance to ensure the achievement of targeted non-financial dimension scores for the portfolio. The general model takes this critical constraint to the financial optimization into account by utilizing a slight modification of formula (4) from the previous section for each dimension utilized by the college or university. Let $D_1, \ldots, D_q$ be the set of dimensions that are important to the college or university. Consider dimension D_a for some $i \in \{1, \ldots, q\}$, then the corresponding targeted portfolio dimension scores for the portfolio *PP* in year *j* is denoted by $DimensionTarget_{D_a}(PP)_j$. The constraint should reflect that the portfolio score for a dimension D_a in a certain year *j* must be larger than the dimension target score of this dimension in that year, i.e.

$$(10) \qquad DimensionScore_{D_a}(PP)_j \geq DimensionTarget_{D_a}(PP)_j \ for\ each\ j \in Y$$

where the calculation of $DimensionScore_{D_a}(PP)_j$ is applied using the headcount for the programs in year *j* and formula (4).

The general model portfolio planning model described above which includes the decision variables, program type parameters, objective function, and constraints can be solved using appropriate software (e.g. Matlab). The solution of this optimization problem is an optimal program management plan for a portfolio that maximizes financial surplus for the period while also achieving the desired non-financial dimension scores.

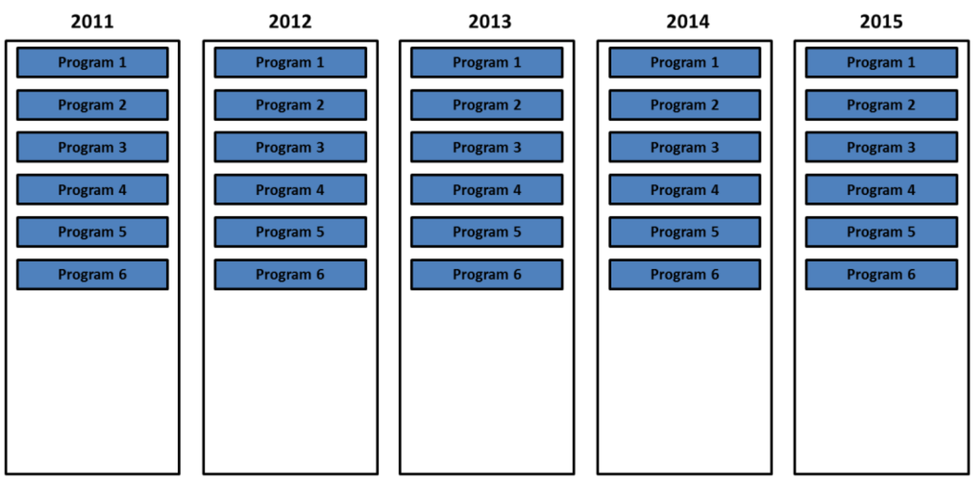
4. Case study

To illustrate how the general portfolio planning model described can be utilized by a college or university and qualitative program elements can be quantified, a portfolio of programs from a school of continuing education at a prestigious private university in the US ("SCE") is analyzed.

Case description. Detailed annual program financial and non-financial measures from 2011 through 2015 for a set of programs were available for this analysis from SCE. During this period, SCE had over 6,500 students enrolled annually in a variety of interdisciplinary subject areas such as bioethics, sustainability management, technology management, negotiation and conflict resolution, and strategic communications. The total size of the portfolio for the school at this time included approximately 55 programs (including 14 master of science programs).

For this case, data for a portfolio of six masters programs were selected for analysis. These six programs (fundraising management, construction administration, technology management, sustainability management, strategic communications, and sports management) were all of the masters degree programs sharing a core academic domain focus on management. There was limited change during the period between 2011 and 2015 in this set of programs while during the same period, the school expanded significantly. The same six programs that were present at the beginning of the 5-year planning time period beginning in 2011 were still present in their near original form at the end of the time period. Additionally, no new programs were added to this division during this period. Annually during this timeframe, there were approximately 800 students enrolled in the division with program size ranging from 80 to 300 students per program. Approximately 50% of the total population was female (22%-83% range) and 16% of the students in the division were international (4%-29% range).

Actual financial and non-financial data for each program in this portfolio is available for analysis. **Figure 3** illustrates the actual portfolio along with the annual financial surplus of the division and portfolio scores for the division in the qualitative dimensions of interest for this case: mission alignment, student demographics, and faculty characteristics. During this period, the portfolio yielded a total of $42.7M in surplus and achieved scores of 3.49, 2.68, and 3.93 in year 5 (i.e., 2015) in the mission alignment, student demographics, and faculty characteristics dimensions.



						TOTAL/AVERAGE
Financial Surplus	$7.83M	$9.21M	$8.92M	$9.06M	$7.65M	**$42.7M**
Mission Alignment Score	3.25	3.50	3.58	3.58	3.49	**3.48**
Student Demographic Score	2.26	2.45	2.62	2.61	2.68	**2.53**
Faculty Characteristic Score	3.95	3.96	3.95	3.94	3.93	**3.95**

Figure 3: SCE management programs actual performance: 2011 through 2015

Considerations for planning model. The model described previously allows for considerable tuning to match a college or university's strategy, parameters, constraints, and objectives. Incorporating these settings into the model and leveraging program financial and non-financial data from SCE programs during this same period, it is possible to observe the optimal portfolio as compared to the actual results. The difference between the actual results and the model results could be seen as 'missed opportunity' for the school. Specific settings for SCE's planning model are described in the following sections.

Parameters. While in theory, there are many types of programs that can be launched by a college or university, efforts have been underway to develop standardized program designs that seek to optimize resources and enhance the achievement of learning objectives (Attis, 2014; National Research Council, 2008; Council of Graduate Schools, 2011). SCE, during this period, was also working to minimize variation and simplify the program design, development, and execution of market-driven academic programs. To achieve these objectives, the school targeted three main standard program types for new program development and program redesign. Size of the cohort was the most significant element defining the program types for two main reasons: internal planning models used 25-person course sections for instructional staffing and expense models and depending on the subject area, market demand for a program was roughly estimated to fall into one of three categories, i.e., 25-, 50-, or 75-person cohort sizes. The size of the program type also had ramifications on the expenses required to support the program and these have been considered in the financial projections utilized by the model for each program type.

- *Type 1 ("small/boutique program"):* 25 person cohort annually, $100,000 program support, 15% of revenue allocated expense rate, 50% part-time student enrollment, 12 classes, $50,000 startup marketing. These inputs lead to program surplus $S_{1j}^{N}\ (S_{1j}^{E}, S_{1j}^{M})\ for\ each\ j\ \in\ Y$.
- *Type 2 ("mid-sized program"):* 50 person cohort, $160,000 program support, 20% of revenue allocated expense rate, 50% part-time student enrollment, 12 classes, $100,000 startup marketing. These inputs lead to program surplus $S_{2j}^{N}\ (S_{2j}^{E}, S_{2j}^{M})\ for\ each\ j\ \in\ Y$.

- *Type 3 ("large program"):* 75 person cohort, \$220,000 program support, 25% of revenue allocated expense rate, 50% part-time student enrollment, 20 classes, \$200,000 startup marketing. These inputs lead to program surplus $S_{3j}^{N}\ (S_{3j}^{E}, S_{3j}^{M})\ for\ each\ j\ \in\ Y.$

Observe surplus levels for each program type vary for new, existing, and modified programs given that varying levels of current student enrollment and revenue, courses, and other considerations for existing and modified programs will impact the level of surplus and timing for ramping programs to the desired level.

There are nine program type decision variables each year *j*, i.e. $N_{1j}, N_{2j}, N_{3j}, E_{1j}, E_{2j}, E_{3j}, M_{1j}, M_{2j}, M_{3j}$. In the year prior to start of the planning period, year 0, $N_{\mathbf{10}}, N_{2j}, N_{3j}, E_{1j}, E_{2j}, E_{3j}, M_{1j}, M_{2j}, M_{3j}$ all have a value of zero.

Objective*.* As part of the overall university operating budget, SCE was intended to be net positive financially to offset other components that are not. SCE's financial objective was to maximize cumulative financial surplus (i.e., revenue – expense) for the planning period, i.e. adding the values corresponding to $S_{ij}^{N},\ S_{ij}^{E}, and\ S_{ij}^{M}$ representing the financial surplus for each program type obtained in all years. For SCE, revenue was primarily tuition revenue and was calculated by multiplying the total number of credits students were enrolled in for the fiscal year by the credit tuition rate for the program. Total expense for a program type was a combination of direct and allocated expenses as described in the program type section previously.

Constraints*.* SCE desired to maximize cumulative financial surplus for the portfolio of management programs while also achieving targets in the areas of mission alignment, student demographics and faculty characteristics. Additionally, constraints for program development and modification capacity as well as investment capital available were present for the school during this period.

Mission alignment measures the alignment of the program to the mission of the school or unit (0-low and 5-high mission alignment). Measuring mission in a university or any nonprofit organization is fraught with complexity. Sawhill and Williamson (2001) illustrate this complexity through their analysis which includes over thirty nonprofit organizations and Palmer (2008) provides an in-depth view of variance between mission statements among business schools. Measuring mission alignment for nonprofit organizations is non-standardized and likely very important for organizations that hold mission and impact very close.

The *mission alignment dimension score* for an individual program for SCE during this time period was informally determined by five elements: area of interest for school (E_1), association with other programs (E_2), alignment with other areas of university (E_3), existing market need (E_4), and degree of program innovation (E_5). SCE had a desire to develop programs and serve faculty and students in areas where there was alignment in subject area domain both internally at the school and at the University. This enabled SCE to build on existing brand and capabilities, extending and growing on a solid foundation. Additionally, the school's role at the University was to be innovative and market-responsive in developing new programs and offerings in current domains and emerging domains and given the broad range of subject area domains possible, interest for the school in the domain was also a key consideration. Using the rubric approach described in section 2, each of these elements were assigned a score between 0 and 5. Additionally, these five elements were considered equally important to the mission of SCE. Therefore, the weight of each element was chosen to be equal, i.e. $W_1=W_2=W_3=W_4=W_5= 0.2$, in the calculation of the mission alignment dimension score using formula (3). SCE then sets an annual minimum target for the overall portfolio mission alignment dimension score. Mission alignment is critical and the school worked diligently to improve over this period, so a ramping dimension target for the portfolio over the 5-year period from a score of 3 in year 1 to a score of 4.5 in year five is assumed in the model.

Colleges and universities that focus on market-driven academic programs are keenly aware that the cohort of students assembled is critical to the success of individual programs and the overall organization as well. Market-driven academic programs are designed to address specific needs of the market and student demographics come into play significantly in the design of each program. For example, if the market demands individuals who have 5-8 years of work experience in addition to a graduate degree, the program will be designed to fit the needs of a population who has some work experience versus covering elements that would be considered too basic for the students enrolled. For example, in response to an increasing international student population, business schools are working to develop ways to incorporate new elements into their curricula to foster success for these students (Zhang, 2016)

Additionally, from a recruitment perspective, it is important for most all colleges and universities to bring in top candidates for each program. Tracking the realization of this objective is important to the long-term success of the program as well as the college and university. Matriculating students who are not at the standard of the program likely will cause the program to be perceived by the market poorly and lead to limited value of the program in the market.

There are many potential student demographic dimensions related to the student population that colleges and universities could be interested in analyzing and managing. Gender, GPA of incoming population, percentage of students with previous degrees, undergraduate degree, and amount of previous work experience are just a few. The *student demographic dimension score* for SCE during this time period primarily used only two student demographic elements: percentage of international students enrolled (E_1) and gender balance (E_2). Percentage of international students is a measure of internationalization of the student population in a given program. Gender balance measures the variance from target equal representation of each gender in a program. During this period, SCE was aggressively growing the number of international students in programs both to diversify the cohorts and diversify the sources of students for the portfolio.

Additionally, while the school was evolving into a data-driven organization where many program elements were codified and available, gender was one of the fields that was more readily available during this entire period. Data such as undergraduate GPA, other schools attended, etc. was not codified in a way where it could be easily reported on during this time. The target score method in formula (2) is used to calculate the difference between the target and actual program performance for both elements. For SCE, each of these elements resulted in a score between 0 and 5 was calculated. Similarly to the mission alignment score, the elements that influence the student demographic score are considered to be equally important, i.e. W_1=W_2= *0.5.* SCE then would have set an annual minimum target for the overall portfolio student demographic dimension score. At the start of this planning period, SCE's portfolio scored poorly (i.e., 2.26) and the school worked to improve over this period. A ramping target dimension score over the 5-year period from a score of 2.35 in year 1 to a score of 3.50 in year five is assumed in the model.

As discussed previously, for market-driven academic programs, significant consideration is put into determining the appropriate characteristics of the faculty to best achieve the objectives of the program as well as the college and university. The *faculty characteristics dimension score* for SCE during this period was calculated using primarily one element: the percentage of faculty in the program who were full-time faculty versus faculty who were practitioners in the discipline/field of study (E_1). SCE was primarily focused on this element during this period given little standardization in the requirements for faculty existed at the school level. Most requirements were at the program level and these requirements varied significantly limiting the value of analysis across the portfolio. Again the target score is utilized for this dimension. For SCE, a score between 0 and 5 was calculated. Observe, since only one element influences the faculty characteristic dimension we have that this element receives all the weight, i.e. W_1=*1.0.* Given the sole focus of the school on this limited measure for the portfolio, the faculty characteristic score was higher than the other non-financial dimensions, i.e. 3.95, so it is assumed that SCE would like to increase this score over the 5-year planning period from a score of 4.00 in year 1 to a score of 4.20 in year five.

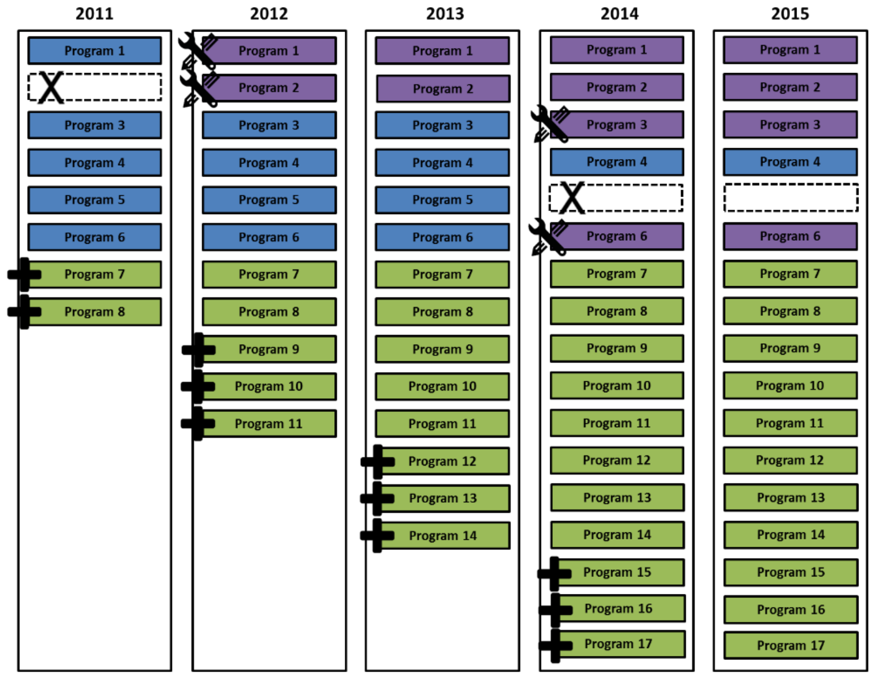
Desired annual *financial surplus growth* for the portfolio is a constraint in the model to ensure annual growth targets are achieved in addition to the cumulative financial surplus for the planning period. For SCE, a target of 10% growth over the previous year's financial surplus was required, i.e. $G_j = 0.10$ for all $j \in Y$). The 10% annual growth rate was an expectation from University leadership as part of multiyear planning effort that had taken place in 2009.

At SCE during this period, three programs were able to be developed annually ($PDC_j = 3$ for all $j \in Y$) and two programs were able to be modified annually ($PMC_j = 2$ for all $j \in Y$). This capacity constraint was a result of both limited direct staffing to design, develop, and implement program development and/or modification efforts as well as limited resources in shared services (e.g., admissions, student affairs, etc.) required to support these efforts.

In this case, SCE is assumed to have had a total investment capital fund of $1.5M available for the planning time period (*IC* = $1.5M). While it is difficult to pull apart investments in the school to improve quality in existing programs and departments from investments in the growth of new and/or modified programs, assuming an average cost of development or modification of approximately $50-$100K and given the development and modification capacity constraints, it is fair to assume that $300K of investment per year on average would have been estimated for the 5-year planning horizon.

Model output and analysis. Upon configuring the model with the case-specific objective, constraints, and parameters described in the previous section and leveraging 2011 program data as 'existing' programs in the portfolio, an optimal program management and development schedule is shown in **Figure 4.** Whereas in the actual portfolio during this period, all existing programs persisted, no additional programs were added and no existing programs were modified, the portfolio suggested by the model includes adjustments in each of these areas.

Specifically, in year 1, 2 and 3, three additional programs are launched each year (e.g., programs 7, 8, and 9 in 2011; programs 10, 11, and 12 in 2012; and programs 13, 14, and 15 in 2013). Three of the original six programs are modified during this planning horizon (e.g., programs 1, 2, and 6) and two programs are not executed in one year prior to being modified (e.g., programs 2 and 6 in 2013). Only one program is cancelled (e.g., program 5). The cumulative financial surplus for the portfolio when optimized by the model is $79.8M for this planning horizon. Mission alignment, student demographic, and faculty characteristic scores in year 5 (i.e., 2015) are 4.50, 3.51, and 4.28 respectively.



		2011	2012	2013	2014	2015	TOTAL/AVERAGE
Model Output	Financial Surplus	$7.86M	$8.67M	$16.14M	$21.03M	$26.09M	**$79.8M**
	Mission Alignment Score	3.43	3.86	4.10	4.29	4.50	**4.04**
	Student Demographic Score	2.39	2.76	3.07	3.32	3.51	**3.01**
	Faculty Characteristic Score	4.03	4.09	4.19	4.21	4.28	**4.16**
Actual Performance	Financial Surplus	$7.83M	$9.21M	$8.92M	$9.06M	$7.65M	**$42.7M**
	Mission Alignment Score	3.25	3.50	3.58	3.58	3.49	**3.48**
	Student Demographic Score	2.26	2.45	2.62	2.61	2.68	**2.53**
	Faculty Characteristic Score	3.95	3.96	3.95	3.94	3.93	**3.95**

Figure 4: Model output and Actual Performance for SCE management programs: 2011 through 2015

As compared to actual performance of the portfolio (**Figure 4**), the performance of the model not only projected higher financial surplus annually and in total for the planning horizon, it also resulted in achievement of higher scores in all non-financial dimensions (e.g., mission alignment, student demographics, and faculty characteristics) every year in every dimension. Financially, an additional $37M of cumulative surplus (86.6% increase) could have been realized by SCE during this planning timeframe if the portfolio would have been composed of the suggested programs. With the exception of year 2 of the planning horizon, annual surplus was also greater in the model as compared to actual performance. As illustrated in **Figure 4**, significant improvement in all non-financial dimensions by year 5 could also have been achieved. By using this model, additional funding could have been created and have had a meaningful impact on the overall university operating budget and the portfolio itself could have more effectively achieved the school's qualitative objectives.

Evaluation of model constraints for further policy direction.

To ensure quality of the portfolio, constraints on the model and portfolio such as mission alignment, student demographics, and faculty characteristics must remain at the defined levels regardless of the size of the portfolio. These values are established by senior leadership and while adjusting the dimension calculation weights for elements in formula (3) and/or adjusting target values for specific elements when using the target method in formula (2) will impact the solution for the model, it is assumed that values are determined independently for these constraints.

However, the capacity to develop of new programs, the capacity to modify existing programs and the determination of the amount of investment capital are parameters that can be adjusted. Holding the constraints that ensure quality of the portfolio, i.e., mission alignment, student demographics, and faculty characteristics, at their previously described targets and relaxing the capacity to develop, capacity to modify, and amount of investment capital constraints, provides insight on the individual impact of each of these constraints on the objective solution value established.

Given that the previously described model for SCE represents the optimal balance of financial and non-financial elements of the portfolio, analyzing the impact of the constraint values on the solution established by the model, specifically, the capacity to develop, capacity to modify, and amount of investment capital, can provide additional insights for leadership in capacity and investment decisions as part of the planning process. Significant consideration of the appropriate level of investment and resources takes place by colleges and universities with portfolios of market-driven academic programs. Understanding the interplay of these constraints, the importance of each to the achieving the overall financial and qualitative objectives, and the appropriate level to invest is very important for leadership's ability to clearly describe what can be significant investments intended to drive return for the college or university. In the remainder of this section, these three constraints will be analyzed further.

Sensitivity analysis of the constraints.

We apply the model in three ideal, but unrealistic, situations to illustrate the impact of each of these constraints on the model solution: (a) capacity limited to develop new programs, (b) capacity limited to modify existing programs, and (c) investment capital limited. In each of these scenarios, it is assumed that the unlimited capacity exists for the other two parameters. If left unbounded for any of these constraints, the maximum of the model will also be unbounded. Therefore for (a) and (b), the capacity to develop and capacity to modify constraints were set to (the unrealistic huge number of) 10,000 programs and for (c) investment capital available was set to (the similar unrealistic huge number of) $100M for the period. Constraints on the model and portfolio such as mission alignment, student demographics, and faculty characteristics remained at the desired levels to ensure quality of the portfolio regardless of the size of the portfolio.

Table 1 summarizes the model output for each of these scenarios as compared to the actual performance of the portfolio, the model output from the previous section, and an unrealistic maximum case where unlimited capacity and capital are assumed available. The capital constraint is shown to have the most significant impact on the objective value for the model. The new program development capacity constraint and the program modification capacity constraint are shown to have much less impact on the objective value for the model than the capital constraint. That said, the capacity constraint for new program development is more impactful than the capacity constraint for program modification, i.e., approximately $2M cumulatively over the 5-year period.

		2011	2012	2013	2014	2015	TOTAL/AVERAGE
Model Output	Financial Surplus	$7.86M	$8.67M	$16.14M	$21.03M	$26.09M	**$79.8M**
	Mission Alignment Score	3.43	3.86	4.10	4.29	4.50	**4.04**
	Student Demographic Score	2.39	2.76	3.07	3.32	3.51	**3.01**
	Faculty Characteristic Score	4.03	4.09	4.19	4.21	4.28	**4.16**
Actual Performance	Financial Surplus	$7.83M	$9.21M	$8.92M	$9.06M	$7.65M	**$42.7M**
	Mission Alignment Score	3.25	3.50	3.58	3.58	3.49	**3.48**
	Student Demographic Score	2.26	2.45	2.62	2.61	2.68	**2.53**
	Faculty Characteristic Score	3.95	3.96	3.95	3.94	3.93	**3.95**
Unlimited capacity and capital (unrealistic maximum)	Financial Surplus	$18.99M	$20.88M	$22.98M	$25.27M	$27.80M	**$115.9M**
	Mission Alignment Score	3.43	4.09	4.47	4.75	4.51	**4.25**
	Student Demographic Score	2.39	2.86	3.18	3.43	3.50	**3.07**
	Faculty Characteristic Score	4.03	4.10	4.19	4.24	4.25	**4.16**
(a) Capacity limited to develop new programs	Financial Surplus	$18.63M	$20.50M	$22.55M	$24.80M	$27.28M	**$113.8M**
	Mission Alignment Score	3.61	4.07	4.40	4.59	4.51	**4.24**
	Student Demographic Score	2.43	3.01	3.34	3.47	3.50	**3.15**
	Faculty Characteristic Score	4.04	4.20	4.22	4.23	4.37	**4.21**
(b) Capacity limited to modify existing programs	Financial Surplus	$18.99M	$20.87M	$22.98M	$25.27M	$27.80M	**$115.9M**
	Mission Alignment Score	3.43	4.09	4.47	4.75	4.51	**4.25**
	Student Demographic Score	2.39	2.86	3.18	3.43	3.50	**3.07**
	Faculty Characteristic Score	4.03	4.10	4.19	4.24	4.25	**4.16**
(c) Investment capital unlimited	Financial Surplus	$7.85M	$8.64M	$15.87M	$23.00M	$26.86M	**$82.2M**
	Mission Alignment Score	3.43	3.86	4.05	4.31	4.51	**4.03**
	Student Demographic Score	2.39	2.76	3.09	3.32	3.50	**3.01**
	Faculty Characteristic Score	4.03	4.09	4.23	4.31	4.28	**4.19**

Table 1: Summary of financial and qualitative impact of capacity constraints

Capacity to develop new programs.

Investing in capacity to develop new program is an important decision colleges and universities with market-driven academic programs must consider. Further, the decision is not only to have this capacity within the school or unit, but also how much capacity should be on hand.

The case includes a capacity constraint equal to three programs able to be developed annually. To understand the impact of this parameter on the overall portfolio over the planning horizon, we adjusted the program development capacity parameter in the base model while holding everything else constant. Program development capacity parameter values between 0 and 4 were modeled (**Figure 5).** Cumulative surplus for each scenario is also provided in **Figure 5**. The impact to cumulative surplus between the capacity to develop 1 program each year versus 4 is clear, i.e., $24.8M, and even the impact between the capacity to develop 3 programs each year, i.e., $2.4M cumulative surplus, is attractive. Program development capacity parameter values of 5 and greater resulted in the same solution as a parameter value of 4.

Several findings that potentially impact how managers make decisions in this area are highlighted.

First, with no program development capacity, no solution exists. It is not possible to achieve the qualitative dimension targets for the portfolio. It is known in colleges and universities focused on market-driven academic programs and illustrated in the model output (**Figure 4**) that program development is important to maintain the desired financial surplus, however, it appears as important to achieving the qualitative dimensions.

Second, relatively small investment in the capacity to develop has the potential to significantly impact the total financial surplus of the portfolio. As illustrated in **Figure 5**, if the capacity to develop new programs is 3 versus 1 each year, the total cumulative surplus (including the additional expense) is $21M greater.

Third, logic holds that with more capacity, the total value of the portfolio is greater, however, other constraints such as investment capital available and the planning horizon also come into play. For example, if investment capital is limited, the number of programs developed could be limited making the capacity to develop new programs non-impactful for the model.

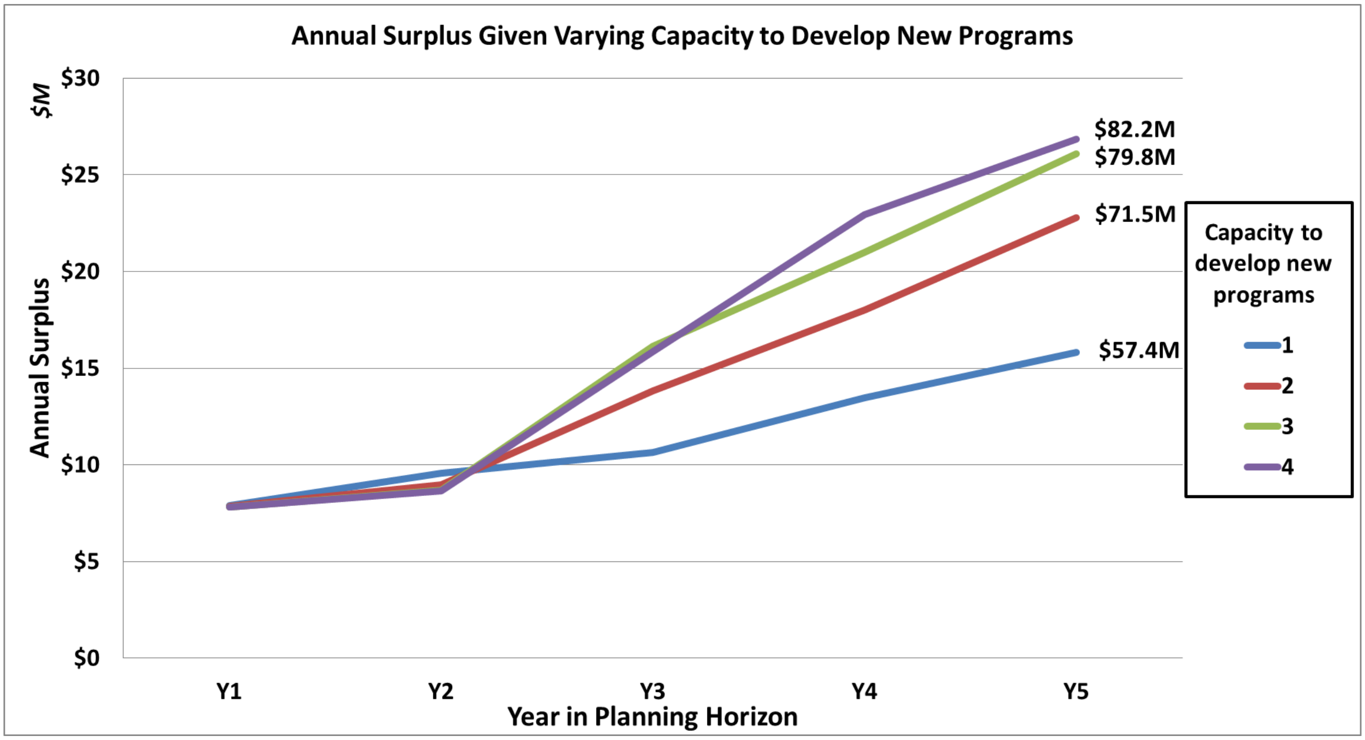


Figure 5: Impact of Capacity to Develop New Program on Portfolio

Capacity to modify programs. In the case, the capacity to modify capacity is limited to two programs each year. To understand the impact of this parameter on the overall portfolio over the planning horizon, we adjusted the program modification capacity parameter in the base model while holding everything else constant. Program modification capacity values between 0 and 2 were modeled as scenarios greater than 2 resulted in the same outcome as 2.

As illustrated in **Figure 6**, when there was no capacity to modify programs (e.g., modification capacity equal to zero), the cumulative financial surplus for the portfolio during this planning horizon was $69.3M - $10.4M less than the solution with a capacity to modify two programs each year. When the capacity to modify programs was one, the result was within $2M of the cumulative surplus total of the optimal solution and anything higher than a capacity to develop two programs per year had no impact on the results.

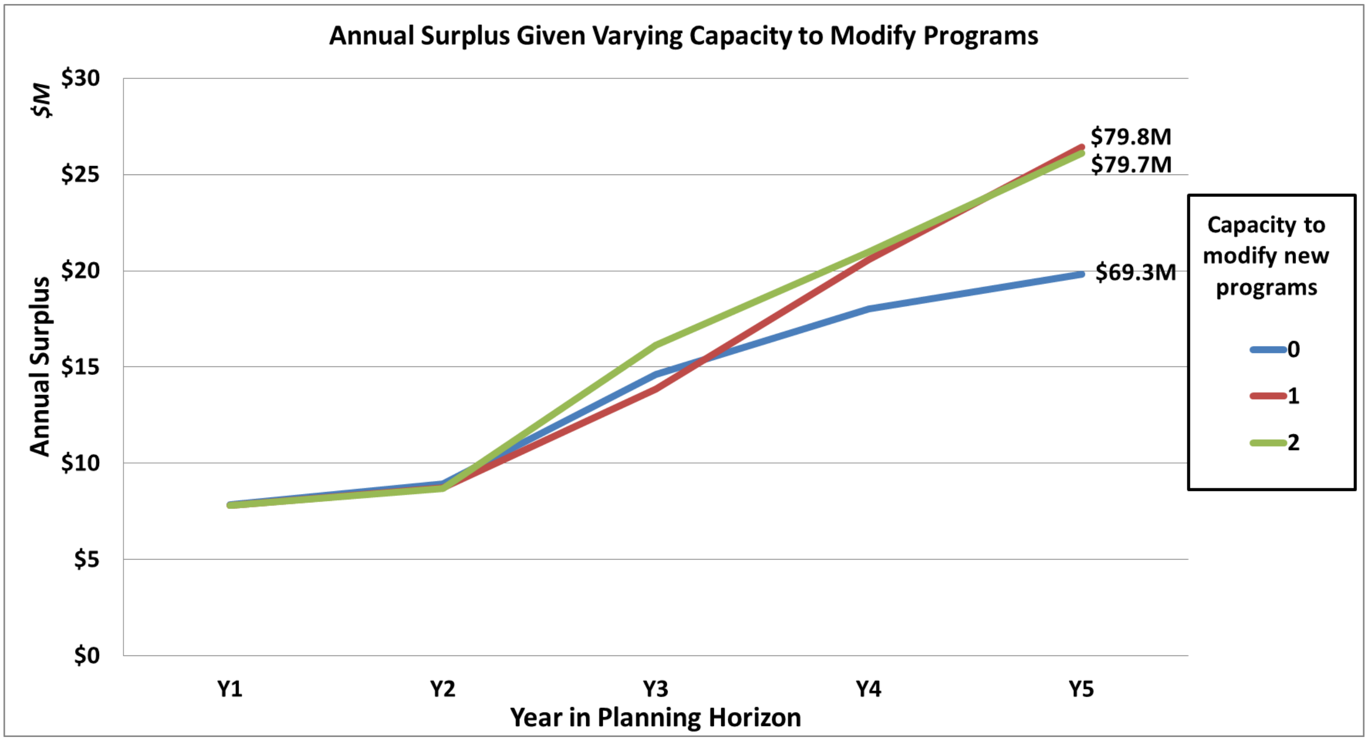


Figure 6: Impact of Capacity to Modify Programs on Portfolio

Investment capital. Identifying, retaining, and growing investment capital is a significant effort for leadership at colleges and universities developing market-driven academic programs. In reality, as described previously, universities have limited levers to pull when it comes to increasing funding and colleges and universities in this area are one of the most effective sources of funding for the larger college or university. The shared responsibility and challenge for leadership at both levels is to understand the appropriate amount of investment required as to not over-invest and not under-invest.

The case model includes a total pool of $1.5M of investment capital that can be used in any year during the planning horizon. To understand the impact of investment capital on the overall portfolio over the planning horizon, we adjusted the amount of investment capital in the case while holding everything else constant. Investment capital between $1.3M and $10M were modeled (**Figure 7**). No solution existed for investment capital amounts less than $1.3M since the required dimension targets cannot be attained.

Several findings that potentially impact how managers make decisions in this area are highlighted.

First, investment capital, even a small amount, is required to achieve a solution that balances the financial and non-financial objectives of a portfolio. In this case, investment capital levels of less than $1.3M do not allow the model to establish a solution.

Second, increased investment capital available, to a point, results in higher annual and cumulative surplus for the portfolio. At a certain point, marginal return of investment capital reduces significantly and further investment has no impact to annual or cumulative surplus. For example, between investment capital pools of $2.5M and $10M, when you take into account the additional amount of investment, there is no difference in the cumulative surplus created. Between investment capital pools of $1.3M and $2.0M on the other hand, there is a difference of $24.4M in the cumulative financial surplus achieved taking into account the additional investment capital provided.

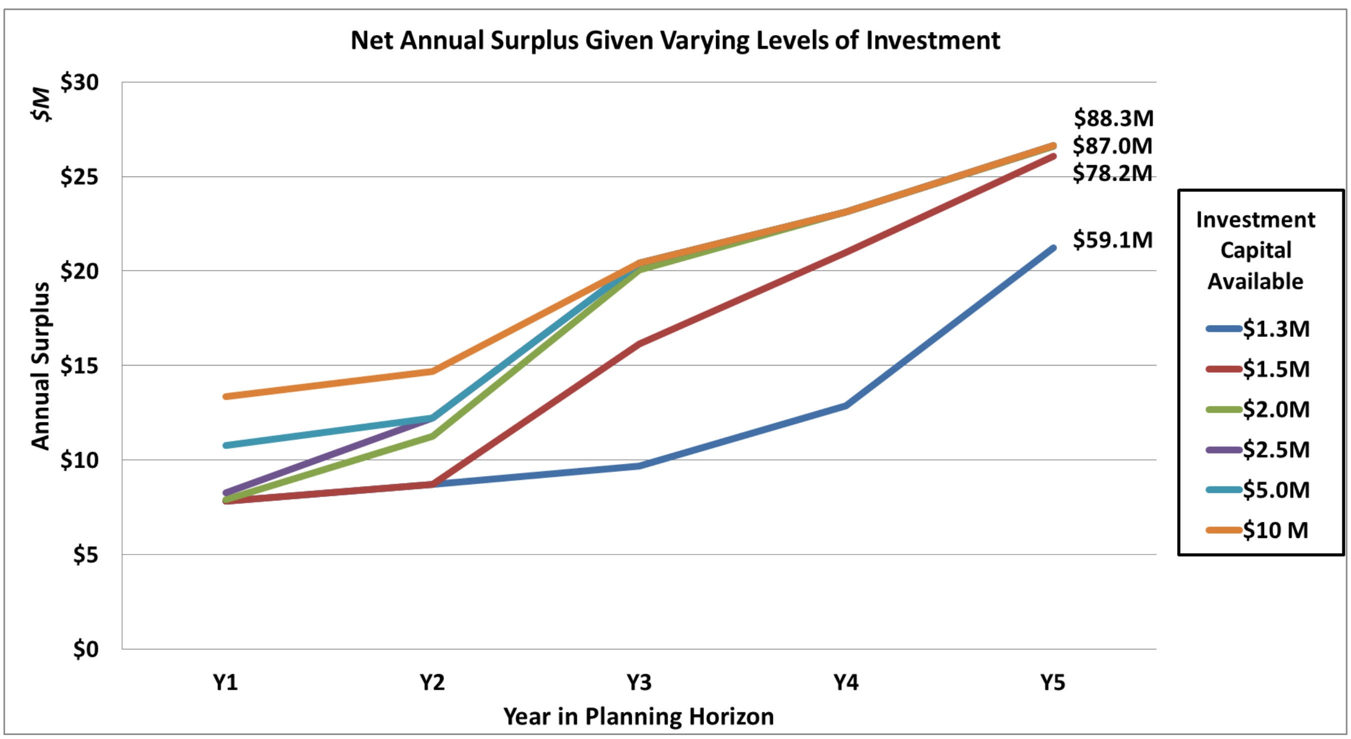


Figure 7: Impact of Level of Investment on the Portfolio

Based on the sensitivity analysis on the constraints we can conclude the following two major results based on this case.

First, effectively managing the amount of investment capital available for the portfolio has the potential to yield significant return. Given limited capital available for investment in many colleges and universities, this analysis illustrates that while for this model, investment is required to achieve a solution, large amounts of capital investment may not be required to achieve targeted financial and non-financial objectives.

Second, the capacity to develop new programs is minimally more impactful than the capacity to modify existing programs. Significant political challenges are many times associated with program development in colleges and universities. Additionally, the skillset of individuals who develop a new program and/or modify an existing program are very similar. Given the challenges associated with developing new programs, the similarity in resources required, and minimal value from focusing on development versus modification of programs, this case highlights that colleges and universities should consider prioritizing program modification over development.

5. Conclusion

This paper presents two methods of quantifying qualitative program attributes and a general program portfolio planning model that leverages such data and seeks to maximize the financial return of a portfolio of market-driven academic programs while also achieving non-financial dimension targets. As illustrated in the case with a school of continuing education at a prestigious private university in the US, the methods and model can be effective in both the planning process and as a 'policy guide' for portfolios of (market driven) academic programs. While colleges and universities will differ in their unique financial and non-financial objectives, decisions and input parameters, this program portfolio assessment model can be leveraged and impactful. Using the model to both assess and support decisions in portfolios of (market driven) academic programs can add substantively to the achievement of qualitative objectives, as well as, to the financial operating budgets of colleges and universities, improving the state of higher education and ultimately enabling economic growth and expansion.

This paper adds to current theory and practice first by developing and testing two methods of quantifying qualitative data and proving data such as this can be useful through the model. These methods enable the field to move forward via the possibility to incorporate qualitative elements in quantitative optimizations in many areas. Second, this paper shows that the linear programming can also be used to optimize educational portfolios. This is an extension of the applicability of this method. Future research in this area could include leveraging the portfolio planning model to analyze additional colleges and universities and/or expanding the scope to include all programs within a college or university (both market-driven and traditional). Additionally, the model can be altered to consider objectives other than financial maximization and considerations other than mission alignment, student demographics, and faculty characteristics to match the specific college or university's strategy. For example, a college could instead have an objective to maximize mission alignment and a constraint for achieving a certain financial return or impact measure.

Another area of potential research is to utilize this model to better design program types to fit the portfolio. For example, if one or more program types are not utilized (i.e., selected) by the general planning model, they could be redesigned to better fit the needs of the organization. Additionally, to achieve desired financial and qualitative targets for program types, looking back through the complete process required to identify and recruit students and faculty, as well as, identify and select subject areas could yield enhanced outcomes for the program portfolio. In fact, the complete system can be considered a supply chain for students, faculty, and subject areas. As illustrated in **Figure 8**, the design of a market-driven academic program is influenced significantly by the market of students demanding the program and faculty with appropriate skills available to design and teach in the program. From a student perspective, the reasons individuals decide to investigate, apply, and ultimately start a program as well as the skills they have coming into that program have a big impact on the design. A program that would best enable a junior population of students with limited experience and a focus on impact to achieve their goals might not be the best program for a more senior population hoping to achieve the next level in their career. Top faculty are also a critical element for a market-driven academic program. For such programs, faculty are sourced from either traditional research and/or academic fields or are currently practitioners in the field of study. Availability of the right type and quantity of faculty for a program impacts the program design. Additionally, from a financial perspective, the cost of student acquisition and/or the salary required for faculty will impact the program design and ultimate impact. By analyzing the sources of students and faculty for each market-driven academic program, it is possible to optimize the design and financial performance at the program level as well.

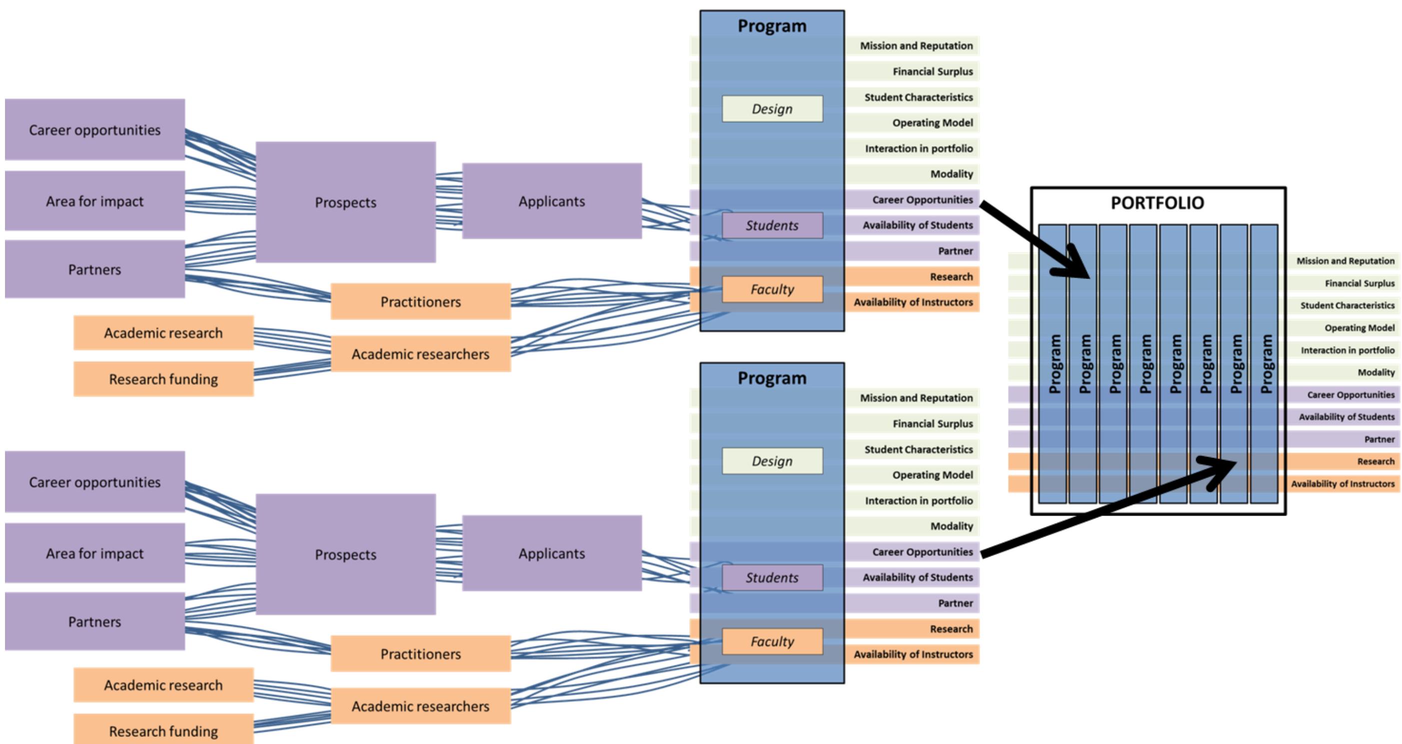


Figure 8: Portfolio of market-driven academic programs

The sensitive analysis performed in this paper is illustrative in nature and elementary. For a more rigorous mathematical approach, we recommend the use of stochastic optimization techniques (King et al, 2012) or robust optimization techniques (El Ghaoui, 2009). Further enhancement of this model would leverage these techniques to model uncertainty related to program launch, enrollment, and other program elements.

Identifying new ways to support research and education are very important for colleges and universities and economic growth and expansion. Market-driven academic programs are one lever to achieving this critical objective. This paper shows that it is possible to optimize the value of portfolios of these types of programs to achieve enhanced financial return and non-financial dimension target achievement. While strategic planning is essentially adding error to chaos, by analyzing the chaos with a variety of qualitative and quantitative decision models such as this, colleges and universities have the potential to create additional capacity and impact.

6. References

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